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Cemal Tosun
Bartın University, Turkey

Erdal Senocak
Gaziosmanpasa University, Turkey

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The Effects of Problem-Based Learning on Metacognitive Awareness and Attitudes toward Chemistry of Prospective Teachers with Different Academic Backgrounds

Cemal Tosun

Department of Science Education, College of Education, Bartin University, Bartin, 74100, Turkey

Erdal Senocak

Department of Science Education, College of Education, Gaziosmanpasa University, Tokat, 60140, Turkey

Abstract: The aim of this study was to reveal the effects of Problem-based Learning (PBL) on the metacognitive awareness and attitudes toward chemistry of teacher candidates with different academic backgrounds. The study was carried out on one group using both pre- and post-test experimental studies. The findings of the study were obtained through quantitative approaches. The sample of the study was 70 first-year undergraduate students at a state university in Turkey taking General Chemistry/General Chemistry-II classes. The study was implemented during the spring semester of the 2011-2012 academic years and for a period of 20 hours. Quantitative data was obtained using the Metacognitive Awareness Inventory and the Chemistry Attitude Scale. Two dependent sample t-tests were used for the pre- and post-test comparisons. The findings showed that PBL was more effective in developing metacognitive awareness levels of students with weak science background knowledge compared to those with strong science backgrounds. In addition, the findings showed that PBL was effective in increasing the attitudes positively toward chemistry of students with weak scientific backgrounds.

Introduction

In the last 20 years, the efforts to raise the self-consciousness of individuals increased the importance of metacognition in cognitive psychology. Metacognition affects the learning process of a person. According to experts, although metacognition is not enough to estimate the success in advance, it has an intermediary role in learning (Baykara, 2011). Individuals with higher metacognitive awareness are better at planning, managing information, monitoring, debugging mistakes, and evaluating compared to individuals with low metacognitive awareness.

The basic definition of metacognition is that it is cognition about cognition (Blakey and Spence, 1990). In fact, metacognition includes how to reflect the known, how to analyze what is taught, how to solve what is analyzed, and how to apply what is learned. According to Senomoglu (2009), metacognition, which includes individuals being aware of their knowing and learning ways and being able to effectively organize their own learning, requires students to know how their minds work, in other words, to perceive how such important cognitive

activities as remembering, learning, and problem solving are realized in order to solve problems effectively (Demirel and Arslan-Turan, 2010).

Although there is not a broadly accepted definition of metacognition, according to many researchers, it has two main components: metacognitive knowledge and metacognitive control. Flavel (1979) divided metacognitive knowledge into three categories: procedural knowledge, declarative knowledge, and conditional knowledge. Procedural knowledge refers to knowing how to successfully accomplish a task and knowing how to do it. Declarative knowledge refers to awareness on the part of the individual as to know whether he/she can do a specific task or duty by him/herself. Conditional knowledge requires individuals to know which information they can use functionally in a situation they face, in other words, to know what to do under a certain set of circumstances.

Metacognitive control, also known as metacognitive strategies, is composed of mental processes in metacognitive processes. Organizing metacognition comprises some activities which help students in their own learning. Although many metacognitive regulatives are defined, most of them cover four basic skills: i) predicting, ii) planning, iii) monitoring, and iv) evaluation (Schraw and Moshman, 1995; Lucangeli and Cornoldi, 1997; Deseote, Roeyers and Buysee, 2001). When individuals face a new problem, metacognitive strategies play an important role in their arriving at a successful result. By using these strategies, individuals can evaluate if they will be successful or not and then decide on the steps they should take to complete a task, observe how processes proceed, and transfer the experiences they had to the next process (Gourgey, 1998).

