Enhancing problem-solving skills of pre-service elementary school teachers through problem-based learning

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Abstract

The purpose of this research is to enhance pre-service teachers' problem-solving skills by giving them opportunity to understand the problem solving process. The study, using an experimental approach, was conducted with 85 pre-service elementary school teachers. The experimental group experienced problem based learning (PBL), while the control group experienced traditional instruction (TI) in their science instruction course. Independent t-test and content analysis were used to analyse the quantitative and qualitative data. The quantitative results, supported by the qualitative research, revealed that the problem solving skills of the pre-service elementary school teachers experiencing PBL were increased more than those experiencing TI.

Key words: pre-service elementary school teacher education, problem-based learning, problem solving skills

Introduction

Problem solving skills are essential to success in a range of activities in everyday life. Graduates with strong problem-solving abilities are life-long learners that are able to critically analyse complex problems. Although developing problem solving skills is often accepted as a desirable goal in many educational settings, there is little evidence that students are graduated as better problem solvers. Traditionally, problem solving has been presented by most of the teachers just after the introduction of the course concepts by solving related problems and then asking students to solve similar problems. As a result, the students can solve routine problems, but they cannot adapt their prior knowledge for the solution of new problems (Hollingworth & McLoughlin 2001). Enhancing the problem solving skills of pre-service teachers by giving them the opportunity to understand the problem solving process may help them improve their students' problem solving skills.

Problem-based learning (PBL) is one of the recent educational methods promoting problem-solving skills. This approach is often used with collaborative or cooperative-learning strategies and utilizes small student groups of three to six individuals each. In PBL, problems are driving forces for learning. These problems are confronted before the acquisition of all the relevant knowledge. The groups formulate an understanding of the problem and perform research to reach a solution. As a result they acquire both content knowledge and problem solving skills (Littlejohn & Awalt 1999). Research shows that the PBL approach also develops a range of skills including group working and communication (Bernstein, Tipping, Bercovitz, & Skinner 1995, Eng 2000, Gibbon & Wall 2005, Lieux 1996, Lo 2004, Vernon, 1995). Science education in primary school teacher education requires being active and having appropriate affective prerequisites in an inquiry process to solve real life problems. PBL is a good candidate to provide these requirements. There are successful examples in science education research in which PBL is used as an inquiry way to solve real life problems, increase creativity, logical thinking, achievement, attitude and concept learning as an indicators of the quality of science education (Akınoğlu & Tandogan, 2007,Yaman &Yalçın, 2005a,Yaman& Yalçın, 2005b;). Therefore, in science education, problem based learning might provide open-ended, real life situations to experience inquiry and problem solving skills might also be developed with the experience on these problems.

The purpose of the present study is the application of PBL in order to give pre-service elementary school teachers the opportunity to understand the problem-solving process and to foster their problem-solving skills. Hence, to reach the purpose, PBL application through cooperative learning was applied in experimental group whereas the control group students were exposed to traditional learning applications. The main problem is, 'Is PBL effective on developing pre-service elementary school teachers' problem solving skills?' and the sub problems were: (1) Is there any difference with respect to problem-solving skills between the control and experimental group? (2) What are the opinions of the students about the implementation and implications of PBL?

Subjects

The sample of this research consisted of 85 pre-service elementary school teachers in Ereğli Education Faculty in Zonguldak, Turkey. There were two classes involved in the study. One of these classes was randomly assigned as the experimental group and instructed by PBL, whereas the other group was assigned as the control group and instructed by traditionally designed instruction. The number of students in experimental and control groups were 41 and 44, respectively.

Instruments

In order to measure the problem-solving skills of the students, Problem-solving skills inventory (PSSI) developed by Yaman (2003) was used. The inventory consisted 28 items in 5 point likert scale which were fully agree, agree, undecided, disagree, fully disagree. The cronbach α reliability of the test was found to be 0.87.

A semi-structured interview and open-ended questionnaire were prepared in order to determine opinions of experimental group students about the implementation and implications of PBL. Interviews were carried out with 6 groups (n=25) of 10. The group selections were made based on their achievement and participation levels during the instruction period: Two high achievers, 2 medium achievers, and 2 low achievers. The number of students responding to open-ended questionnaire was 25.

