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The impact of inquiry-based learning on the critical thinking dispositions of pre-service science teachers

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ABSTRACT

In the study, the impact of inquiry-based learning on pre-service teachers' critical thinking dispositions was investigated. The sample of the study comprised of 56 pre-service teachers in the science education teacher education programme at the public university in the north of Turkey. In the study, quasi-experimental design with an experimental and a control group were applied to find out the impact of inquiry-based learning on the critical thinking dispositions of the pre-service teachers in the teacher education programme. The results showed that the pre-service teachers in the experimental group did not show statistically significant greater progress in terms of critical thinking dispositions than those in the control group. Teacher educators who are responsible for pedagogical courses in the teacher education programme should consider that the inquiry-based learning could not be effective method to improve pre-service teachers' critical thinking dispositions. The results are discussed in relation to potential impact on science teacher education and implications for future research.

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Introduction

The considerable significance of inquiry-based learning and critical thinking has long been recognised in science education for more than a century. In America, National Science Education Standards emphasises student understanding through inquiry and has many goals that focus on critical thinking (NSES, 1996). The National Council for Accreditation of Teacher Education (NCATE, 2008), which is officially recognised by the U.S. Department of Education as an accrediting body for institutions that prepare teachers and other professional personnel for work in pre-school, elementary, and secondary schools, have programme standards related to the inquiry-based learning. For example, the following programme standard includes inquiry-based learning: 'Science teachers understand multiple methods of inquiry and engage students in scientific inquiry that requires students to ask questions, design studies, collect and interpret data and draw conclusions and do so in a developmentally appropriate manner.'

The importance of promoting students' inquiry ability also has been emphasised in the science education curriculum in Turkey. In 2005, the science education elementary school

curriculum was revised by the Ministry of National Education. The curriculum based on constructivist learning theory consists of student-centred learning approaches such as problem-solving, project-based learning, and inquiry-based learning. One of the main goal of the curriculum is to improve scientific research abilities and inquiry skills of the students by the guidance of teachers. According to the programme principles, science teachers should promote active learning as a guidance, and create positive and democratic classroom environment, and students need to learn new knowledge about science through inquiry and investigation (MEB, 2013). Elementary school students who learn science can have critical thinking skills through the implementation of the new science education programme in Turkey. Thus, science teachers need to use a variety of teaching strategies that encourage elementary students' development of critical thinking through inquiry. In Turkey, the teacher education standards defined by Ministry of National Education include competences related to inquiry-based learning and critical thinking. For example, teachers should have the following competence: 'Teachers have high level of thinking skills such as critical thinking and problem solving' (MEB, 2012). Science teachers and teacher candidates need to learn science through inquiry by having the same opportunities as their students will have to develop understanding and critical thinking.

Critical thinking

John Dewey, pioneer of progressivism of educational philosophy, defined critical thinking as 'active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusion to which it tends' (Dewey, 1933, p. 9). Paul (1995) described critical thinking as 'at the ability to analyse, criticise, advocate ideas, reason inductively and deductively, and to reach factual or judgmental conclusions based on sound inferences.' According to Ennis (1985), critical thinking is a form of rational, reflective thinking, focused on deciding on what to believe or do, and it includes three main process: First, critical thinking begins with a problem-solving process. Second, it continues a reasoning process, and it results in a number of inferences through induction, deduction, and value judging. Finally, the critical thinking process ends in a decision about what to do or believe. Indeed, critical thinking competence can be divided into two sub-categories, disposition and skills. In the current study, the author focus on the critical thinking dispositions of science pre-service teachers.

Ennis (1985) defined the critical thinking disposition as the critical spirit, which is the motivation that critical thinkers used to apply critical thinking abilities to the thinking of others and to their own thinking. Facione (1990, p. 3) defined critical thinking dispositions as 'purposeful, self-regulatory judgement which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodical, criteriological, or contextual considerations upon which that judgement is based.' Critical thinking dispositions consist of truth seeking, open-mindedness, analyticity, systematicity, self-confidence, inquisitiveness, and maturity (Facione & Gittens, 2013). Truth seeking is intellectual integrity and a desire to find possible knowledge. Open-mindedness is to be sensitive to and tolerant of different views. Analyticity includes predictions of results of events, decisions and actions. Systematicity means solving problems in an organised way. Self-confidence is to be trustful to someone. Inquisitiveness means seeking new information. Maturity includes cognitive skills to construct knowledge in a complex manner.