In today's world where technology is widely used, undergraduate students many things to learn. Research shows that even though students may learn information, they cannot use this information to solve daily life problems (Dahlgren, Castensson and Dahlgren, 1998). Since information is not a ready tool that can be used without examining its nature, it is necessary to know about knowing. Knowing how to know is only possible by training individuals to learn how to learn (Hmelo, Gotterer, and Bransford, 1997). Problem-based Learning (PBL) is the leading method among student-centered methods that provides individuals with self-learning and lifelong learning skills, developing their metacognitive skills and helping them find alternative solutions to the problems they face/might face in daily life (Yurdakul, 2004). In order to do planning, to provide alternative solutions, to analyze and synthesize, to present the alternative solutions provided, and to evaluate the process when a new problem is faced, a person should be able to use metacognitive skills successfully. Therefore, since metacognitive strategies are of great importance when an individual faces a new problem, it is necessary to identify what kind of changes occur after PBL implementation at the metacognitive level of students with either a strong or a weak science background.

PBL and Metacognition

According to Biggs (1999), the aim of undergraduate education is to educate individuals who know whether they can do a task or duty by themselves, who know how to successfully complete a duty or task, who know how to bring an issue to a conclusion, and who know which information should be used functionally in a problem situation, in other words, individuals who know what to do. Hmelo et al. (1997) stated that PBL requires using information in a different way to solve problems; information learned in this manner is functional information and includes metacognitive processes. Therefore, it is necessary to develop individuals' self-directed learning skills. When individuals try to be self-directed learners, metacognitive thinking and using information become important. With self-directed learning sessions, students first experience problem situations. And since it is necessary to

evaluate students' existing knowledge of a situation, it is important to improve students' metacognitive awareness levels (Hmelo et al., 1997).

In the literature, it can be seen that PBL has a relatively more significant effect on increasing students' metacognitive awareness levels compared to the traditional teaching methods (Downing, Kwong, Chan, Lam and Downing, 2009). In a study carried out by Demirel and Arslan-Turan, (2010), the effects of PBL on the metacognitive awareness levels of 6th grade students were examined. At the end of the study, a significant difference was found between the metacognitive awareness of the experimental group students with whom PBL was implemented and the control group students with whom the traditional teaching method was implemented.

In a review of the literature, a few studies can be found that examine the effects of PBL on students' metacognitive awareness levels (e.g. Downing et al., 2009; Tosun & Taskesenligil, 2012). But these studies are limited to students studying in primary and high schools. However, the current study examined the effects of PBL on the metacognitive awareness levels of college undergraduates. This study is also important because it compared the effects of PBL on students with different science backgrounds.

PBL and Attitude

Student attitudes are considerably related to motivation and success. Having high skills and talents is not enough for students to complete a task successfully and to make them like an activity as they are doing it. In order to sustain students' motivation, a positive opinion about the learning task and an internal stimulus is needed. Attitudes and beliefs are accepted as the pioneers of behavioral objectives. The probability of having willingness about learning tasks and sustainability of efforts is higher in students with a positive attitude. According to Mattern and Schau (2002), a positive attitude toward science classes is directly proportional to success. According to Osborne, Simon, and Collins (2003), there has been a drop in the attitudes of students who are over 11 years old toward science and science classes in the last 20 years. The teacher, curriculum, culture, and other factors affect student attitudes. Therefore, it is important to find answers to questions asking what can be done to increase student interest toward science classes and to turn science classrooms into more enjoyable places. This study also aims to identify the effect of PBL on the attitudes of first-year undergraduate students toward chemistry.

Purpose of the Study

This study examines the effects of PBL on metacognitive awareness levels and attitudes toward chemistry of teacher candidates with different science backgrounds. In addition, the following research questions have been studied:

1. What is the effect of PBL on the metacognitive awareness levels of students?
2. What is the effect of PBL on the attitudes of students toward chemistry?
3. Is there any relationship between attitude and metacognitive awareness of students?

Assumptions and Limitations of the Study

The study was limited to the solution concepts in chemistry. Also, it was limited to 20 course hours for 10 weeks in the Primary School Classroom Teacher Education Program

(PSCTEP) and 20 course hours for 5 weeks in the Secondary School Science Teacher Education Program (SSSTEP).

Material and Method

The research was carried out as an experimental study with a pre- and post-test design. In addition, the research findings were obtained by means of a quantitative approach.

Sample

A total of 70 first-year undergraduate students who were teacher candidates from two different departments of a state university in Turkey constituted the sample of the study. Forty of the sample was students of the PSCTEP accepting students who did not need to have a science background, and rest of the sample was students of the SSSTEP accepting students who had to have a science background.

