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An In-service Training about Developing Materials Including Critical Thinking Elements¹

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Abstract

This study aims to evaluate the effects of the in-service training called ‘Developing Materials Including Critical Thinking Elements’ by evaluating the knowledge, opinions and implementations of in-service biology teachers before and after the implementation. The study adopted convergent mixed method design which applies qualitative and quantitative research synchronously. In the training, fundamentals of critical thinking-based instruction, critical thinking-based activities and a sample biology unit were presented and discussed. The in-service training was delivered to 27 volunteer teachers as a formal, local in-service training of the Ministry of National Education, in twelve hours. The data were collected by teacher portfolios, pre and post “Critical Thinking Concept Test” and participant teacher semi-structured interviews. The participants evaluated the in-service training as useful. After the training, the teachers reported that their perceptions about students’ critical thinking attainment were changed, the activities presented during the in-service training had positive effects on their classroom instructions and they felt themselves more confident about developing and applying critical thinking activities. The concept test showed that the conceptual knowledge of the participants did not improve significantly. However, interviews and observations indicated that the procedural knowledge of the participants improved better than their declarative knowledge on how to support student critical thinking.

Keywords: Biology, critical thinking activities, higher order thinking, in-service training, procedural knowledge

1. Introduction

Variety of different ideas come out while concepts of the thinking process are tried to be defined (Stein, Haynes, and Unterstein, 2003). So, it is necessary to define and differentiate the terms before starting a study in this field. Members of the contemporary societies should be equipped with critical thinking and other higher order thinking skills (Low, Hui and Cai, 2017; Paul, Binker, Jensen, and Kreklau, 1990; Schleicher, 2008; Sector, 2004). Critical thinking-based activities have potential to influence students’ critical thinking competence and comprehension. There have been studies showing critical thinking-based educational innovations positively affected; critical thinking skills and dispositions (Collier, 2017; Sundararajan, Adesope and Cavagnetto, 2018; Ulger, 2018; Wartono, Batlolona, and Mahapoonyanont, 2019; Prayogi and Yuanita, 2018) and course achievement (Tomaç, 2012; Yoldaş, 2009). The definition, borders and sub-components of Higher Order Thinking Skills (HOTS) and critical thinking are considered within the framework defined by (Timucin and Cimer, 2022).

1.1. The Aim of the Study

Critical thinking skills can help teachers meet future demands in teaching like forming a habit of thinking carefully and thoroughly about pedagogical alternatives and strategies (Low, Hui, and Cai, 2017). Moreover, teachers should be well versed in teaching critical thinking and designing the learning environment for students to apply critical thinking in learning so that the desired pedagogical shift could be managed (Tan, Koh, Lee, Ponnusamy, and Tan, 2017). Therefore, supporting students’ critical thinking skills and possessing these skills themselves are essential for contemporary teachers (Facione, 1990; Paul and Elder, 2005; Thompson, 2011; Wei, Lin, Chen and Chen, 2020).

The Ministry of National Education, which is the institution hiring teachers in Turkey and Higher Education Council, which is responsible for teacher education declared that teachers’ needs for preservice and in-service training diversify continuously, thus, teacher competencies and accordingly teacher training curricula are being

¹ This paper is based on Doctoral Dissertation called “Eleştirel düşünmeyi esas alan biyoloji dersi modelinin öğrenci başarısına etkisi / The effect of critical thinking based biology instruction model on student achievement” submitted to Trabzon University The Institute of Graduate Education by Melih TİMUCİN (Corresponding Author)

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renewed continuously. (MEB, 2017; YÖK, 2018). However, there are not sufficient courses and content under individual courses targeting critical thinking in the curricula of education faculties (YÖK, 2018).

Critical thinking instruction of teachers can be improved via proper in-service training (Yeşilpınar, 2011). There have been sample practices of such trainings (Dolapçı, 2009). There have been only a few in-service studies targeting science or biology teachers' critical thinking supporting knowledge and skills (Zohar, Weinberger and Tamir, 1994).

The literature review presented implies that providing teachers with further critical thinking knowledge and critical thinking-based activities have potential to improve the quality of their instruction. Within this framework, the aim of the present study is to develop and implement in-service training to support biology teachers in terms of critical thinking concepts and activities, assessing the effects of the training. Along with this aim an in-service training called "Developing Materials Including Critical Thinking Elements" was developed and the effects of the training on critical thinking knowledge, awareness, and applications of the participant biology teachers were investigated. In order to put forward comprehensive outputs of this inquiry, answers to the following questions were pursued:

1. How was the in-service training evaluated by the participants?
2. How did the in-service training affect the critical thinking related classroom implementations of the participants?
3. How did the in-service training affect the critical thinking knowledge and awareness of the participants?