Critical thinking dispositions of teachers are critical for improving their students' critical thinking skills. Thus, pre-service teachers need to have positive critical thinking dispositions by having learning experiences in the teacher education programmes.

The studies regarding critical thinking skills and dispositions of pre-service science teachers in Turkey showed that their critical thinking skills and dispositions are not enough strong, in general at medium and low level (Alper, 2010; Akgün & Duruk, 2016; Bakır, 2015; Demirhan & Köklükaya, 2014; Yenice, 2012). For example, Alper (2010) investigated the critical thinking dispositions of pre-service teachers. The study revealed that pre-service teachers' critical thinking dispositions are not weak but not enough strong, in particular the low truth-seeking disposition scores were observed in the study. Also, the results of another study conducted by Bakır (2015) showed that the level of critical thinking dispositions of pre-service teachers is low overall. Thus, the critical thinking dispositions of pre-service teachers should be improved through the teacher education programme. There are many studies (Arsal, 2015; Kezer & Turker, 2012; McBride, Xiang, & Wittenburg, 2002; Zhou, Yan, Zhao, Liu, & Xing, 2012) showing that critical thinking dispositions of pre-service teachers can be improved by integrating critical thinking activities into the teaching and learning process or the context of a course in the teacher education programme. For instance, Arsal (2015) investigated the effects of microteaching on the critical thinking dispositions of pre-service teachers. The results of the study showed that the pre-service teachers who have microteaching experience showed greater progress in critical thinking dispositions. In the light of the literature on critical thinking, the student-centred learning experiences such as inquiry-based learning should be planned by teacher educators in order to improve pre-service teachers' critical thinking dispositions. As a result, in this study the effect of inquiry-based learning on pre-service science teachers' critical thinking dispositions was examined.

Inquiry-based learning

Inquiry-based learning is an active, student-centred, and self-directed learning that students take responsibility for their learning (Spronken-Smith & Walker, 2010). According to Lee, Greene, Odom, Schechter, and Slatta (2004) inquiry-based learning refers to a range of strategies used to promote learning through students' active, and increasingly independent investigation of questions, problems and issues. In this definition, inquiry includes a driving of learning and developmental process of students' learning.

According to Justice et al. (2006) inquiry-based learning is a research process including seeking knowledge and new understanding, as well as a method of teaching. Inquiry-based learning process includes many scientific activities such as observation, questioning, reviewing, investigation, gathering, analysing and interpreting data, predictions, and communication of the results (National Research Council, 2000). Banchi and Bell (2008) suggested that there are four levels of inquiry including confirmation, structured, guided, and open. At the first level, confirmation inquiry, teachers provide scientific questions to students for the experience of conducting investigation. In this phase, they can have scientific skills such as collecting and analysing data. At the second level, structured inquiry, teachers provide scientific question to students, and they interpret the data they collect. At the third level, guided inquiry, the teacher provides students with only the research question, and students design research process including method, results and discussion, and

conclusion section by the guidance of teacher. At the fourth and final level, open inquiry, students plan their research as a scientist by framing research questions, collecting, analysing and interpreting data process, and communicating their results. The open inquiry improves students' scientific reasoning skills and cognitive strategy using. At the end of the open inquiry, students can reach deeper scientific thinking level. Students can have experience multiple levels of inquiry experiences during inquiry-based learning process.

Teacher competence is a key factor in the implementation of inquiry-based learning activities. Teachers need to provide inquiry-based learning experiences and opportunities for students to improve their academic achievement, attitude toward science, critical thinking and scientific skills. Some studies (Dibiase & McDonald, 2015; Hollingsworth & Vandermaas-Peeler, 2017; O'Connor, Jeanes, & Alfrey, 2016; Voet & Wever, 2016) indicated that teachers do not have desirable teaching skills to design and implement inquiry-based learning. For instance, Hollingsworth and Vandermaas-Peeler (2017) revealed that teachers have moderate confidence in their inquiry-based teaching practices. Other research conducted by Dibiase and McDonald (2015) showed that the teachers, for the most part, do not feel prepared to implement inquiry nor do they have the skills necessary to manage inquiry-based learning activities. In addition, the teachers believed not have necessary background knowledge to effectively implement inquiry-based learning. Teacher educators have responsibility for providing pre-service teachers with inquiry-based learning experiences that can improve their not only inquiry skills but also motivation, academic achievement, and thinking skills.