The sampling method chosen for the study was nonprobability sampling. Quantitative research data was collected using purposeful sampling and convenience sampling methods, which are among the nonprobability sampling methods. For convenience sampling, individuals or groups who can participate more easily or who can be more easily contacted are preferred (Johnson and Christensen, 2004). The implementation was carried out for 20 class hours over 10 weeks in a general chemistry class of PSCTEP and for 20 class hours over 5 weeks in a general chemistry class of SSSTEP.

Data Collection Tools:

Metacognitive Awareness Inventory

The Metacognitive Awareness Inventory, developed by Schraw and Sperling-Dennison (1994), was used to identify the effect of PBL on the metacognitive awareness levels of the sample. The adaptation of the 5-point Likert type scale, comprising 52 items, into Turkish was conducted by Akin, Abaci and Cetin (2007).

The validity and reliability of the Turkish version of the instrument were studied using a sample of 607 undergraduate students. Explanatory factor analysis was considered for structural validity, and test-retest coefficients were examined for reliability. Linguistic equivalence findings showed that the relation between the original and the adapted form of the instrument was .93. As a result of factor analysis, eight sub-dimensions were found in the inventory. These dimensions are: declarative knowledge, procedural knowledge, conditional knowledge, planning, monitoring, evaluating, debugging, and information management. It was also found that the cohesiveness correlation of the adapted version with the original form was .95. Item analysis results showed that in the sub-dimensions of the inventory, item test correlation results were between the values .35 and .65. Internal consistency and test-retest reliability coefficients of the inventory were found at .95. Based on these explanations, it is possible to say that the total inventory and sub-dimension values are adequate.

The inventory has a total of 52 items and there are no negative items in the inventory. The highest score that can be obtained from the inventory is 260, while the lowest is 52. High scores show high metacognitive awareness. The total score from the inventory is divided by 52 creating a scale that ranges from 1 to 5 which is the number of items in the inventory. This way, a decision is made on the metacognitive awareness level of the related individual. It can be said that individuals with a score below 2.5 on the Metacognitive Awareness Inventory

have low metacognitive awareness, while those with a score above 2.5 have high metacognitive awareness.

Chemistry Class Attitude Scale

In order to determine the effect of PBL on the attitudes of students toward chemistry, the Attitudes towards Chemistry Lessons Scale (ATCLS), developed by Cheung (2009) and adapted into Turkish by Senocak (2011), was used. It includes 12 items in 4 sub-scales: liking for chemistry theory lessons, liking for chemistry laboratory work, evaluative beliefs about school chemistry, and behavioral tendencies to learn chemistry. Five hundred and fifty-four students participated in the reliability and validity study of the instrument. The normed fit index of the adapted scale was found to be .93, the comparative fit index was found to be .95, and the approximate root mean square error was found to be .07. These results revealed a good fit between the model and the real values. The reliability of the scale was examined based on Cronbach Alpha and item point-total point relation. While the Cronbach's Alpha value was found to be .88 for the whole scale, the values of the 4 sub-dimensions changed between .68 and .84. Item point-total point relation values for the 12 items ranged between .49 and .72.

Problem Scenarios

Six PBL scenarios developed by the researchers were used in this study. Each problem scenario covered a different concept in the solution topic in chemistry. Each problem scenario was related to or linked to a real life context, and the problems had multiple solution paths. Each problem scenario was supported with a topic, image, text, and keywords. The two problem scenarios used in the PBL sessions are presented in Appendix 1.

Procedure

The study was carried out by the same researcher for a period of 10 weeks: 5 weeks in the SSSTEP for 4 class hours every week and 10 weeks in the PSCTEP for 2 class hours every week. In both programs, the courses were taught using a PBL approach by the same lecturer. First, students were informed about how to do PBL. Later, six groups each with seven members were formed in the PSCTEP. Five groups, each with six members, were formed in the SSSTEP. The following five steps were performed with both groups during the courses.

