

The effects of problem-based learning on pre-service teachers' critical thinking dispositions and perceptions of problem-solving ability

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The aim of this study was two-fold. The first aim was to determine the levels of critical thinking disposition and perception of problem-solving ability of pre-service teachers. The second aim was to compare the effects of problem-based learning and traditional teaching methods on the critical thinking dispositions and perceptions of problem-solving ability of pre-service teachers, when implemented in the teaching of the acid-base topic. Participants for the study consisted of 49 pre-service teachers. A pre-test–post-test control group design was used. Data were obtained using the California Critical Thinking Disposition Inventory and Problem-Solving Inventory. It was generally determined that pre-service teachers exhibit low levels of critical thinking disposition and medium levels of perception of problem-solving ability. Also, while problem-based learning and traditional teaching methods did not have different effects on the critical thinking dispositions of pre-service teachers, they had different effects on their perceptions of problem-solving ability.

Keywords: critical thinking disposition; perception of problem-solving ability; problem-based learning; traditional teaching method

Introduction

Our ever-changing and challenging world requires students, our future citizens, to go beyond the building of their knowledge capacity; they need to develop their higher order thinking skills, such as critical thinking, decision making, and problem-solving (Miri, David & Uri, 2007:354). The rapid change and transformation in the nature of information requires changes in the workforce profile. To equip individuals with skills to conduct research, use and transform information, think critically and reflectively, and make higher order decisions is needed to survive in this competitive world for societies (Şendağ & Odabaşı, 2009:132). Accordingly, qualities such as being able to think critically and to express one's thoughts, communicate effectively, make conscious choices, have the power of judgement and ability to make comparisons are among the qualities that individuals should have in today's information society (Özden, 1998:85).

Thinking is the process by which individuals find meaning in the world that they inhabit (Dewey, 1933). Cole and Scribner (1974:145) define thinking as "obtaining a different thing from current knowledge and going beyond the current knowledge". Thinking skills, however, constitute critical thinking, problem-solving, reading com-

prehension, writing, scientific thinking, creative thinking, and creative problem-solving (Özden, 2011). Critical thinking, one of the skills associated with thinking, is the evaluation of our own and others' ideas with no prejudices. It is concerned with how we think rather than what we think (Mulnix, 2012). It is a higher order thinking skill and it has properties such as analysing, evaluating, being reasonable and thinking deeply, which all enable the individual to make judgements about the world (Jeevanantham, 2005).

A more comprehensive view of critical thinking refers to as a disposition, to describe an individual's inclination to use critical thinking when faced with problems to solve, ideas to evaluate, or decisions to make (Giancarlo & Facione, 2001). Dispositions identified in the critical thinking literature include "tolerating ambiguity, willing to suspend judgment, being open-minded, inquisitive, and sensitive to other ideas; in short, a willingness to engage in sustained critical thinking" (McBride, Xiang & Wittenburg, 2002:30). The disposition toward critical thinking refers to "the likelihood that one will approach problem framing or problem solving by using reasoning" (Giancarlo & Facione, 2001:3). A disposition toward critical thinking is a necessary pre-condition for critical thinking and an integral part of the critical thinking capability (Zoller, Ben-Chaim, Ron, Pentimalli, Scolastica, Chiara & Borsese, 2000:572). According to Underbakke, Borg and Peterson (1993), developing teaching for critical thinking might first begin with an examination of one's dispositions. The California Critical Thinking Disposition Inventory (CCTDI) is one of the first valid and reliable measures of an individual's critical thinking disposition (Giancarlo & Facione, 2001: 4). For this aim, Giancarlo and Facione (2001), Nelson Laird (2005) and McBride et al. (2002) used CCTDI in their study.

Critical thinking is thinking which helps in solving problems and making judgements (Halpern, 2003); thus, an important dimension of critical thinking is problem-solving (Tapper, 2004). In his study, Faux (1992) examined the relationship between creative thinking, critical thinking, intelligence and problem-solving skills and found a positive and strong relationship between critical thinking and problem-solving skills.

Problem-solving is the process by which an individual overcomes the hurdles encountered in attaining the target (Temel & Morgil, 2012:59). According to Wheatley (1984:1), "something is a problem when one doesn't initially know how to do it, and problem-solving is what you do when you don't know what to do". Problem-solving skills, however, are shaped in accordance with the beliefs and expectations about one's problem-solving skills (Heppner, Witty & Dixon, 2004) because coping with environment and problems occur through one's problem-solving capacity. The individual's self-evaluation of the ability to cope with problems effectively is extremely important in this respect. Thus, individuals with positive perceptions of their problem-solving ability might also be much better at problem-solving than those with negative perceptions of their problem solving ability (Güçlü, 2003). Heppner and Krauskopf (1987) identified that perception of problem-solving ability plays a central role in the way an

individual perceives and experiences different aspects of dealing with problem. Heppner and Petersen (1982) developed the Problem Solving Inventory (PSI) to assess perceptions of one's problem solving ability. The PSI has been used in several studies (Good, Heppner, DeBord & Fisher, 2004; MacNair & Elliot, 1992) to measure individuals' perceptions of their problem-solving ability.