2. Methodology

In this study mixed method was used. In the course of in-service training quantitative and qualitative data collecting tools were used separately but simultaneously. The data from the tools separately analysed, related to each other and collectively interpreted to develop conclusions (Clark, 2019).

2.1. Research Group

The in-service training was formal, local training by the Ministry of National Education with reference number 2011610302. The main implementation was conducted with 27 volunteer in-service biology teachers (Table 1). Since all the participants are biology teachers working in the same city and they voluntarily followed the formal in-service application steps sampling was purposive and can be named as criterion sampling (Etikan, Musa and Alkassim, 2016).

Table 1. Profile of the participant teachers

Code	Gender	School Type (Secondary)	Education (Degree)	Experience (years)
T1	F	Anatolian	MBA	10
T2	M	Anatolian	Bachelor's	9
T3	F	Anatolian	Bachelor's	4
T4	M	Anatolian Teacher	Bachelor's	8
T5	M	Fine Arts and Sports	Bachelor's	9
T6	M	Science	Bachelor's	17
T7	F	Anatolian Teacher	Bachelor's	9
T8	M	General	Bachelor's	12
T9	M	VTTC	Bachelor's	14
T10	M	VTTC	Bachelor's	8
T11	M	Anatolian Vocational	Bachelor's	8
T12	M	Vocational	Bachelor's	11
T13	M	Fine Arts and Sports	Bachelor's	13
T14	M	Anatolian	MBA	9
T15	M	Multi Program	Bachelor's	10
T16	F	Anatolian	PhD	20
T17	M	Anatolian	MBA	18
T18	M	General	Bachelor's	21
T19	M	Anatolian	Bachelor's	10
T20	M	Anatolian	Bachelor's	9
T21	M	General	Bachelor's	14
T22	M	Science	Bachelor's	13
T23	F	Vocational	Bachelor's	4
T24	M	Vocational	Bachelor's	20
T25	M	General	Bachelor's	25

Table 1 (continued)

T26	M	General	Bachelor's	18
T27	M	General	Bachelor's	10

In Table 1 science secondary schools can be referred as having the highest achievement profile. Anatolian secondary schools also accept students with central examinations. The schools called “general” are mainstream upper secondary schools. Vocational and Technical Training Centres (VTTC) mainly offer module certificates for working learners.

2.2. Content of the Training

The content included basic critical thinking concepts, skills dispositions, supporting strategies, activities, and assessment. A sample critical thinking-based lesson plan for environmental problems and sustainability unit from the actual 9th grade biology course curriculum was supplemented with the training. Critical thinking supporting strategies presented in the training were; enrichment of lesson and environment (Potts, 1994), associating it with daily life (Bustami, Syafruddin and Afriani 2018; Carvalho *et al.*, 2015; Zohar and Dori, 2003), including ethical elements in problem scenarios (Ritchhart, 2002), supporting students' thinking skills and encouraging them to think systematically (Marzano, 1992), being a role model in terms of thinking systematically, focusing the core of the topic and adjusting the content as students can understand best (Low, Hui and Cai, 2017; Schrag, 1992), defining fundamental problems well, learning by setting up categories, sharing the aims with students (Paul *et al.*, 1990; Potts, 1994) and applying proper assessment (Black and William, 1998).

The way the literature review shaped the activities presented in the training can be summarized as follows: Active learning strategies have positive effects on cognitive processes and critical thinking skills. Student portfolios, diaries, reflective student reports, group presentations, case problems from daily life, examination analysis, and cooperative learning activities are some examples of active learning activities (Youngblood and Beitz, 2001). Zohar and Nemet (2002) posed daily life cases to their students in the biology course and monitored the argument development process of them. Similar activities including decision making based on ethical issues were applied in the science course by Tonus (2012) and proved effective. Potts (1994) noted that problems should be expressed in daily life language and students should decide which data are irrelevant or which led to the result. Such ill-structured problems may include missing information or assumptions; solutions may be based on moral evaluations and personal choices (Akay, Soybaş and Argün, 2006; Kohlberg, 1971). Examples of the argumentation process extracted from daily life can be used to explain the process of critical thinking (Bowell and Kemp, 2014). Finally, critical thinking text activities similar to the texts in certain critical thinking tests can contribute to the critical thinking skills of students (Table 2).