First step: This step lasted approximately 2 course hours ($50 \times 2 = 100$ min). Groups were given the problem scenarios in the class time, and these scenarios were asked to be read out loud by a chosen member of each group. Also, students were encouraged to write their opinions about the problem scenarios after the reading.

Second step: Students were asked to define the learning subjects related to the problem scenarios and then were asked to answer the following four questions for each problem. What do we know about the problem? What should we learn to find a solution to the problem? Which resources help us find the necessary information? What are our hypotheses? This step lasted almost 6 course hours ($50 \times 6 = 300$ min). At this step, terms which the students did not know were identified by the lecturer. Problem scenarios were discussed in groups, and questions that might help in finding solutions were created. Hypotheses were identified via a brain storming method and students planned how to do a search for a solution. In addition,

distribution of tasks among group members was carried out toward the end of the step. Also, the lecturer visited each group to guide them in group work. Groups were asked to write their opinions and questions on their worksheets because the worksheets played a vital role in identifying the problem, collecting the information, and analyzing and synthesizing the information.

Third step: This step covered the study process outside the classroom. Students were asked to collect data to find answers to their own questions. Therefore, they searched for information via different sources such as the library, internet, laboratories, and expert opinions. After searching process, students came together in the classroom and discussed what they had learned during their independent studies. They then analyzed and synthesized what they learned. This step lasted for almost 4 course hours ($50 \times 4 = 200$ min).

Fourth step: In this step, the lecturer shaped some expert groups. Namely, any student from each group assigned a member of an expert group to become an expert on a special topic about the solution concepts. Expert group members shared their ideas about the specific topics. In this way, they enhanced their knowledge about the solution concepts. At the end of this phase, the students in the expert groups returned to their home groups and shared their learning with the home group members in order to find a reasonable solution to the problem. This step lasted almost 4 class hours ($50 \times 4 = 200$ min).

Last step: Students were asked to report their solutions to the problem situation, and then present them orally to the other groups in the classroom for 15-20 minutes. After all the groups presented their solutions, they were asked to pose their questions about solutions to the other groups under the direction of the lecturer. Later, the lecturer explained the solution or solutions to the problem. This step took almost 4 course hours ($50 \times 4 = 200$ min).

Data Analysis

Data was analyzed by SPSS/PC 15.0. The significance level was set to .05. A paired sample t-test was used in order to find out the effects of PBL on students' metacognitive awareness and attitudes toward chemistry.

Findings

Analysis of Metacognitive Awareness Inventory Data

The results of the Metacognitive Awareness Inventory, which was implemented as pre- and post-tests in order to examine the effect of PBL on the metacognitive awareness levels of students, were analyzed to reveal if there was a statistically significant difference between the data obtained from the tests. The results of the paired sample t-test are presented in Table 1.

Dimensions			N	\bar{X}	S	sd	t	p
Declarative knowledge	SSSTEP	Pre-test	28	3.61	.689	27	-2.269	.031
		Post-test	28	3.79	.547			
	PSCTEP	Pre-test	39	3.82	.516	38	-5.066	.000
		Post-test	39	4.17	.414			
Procedural knowledge	SSSTEP	Pre-test	28	3.26	.829	27	-1.039	.308
		Post-test	28	3.38	.881			
	PSCTEP	Pre-test	39	3.38	.582	38	-4.711	.000
		Post-test	39	3.82	.564			
Conditional knowledge	SSSTEP	Pre-test	28	3.49	.709	27	-1.480	.150
		Post-test	28	3.66	.609			
	PSCTEP	Pre-test	39	3.85	.524	38	-2.934	.006
		Post-test	39	4.11	.507			
Planning	SSSTEP	Pre-test	28	3.40	.714	27	.409	.686
		Post-test	28	3.35	.661			
	PSCTEP	Pre-test	39	3.55	.584	38	-4.485	.000
		Post-test	39	3.96	.596			
Monitoring	SSSTEP	Pre-test	28	3.30	.637	27	-.429	.671
		Post-test	28	3.34	.667			
	PSCTEP	Pre-test	39	3.55	.622	38	-4.334	.000
		Post-test	39	3.97	.568			
Evaluating	SSSTEP	Pre-test	28	3.54	.653	27	-.502	.620
		Post-test	28	3.58	.611			
	PSCTEP	Pre-test	39	3.62	.616	38	-3.390	.002
		Post-test	39	3.93	.571			
Debugging	SSSTEP	Pre-test	28	3.87	.791	27	.000	1.000
		Post-test	28	3.87	.550			
	PSCTEP	Pre-test	39	3.98	.697	38	-1.156	.255
		Post-test	39	4.10	.660			
Information management	SSSTEP	Pre-test	28	3.59	.614	27	-2.301	.029
		Post-test	28	3.82	.674			
	PSCTEP	Pre-test	39	3.82	.526	38	-3.907	.000
		Post-test	39	4.17	.471			