Individuals capable of thinking critically try to understand the cause of every situation or occurrence that they face, they question the underlying truths, they are informed concerning the truth of what they read and hear, and make efforts to generate solutions to handle the problems they encounter (Özdemir, 2005). They can also solve their problems effectively (Snyder & Snyder, 2008). On the contrary, individuals lacking the ability to think critically may not succeed to think scientifically, analytically and in a questioning manner, nor do they behave critically in situations that they face or in the research process. In addition, the latter hardly ever use problem-solving methods, – which represent one of the most important components of the research process (Özdemir, 2005).

Gagne (1980) suggested that the main objective of education is to teach individuals how to think and how to be good problem-solvers because in real life individuals who are able to think, question, research and produce solutions to the problems they meet may (are likely to) be successful (Aydoğdu, 2012). A great majority of the criticisms concerning Turkish Education System relates to the fact that students who are raised as the passive recipients of knowledge may have difficulties in making critical choices, solving the complex problems they will face, and achieving in their academic studies in the face of today's information explosion (Şahinel, 2007), and thus it is suggested that the new implications in the Turkish Education System should concentrate on students' intellectual development. The content and methods should be re-arranged in a way so as to instil in them such skills as critical thinking, creative thinking, relational thinking, and reasoning (Özden, 2011). For this aim, student-centred learning may be a new implication. Student-centred learning is a broad approach that “includes such techniques as substituting active learning experiences for lectures, holding students responsible for material that has not been explicitly discussed in class, assigning open-ended problems and problems requiring critical or creative thinking that cannot be solved by following text examples, involving students in simulations and role-plays, assigning a variety of unconventional writing exercises, and using self-paced and/or cooperative (team-based) learning” (Felder & Brent, 1996: 43). Accordingly, problem-based learning (PBL) may be implemented as one of the student-centred learning approaches.

As an instructional approach, PBL was first applied in the Medical School of Case Western University, United States of America (USA), in the 1950s. It entered into the literature in the late 1960s following a research study undertaken at McMaster University in Canada (Rhem, 1998). “PBL is a student-centred learning approach that empowers students to conduct a research, integrate theory and practice, and apply know-

ledge and skills to develop a viable solution to a defined problem” (Savery, 2006:12). PBL is consistent with the constructivist theory by challenging the student to take a responsibility for learning (Coombs & Elden, 2004). Since, in the process of PBL, individuals try to make sense of newly encountered situations based upon their prior knowledge, this approach is based on the constructivist theory. As planning the learning activities necessitates students’ active participation in a specific problem state, it is one of constructivist theory’s most important applications (Saban, 2010). Furthermore, it also draws from another aspect of constructivism, which is to do with learning through social interaction, which recognises the impact of others’ ideas on the way students make sense of things (Harlen, 2006 cited in Kelly & Finlayson, 2007). PBL is an approach of learning in which the process of constructing knowledge activates students’ prior knowledge, and problem-solving strategies of ill-structured problems are developed and acquired through in-group discussions and through research (Koçakoğlu, 2010). The selection of ill-structured problems is critical to the success of the PBL (Savery, 2006). Ill-structured problems are routinely encountered in everyday and usually have divergent or alternative solutions (Shin, Jonassen & McGee, 2003). Bringing students face-to-face with ill-structured problems which reflect real life and making them take on active roles helps them to develop higher order thinking skills (Yuzhi, 2003). “A critical skill developed through PBL is the ability to identify the problem and set parameters on the development of a solution. When a problem is well-structured students are less motivated and less invested in the development of the solution” (Savery, 2006:13). The problems used in PBL should be designed in such a manner as to improve students’ knowledge, personality, academic behaviour and attitudes (Barrett, 2012) and must allow for free inquiry (Savery, 2006). Problems should be presented to students through scenarios (Neville & Britt, 2007). Problem scenarios that are ill-structured may lead to critical and creative thinking, and thus PBL develops higher order thinking skills (Yuzhi, 2003). Using problem scenarios in education differentiates PBL from other teaching approaches (Tan, 2010). Especially, PBL differs from a problem-solving approach “in that in the PBL problems are encountered before all the relevant knowledge has been acquired and, therefore, necessitates both the acquisition of knowledge and the application of problem-solving skills. In some cases, defining the problem itself forms part of the PBL. In a problem-solving approach, the knowledge acquisition has usually already taken place and the problems serve as a means to explore or enhance that knowledge” (Belt, Hywel Evans, McCreedy, Overton & Summerfield, 2002:65). In contrast to the traditional approach in which knowledge is transferred to students by the teacher, problem states are established by the teacher to match the concepts in PBL, and the students are required to find solutions to those problem states (Tan, 2010). Using complex and real-world problems to introduce a concept and motivating learning in an active and cooperative learning environment, PBL is a powerful alternative to the traditional teaching method in introductory courses in biology, physics and chemistry (Allen, Duch & Groh, 1996). Also, in her