Literature

In the literature there are many studies investigating the effect of IBL on pre-service teachers' scientific abilities, academic achievements, attitudes toward science, thinking skills. These studies showed that inquiry-based learning activities positively affected the pre-service teachers' scientific abilities (Bozkurt, 2012; Psycharis, 2016). For instance, Psycharis (2016) investigated the effects of IBL on scientific abilities of prospective teachers. The findings of study revealed that the development of inquiry-based scenario is strongly affected the scientific abilities of pre-service teachers. In other study, Bozkurt (2012) found that IBL improved pre-service science teachers' academic achievements and scientific thinking skills.

Some studies (Bayram, Oskay, Erdem, & Dinçol Özgür, 2013; Preston, Harvie, & Wallace, 2015; Sarı & Güven, 2013; Şensoy & Aydoğdu, 2008) suggested that IBL is effective in improving pre-service teachers' attitudes towards science and self-efficacy beliefs. For instance, Şensoy and Aydoğdu (2008) investigated the effect of inquiry-based science instruction approach on the development of self-efficacy belief levels of secondary science education teacher candidates. The results of the study revealed that inquiry-based science instruction approach is more effective for developing pre-service teachers' self-efficacy belief levels intended for science teaching than traditional methods.

Many researchers investigated the effects of IBL on pre-service teachers' academic achievement and learning performance (Bozkurt, 2012; Laursen, Hassi, & Hough, 2016; Preston et al., 2015; Sarı & Güven, 2013). For instance, Sarı and Güven (2013) examined the effects of interactive whiteboard supported inquiry-based learning approach on prospective teachers' the academic achievement in modern physics. As a result of

applications, the teaching materials used in experimental group significantly increased the prospective teachers' motivations and academic achievements.

In the literature, there are some studies examining the effects of IBL on pre-service teachers' thinking skills (Çalışkan, 2009; Kwan & Wong, 2015; Madhuri, Kantamreddi, & Gotet, 2012; Thaiposri & Wannapiroon, 2015). One study conducted by Qing, Jing, Yazhuan, Ting, and Junping (2010) showed that the inquiry-based chemical experiment for pre-service teachers positively affected their critical thinking dispositions. Other study (Kwan & Wong, 2015) examining the direct relationship between the constructivist learning environment and critical thinking ability indicated that the constructivist nature of the learning environment affects critical thinking ability when fully mediated through cognitive strategies and goal orientations.

Finally, there are many studies indicating considerable effect of IBL on pre-service teachers' academic achievement, learning performance, motivation. However, in the literature there are limited studies investigating the effects of IBL on pre-service science teachers' critical thinking skills and dispositions. In this case, the current study aims to determine the effects of inquiry-based learning on pre-service science teachers' critical thinking dispositions. The present study was prompted by the following main research question:

Is there a significant difference in the reported critical thinking dispositions between pre-service teachers who participate in inquiry-based learning and those who do not?

Method

Research design

In the study, a quasi-experimental design with an experimental and a control group and a pre-test–post-test were applied to determine the impact of inquiry-based learning on the critical thinking dispositions of pre-service teachers. The pre-service teachers in the experiment group exposed to inquiry-based learning activities for 14 weeks in the spring semester. The study was conducted in the Educational Psychology course, which is given in the first semester of the Science Education teacher education programme implemented in the College of Education in Turkey. This course has objectives and content related to cognitive, emotional, social, personal and moral development, learning theories such as behavioural, social cognitive, and constructivism. The instructor of the course was the same for both groups.

In Turkey, the Higher Education Council is responsible for teacher education in the 4-year undergraduate programmes of universities. The science teacher education programme includes subject area courses such as biology, chemistry, physics and science, and pedagogical courses such as educational psychology, methods of teaching and classroom management to qualify pre-service teachers as teachers in elementary schools in Turkey. The pre-service teachers of the Science Education Teacher Education programme have school experience in their seventh semester, and they have teaching practice opportunity with students through the guidance of a mentor teacher in the eighth semester. The new teacher education programme emphasises the importance of inquiry-

based learning and critical thinking skills of pre-service teachers (Higher Education Council, 2014).

Participants

The sample of the study included of 56 pre-service science teachers (78.6% females, 21.4% males) in the science education teacher education programme at a public university in the north of Turkey. The sample was limited to 56 freshman students who were enrolled in the Educational Psychology course. The experimental group in which inquiry-based learning was implemented, consists of 28 pre-service teachers, and there were 28 pre-service teachers in the control group. Therefore, one of the groups was randomly selected as the experimental group and the other as the control group. The pre-service teachers in both groups voluntarily took part in the study.