Table 2. Sample critical thinking activities

Activity Type	Name of the Activity	Resources	Used in
Critical thinking texts	Deduction	Watson, 1980	Activity 15
	Recognizing hypothesis	Watson, 1980	Activity 16
	Interpretation	Watson, 1980	Activity 14, Sample Unit
	Critical reading and text analysis	Paul, <i>et al.</i> , 1990	Activities 5, 6, 7 and 8
Real life problems	Ill-structured real life problems	Akay, <i>et al.</i> , 2006	Activity 1, Sample Unit
Six thinking hats	Six thinking hats	De Bono, 1985	Sample Unit
Reflective thinking activities	Know, Want to know, Learned (KWL) schemes	Ogle, 1986	Sample Unit
Critical debates	Corner debate	“Four corners,” n.d.	Activity 3
	Debate and write activity	“VCU CTE,” n.d.	Activity 2, Sample Unit
	Debate and role-playing	“VCU CTE,” n.d.	Activity 4
Activities towards learning basic critical thinking concepts	Propositions and argument definition, correctness of propositions, validity of arguments, fallacies	Bowell and Kemp, 2014	Activities 9, 10, 11 and 12

Activities in Table 2 had been subjected to a continuous feedback loop process by evaluation of field experts and teachers and implementation in different school types.

2.3. Implementation of the Training

The training was performed in Trabzon, Turkey, in the pre Covid-19 pandemic setting. The training was planned based on working groups in-service training model (Saban, 2000) by which teachers from different professional development stages with various perspectives actively and collectively evaluate an educational innovation. Both the pilot and main implementation were conducted in three days and twelve hours within a week. The theoretical knowledge was provided by the researcher with six different presentations via lecturing. The content supported with real-life examples and issues were discussed and exemplified by teachers' own experiences when it is needed. All of the participants were given a content book by which they can follow the instruction or self-study afterward. The participant teachers were provided with the portfolio sheets within the in-service content booklet. They included individual and group activities to help the participants think reflectively and assess their learning. There was also an activity for teachers to classify the thinking styles in the given real-life cases. The portfolios were collected and analysed after the training.

2.4. Data Collecting Tools

Interviews and "Critical Thinking Concept Test" were supported by the researcher's observations and the participants' portfolios. Critical Thinking Concept Test was composed of open ended questions asking teachers to define all the critical thinking concepts presented within the content of the training. The items were one-to-one corresponding to the concepts covered. For the validity, two field experts evaluated it and the test was finalized along with the feedback by the experts. The participants of the pilot study were interviewed with unstructured focus group interviews for their opinions to improve in-service training. Before and after implementation the participants were interviewed with semi-structured open-ended questions, and they were asked about their knowledge and implementations about critical thinking. In the post-interviews, they were also asked to assess the in-service training. The post-interviews were applied after a week to a month after the training which gave opportunity to participants to implement what they gained from the training (Figure 1).

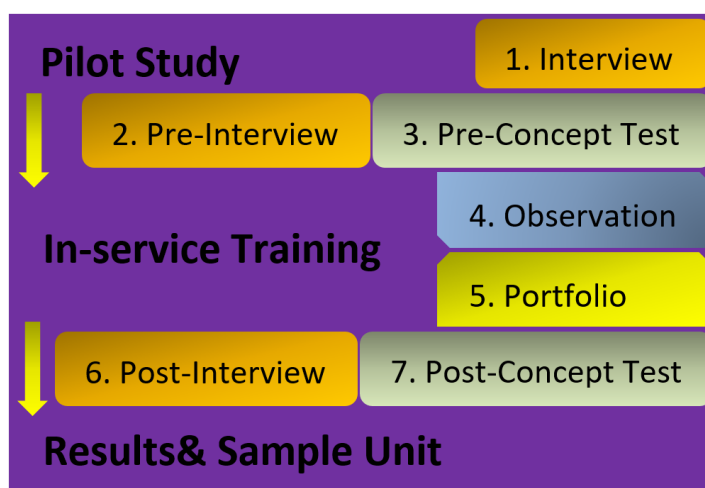


Figure 1. Data collecting tools

In the concept test, the teachers were asked to define: Higher order thinking, Critical thinking, Creative thinking, Reflective thinking, Performance assessment, Metacognition, Proposition, Argument, Fallacy, Socratic questioning, Critical thinking skills and dispositions. Each definition was graded as 5 points; total score was 60 max. The test was repeated before and after the training with the same questions. The relevance between test questions and content of the in-service training and research questions were approved by two field experts.