study, Van Loggerenberg-Hattingh (2003) found that the use of PBL is more effective in learning science than the traditional teaching method and that students taught through PBL scored significantly higher than students taught traditional teaching method on selected questions in the post-test that were classified on Bloom's taxonomy as higher order questions.

Against this background, it may be said that it is becoming increasingly important for individuals to possess higher order thinking skills in adjusting to today's changing circumstances and in coping with the problems they encounter. Critical thinking which is one of the higher order thinking skills and problem-solving, a basic dimension of critical thinking, are becoming obligatory for individuals in the 21st century. Thus, it is necessary to examine these notions objectively and elaborate on the ways to equip individuals with such skills (Şendağ & Odabaşı, 2009). In this respect, implementing PBL may serve as a way to develop these skills. Also, schools' capacity to raise individuals who can think critically, gain and produce the knowledge they need, requires that teachers are equipped with such skills (Korkmaz, 2009). Research suggests, however, that while faculty support the development of critical thinking skills and acknowledge their importance, they are infrequently taught how to define critical thinking or how to facilitate development of critical thinking skills in the classroom (Bailin, Case, Coombs & Daniels, 1999; Paul, Elder & Bartell, 1997). According to Lombard and Grosser (2008), it is clear that critical thinking skills, as well as an understanding of how to teach these skills, are lacking among pre-service and practising teachers. Furthermore, despite the fact that there is consensus that university education should develop students' critical thinking skills, the number of research studies confirming these assumptions is very limited (Saçlı & Demirhan, 2008).

A review of the literature demonstrates that most research studies examined the effects of PBL on student success and understanding in the teaching of various chemistry subjects (Aydoğdu, 2012; Bayrak, 2007; Bilgin, Şenocak & Sözbilir, 2009; Kelly & Finlayson, 2007; Özekan & Yıldırım, 2011; Ram, 1999; Van Loggerenberg-Hattingh, 2003; Wenzel, 1995; 1998; Yuzhi, 2003). Also, the results showing that PBL has positive effects on critical thinking skills comes mainly from medical literature (Birgegård & Lindquist, 1998; Tiwari, Lai, So & Yuen, 2006) makes this research remarkable in education, especially in chemistry education. Hence, it is believed that the research that is presented in this paper will contribute meaningfully to the existing related literature.

Aim of the study

The aim of this study was two-fold. The first aim was to determine the levels of critical thinking disposition and perception of problem-solving ability of pre-service teachers. The second aim was to compare the effects of PBL and traditional teaching methods on the critical thinking dispositions and perceptions of problem-solving ability of pre-service teachers, when implemented in the teaching of the acid-base topic. The

present study focused on the following research questions:

- What are the levels of critical thinking disposition of pre-service teachers?
- What are the levels of perception of problem-solving ability of pre-service teachers?
- Is there a significant difference between pre-service teachers' critical thinking dispositions according to the different teaching methods implemented?
- Is there a significant difference between pre-service teachers' perceptions of problem-solving ability according to the different teaching methods implemented?

Method

The study used a pre-test–post-test control group design. It belongs to a true experimental design. The essential ingredient of the true experimental design is that subjects are randomly assigned to treatment groups. Random assignment is a powerful technique for controlling the subject characteristics threat to internal validity, a major consideration in educational research (Fraenkel & Wallen, 2006).

The sample

The sample for the study consisted of 49 pre-service teachers from the Department of Secondary Science and Mathematics Education, Hacettepe University, Ankara, Turkey, who participated in the spring term of the 2011–2012 academic year. They were first-year students at the Hacettepe University.

Instruments

California Critical Thinking Disposition Inventory (CCTDI)

The CCTDI, which is used to measure respondent's disposition toward critical thinking, was developed from the Delphi project organized by the American Philosophy Association in 1990. The CCTDI is a 75-item Likert-type scale (Facione, Facione & Giancarlo, 1998). Seven characteristics of the overall disposition toward critical thinking emerged when statistical factor analytic techniques were applied in the initial development of the CCTDI. These are: truth-seeking, open-mindedness, analyticity, systematicity, critical thinking self-confidence, inquisitiveness and cognitive maturity (Facione, Facione & Giancarlo, 2000). The total score indicates whether a respondent is generally disposed to think critically — whether the respondent habitually exhibits the characteristics of the ideal critical thinker (Facione et al., 1998).