Context

The pre-service teachers who participated in the study were enrolled in the Science Instruction II course. The course has four sessions in a week and each session takes

50-minutes. One lecturer and two assistants conduct the course. In the course, theoretical subjects and their applications are separated as two-session periods. In the course, basic techniques such as concept mapping, mind maps and brainstorming are introduced for two sessions in each week and they are applied in the other two sessions in the same week. In addition to these techniques, teaching approaches in science education are introduced and applied. One of these approaches is PBL. In the course, the approaches take more time than the techniques due to their more comprehensive natures. In the course, the students might study individually or as a group, considering the aim of the course subjects. For the evaluation, the outcomes are considered as two different things, as outcomes for the theoretical part and the application part. Theoretical outcomes are assessed by paper and pencil tests whereas the applications are assessed by collecting products such as a portfolio, presentation rating, etc. The target population of the study enrols in the basic science courses such as biology, chemistry and physics out of science instruction courses. The type, content and number of the courses taken by the pre-service elementary teachers are the same for all of the pre-service teachers in Turkey.

Procedure

A total of 85 pre-service elementary school teachers, enrolled in ESN322 class, were involved in the study. ESN322, Science Instruction II, class had four 50-minute sessions per week. One of the ESN322 classes was assigned as an experimental group and the other as a control group. For this study, two sessions of the classes were used for 10 weeks during spring 2005. The post-test only control group design was used. During the research, both of the groups had the same learning objectives and were instructed by the same instructor. As opposed to the control group, there were 3 research assistants in the experimental group. The topics for the classes were composed of genetic engineering and global warming. The topics related to genetic engineering were gene cloning, the human genome project, genetic ethics, genetic products, agriculture and the topics related to global warming were effects of global warming on a sea ecosystem, the relationship of global warming with climate changes, the effects of global warming on human health and the relationship of global warming with agriculture.

In the first week of the research, the instructor asked students to form groups, each including four to five students. Each group was asked to pick a topic for their project, develop, design and present it.

Groups in the control group were responsible for giving a lecture to their classmates about their findings every week. In lecture process, the depth and quality of the information was evaluated by the instructor and their classmates.

Groups in the experimental group were responsible for the construction of necessary information and products based on the PBL approach. Hence, as the instructor provided these students with preliminary descriptions of problem-solving process and applications of PBL, she then asked them to prepare their problem sentences about their topics for the next week. In the second week of the study, the instructor and the research assistants gave feedback to the students' problem sentences. After the instructor had shown a sample of a scenario, the students wrote their own scenarios related to their own topics. They also contacted the instructor and the research assistants for their scenarios during that week. In the third week, they constructed sub problems for their scenarios and shared their tasks. They did research for the solution of their problems during the following two weeks. The sixth week of the study mainly included brainstorming in which they tried to produce various types of solutions to their sub problems. In the seventh week, deciding on the best solution, students determined what kind of products they would prepare. Almost half of the products were constructed for the eighth week. All of the groups made their presentations in the ninth week of the study.

After this instruction period the PSSI was administered to both experimental and control group students, and an open-ended questionnaire was distributed to experimental group students. Moreover, interviews were conducted with 6 of the experimental group students.

Data Analysis

The quantitative data gained from PSSI scores was analysed by using independent t-test.

The qualitative data gained from open-ended surveys were analysed using content analysis, whereas the data gained from the interviews with the students were analysed using descriptive analysis. After data coding of the open-ended surveys, the common aspects of these codes were gathered together. These common aspects were used for the determination of the categories. The frequencies and percentages for each of the concepts related with these categories were calculated. In addition, the recordings from interviews were listened, and the transcriptions were read carefully to gain an overall picture of their content. Each quote of the students was coded. These coded quotes that are related with the concepts gained from the interviews were used for the definition of the organized data.