Data collection instrument

In the present study, the California Critical Thinking Dispositions Inventory (CCTDI) was conducted to find out the levels of the critical thinking dispositions of both the experimental and control groups at the beginning and end of the study. The original version of the instrument was developed by Facione, Sanchez, Facione, and Gainen (1995). The instrument, which has been used by many other researchers (Kezer & Turker, 2012; Kökdemir, 2003; McBride et al., 2002; Toy & Ok, 2012; Zhou et al., 2012) to assess teachers' and pre-service teachers' critical thinking dispositions, was adapted into Turkish by Kökdemir (2003). The original version of the instrument comprise of 75 6-point Likert-style-ranking items with 7 subscales: Truth-seeking, open-mindedness, analyticity, systematicity, inquisitiveness, self-confidence and maturity. The Turkish version of the instrument consists of 6 subscales and 51 items. The structure of the original scale was confirmed in the Turkish version, but open-mindedness and maturity were loaded on one construct. The reliability value of the scale was found to be 0.88. In this study, the Cronbach Alpha reliability value of the scale was .77. The meaning of the total scores on the CCTDI was following: A score of 240 and below means a low CCTD, between 240 and 300 scores means a positive CCTD and a score 300 and higher means a high CCTD (Kökdemir, 2003).

Process

Instruction of the experimental group

In the study, the inquiry-based learning process determined by Bell, Urhahne, Schanze, and Ploetzner (2010) was adapted into Educational Psychology course content for the teaching in the experimental group. Bell and his colleagues identified nine phases of inquiry-based learning process by analysing studies regarding inquiry-based learning. However, they reported that the order of nine main inquiry phases is not fixed, but very likely to be found. These are orientation and questioning in the beginning, processes of investigation like experimenting in the middle, and finalising activities like conclusion and evaluation at the end. In the present study, the inquiry-based learning process was

planned in five main phases including orienting and asking questions, hypothesis generation, investigation, analysis and interpretation, and conclusion and evaluation.

The first phase, orienting and asking questions, students make observations, and teachers try to take students' interest to the subjects of course and awake their curiosity about scientific problems. Furthermore, students formulate scientific questions, which have scientific value and meaning, for their research. In the present study, the teacher of the experiment group presented a scientific problem related to the context of Educational Psychology course. For example, teacher asked to students '*How can teacher solve learning problems of disabled students in the classroom?*' Teacher also tried to take their interest to the problem by showing pictures, videos of case studies taken from real classroom environment. After that, pre-service science teachers formulated their research questions related to learning problems of disabled students by the guidance of teacher. For example, one pre-service teacher formulated the following research question: 'Is there any relationship between learning performance and disability levels of students?'

The second phase, hypothesis generation, includes formulation of relations between variables and problems of the study. The pre-service science teachers defined hypotheses of the research, however, stating a hypothesis for pre-service teachers is a difficult task because they do not know what a hypothesis look like, how it can be defined. In the hypothesis generation phase of the study, pre-service teachers generated hypothesis related to their research questions. For example one pre-service science teacher created following hypothesis:

"There is a positive relationship between learning performance and the level of disability of students." Other one reported his hypothesis as "Punishment increase learning and test anxiety of students."

The third phase, investigation, is related to the empirical aspect of inquiry learning and includes collecting and organising data of the study. In this phase, pre-service teachers collected data to test hypotheses which they formulated by the guidance of teacher. In this process they also used published documents such as academic journals, thesis, books, and proceedings for data collection. Some pre-service teachers used meta-analysis technique to investigate the scientific problem.

The fourth phase, analysis and interpretation, includes the basis of empirical claims and arguments for the proposition of a model (Windschitl, 2004). In this phase, pre-service science teachers interpreted the data of the study in the light of hypotheses of their research. However, they could have problems about the interpretation of graphs, for example, as a result of a computer simulation (De Jong & van Joolingen, 1998; Mokros & Tinker, 1987). In this study, pre-service science teachers analysed the data, and showed them in the graphs and tables, and interpret the findings of their studies in the light of literature.

In the final phase, conclusion and evaluation, students reach to some results and conclusion from their inquiry. Conclusions might be drawn from data and in comparison with models, theories or other experiments. In the last phase of this study, pre-service science teachers presented the conclusions of their research, and compared them with other results of studies in the literature. Finally, they presented implications and limitations of their studies regarding inquiry-based learning.