The scale was adapted into Turkish from English by Kökdemir (2003), and the necessary factor, validity and reliability analyses were also determined. Cronbach's alpha reliability coefficient for the scale was found to be 0.88. The CCTDI is a 6-point Likert-type scale consisting of 51 items. The scale consists of 6 sub-scales that address the following characteristics: open-mindedness, analyticity, systematicity, self-confidence, inquisitiveness and truth-seeking (Kökdemir, 2003). The open-mindedness sub-scale addresses being tolerant of divergent views and sensitive to the possibility of one's bias. The analyticity sub-scale assesses prizing the application of reasoning

and the use of evidence to resolve problems, anticipating potential conceptual or practical difficulties, and consistently being alert to the need to intervene. The systematicity sub-scale measures being organized, orderly, focused, and diligent in inquiry. The self-confidence sub-scale measures the trust one places in one's own reasoning processes. The inquisitiveness sub-scale measures of one's intellectual curiosity and desire for learning even when the application of the knowledge is not readily apparent. The truth-seeking sub-scale targets the disposition of being eager to seek the best knowledge in a given context, courageous about asking questions, and honest and objective about pursuing inquiry even if the findings do not support one's self-interests or one's preconceived opinions (Facione, Giancarlo & Facione, 1993:6-7). An overall CCTDI score of less than 240 shows serious overall deficiency in critical thinking dispositions, whereas an overall score of greater than 300 shows strength in overall critical thinking disposition. The maximum score for CCTDI is 360 (Kökdemir, 2003). Sample items on the CCTDI are:

“I'm proud that I can think with great precision” (self-confidence sub-scale)

“It's important to me to understand what other people think about things” (open-mindedness sub-scale) (Facione et al., 1998).

Problem-solving inventory (PSI)

The PSI, which is used to assess perceptions of one's problem-solving ability, was developed by Heppner and Petersen (1982). The inventory does not assess actual problem-solving skills but rather one's perception of one's problem-solving beliefs and style (Heppner et al., 2004). The scale was adapted into Turkish from English by Savaşır and Şahin (1997). It consists of 35 items and employs a 6-point Likert-type scale. The Cronbach's alpha reliability coefficient for the overall inventory was found to be 0.90 by Savaşır and Şahin (1997). The range of scores attainable on the inventory is between 32 and 192. According to Taylan (1990:41), high scores show that the respondent perceives oneself as insufficient in terms of problem-solving skills, while low scores show the respondents' problem-solving skills as being at a satisfactory level. The inventory has 3 sub-scales: problem-solving confidence “... self-assurance while engaging in problem-solving activities”; approach-avoidance style “... a general tendency of respondents to approach or avoid problem-solving activities”; and personal control “... the extent to which respondents believe that they are in control of their emotions and behaviour while solving problems”. Sample items on the PSI are: “I am usually able to think up creative and effective alternatives to solve a problem” (problem-solving confidence sub-scale)

“Sometimes I get so charged up emotionally that I am unable to consider many ways of dealing with my problem” (personal control sub-scale) (Heppner, 1988).

Procedure

In this study, the acid-base topic, which is related to daily life, was chosen. Acids and bases play an important role in our bodies, in medicine, in our homes, and in industry,

they are useful products in many ways, as industrial by-products, they can damage the environment. Their use requires caution, and their misuse can be dangerous to human health. For example: Acid rain is an important environmental problem that involves both air pollution and water pollution (Acids and Bases n.d.).

Initially, the researcher informed the pre-service teachers of the importance and justification for the study. The aim of the research was explained to the pre-service teachers. Then, the pre-service teachers were randomly assigned to an experimental group ($n = 22$) and a control group ($n = 27$) according to their semester scores in General Chemistry I and Basic Chemistry I during the autumn semester in the 2011–2012 academic year. The CCTDI and PSI were administered as pre-test treatments to determine whether or not both the experimental group and control group were equivalent in respect of their critical thinking dispositions and their perceptions of problem-solving ability.

Secondly, the pre-service teachers in the experimental group were informed of principles of and application stages of PBL and pre-service teachers in the control group were informed of traditional teaching method. Then the pre-service teachers in the experimental group were randomly assigned to five groups (two groups of five pre-service teachers and three groups of four pre-service teachers) because PBL activities are presented through group learning. According to Wood (2003:328), “group learning facilitates not only the acquisition of knowledge but also several other desirable attributes, such as communication skills, teamwork, problem-solving, independent responsibility for learning, sharing information, and respect for others. PBL can therefore be thought of as a small group learning approach that combines the acquisition of knowledge with the development of generic skills and attitudes”.