Results and Discussion

The results of the study will be presented and discussed under this title. As shown in Table 1, the mean of the PSSI scores of the experimental group was 121.68 and that of the control group was 112.11. At the significance level α=0.01, the t-value was 4.27 while the p value was 0.00 which was statistically significant with 83 as degrees of freedom. Therefore, the independent t-test results of PSSI of the experimental and control groups revealed that there was a statistically significant mean difference between these two groups with respect to problem solving skills after the instruction. Hence, it can be said that students participating in a PBL environment performed significantly better on the problem solving skills inventory than students participating in a traditional learning environment. This result is in agreement with the related literature (Hamil 1997, Littlejohn & Awalt 1999, Musal, Taskiran, & Kelson 2003). In addition, the analysis of the data gained from open-ended surveys and interviews indicated that group work, problem-solving processes and general opinions about PBL were the 3 main categories to be considered as related to the problem solving skills of the students.

Table 1 ***Independent samples test results with respect to PSSI***

Group	n	mean	sd	t	df	p
Experimental	41	121.68	9.19	4.27	83	0.00
Control	44	112.11	11.28	1.62	41	0.11

As in Table 2, the concepts about group work were responsibility, cooperation, sharing, discussion and brainstorming, information or opinion exchange, and communication and socialization. The percentages of students using each of these concepts were 100%, 92%, 68%, 52%, 36%, and 32% respectively.

Table 2 ***Frequencies and percentages of responses related to group work***

Concepts	f	%
Responsibility	25	100
Cooperation	23	92
Sharing	17	68

Discussion & brain storming	13	52
Information/opinion exchange	9	36
Communication & socialization	8	32

All of the students interviewed also mentioned the group work during the research. Statements of the students about group work are given as follows:

The first group member said, ‘We were a team supporting each other. Being a team needs patience and helps us to find out the best solutions’. The second member of this group added, ‘If I were preparing this project alone, I would only do some research and get the available limited information. That’s it!’ Agreeing with these two friends of hers, the third group member of the same group started with one of the Turkish proverbs: ‘One hand does not clap and produce noise. Two hands do,’ and said, it was easier to produce various opinions when they were working in groups. Believing that the group study was more effective than individual study, the second group member stated that working in groups and cooperating with others gave them the opportunity to synthesize different opinions. Having similar thoughts about cooperative group work, the third and fourth group members also said that they were coming together almost everyday and decided the best idea for a better result.

It may be summarized that group members worked cooperatively as a team in this PBL environment. They met systematically in their meetings in which they shared their ideas, made discussions, produced different ideas, selected the best of those and produced solutions as a team. Similar to this result, Gibbon and Wall (2005) also mentioned about the improved collaborative skills of students through PBL. According to Vygotsky, students are capable of performing at higher intellectual levels when they work in collaborative situations than when they work individually. During cooperative learning, students realize that although there are different viewpoints, they have to reach a joint resolution. Hence, being forced to justify and defend their own opinions well, they examine their own points of view and assess their validity (cited in Savander-Ranne 2003). As a result, these types of active exchange and sharing of ideas within groups provide students the ability to communicate with their partners, make explanations, interpretations, be engaged in discussions, construct knowledge and become good problem solvers.

As seen in Table 2, in their open-ended questionnaires all of the students reported about their responsibilities in this PBL environment. As one of the sixth group member stated, 'In order to take an important place in life, an individual must have responsibilities, put his/her hand under a stone whenever needed, must struggle with the difficulties and do his/her best.' During the interviews, all of the groups also mentioned that task sharing resulted in having responsibilities. How the students shared their tasks were explained by the following sentences:

The second group member said, 'After the determination of the sub-topics of our project, we shared our tasks. For instance, the research for society dimension was under my responsibility. After each of us prepared our subjects, we came together and evaluated each other.' The fourth group member also said that each of the group members was supposed to write an article about his/her subtopic. As stated by the fifth group member, the males' task in this group was to prepare a PowerPoint presentation whereas the females' task was to write the article. However, they were all responsible for the literature review. The third group member explained how sharing tasks resulted in being more responsible. He said, 'Each of us had different tasks. Our main philosophy was being responsible. We were like the links of a chain. Because we knew that one weak link would affect the product, we all tried to do our best'.