Instruction in the control group

In the control group, the instructor presented the theoretical dimensions of the Educational Psychology by using teaching methods such as explaining, question and answer, and discussion at the beginning of the study. The instructor prompted group discussion activities related to findings of empirical studies in the context of the course. Teaching practice related to subjects of the study was implemented with the guidance of the instructor; however, the pre-service teachers in the control group did not expose to inquiry-based learning. Teacher provided some scientific materials such as journals thesis, and books to pre-service teacher in the control group, and they exposed to many problems, implications of scientific studies, however, they did not formulated research questions, hypotheses, and collect data to test them.

Data analysis

In this study, a paired samples *t* test was used to determine the effect of time on critical thinking dispositions of pre-service teachers in experiment and control groups. Furthermore, the analysis of covariance (ANCOVA) was conducted to analyse the effects of inquiry-based learning on the critical thinking dispositions of pre-service teachers. ANCOVA is used to adjust or control for differences between the groups based on another, typically interval-level variable, called the covariate. Moreover, ANCOVA can be used if one wants to use one or more discrete or nominal variables and one or two continuous variables to predict differences in one dependent variable (Leech, Barrett, & Morgan, 2008). In this study, the inquiry-based learning was the independent variable and the critical thinking dispositions were the dependent variable; the scores of the pre-test were described as 'covariate' variable.

Results

The descriptive statistics of the CCTD pre-test and post-test, and the paired samples *t* test results are given in Table 1:

The results in Table 1 revealed that there was an increase in the post-test mean scores of the critical thinking dispositions of the pre-service teachers in the experiment group; however, there was no significant difference between pre-test and post-test mean scores ($t = 1.85$; $p > .05$). The findings also showed that there was a decrease in the post-test mean scores of the pre-service teachers' critical thinking dispositions in the control group, and there was no significant difference between pre-test and post-test mean scores ($t = 0.47$; $p > .05$).

Table 1. Means and standard deviations of the CCTD pre-test and post-test scores, and the paired samples *t* test results.

Groups	Time	<i>N</i>	Mean scores	Standard deviation	<i>T</i>	<i>P</i>
Experimental	Pre-test	28	213.96	13.39	1.85	.076
	Post-test	28	220.86	11.43		
Control	Pre-test	28	219.04	17.43	0.47	.638
	Post-test	28	216.79	21.62		
	Total	28	218.80	17.25		

$p < .05$.

Table 2. ANCOVA results for the effects of inquiry-based learning on the CCTD.

Source	Sum of squares	df	Mean square	<i>F</i>	<i>p</i>	μ^2
Corrected model	297.326	2	148.663	0.49	.615	.018
Intercept	11419.335	1	11419.335	37.63	.000	.415
Group	264.399	1	264.399	0.87	.355	.016
Pre-test	69.308	1	69.308	0.22	.635	.004
Error	16079.513	53	303.387			
Total	2697377	56				
Corrected total	16376.839	55				

p < .05.

The results in Table 2 show that there was no any significant difference between the experimental and control groups in terms of their critical thinking dispositions at the end of the application of inquiry-based learning, $F(1.56) = 0.87$ $p > .05$ Partial $\mu^2 = .016$. The covariate variable (pre-test) had no any significant effect on the critical thinking dispositions, $F(1.56) = 0.22$ $p > .05$ Partial $\mu^2 = .004$. The finding of the study indicates that the inquiry-based learning in the experimental group was not effective in improving the critical thinking dispositions of the pre-service teachers than the teaching in the control group.

Discussion and conclusions

The aim of this study was to determine the effects of inquiry-based learning on the critical thinking dispositions of pre-service teachers. The descriptive findings of the study revealed that the critical thinking dispositions of the pre-service teachers in the experimental group increased, however, there was no significant difference between pre-test and post-test scores. It means that the increase of critical thinking dispositions of pre-service science teachers in the experiment group might not be related to their inquiry-based learning experiences. The results of the study also showed that there was a decrease in the post-test mean scores of the pre-service teachers' critical thinking dispositions in the control group. It means that the teaching in the control group might not affect the critical thinking dispositions of the pre-service teachers.

The findings of the study revealed that there was no any significant difference between the experimental and control groups in terms of their critical thinking dispositions at the end of the application of inquiry-based learning. It means that the inquiry-based learning in the experimental group was not effective in improving the critical thinking dispositions of the pre-service science teachers than the teaching in the control group. The result of the study is not consistent with the literature (Kwan & Wong, 2015; Qing et al., 2010; Thai-posri & Wannapiroon, 2015) indicating that inquiry-based learning positively affect the critical thinking dispositions of pre-service teachers. For instance, the study conducted by Qing et al. (2010) showed that pre-service teachers' inquiry-based experiences in chemical experiment course positively affected their critical thinking dispositions. The main reason of the discrepancy between the results of the present study and literature might be related to the main structure of course that the inquiry-based learning activities were implemented. Qing et al. implemented inquiry-based learning activities in the chemical experiment course, however, in this study inquiry-based learning was implemented in the Educational Psychology course that its content is generally theoretical and do not

include practical learning activities such as experiment and observation for science learning.