2.5. Data Analysis

Assessment of critical thinking is hard. Whether they are quantitative or qualitative, all assessment tools bring about certain advantages and disadvantages. Thus, rubrics prepared specifically for the particular case are one of the best solutions of assessment (Stein, Haynes and Unterstein, 2003; Willingham, 2007). Definitions of the critical thinking concepts can also be similar, confusing and overlapping. Therefore sticking a single correct definition for each question was not a productive evaluation way. Eventually, a rubric evaluating the participant responses with respect to general borderlines and by comparing with other responses was developed. The concept test was evaluated with the rubric presented in Table 3.

Table 3. In-service training concept test scaling rubric

Grade	Explanation	Sample Answer
5	Adequate and right information without false examples and details.	Higher Order Thinking: “Ability to perceive events with another point of view. Ability to think about the events deeper in a reason-result relationship.” (T12)
4	Right information including wrong parts and examples. Incomplete but mainly correct information.	Higher Order Thinking: “Debate, mainly coming up with a different view from everybody else’s point of view.” (T4)
3	Right but considerably incomplete information including errors / false examples.	Critical Thinking: “Being productive... But only after talking about the real value of the knowledge, real and true syntheses can be done.” (T15)
2	Information with a narrow relation with reality, including major mistakes or false examples.	Reflective Thinking: “Thinking skill towards presenting data, forming an idea or a product etc. Painting an authentic picture, for example.” (T5)
1	Wrong information, false example, obvious mistake.	Creative Thinking: “We call it empathy.” (T9)
0	No response	-

The data from the interviews were subjected to content analysis by assigning codes for common expressions and determining their frequency (Table 4). Topics that go together such as methods the teachers use in their lessons were grouped and tabulated with frequencies.

Table 4. Sample coding

T17: Words you frequently used like “algorithm” were words we were accustomed to but unable to define. I believe, we have understood them. I shared this experience with my friend day by day.	Comp+ Con
T11: Things I have learned were useful. But we may have some problems in implementation related to school and infrastructure.	Comp+ -CT-inf
T11: Even if I cannot fully define the concepts, my knowledge was extended. I have seen that naming the process and following certain steps can be more useful. I try to apply on my students...	Imp Chan+
T24: Improved. I applied “Six Thinking Hats.”	CTimpl

The statements by T17, indicate his competence has improved. Hence “Comp+” code was used. “Con” (Concept) refers to expressions like: “We have learned the definitions of the concepts we previously used.” “-CT-inf” refers to infrastructure originated problems adversely affecting critical thinking interventions. “Imp” explains the cases that the participant teachers’ awareness improved, and they found critical thinking more important after the training. “Chan+” shows that there have been changes in classroom implementations of the teachers after the in-service training. “CTimpl” is the code to group and count the critical thinking implementations used by the teachers (Table 4).

3. Findings

Findings were presented to reveal data about teacher opinions about the training, changes in their classroom applications, their conceptual and methodical knowledge.

3.1. Teacher Opinions about the Training

The content book of the in-service training was positively evaluated (Table 5). Three teachers gave answers expressing their negative thoughts. One of these teachers discoursed his general discontent about the in-service training due to not being practical. Majority of the teachers answering the related question, positively evaluated the lesson presentations of the training. The presentations were also criticized for being far from practical. The presentations about types of thinking, critical thinking concepts and critical thinking supporting strategies (T8) and the barriers of critical thinking (T5, T7, T8, T11 and T16) were mentioned as particularly useful.

Table 5. Opinions of the participants about the training

Opinions of the Participants	f	Teachers
The content book was sufficient.	18	
The participants should have taken more part in shaping the content and activities.	14	T1, T3, T5, T6, T7, T8, T9, T10, T13, T14, T16, T20, T21 and T27
The time period was short for the training.	11	T4, T5, T6, T8, T16, T17, T18, T20, T22, T23 and T26

Table 5 (continued)

The lesson presentations were sufficient.	8	T4, T8, T10, T11, T13, T14, T16 and T27
The teacher portfolios were helpful.	8	T4, T8, T10, T11, T13, T14, T16 and T27
The sample unit can be improved	6	T3, T6, T7, T21, T26 and T14
The presentations were informative.	2	T4 and T11
The training was improvable.	2	

T14 and T21 argued that defining critical thinking by comparing with Bloom’s taxonomy (Bloom *et al.*, 1956) was helpful in terms of making the critical thinking concept memorable. The teachers noted that, more hand-on activities towards biology classrooms should be added, sample lessons supporting critical thinking should be demonstrated as if they were in the classroom in order to improve the in-service training. The participant teachers also noted that they should have taken more part in shaping the content and the delivery of the in-service training. Moreover, some of the teachers asserted that in-service training should be fully practical without any theoretical presentations (T3, T20 and T21). Similarly, T5, T6 and T16 said that the concepts presented in the training were excessive, condensed, and hard to understand. T8 put forward the idea that practical activities and real-life examples were useful in understanding abstract concepts such as types of thinking and they should be used more. Determining hypothesis activity (Activity16) included in the first lesson presentation was found ambiguous. T8, T17 and T25 described the questions in the activity as complex and conflicting to apply in their classrooms. The teachers submitted a wide range of different ideas about the activities on basic critical thinking concepts (proposition, argument, and fallacy: Activities 9, 10, 11, and 12). Some of the teachers reporting negative ideas about these activities changed their minds during the training process.