As it is seen, during the PBL students had responsibility for one another's learning as well as their own. This responsibility helped them to work in harmony during their problem-solving process. They made plans, shared their tasks within groups, and evaluated each other's opinions and products. As Gokhale (1995) mentioned, we believed that the responsibility and success of one student helped other students be successful in this collaborative PBL environment.

As seen in Table 2, the results gained from the open-ended survey showed that 32% of the students reported their communication and socialization during the research. The social interaction of the students with their environment was also mentioned during the interview, especially when they were talking about the cost of their products. The first group member said, 'Although the cost of our poster was 22NTL, the person who prepared it didn't take any money. It was free, because he was our neighbour'. The 3rd group member said 'The cost of newspaper was 125NTL, but since we had four advertisements, we didn't pay any money.' This group was also thankful to their friend who had introduced them to the local newspaper staff. The fourth group members having sponsors from bread store, Aydın Electric, tradesmen association did not have to pay 140NTL for the publication of their newspaper. Moreover, they got the white hats, the symbols of their environmental awareness, for free. The fifth group members said that they learned how to decrease the cost of the materials that they could use for their students for the following years.

As it is seen, although the cost of the products were high, none of the groups made any payments as a result of their social interactions within their environment. We believed that valuable interpersonal and communication skills of these groups of students are enhanced as the results of student to student interactions including teamwork, presentation and defence of their own plans, peer evaluation, and student-environment interaction including interaction with tutors, friends, and other experts. Bernstein et al. (1995) and Vernon (1995) are the other researchers having similar beliefs about the effect of PBL on students' acquisition of interpersonal and communication skills. Moreover, in a survey on reactions to the new teaching/learning style of PBL, one of the positive comments suggested by medical students was about the increased interaction between themselves and their tutors (Eng 2000). The results of student course evaluations of Lieux (1996) also revealed that PBL students felt and experienced learning communication skills. In addition, one of the four factors revealed from a tutorial-based test for PBL students, developed by Hebert and Bravo (1996), was communication with the variance of 11% (accounting for 82% of the variance).

Table 3, which displays the problem solving aspects of the study, frequencies and percentages of the students using concepts related to problem solving process can easily be seen.

As shown in Table 3, determination of main and sub problems, research from different types of resources, determination of the best solution and construction of the product are the steps of problem solving. This process was also explained by all of the groups interviewed. These problem solving steps can be summarized as the first group presented, 'After the determination of our problem sentence and the scenario of it, we wrote the sub problems and scenarios of these sub problems. The next step was to find various solutions for each of the scenarios. Then we synthesized the solutions and selected the best of them. At the end we presented our products including PowerPoint presentations, slogans and posters'. One of the sixth group members made a comment about this process: 'Let's say we wanted Mimar Sinan, who was a famous architect in Turkish history, to construct a building. First of all, he needs to gather the required materials, such as bricks, cement and gravel. Without these, in spite of the fact that he is a good architect, he cannot start construction of the building. Similar to Mimar Sinan, after the determination of our main and sub problems, we gathered the information from different types of sources, synthesized those and constructed the product of our group'. According to the fifth group members, problem solving process taught them to seek out and evaluate information from various sources for the solutions of the main and sub problems, and the first strategy to synthesize this collected information was to understand the problem well.

Table 3 ***Frequencies and percentages of responses related to problem-solving process***

Concepts	**f**	**%**
Determination of the main and sub problems	6	24
Research from different types of sources	25	100
Production of various solutions	13	52
Determination of the best solution	4	16
Construction of the products	11	44
Solution of various problems	8	32

It can be said that this PBL environment put the students in the position of solving problems through exhaustive research, similar to the way a scientist did. As Hollingworth (2001) states, students need to practice problem solving processes over a period of time in order to develop their problem-solving skills.