Table 1. The results of paired group t-tests for metacognitive awareness inventory

The test results showed that there were significant differences between the pre- and post-tests results of the PSCTEP students with respect to seven out of eight dimensions: declarative knowledge ($t_{(38)} = -5.066$ $p < 0.05$), procedural knowledge ($t_{(38)} = -4.711$ $p < 0.05$), conditional knowledge ($t_{(38)} = -2.934$, $p < 0.05$), planning ($t_{(38)} = -4.485$ $p < 0.05$), monitoring ($t_{(38)} = -4.334$, $p < 0.05$), evaluating ($t_{(38)} = -3.390$, $p < 0.05$), and information management ($t_{(38)} = -3.907$, $p < 0.05$). In addition, according to the test findings, while there were significant differences between the pre- and post-tests results on the declarative knowledge ($t_{(27)} = -2.269$ $p < 0.05$) and information management ($t_{(27)} = -2.301$ $p < 0.05$) dimensions of the SSSTEP students, there was no statistically significant difference between the pre- and post-test results on procedural knowledge ($t_{(27)} = -1.039$ > 0.05), conditional knowledge ($t_{(27)} = -1.480$, $p > 0.05$), planning ($t_{(27)} = .409$ $p > 0.05$), monitoring ($t_{(27)} = -.429$, $p > 0.05$), evaluating ($t_{(27)} = -.502$, $p > 0.05$), and debugging ($t_{(27)} = .000$, $p > 0.05$) sub-dimensions.

As seen in Table 1, there was an increase in metacognitive awareness of the PSCTEP students in all sub-dimensions of the instrument: declarative knowledge ($\bar{X}_0 = 3.61$; $\bar{X}_S = 4.17$), procedural knowledge ($\bar{X}_0 = 3.26$; $\bar{X}_S = 3.82$), conditional knowledge ($\bar{X}_0 = 3.49$; $\bar{X}_S = 4.11$), planning ($\bar{X}_0 = 3.40$; $\bar{X}_S = 3.96$), monitoring ($\bar{X}_0 = 3.30$; $\bar{X}_S = 3.97$), evaluating ($\bar{X}_0 = 3.54$; $\bar{X}_S = 3.93$), and debugging ($\bar{X}_0 = 3.87$; $\bar{X}_S = 4.10$).

$\bar{X}_S=3.93$), debugging ($\bar{X}_O=3.98$ $\bar{X}_S=4.10$), and information management ($\bar{X}_O=3.82$; $\bar{X}_S=4.17$). There were also increases in six dimensions out of eight for the SSSTEP students: declarative knowledge ($\bar{X}_O=3.61$; $\bar{X}_S=3.79$), procedural knowledge ($\bar{X}_O=3.26$; $\bar{X}_S=3.38$), conditional knowledge ($\bar{X}_O=3.49$; $\bar{X}_S=3.66$), monitoring ($\bar{X}_O=3.30$; $\bar{X}_S=3.34$), evaluating ($\bar{X}_O=3.54$; $\bar{X}_S=3.58$), and information management ($\bar{X}_O=3.59$; $\bar{X}_S=3.82$). These findings showed that PBL had a more significant effect on increasing metacognitive awareness levels of the PSCTEP students than it did on the SSSTEP students.

Analysis of Chemistry Attitude Scale Data

The results of the paired sample t-tests are presented in Table 2 to see if there is a statistically significant difference between the pre- and post-test results of ATCLS to find the effect of PBL on students' attitudes toward chemistry.