The teaching of the acid-base topic was presented in five sessions through the PBL in the experimental group. In the first session, each of the five groups was given a problem scenario by the researcher. A sample of the problem scenarios is given in Figure 1 ('Benim çocuğum içmez' demeyin!, 2011). The problem scenarios were formed in accordance with the properties that a problem of PBL should possess, as determined by Groh (2001). The groups analysed the problem scenarios given and tried to determine the issues given to them in the problem scenarios. The groups began to ask that what they know, what they do not know and what they need to know related to the issues. Then the groups listed the key issues to be learned. Related to the sample problem scenario, some of the key issues listed were: *Corrosive substances, acid, base, pH, corrosive properties of acid-bases*. The groups also tried to define a problem state in the problem scenario. At this point, the researcher acted as a facilitator to guide groups' analysis process of the problem scenarios. When the first stage was concluded, five groups prepared a work plan and decided on the distribution of tasks to gather data related to their key issues. In the second session, the groups presented the knowledge gathered to each other. Through group discussions, the groups determined the problem state. Related to the sample problem scenario, the problem state was: *If a child drinks a corrosive substance by mistake, what should be done?* Then the groups determined

sub-problems of their problem scenarios. Related to the sample problem scenario, one of the sub-problems was: *What damages can be occurred, when corrosive substances are swallowed by a child?* Meanwhile, the researcher tried to make observation of groups' discussion and to ask questions in order to lead groups to thinking during determination of sub-problems. Afterwards, the groups formed hypotheses about their sub-problems. Related to the sample problem scenario, one of the hypotheses about the sub-problems was: *If a child swallows corrosive substances, this can lead to serious damage.* At the end of the session, the groups determined areas of deficiency in their knowledge and strategies to address these, and prepared a new distribution of tasks accordingly. In the third session, all five groups made brief summaries of the previous session. Then the groups revised their hypotheses based on the knowledge obtained, and made corrections. Subsequently, the groups tried to determine the solutions to the sub-problems. In the fourth session, having made a summary of the previous sessions, they prepared a list of what had been done. The groups examined the solutions offered and decided on the best solution. The best solution for the sample problem scenario was: *Making individuals conscious of the properties and damages of corrosive substances.* The groups also determined what the final product would be. In the fifth session, the groups considered the problem states, the sub-problems and the hypotheses and the solution that they had constructed. The groups prepared a report for presentation to the classroom. Then the groups presented what they learned about their problem scenario. During all PBL processes, the researcher tried to make observations and provide each pre-service teacher in the different groups an opportunity to participate in the process. When groups had a problem during the PBL process, the researcher guided them with questions without giving any information. The researcher helped pre-service teachers collaborate well and encouraged them to justify their thinking.

In the control group the teaching of the acid-base topic followed the traditional teaching method. The teaching was conducted in such a way that the researcher was active and the students were passive listeners, the latter asking for explanations of the parts that they did not understand. In particular, the traditional teaching method consisted of a subject-based approach. The researcher employed such techniques as direct explanations and question-and-answer in the presentation of the topic.

In the final stage of the study, the CCTDI and PSI were administered as the post-test treatments to both the experimental group and control group for obtaining post-test measures after the implementation of the different teaching methods.

Data analysis

Descriptive statistics, independent t tests and a two-way ANOVA for mixed measures were employed in the data analysis.

Results

Independent t tests were used to analyse the data obtained from pre-test treatments. The results are given in Table 1 and Table 2.

Do not say "my child never drinks milk"

Detergents in our homes rank the first in child poisoning. They are followed by medicines... For instance, 793 children drinking the chemicals in the house were poisoned in 2010 in Samsun.

SAMSUN- Assoc. Prof. Dr Ilknur Avci from the College of Medical Sciences, Ondokuz Mayıs University, pointed out that children's curiosity forced them to drink the chemicals.

Avci saying "the chemicals at homes stand as serious hazards for children under the age of 6, when especially the feeling of curiosity is intensely experienced" stated:

"The chemicals, especially those used for cleaning purposes in our homes, are increasing day by day. The substances known as corrosive substances in medical jargon are of strong acidic-alkaline characteristic powder or liquid caustics such as nitric acid, detergents for washing machines and dishwashers, drain cleaners, and oil-solvents which are used for cleaning purposes in homes. Those substances have increased both in kind and in number recently, and are likely to be drunk by children mistaking them for water."

What might happen if your child drank it?