T11 and T14 discoursed they would like to apply critical thinking activities in different units. T6 said that it was not possible to instruct as the sample unit offers with the existing curriculum load. T21 stated that sample unit could be associated with the formal intended learning outcomes of the unit more rigorously. T7 mentioned the importance of selecting questions in Activity 15. T1, T5, T7, T14, and T17 stated that the activity can be improved by matching these questions with the learning outcomes better.

3.2. Changes in the Classroom Applications

In the pre-interviews, only four participants responded to the question about what type of critical thinking activities they use. T1 said “I applied Six Thinking Hats. I assign video performance tasks and short role-plays.” Rest of the answers were rather superficial: T8 mentioned activities in resource books; T14 said he used such questions in multiple choice and other tests and T20 said that he tried to use interpretations in exams, but he had to use multiple choice questions in general.

The instructional methods, techniques, and activities that the participant teachers reported they use during the pre-interview are presented in Table 6. Particularly strategies such as group work, performance assignments, laboratory activities, debates, drama, conceptual change texts, games, and inventory learning can bring about support of higher order skills. However, apart from T1, none of the teachers could articulate the direct relation between these strategies and supporting critical thinking. Moreover, mentioned items such as student centred instruction, proper activities for scientific development and brainstorming were unclear or too general to explain what was exactly done in the classroom.

Table 6. Instructional methods, techniques and activities used pre-implementation

Method/Technique/Activity	f
Questioning	12
Demonstration, animation, presentation <i>etc.</i>	11
Lecturing	9
Group work	4
Project, performance or research assignments	3
Student centred instruction	3
Debate	2
Laboratory activities	2
Taking notes	2
Brainstorming	1
Drama	1
Concept maps	1
Conceptual change texts	1
Proper activities for scientific development	1
Games	1
Inventory learning	1

After the in-service training 20 teachers reported that their classroom applications had changed /were going to change (T3, T4, T5, T6, T7, T8, T9, T10, T11, T12, T16, T17, T18, T20, T21, T23, T24, T25, T26 and T27) and explained their applications with examples (Figure 2).

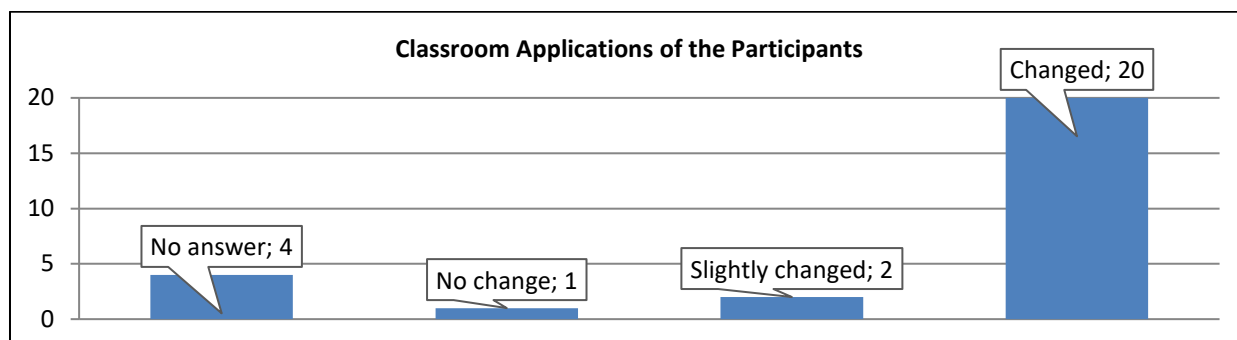


Figure 2. Status of participant teachers' classroom applications after the training.

Four teachers thought that the training had not affected their classroom applications. T22, saying he was waiting for suitable conditions to apply and T14, who was thinking he could not precisely decide which applications to use to support students' critical thinking, were classified as "slightly changed." In Table 7 critical thinking activities the teachers used after the training are presented.