The results of this study showed that inquiry-based learning did not improve pre-service teachers' critical thinking dispositions, which is emotional aspect of critical thinking, whereas the findings of some studies in the literature suggested that inquiry-based learning is effective for increasing pre-service teachers' motivation (Preston et al., 2015; Sarı & Güven, 2013). It might be related to inquiry-based learning activities with cognitive and metacognitive skills. Inquiry-based learning generally includes cognitive skills and is based on a process of constructing knowledge and new understanding (Lee et al., 2004; Spronken-Smith & Walker, 2010). Furthermore, critical thinking is complex and multidimensional that includes both cognitive and metacognitive skills, purposeful and self-regulatory judgement which results in such as interpretation, analysis, evaluation, and inference (Dwyer, Hogan, & Stewart, 2014; Facione, 1990; Paul, 1995). Disposition is the emotional aspect of critical thinking. Dispositions also have important implications when teaching for critical thinking. (Facione & Gittens, 2013; Paul, 1995). This might be other reason why IBL did not affect critical thinking dispositions of the pre-service teachers in the current study. Pre-service teachers' learning experiences in their previous school life and other courses in the teacher education programme might affect their critical thinking dispositions. All of these factors could not be controlled in an experimental study that researchers try to determine the effects of inquiry-based learning on the critical thinking dispositions of pre-service teachers.

Although the findings of the study indicated that there is no significant difference between critical thinking dispositions of pre-service teachers in the experiment and control group, there is a considerable increase in the critical thinking dispositions of pre-service teachers in the experiment group. During the inquiry-based learning experiences, the pre-service teachers in the experiment group formed hypotheses, collected, analysed, and interpreted data and finally reached some scientific conclusion, all of these activities might be reason for why the critical thinking dispositions of the pre-service teachers in the experiment group increased. The study suggested that inquiry-based learning could be useful for improving critical thinking skills and dispositions of pre-service science teachers if the factors such as activities in other courses, pre-service teachers' previous experiences, motivations, and academic achievements were controlled by a researcher in an experimental study. As a result, teacher educators and researchers should consider inquiry-based learning as an approach that might improve critical thinking dispositions of pre-service science teachers. Researchers should investigate the effect of inquiry-based learning on critical thinking skills of pre-service teachers in other courses of teacher education programmes.

Finally, the findings of the study indicate that inquiry-based learning might be useful approach for increasing pre-service teachers' critical thinking dispositions though there is no statistically meaningful evidence for the effect of inquiry-based learning on the critical thinking dispositions of pre-service teachers. Teacher educators should plan and implement inquiry-based learning in their courses to improve the critical thinking dispositions of pre-service teachers. The improvement of the critical thinking dispositions of pre-service teachers in the experimental group might depend on not only inquiry-based learning but also other factors mentioned above; thus, there are a number of limitations to the current study that need to be addressed in future research. First, critical thinking

dispositions are related to critical thinking skill (Paul, 1995). In future study, researchers should consider the mediating roles of critical thinking skills on critical thinking dispositions of pre-service teacher, therefore they should define them as a covariate variable in their empirical studies. Second, scientific abilities of pre-service teachers are important for inquiry-based learning and teaching. Researchers should take account of scientific abilities of pre-service teachers during experimental studies on inquiry-based learning. Moreover, many teaching methods such as questioning, group discussion, cooperative learning, and problem-based learning might also promote critical thinking dispositions (El-Shaer & Gaber, 2014; Walker, 2003). Researchers should investigate the effects of these methods with inquiry-based learning on the critical thinking dispositions of pre-service teachers. Third, the critical thinking dispositions of pre-service teachers might be related to their critical thinking skills, anxiety, and self-efficacy beliefs. For this reason, researchers examining critical thinking dispositions should consider these factors as covariate variables in experimental studies. Finally, the effect of inquiry-based learning on the critical thinking dispositions of pre-service science teachers should be tested in the other courses related to science learning and teaching.

Disclosure statement

No potential conflict of interest was reported by the author.

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