Figure 1 A sample of the problem scenarios

Table 1 The CCTDI pre-test scores of pre-service teachers in both groups

| Groups | <i>N</i> | \bar{x} | <i>SD</i> | <i>df</i> | <i>t</i> | <i>p</i> |
|--------------|----------|-----------|-----------|-----------|----------|----------|
| Experimental | 22 | 212.000 | 18.178 | 47 | 1.887 | 0.066 |
| Control | 27 | 199.518 | 27.842 | | | |

When Table 1 is examined, it can be observed that there is no significant difference between the critical thinking disposition scores of pre-service teachers in both the experimental group and control group ($t = 1.887, p = 0.066$).

Table 2 The PSI pre-test scores of pre-service teachers in both groups

| Groups | <i>N</i> | \bar{x} | <i>SD</i> | <i>df</i> | <i>t</i> | <i>p</i> |
|--------------|----------|-----------|-----------|-----------|----------|----------|
| Experimental | 22 | 94.318 | 13.537 | 47 | 0.243 | 0.809 |
| Control | 27 | 93.185 | 18.106 | | | |

When Table 2 is examined, it can be seen that there is no significant difference between the perception of problem-solving ability scores of pre-service teachers in both the experimental group and control group ($t = 0.243, p = 0.809$).

According to the scores in Table 1 and Table 2, it was observed that the experimental group and control group are equivalent in respect of their critical thinking dispositions and perceptions of problem-solving ability at the beginning of the study.

In relation to the first research question, the levels of critical thinking disposition of pre-service teachers in both the experimental group and control group were determined. The percentages of pre-service teachers for the CCTDI scores of each group are shown in Table 3.

Table 3 Percentages for the pre-service teachers' CCTDI pre-test–post-test scores

| Groups | | Levels of critical thinking disposition | | |
|--------------|-----------|---|--------------------------|------------------------|
| | | low-scoring group (%) | middle-scoring group (%) | high-scoring group (%) |
| Experimental | Pre-test | 90.90 | 9.10 | 0 |
| | Post-test | 86.36 | 13.64 | 0 |
| Control | Pre-test | 92.59 | 7.41 | 0 |
| | Post-test | 88.88 | 11.12 | 0 |

As can be seen from Table 3, the pre-service teachers were divided into two groups according to their CCTDI pre-test and post-test scores. When the CCTDI pre-test and post-test scores of pre-service teachers in both the experimental group and control group were examined, it was determined that the majority scored lowly and none of them scored highly. When the CCTDI post-test scores of pre-service teachers in both the experimental group and control group were examined, it was seen that there is an increase in the scores of pre-service teachers in the middle-scoring group. However, the increase is low. According to these scores, it can be said that the levels of critical thinking disposition of pre-service teachers in both the experimental group and control group are generally low.

In relation to the second research question, the levels of perception of problem-solving ability of pre-service teachers in both the experimental group and control group were determined. The mean scores of pre-service teachers for the PSI of each group are shown in Table 4.

As can be seen from Table 4, from the mean scores for the PSI pre-test–post-test results, it was determined that the mean scores are higher than the middle value ($\bar{x} = 80$) of the PSI. According to these results, it can be said that the levels of perception of problem-solving ability of pre-service teachers in both the experimental group and control group are generally middling.

Table 4 The mean scores for the PSI pre-test–post-test results

| Groups | | \bar{x} | <i>SD</i> |
|--------------|-----------|-----------|-----------|
| Experimental | Pre-test | 94.318 | 13.537 |
| | Post-test | 84.045 | 14.977 |
| Control | Pre-test | 93.185 | 18.106 |
| | Post-test | 95.185 | 17.890 |

Related to the third research question, the values of the CCTDI pre-test–post-test mean scores and standard deviations for the pre-service teachers in both the experimental group and control group were calculated. The scores are given in Table 5.

Table 5 Values of mean scores and standard deviations for the CCTDI

| Groups | <i>N</i> | Pre-test | | Post-test | |
|--------------|----------|-----------|-----------|-----------|-----------|
| | | \bar{x} | <i>SD</i> | \bar{x} | <i>SD</i> |
| Experimental | 22 | 212.000 | 18.179 | 220.500 | 20.075 |
| Control | 27 | 199.518 | 27.842 | 204.666 | 28.085 |

According to the scores in Table 5, it can be said that there is an increase in the scores for the critical thinking dispositions of pre-service teachers in both the experimental and control groups.

A two-way analysis of variance (ANOVA) results relating to the statistical significance of the increase between the CCTDI pre-test–post-test scores are given in Table 6.