Dimensions	Groups		N	\bar{X}	S	sd	t	p			
Liking for chemistry theory lessons	SSSTEP	Pre-test	28	4.69	1.46	27	.051	.960			
		Post-test	28	4.68	1.22						
	PSCTEP	Pre-test	39	2.36	1.26				38	-5.084	.000
		Post-test	39	3.48	1.38						
Liking for chemistry laboratory work	SSSTEP	Pre-test	28	5.29	1.27	27	.548	.588			
		Post-test	28	5.15	1.56						
	PSCTEP	Pre-test	39	4.03	1.49				38	-2.350	.024
		Post-test	39	4.74	1.51						
Evaluative beliefs about school chemistry	SSSTEP	Pre-test	28	5.01	1.38	27	.267	.791			
		Post-test	28	4.95	1.42						
	PSCTEP	Pre-test	39	3.98	1.48				38	-4.801	.000
		Post-test	39	4.81	1.26						
Behavioural tendencies to learn chemistry	SSSTEP	Pre-test	28	3.39	1.22	27	-.477	.637			
		Post-test	28	3.49	1.24						
	PSCTEP	Pre-test	39	2.23	1.08				38	-4.553	.000
		Post-test	39	3.21	1.26						

Table 2: The results of paired group t-test for chemistry attitude scale

The findings showed that there was a statistically significant difference between pre- and post-test results on PSCTEP students' attitudes toward chemistry in all sub-dimensions: liking for chemistry theory lessons ($t_{(38)} = -5.084$, $p < 0.05$), liking for chemistry laboratory work ($t_{(38)} = -2.350$, $p < 0.05$), evaluative beliefs about school chemistry ($t_{(38)} = -4.801$, $p < 0.05$), and behavioral tendencies to learn chemistry ($t_{(38)} = -4.553$, $p < 0.05$). It was also revealed that there was no statistically significant difference between pre- and post-test results of SSSTEP students' attitudes toward chemistry: liking for chemistry theory lessons ($t_{(27)} = .051$, $p > 0.05$), liking for chemistry laboratory work ($t_{(27)} = .548$, $p > 0.05$), evaluative beliefs about school chemistry ($t_{(27)} = .267$, $p > 0.05$), and behavioral tendencies to learn chemistry ($t_{(27)} = -.477$, $p > 0.05$). These findings showed that while PBL had a significant effect on improving the attitudes of PSCTEP students toward chemistry, it did not improve the attitudes of SSSTEP students toward chemistry.

The Relationship between Metacognition and Attitude

In order to find an answer to the third research question of this study, which is “Are there any relations between the metacognitive awareness levels of first-year undergraduate students and their attitudes towards chemistry classes?” Pearson Correlation analysis was used. According to Table 3, while there was a very weak ($r=.215$; $p>0.05$) positive relation between PSCTEP students’ metacognitive awareness levels and their attitudes toward chemistry classes before the implementation, this relation was weak in a positive direction after the implementation ($r=.285$; $p>0.05$). While there was a weak ($r=.384$; $p<0.05$) and significant positive relation between SSSTEP students’ metacognitive awareness levels and their attitudes toward chemistry classes before the implementation, this relation was found to be very weak in a positive direction after the implementation ($r=.175$; $p>0.05$).

		Pre-test		Post-test		
			Attitude			Attitude
PSCTEP	Metacognition	Pearson	.215	Metacognition	Pearson	.285
		p	.183		p	.079
SSSTEP	Metacognition	Pearson	.384	Metacognition	Pearson	.175
		p	.039		p	.364

Table 3: Relation between metacognition and attitude

Results and Discussion

This study aimed to reveal the extent to which PBL affects the metacognitive awareness of prospective teachers with different science backgrounds as well as their attitudes toward chemistry. The study covered General Chemistry courses of PSCTEP and SSSTEP.