As shown in Table 3, all of the students reported that they performed research using different types of sources, such as books, science and technical magazines and the Internet. In addition to these, other ways the groups gathered information were as follows:

One of the third group members said, "We contacted with our friends, research assistants and professors in our faculty, have sent e-mail to the other biotechnology professors and called to the head of the cloning team in Turkey. He sent us specific books and his own articles related to our subject.' Realizing that the information they gained from the books and the Internet was limited to answer some of their questions, the fourth group members decided to ask experts about their questions by sending emails. 'Butunfortunately nobody replied back to our e-mails. Then we contacted our faculty professors to reach those professors. All of the experts we called answered our questions just after we identified them, gave information about what we already knew and wanted to learn about,' said one of the fourth group members. 'We learned that if somebody gives you reference in Turkey, then you can solve your problems easier,' another member of this group completed her friend's sentence. The second group members contacted with environmental engineers in Balıkesir, Manisa and Tekirdağ via calling by phone and e-mailing. In addition they prepared a news archive related to genetically modified foods. Besides having a phone interview with a professor in Izmir, one of the fifth group members contacted 2 friends studying in the Faculty of Medicine in Gazi and Ege Universities. All of the sixth group members watched a panel discussion about the applications of genetic engineering and visited the Criminology Department of a police directorate in Istanbul in order to see the applications in Turkey. In addition to their detailed research, the first group members watched the movie, The Day After Tomorrow.

As described above, the groups expanded their research skills in order to find new sources for the solution of their problems. We believe that using a wider variety of resources to support their learning in this PBL environment, students acquired information seeking and information literacy skills. Information is mostly available through libraries, media, and the Internet, However, the especially miscellaneous, abundant information on the Internet mostly comes to individuals in an unfiltered format, raising questions about its accuracy, validity,, and reliability. During PBL, students reasoned about course content at a deeper level than the students instructed through the traditional approach, the experimental group students used various research sources, critically evaluated the gathered information and used the efficient information for problem-solving. Similar to these finding, medical education students at McMaster University also reported that PBL introduced in their university improved their research skills (Eng 2000). Chambers (2002) was another researcher stating that students in a PBL environment developed a rich knowledge of useful and reliable sources of information about matters relating to IT in schools.

As presented in Table 3, products based on the group opinions, as the final step of the problem solving process are reported by 44% of the students in the open-ended questionnaire. At the end of the 8 weeks, the products of each group were ready. The first group had a PowerPoint and a poster presentation; the second group published a magazine and the third and fourth groups published a newspaper and had poster presentations. In addition to their PowerPoint presentation, the fifth group read the article they wrote. The sixth group's product was a webpage. Members of this group described their web page as being more professional than those related to their subject: 'We examined various web pages but we can say that they even do not have the 10% percent of the information available in our web page.' With the similar self-confidence, members of the fifth group also claimed that any person may learn everything in detail from watching their PowerPoint presentation.

During the interviews, groups also talked about their products. The second group members mentioned that they used the pen advertisement that they had previously prepared for their magazine. This advertisement was a project of the students during the first weeks of the science instruction course when they were learning about creativity. Another member of the second group added that, 'We also had a poster for the invitation for a conference written both in English and Turkish about the genetically modified products'. The writing style we used in this product was based on what we learned in our writing course last year'. Third group members also explained how they applied the principles of material development. 'We focused on the background, style of letters and the pictures that might be used for the poster. Moreover, we used a glass frame to protect it for a long time period in case it might be used in the schools,' said one of the group members. These students learned about material development in their instructional technology and material development course in the previous semester.

As the findings of the previous studies show, bringing together various disciplines, PBL allows students to construct their products. According to CTL (1998), for a successful transfer, students identify the central theme, which is common to a set of problems, and apply it in other settings. The interview results of this study also showed that when students were working on their projects, they used their prior knowledge and transferred other types of information for the construction of their products.