Table 7. Critical thinking activities and strategies used by the participant teachers after the training

Activities/Strategies	f	Teachers
Sample Unit	6	T5, T9, T11, T14, T20 and T27
Encouraging / Motivating Questions	5	T3, T8, T11, T23 and T25
Portfolio	5	T4, T5, T8, T10 and T14
Critical Thinking Supporting Strategies	5	T4, T11, T16, T18 and T24
Six Thinking Hats	4	T9, T10, T17 and T24
Real Life Problems	3	T6, T7 and T25
Supporting Lesson with Visuals	3	T7, T16 and T18
Student Centred Learning	3	T6, T11 and T17
Socratic Questions	2	T9 and 27
Reflective Thinking	2	T10 and 24
Argumentation	1	T20

6 teachers indicated the sample unit. T27 explained his approach as "Not, much but I have made little tries based on it." T9 indicated his intention by saying "Since it was going to be time and effort consuming to plan activities fully based on the sample unit, I plan to scatter the things we have learned to more available times." Additionally, four teachers (T3, T13, T14 and T25) noted that they would apply the sample unit and activities depending on other factors such as availability of time and previously prepared materials.

Ten teachers (T8, T9, T10, T11, T17, T18, T21, T24, T25 and T26) said that the training increased their competence to develop activities with potential to support students' critical thinking. Eight teachers (T4, T5, T6, T7, T20, T23 and T27) were thinking that their competence was improved but they had some problems with implementation or they think activities should be prepared by professionals.

Certain teachers provided rather detailed snapshots from their post-training classroom environments which can account for change in implementations with a critical thinking perspective. Although T16 implied that she was not interested in conceptual dimension, her explanations indicated that she carried out critical thinking-based lessons after the training with a certain system and awareness and that she discussed with her students on how to think.

T16: I used to make them talk. But now I try to reach different points starting from their rights and wrongs. By this way they learn things like that their thoughts can sometimes be wrong and how to think. I said something and asked "Is it right or not?" and I collected their opinions. Then the other students tried to explain the reasons. There was chaos in the classroom but everybody spoke about their ideas and learned what is right or wrong eventually.

Another teacher with similar reaction towards supporting higher order thinking skills, T11 noted the difficulties he had faced:

T11: *We used to say things like “this activity is going to be done and these are the materials.” Now we are not doing so. We even sometimes go out of the topic and have the lesson in a way that students can question the subject matter and contribute with their own experiences. Some of them had serious difficulties in that. There were critics such as “What is that? What is it good for?”*

T18 shared his observations towards the activities increased student interest and learning in groups with moderate achievement level:

T18: (Interviewer: Had not you applied critical thinking activities before?) *Not on this scale. I would play little games in short periods but I used to feel guilty. I had worries like: I wasted time, I had lots to explain and I couldn't catch up with etc. However, this activity (student group presentation, students' decision making with debate and writing poems in the biological classification unit) took 20 minutes and I felt that the children grasped the core of the 90-minute-lesson in 20 minutes.*

As an example of applying real life problems: T11 encouraged his students to talk about “a self-sufficient aquarium child living in her/his own ecosystem.” He evaluated the activity as useful with certain drawbacks. T17 narrated the observations from implementation of Activity 1 in which students were asked to decide how to allocate an imaginary land for housing and farming, what to grow, whether hormones or GMO seeds would be used *etc.*

T17: *I asked students whether they would use hormones. Some of them said yes: it makes more profit. But one of my students came up with a considerable point of view and said: “If my crop is organic, it costs three-fold.” It was a really good point. I felt happy. We caught such things.*

After the training T9 noted that he believes when critical thinking is considered in instruction students can gain life-long necessary skills like; preparing for real life, organization and self-expression skills. T7 mentioned that after the training he realized with a different perspective that students can think critically, propagate and question different ideas.

3.3. Conceptual Knowledge of the Participants

Table 8 summarises average pre and post-test scores of the concepts and presents sample answers and scoring. Low answering rates in the concept test (63% pre-test, 58% post-test, 61% total) impaired the reliability of the statistics. T-test showed that there was no significant difference between average pre and post-test scores ($p > 0,1$. From 14,3 to 18,4 average). This tells that conceptual knowledge of the participant teachers on critical thinking concepts did not improve significantly.