Table 6 The ANOVA results for the pre-test–post-test scores on the CCTDI

| Source | Sum of squares | df | Mean square | <i>F</i> | <i>p</i> |
|------------------------------|----------------|----------|---------------|--------------|--------------|
| Between groups | 44226.245 | 48 | | | |
| Group (D/K) | 4859.458 | 1 | 4859.458 | 5.802 | 0.020 |
| Error | 39366.787 | 47 | 837.591 | | |
| Within groups | 17896.587 | 49 | | | |
| Measure (pre-test-post-test) | 1129.036 | 1 | 1129.036 | 3.178 | 0.081 |
| Group *Measure | 68.097 | 1 | 68.097 | 0.192 | 0.664 |
| Error | 16699.454 | 47 | 355.308 | | |
| Sum | 62122.832 | 97 | | | |

When Table 6 is examined, no statistical difference was found between the CCTDI pre-test–post-test scores of the pre-service teachers, in both the experimental group and control group, according to the different teaching methods implemented

($F_{1,47} = 0.192, p = 0.664$). This result can be interpreted as implying that PBL and traditional teaching methods do not have different effects on the critical thinking dispositions of pre-service teachers.

Related to the fourth research question, the values of the PSI pre-test–post-test mean scores and standard deviations for the pre-service teachers in both groups were calculated. The results are given in Table 7.

Table 7 Values of mean scores and standard deviations for the PSI

| Groups | N | Pre-test | | Post-test | |
|--------------|----|-----------|--------|-----------|--------|
| | | \bar{x} | SD | \bar{x} | SD |
| Experimental | 22 | 94.318 | 13.537 | 84.045 | 14.977 |
| Control | 27 | 93.185 | 18.106 | 92.814 | 18.708 |

The results in Table 7 illustrate that there is a decrease in the scores of perceptions of problem-solving ability of pre-service teachers. Accordingly, it can be said that there is an improvement in the perceptions of problem-solving ability of pre-service teachers in both the experimental group and control group.

A two-way ANOVA results relating to whether or not the decrease in the PSI pre-test–post-test scores is statistically significant are given in Table 8.

Table 8 The ANOVA results for pre-test–post-test scores on the PSI

| Source | Sum of squares | df | Mean square | F | p |
|------------------------------|----------------|----------|----------------|--------------|--------------|
| Between groups | 19668 | 48 | | | |
| Group (D/K) | 353.455 | 1 | 353.455 | 0.860 | 0.358 |
| Error | 19314.545 | 47 | 410.948 | | |
| Within groups | 8150.262 | 49 | | | |
| Measure (pre-test-post-test) | 686.588 | 1 | 686.588 | 4.698 | 0.0035 |
| Group *Measure | 594.344 | 1 | 594.344 | 4.067 | 0.049 |
| Error | 6869.330 | 47 | 146.156 | | |
| Sum | 27818.262 | 97 | | | |

When Table 8 is examined, a statistical difference can be observed between the PSI pre-test–post-test scores of the pre-service teachers in both the experimental group and control group according to different teaching methods implemented ($F_{1,47} = 4.067, p = 0.049$). This result can be interpreted as implying that PBL and the traditional teaching method have different effects on the perceptions of problem-solving ability of pre-service teachers.

Conclusion and discussion

In relation to the first research question, the pre-service teachers were divided into two groups according to their CCTDI pre-test and post-test scores. An examination of the percentages concerning the pre-service teachers in the two groups showed that the percentages of the pre-service teachers in the low-scoring group according to the post-test results in both the experimental group and control group decreased whereas the percentage of those in the middle-scoring group increased. Nevertheless, it was found that the percentages of those in the low-scoring group were quite high in both the experimental group and control group in the pre-test and the post-test. According to the results, it can be said that the levels of critical thinking disposition of the pre-service teachers in both the experimental group and control group were generally low. The results of this study are not unique. A review of the literature also suggests that pre-service teachers' levels of critical thinking disposition are usually low or middling. Channel (2000) and Güven and Kürüm (2007) found that students' levels of critical thinking tendencies in education faculties were generally low, whereas Korkmaz (2009) and Özdemir (2005) found them to be intermediate. However, McBride et al. (2002) provided evidence of a positive inclination toward critical thinking of pre-service physical education students on the total score of the CCTDI. Zoller et al. (2000) determined positive overall disposition toward critical thinking of Israeli and Italian university science students on the total scores of the CCTDI.

In relation to the second research question, the PSI pre-test and post-test mean scores were calculated. Although a decrease was observed in the post-test mean scores for both the experimental group and control group, their mean scores of perceptions of problem-solving ability in the pre-test and the post-test were close to the mean value of the PSI. According to the results, it can be said that the pre-service teachers' perceptions of problem-solving ability in both the experimental group and control group were generally at the middle level. Similarly, in the literature, research conducted by Saracaloğlu, Yenice and Karasakaloğlu (2000) with pre-service elementary school teachers and that of Temel (2009) with pre-service chemistry teachers showed that pre-service teachers were at a satisfactory level in terms of perceptions of problem-solving ability.