As seen in Table 3, the percentage of solution for various types of problems was found to be 32% based on the data gained from the open-ended questionnaire. As the first group members stated, they learned to overcome the difficulties and obstacles they met with when they were solving a problem. Having similar thoughts with the first group, the fourth group members believed that since they overcame all of the problems, they had self-confidence. Another member of this group explained that, 'There are times we may run into barriers. This PBL approach taught us putting commas and struggling with all types of obstacles or problems, instead of putting a dot and giving up'. One of the members of the fifth group said, 'A student who is familiar with PBL won't have any difficulties to solve a problem. As we all know, the scientists never give up for finding a solution to a problem, they try over and over till the time they find the solution. Hence, I believe that after learning to use this PBL effectively, there won't be any type of problem that does not have a solution.' Another fifth group member stated that they had some obstacles when they were trying to solve the problems, but they realized that there were multiple ways to solve the problem. Agreeing with her two friends, another member of this group believed that during the PBL she had self-confidence. She said, 'I learned the difference between me and a grocery boy, and asked why I have never tried something like this before. I mean… although I have been studying for years, I haven't done this much detailed research and spent so much time on solving a problem. I remembered times I was giving up after trying only one main solution. Now I know that there are other alternatives for the solution and I will solve the problem at the end.' The 3rd group member said, 'We were supposed to prepare a PowerPoint presentation and poster about the genetic cloning and results of it. We had no idea about this subject. Moreover, some of our group members were really poor in science. This PBL taught us that we can solve any type of problem in our lives without considering the situation in which we have met with this problem in our previous lives or not'. Another member of this group added that, 'I started to say I can do. Now, I believe that there isn't anything that I can't manage to do,' added another member of this group. Believing that a person who knows how to identify and overcome barriers can easily deal with all types of problems, the second group members said, and, 'If there is a problem, there are solutions. Hence, we aren't scared of any types of problems, anymore.'

Although developing student's confidence on problem solving was extremely challenging task, the interviewees mentioned that since they were able to overcome problems during PBL, they were not scared of any types of problems, anymore. College students frequently suffer from fears and anxieties especially fear of failure, which hamper their problem-solving efforts (CTL, 1998). If instructors help these students overcome their fears, students will build their confidence in their problem solving skills, become effective problem solvers and engage in solving more complex problems. In addition to these interviews, 20% of the students reported that PBL had a positive effect on their self-confidence about problem solving. This result is consistent with the previous literature. In Hamil's study, the experimental group exposed to problem-solving activities was found to have a better perception of their ability to approach problems and to have more confidence in their problem solving ability than the control group exposed to traditional learning in their physical science classes in teacher education programs (Hamil 1997). In addition, at the University of Melbourne, the PBL approach was found to be effective on undergraduate education students' self-confidence (Chambers 2002). In short, it can be said that once students master a particular type of problem, they can begin to tackle other types of problems.

Frequencies and percentages of positive and negative opinions of the experimental group students about PBL are presented in Table 4. Positive opinions of the students were mainly about the effectiveness and applicability of PBL on their cognitive development, better learning and problem-solving experience. Student perceptions of the effectiveness of problem-based learning on their performance appear to be consistent with the previous research findings (Gibbon & Wall 2005, Lo 2004, Steinemann 2003).

Table 4 ***Frequencies and percentages of opinions of the students about PBL***

Opinions	Concepts	f	%
Positive	Effective	25	100
	Good	10	4
	Applicable	9	36
Negative	Tiring & difficult	21	84

As seen in Table 4, although all of the students reported that PBL was an effective method, 84% of these thought it was difficult and tiring. The hardest times of the instruction period are explained by the students below:

The second group member said, 'We started everything from zero point. We had no previous knowledge about PBL.' Another member of this group added, 'At first we couldn't understand what exactly we would do. It was hard to organize the problem-solving procedure in our minds. The construction became easier as we gained more information about our subject from various sources. Then we decided what and how to do.' Having the same thoughts about the novelty of PBL, the third and fifth group members said that it had taken three weeks for them to get used to the instruction. The fourth group members said, 'The first time you told us, we thought it was impossible for us to manage but you helped us a lot. You not only taught us the process, but also guided us during our studies, and gave us feedback,' and one of the comments from this group was: 'First of all a person must have intrinsic motivation during the process. If so, she is ready to deal with all types of obstacles. If not, and if he/she starts the process just because it is obligatory, he/she may give up easily.' The first group who had similar problems for the application of PBL into their project, said, We handled out this problem by asking the research assistants and you, meeting with our group members everyday'. When the instructor further asked about their opinions on PBL, all of the group members stated that because they applied PBL and experienced it, they will not have the same difficulties in the future. The sixth group member said 'Now, we know the rotation we will use for PBL.'