Table 8. Average pre and post concept test scores and sample responses

Concept	Pre-test mean	Post-test mean	Sample Responses
Higher order thinking	3,53	4,31	Thinking by considering properties and all the probable outcomes. T20(Post-test) Scored 5
Critical thinking	3,29	4,33	Thinking towards a specific aim. T12(Pre-test) Scored 3 We will draw a reason-result relationship. We should be aware that our ideas can be wrong. We will sieve the ideas of others. Then we will have a judgement. T12(Post-test) Scored 5
Creative thinking	4,44	4,0	Reaching new outcomes from existing knowledge. T11(Pre-test) Scored 5
Reflective thinking	3,11	3,09	Sharing the gained knowledge with others instead of keeping it for oneself. T23(Pre-test) Scored 3
Performance assessment	3,8	3,69	Explaining subject related knowledge with your own original ideas. Putting forward a product. T25(Pre-test) Scored 4
Meta-cognition	2,4	3,29	To know what we know or not know. T10(Post-test) Scored 5
Proposition	2,0	3,0	An idea we keep about a situation. T5(Pre-test) Scored 3
Argument	1,2	1,56	I can't define concretely. T14 (Post-test) Scored 1
Fallacy	2,55	3,54	A result that not to be concluded. T17(Post-test) Scored 4
Socratic questioning	2,6	4,36	To direct children to an intended point; starting from the way they know and asking the reasons and the bases of an issue. T16 (Post-test) Scored 5
Critical thinking skills	3,33	4,17	The talent of questioning, presenting cognitive skills and reasoning. T24(Pre-test) Scored 5

The greatest improvement was in Socratic questioning which was given concrete examples and found applicable by the participants. Creative thinking, reflective thinking, performance assessment, and critical thinking dispositions concepts could hardly be defined even in the post-test. On teacher-wise; T10 showed improvement in defining 10 concepts. T3, T12, T9 followed him with 8, 7 and 6 concepts respectively. Table 8 presents the concepts defined, sample answers and average scores. 16 teachers in metacognition, 15 in proposition, 12 in argument, 10 in Socratic questioning, 17 in critical thinking skills gave answers neither in pre nor in the post-tests. However, the participants' opinions about their own critical thinking concept knowledge, collected by the interviews, were different (Table 9).

Table 9. Opinions of the participants about their critical thinking concept knowledge

Expressions / Common Thoughts	f
The training increased my conceptual knowledge about critical thinking.	19
We have learned the concepts that we had already been applying in the classroom.	13
The training did not increase my conceptual knowledge about critical thinking.	5

Nineteen participants thought that the training increased their concept knowledge. Only five teachers (T4, T9, T10, T14 and T17) evaluated their conceptual improvement insufficient.

4. Results and Discussion

As a whole, the training was evaluated as informative by the participants. Based on the data obtained by the interviews there were certain changes in critical thinking awareness and classroom implementations of the participants as a result of the training.

The content was evaluated as related and useful by the participants. Although the content had been diluted and practical dimension supported after the feedback from the field experts and pilot study, still it was found too theoretical. The participants demanded that the training should be fully structured with the participants at the beginning.

The training was also criticised in terms of having a short duration compared to its content. Although it was a registered in-service training in the calendar of the Ministry of National Education, it was conducted within the educational term with teachers from all over the city, which brought forward time constrictions for personal and institutional reasons.

Having to plan shorter time periods due to concerns such as workload or participant attendance have also been a problem for previous critical thinking related in-service studies (Yeşilpınar, 2011; Zohar and Nemet, 2002). Akar (2010) suggested school centred structures enable continuity of activities and performing follow up studies to solve similar time problems.

Interpreting Table 6, it can be concluded that the majority of the participant teachers did not have specific methods, targeted effort, related materials and awareness towards improving their students' critical thinking skills before the training. This situation had projections on their applications. They mainly pointed that they preferred methods and techniques like questioning and lecturing in their instruction with the aim of "controlling classroom more easily." Particularly the teachers working for the school types with moderate academic achievement profile thought that their students were not ready for activities demanding critical thinking and they frequently lower the level even to making students take teacher-directed notes. They would try to increase attention and objectify student learning by demonstration, animations and presentations. The teachers who dared higher level activities would use group-work, project, performance or research assignments, laboratory activities and debates. Moreover, some participants, sometimes tried techniques that can be accepted as higher order such as; drama, concept maps, conceptual change texts, activities fitting scientific development, games and inventory learning.

When the data collected after the training with different tools compared, the interviews showed that the participants applied different critical thinking strategies and activities in their biology classes, they realized the importance of supporting instruction with critical thinking elements. Altered classroom implementations of the participants after the training and their observations over students further supported their positive thoughts about critical thinking activities. The interviews also indicated that the participants felt confident about critical thinking terminology. However, their concept test scores did not approve the participant teachers' ideas. There was no significant change between pre and post concept test scores. There were studies citing similar under-scoring of teachers while defining critical thinking concepts. Kanık (2010) reported only a few trainee teachers could explain the dimensions of critical thinking by giving examples from their classroom applications and the rest demonstrated very little improvement in terms of knowledge on critical thinking terms. In a series of in-service training (Zohar, 1999), the teachers were quite successful at solving problems requiring thinking skills related to procedural knowledge (knowledge about how to do a certain task) while they frequently had difficulty in describing their thinking ways of solving the problems (declarative knowledge). In the present study, we can also say that

declarative knowledge of the participant teachers about critical thinking concepts did not increase at an expected level.