After an analysis of the data, it was observed that PBL had a positive effect on increasing metacognitive awareness of PSCTEP students who had a weak science background; however, PBL did not have a positive effect on the metacognitive awareness levels of SSSTEP students who had a strong science background. And when the metacognitive awareness of students was examined, it was found that PBL had no effect on the debugging sub-dimension in the Metacognitive Awareness Inventory of either teacher candidate group. However, it was found that PBL had a significant positive effect on declarative knowledge and information management sub-dimensions in the metacognitive awareness inventory of both groups. While PBL had a significantly positive effect on procedural knowledge, conditional knowledge, planning, monitoring, and evaluating sub-dimensions in PSCTEP, it had no significant effect on these sub-dimensions in SSSTEP.

It was also observed that, compared to the situation before the implementation of PBL, there was a significant positive contribution after the implementation to the declarative knowledge sub-dimension of SSSTEP students. This finding revealed that PBL provided SSSTEP students with the knowledge about whether or not they could perform a task or duty by themselves. On the other hand, PBL had no effect on procedural knowledge for these students, and this showed that they did not learn how to do or successfully complete a duty or task in this period. This can be explained by the fact that PBL implementations in SSSTEP were limited to a 5 week period. It is understood that this period is not enough to expect a positive change in metacognitive information and strategies in SSSTEP students. This finding is parallel with the finding from the research of Tarhan, Ayar-Kayali, Ozturk-Urek, and Acar. (2008), who found that students understood the nature of PBL, but they were not totally ready for the PBL teaching, and they needed some time to gain experience with this method.

The second sub-problem of this study focused on the effect of PBL on the attitudes of prospective teachers with both strong and weak science backgrounds toward chemistry classes. While the data obtained in the scope of this objective showed that PBL had a significant effect in improving the attitudes of PSCTEP students toward chemistry classes, PBL did not improve the attitudes of SSSTEP students. When the students' attitudes toward chemistry were examined with respect to all sub-dimensions of ATCLS, it was found that while PBL had a positive contribution to PSCTEP students' attitudes after the implementation, it had no significant positive contribution to SSSTEP students' attitudes. This can be explained by the fact that the PBL implementations in SSSTEP were limited to a 5 week period. It is understood that this period is not enough to expect a positive change in attitude in SSSTEP students. Similarly, while many studies have argued that PBL provides a significant contribution to students' motivation or attitudes toward science (Diggs,1997; Ram, 1999; Senocak, Taskesenligil and Sozbilir, 2007; Tarhan and Acar, 2007; Rajab, 2007; Kelly and Finlayson, 2009), some others report that PBL had no positive effect on students' motivation and attitudes toward science (Acikyildiz, 2004; Kocakoglu, 2008).

The most important aspect of this study is that it examined for the first time the effects of PBL on teacher candidates with different science knowledge backgrounds. Since there have been no other similar studies in the literature, this study is a pioneer study in the field. In addition, although this study is limited to investigating the effects of PBL on students' attitudes toward chemistry and their metacognitive awareness, the authors believe that the data obtained in this study will lead to other studies following this scope.

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Appendix One

Lost Salt



One day, Ayse saw her mother cooking in the kitchen. She decided to help her mother and ask her how she could help. Her mother said that there was water in the pot and asked Ayse to put some salt in the pot and stir it.

Ayse put some salt in the pot and Then she saw that the salt in the pot disappeared. She was when she saw this and wondered how the salt disappeared. wondered how the particles of water and salt behave when mixed, but she could not find an answer to this event by



began to stir. surprised She also they are herself.

If you were Ayse, what would be your explanation(s) for this situation with a molecular view?

Key Words: Solution, Dissolution, Solvent

Difficult Decision



Demirozu is a town known for its rich water resources (streams, lakes) and green areas. Most of the locals work in the thermic power plant or in fisheries. However, there have been collective deaths of fish (three times) in the Balikli Lake close to the Demirozu electric power plant and this has greatly upset the residents of the area.

The residents are both worried about losing their income and the reasons behind these unexpected events.

Thereupon, the town council met and consulted with a chemist in order to find the reason behind the fish deaths and a logical explanation for the situation.

If you were the chemist, how would you explain the reason(s) behind the deaths of the fish?

Keywords: Solubility, Solubility of Gases, and Temperature