The interviewees emphasized their uncertainty the first time they were faced with PBL. This uncertainty during the PBL teaching was also expressed by hotel and tourism management undergraduate students (Lo 2004). As Huang (2005) states, these negative student perceptions are understandable as it was the first time that they had been exposed to this new PBL approach. The group members did not know what to do and how to approach the problem. However, the guidance and the feedback of the instructor and the research assistants helped them to apply the problem solving process. This result resembles the study by Gibbon and Wall (2005) and Littlejohn and Awalt (1999) in which students improved their PBL with the support, guidance and feed back of the instructor and familiarity with what was expected of them.

According to first, fourth and sixth group members, time was the limiting factor in this part of the study. As the first group mentioned, they had meetings twice a week for their project. One of the group members said, 'Recently we came together almost everyday…. but when we finished our product, our eyes were shining'. Sixth group member explained, 'We also prepare presentations for our other courses but the preparation time is not more than 2-3 hours. For this project, we spent weeks,' explained the sixth group member. One of the fourth group members said, 'We studied a lot, got tired, and even there were times we got bored because of the long time process and obstacles we had. Although my hometown is so close to Ereğli, I couldn't visit my parents.' 'But in every new original step we added to our product, we were proud of ourselves,' continued another fourth group member.

According to the interview results, students spent so much time and effort on their PBL based projects. Similar to this result, 91% of students completing a survey about the evaluation of the PBL in their probability and statistics courses also indicated agreement that PBL required more time and effort than projects in other courses (Longuevan 2000). However, seeing the construction of their products step-by-step was an intrinsic motivation for all of the groups. Believing that they received the results of their efforts, all of the groups were happy. Similar to this result, Huang (2005) also states that students gained an 'intrinsic reward' from their PBL experience.

When groups were asked about the applicability of the theory, all of the group members thought it was applicable for students over ten years old. In addition, they implied their desire to apply this approach with their students. One of the second group members said 'I believe that PBL will give our students the spirit of research'. Fifth group members commented that being responsible for the determination of the depth and analyses of information to resolve the problems, their students would learn to seek out and evaluate information from various sources through PBL approach.

Having the opportunities to see the PBL approach and to realize its benefits, all of the groups agreed on the applicability of the approach.

Conclusion

This research showed that problem-based learning developed problem solving skills of pre-service elementary school teachers while enhancing their communication, group working skills and acquisition of knowledge. Most importantly, these pre-service teachers had the experience of understanding the process. Hence, it is essential that application of problem-based learning be included in pre-service teacher education curriculum. Problem solving skills also are the essential requirement for laboratory studies in science education. The effect of PBL on group working skills and communication, in addition to its effect on problem solving skills, shows its effectiveness for inquiry process in laboratory. Inquiry is important for scientists and the strategies also include group work and good communication skills (Sampson & Clark, 2007, Kaartinen & Kumpulainen, 2002). The process of PBL might use good problem solvers and poor problem solvers to construct groups and to provide effective communication among peers in science laboratories. The mixture of poor and good problem solvers might also provide relative standards for self-evaluation in terms of problem solving skills. Self- evaluation and reflection are the basic ways to improve instruction in science education (Ram, 1999). More hands-on activities occur in science laboratory with the process of PBL than traditional classroom PBL applications. In the lab, PBL may also alleviate knowledge acquisition with group study and reflection.

Since the core characteristic of PBL is student-centeredness, once the problem-solving process begins, the roles of the educators should be facilitation and guidance rather than instruction. During the implementation of PBL, continuous feedback is highly recommended. However, there should be balance between giving students enough feedback and giving them freedom in their projects. Moreover, students may spend quite a bit of time and effort at the beginning, trying to develop their projects, while seeing few results. As Steinemann (2003) suggests, the educators should encourage their students to not get discouraged and to recognize that changes will come, not immediately, but they will come.

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