In terms of the third research question, the values of the CCTDI pre-test–post-test mean scores and standard deviations for the pre-service teachers in both the experimental group and control group were calculated. A close examination of the results showed that there is an increase in the critical thinking disposition scores of the pre-service teachers in both the experimental group and control group. According to a two-way ANOVA analysis, no significant difference was found between the pre-test and post-test CCTDI scores according to the different teaching methods implemented ($F_{1,47} = 0.192, p = 0.664$). According to the result, it may be said that PBL and the traditional teaching method do not differ significantly in terms of increasing pre-service teachers' critical thinking dispositions.

Concerning the fourth research question, the values of the PSI pre-test–post-test

mean score and standard deviations of the pre-service teachers in both the experimental group and control group were calculated. The results showed that there is a decrease in the perceptions of problem-solving ability scores of the pre-service teachers in both the experimental group and control group. In order to determine whether or not the decrease was statistically significant, a two-factor ANOVA analysis was conducted. A significant difference was found between the PSI pre-test and post-test scores of the pre-service teachers in both the experimental group and control group according to the different teaching methods implemented ($F_{1,47} = 4.067, p = 0.049$). Accordingly, the result may be interpreted as PBL and the traditional teaching method having different effects on pre-service teachers' perceptions of problem-solving ability. It is reasonable to argue that the difference observed in the pre-service teachers' perceptions of problem-solving ability arises from the use of PBL approach. It was also found that the PBL approach, in which a greater decrease was observed in the scores of perceptions of problem-solving ability, was more influential than the traditional teaching method in raising pre-service teachers' perceptions of problem-solving ability.

Evaluating the results of this study, it was found that the critical thinking dispositions of pre-service teachers in the experimental group were at a higher level than those in the control group following the implementation. However, the superiority of PBL over the traditional teaching method in the development of students' critical thinking dispositions was not found to be statistically significant. The literature review showed the existence of research studies with findings inconsistent with those obtained in the present study (Gürses, Açıkyıldız, Doğar & Sözbilir, 2007; Şendağ & Odabaşı, 2009; Sulaiman, 2013; Şenocak, Taşkesenligil & Sözbilir, 2007). Moreover, it was also found in this study that PBL and the traditional teaching method have different effects on the perceptions of problem-solving ability of pre-service teachers. The study showed that PBL was more influential in increasing the perceptions of problem-solving abilities of the pre-service teachers than the traditional teaching method. Studies consistent with this finding can also be found in the literature (for examples, see, Gürten, 2011; Yaman, 2003; Yaman & Yalçın, 2005).

To sum up, the fact that critical thinking is a more detailed thinking skill than problem-solving, and that it requires more time to develop than its counterpart, may be considered the first reason for the influence of PBL in increasing perceptions of problem-solving ability and its relative lack of effectiveness in increasing critical thinking dispositions of the pre-service teachers. The possibility that the pre-service teachers were not objective concerning their own problem-solving skills might be considered to be another reason. It was also notable in this study that the levels of critical thinking disposition and perception of problem-solving ability of the pre-service teachers in both the experimental group and control group were inadequate. This may be attributed to the fact that the students included in the study were first year students. In a study, Tümkaya, Aybek and Aldağ (2009) found a difference between pre-service science and social science teachers in terms of critical thinking dispositions

and perception of problem-solving ability according to grade levels favoured those in final year. This result can be interpreted as the positive influence of four years of university education on their critical thinking disposition and perception of problem-solving ability. Furthermore, the fact that the pre-service teachers in this study were newly acquainted with a learning approach, which was different from the traditional teaching method, that is, they were involved in a learning environment to which they were unfamiliar, may be regarded as the reason for the insufficient level of their thinking skills acquisition.

Therefore, in order to ensure that pre-service teachers' critical thinking dispositions and perceptions of problem-solving ability improve, the levels at which pre-service teachers possess those skills should be described, hence the significance of specifying the level of study for the pre-service teachers. Then, situations likely to hinder the development of those skills should be determined. For example, "some beliefs can hinder critical thinking. If you believe you will fail at trying to solve a problem, you probably won't try. If you don't try, you won't avail yourself of the opportunity to learn and develop your talents, including your critical thinking talents" (Carroll, 2004:13). In this process, a model should be provided to the pre-service teachers and opportunities should be given in order for them to develop critical thinking dispositions and perceptions of problem-solving ability. In particular, student-centred learning approaches should be employed in classes to enable them to develop skills such as critical thinking dispositions and perceptions of problem-solving ability. Finally, research studies should be undertaken to analyse pre-service teachers' views of approaches such as PBL, which might give teachers views and the success of new instructional approaches, and to take necessary precautions to mitigate negative effects, if any.

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