There was very little data to compare obtained by the teacher portfolios. Since they preferred to discuss verbally, the reflections written by the participants on the teacher portfolios were much less than expected. The participants mainly took short notes for their group-works.

Before the training the teachers could not state elaborate explanations for their critical thinking implementations. In post interviews, some of the participants reported that they improved their knowledge about critical thinking, they broadened their point of view in terms of implementation and that their instruction improved so as to make more connections with real life. Some of the teachers exhibited deeper insight for critical thinking related concepts by using the terminology compared to the pre-test. After the in-service training the participants started self-questioning in terms of certain aspects of higher order thinking such as “there may not be an absolutely true answer”, “questions with more than one true answer” and “somebody’s thinking on their own thinking processes.”

Most of the participants felt confident about developing critical thinking based activities. Some teachers thought that their competence was improved but not enough to develop their own critical thinking materials. Although the activities used by the teachers after the training did not one-to-one fit the content, teachers took and interpreted the training holistically similar to Dolapçı (2009) reported after his critical thinking seminar with teachers from different majors. The participant teachers of the present study attempted to create a critical thinking based classroom environment, applied critical thinking based trials, utilized the sample unit and activities. They also used ill-structured questions with more than one correct answer or with no clear answers even for teachers. They tried to direct students to think about their thinking processes by using the concepts like argument and proposition. One teacher applied the activity inquiring the ethical elements and he noted that he could observe the intended, “different thinking” of students. A teacher from a low-academic achievement profile school gave his students responsibilities, letting them do peer instructions and activities in different fields of intelligence. The participating teachers applying the gains of the training reported that their instructions were more efficient, took shorter time than usual, that they were impressed by the performances of their students and they regretted not trying it before. There were also teachers saying that they had made these trials occasionally on suitable units or they would apply them in the future.

However, similar to İrez and Yavuz (2009) reported, the teachers in the present study noted that they do not have the opportunity to perform their instruction full time critical thinking based as offered by the training because of the reasons like inadequacy of lesson hours, condensed curriculum and the pressure caused by central examinations (Baştürk and Doğan, 2010; Dindar and Demir 2006).

Another point to be taken into consideration is critical thinking skills, competences and dispositions do not change instantly (Kuhn, 1991; Tiruneh, De Cock and Elen, 2018; Zohar and Nemet, 2002). It needs a certain period to settle a critical thinking culture in the classroom. Therefore, the participant teachers can be expected to improve their critical thinking implementations by time. The critical thinking culture, which will possibly form in their classrooms, will help them achieve more in terms of critical thinking.

5. Conclusions

This study highlights the potential of critical thinking inducing in-service training in shaping instruction of teachers. Some of the participant teachers adopted the provided samples and agreed on their benefits. Some others interpreted the training and exhibited a holistic tendency towards critical thinking. Both those who develop this awareness and the rest, the teachers mentioned factors made them hesitant in applying full time critical thinking based instruction like curriculum load and pressure by central examinations. “Only curricula that are rigorously designed to foster critical thinking competencies can reap the intended student outcome” (Tan, Koh, Lee, Ponnusamy, & Tan, 2017). Thus, the long term achievement of similar critical thinking innovations is largely bound to the constrictions of the context, which should be referred for prospective studies.

Similar to the previous studies (Kanık, 2010; Zohar, 1999), the present study also showed that teachers’ orientation towards procedural knowledge, rather than declarative knowledge should be taken into consideration during planning of critical thinking based in-service training. Teachers, quite naturally, have a tendency towards applicables. Similar prospective training should fully focus on practical activities and the participants should take part in designing the content, selecting the activities.

Activities offered by the present study can be applied in classroom settings by teachers or studied more specifically by researchers. They can be examined in terms of different individual higher order thinking skills like creative thinking or higher order thinking as a whole.

Finally, based on the opinions and classroom implementations of the participant teachers of the present study, it can be said that critical thinking based instruction should be insisted on in all educational levels and profiles. Persistent and comprehensive implementations can lead classroom and institution critical thinking culture, which promise better results in terms of higher order thinking.

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