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# The Effect of Robotics Education on Teachers' Tendencies to Critical Thinking and to Support Critical Thinking

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The purpose of this study is to investigate the effect of educational robotics practices on teachers' tendency to critical thinking and to support critical thinking and to identify public school teachers' views on this topic. This is an embedded design study. In the quantitative part of the research, a quasi-experimental research was conducted, and qualitative data was collected to support quantitative data. The study group consisted of 64 teachers who work in public schools affiliated to the Ministry of National Education (MoNE) in Amasya in the spring term of 2018-2019 and have not received educational robotics practices before. The data collection tools were the "Critical Thinking Disposition (CTD)" and "Critical Thinking Supportive Teacher Behaviors Inventory (CTSTBI)" scales prepared according to the 5-point Likert type. In addition, a semi-structured interview form has been prepared to collect qualitative data. According to the results, educational robotics practices did not have a significant effect on teachers' critical thinking dispositions and their critical thinking supportive behaviors. However, they thought that it had positive effects on their critical thinking dispositions and their critical thinking supportive behaviors. In addition, it has been revealed that teachers consider it important for students' critical thinking disposition to avoid raising monotonous individuals in schools, not to hinder children's imaginations, and to produce solutions by looking at existing problems from different perspectives. Finally, they stated that for effective educational robotics practices of teachers, the environment to be trained should be in a large environment and the materials to be used in education should be in sufficient number.

## Introduction

The basic quality that separates human beings from other beings is the ability to think. This skill has been discussed in various frameworks since Ancient Greece. The Turkish Language Association defines the concept of thinking as "Examining and comparing information in order to ponder, bring to mind, and reach a conclusion, to produce thoughts by making use of the information in between, to form mental abilities, to reason, to search with one's mind, to be interested and meticulous towards something, to reason, predicting what might happen, designing, worrying, worrying and assuming" (TDK, 2011, p.743). We can define thinking as the visualization of everything that exists outside and that we can perceive with our five sense organs, by filtering it through the mind. Along with the emergence of definitions related to thinking, many definitions related to thinking skills have emerged. One of them is the concept of critical thinking that emerged at the beginning of the 20th century.

Dewey, who is accepted as the pioneer of the concept of critical thinking in the modern sense, first approached this concept as reflective thinking and defined it as an active, persistent, and careful review of a belief or knowledge in the light of the foundations (Dewey, 1933). Many researchers have defined critical thinking as a skill that enables individuals to solve problems and events logically (Ennis, 1985). Critical thinking is a systematic way of thinking that is used in problem solving, questioning and discovery, making it possible to reach the most appropriate solution by skillfully evaluating the information at hand (Thompson, F. and Washington, H. L. 2015). Chaffee (2014) defines critical thinking as an approach that helps to evaluate situations from different perspectives based on reasons and evidence, to think actively, to organize thought, to explore and analyze with questions. Gurkaynak et al. (2008, p.2), critic thinking is a form of thinking that the individual does and willingly for a particular purpose, where unique ideas, prejudices, hypotheses, and any information that exists are questioned, evaluated, reasoning and benchmarking, and ultimately a form of thinking, theory and attitudes are achieved.

We can express individuals with critical thinking skills as well-qualified critics, people who have a sense of curiosity in their inner world, who express their words as clearly as they are, who are not rigid in their views and attitudes, who are measured, who are keen to learn, who understand different perspectives, who review and investigate different views. In fact, Ennis (2011) defines a critical thinker as someone who is willing to find the right path and endeavors for it. People who express their thoughts clearly as they are can be expressed as individuals who tend to think critically. On the other hand, the characteristics of the individual who thinks critically; examines them as individuals capable of inquiry, comprehensive thinking, free thinking, and restructuring (Ming-Lee Wen, 1999). Some researchers listed the characteristics of individuals who think critically as being open-minded (Bailin et al., 1999; Ennis, 1985; Facione 1990; Halpern, 1998), being moderate (Bailin et al., 1999; Facione, 1990) and having a desire to seek a reason (Bailin et al., 1999; Ennis, 1985; Paul, 1992). It is thought that a critical thinking teacher should reflect this thinking skill to her/his students. While thinking activity was considered a natural ability of humans in the past, a consensus has emerged from the mid-20th century that thinking or thinking skills can be taught and should be a part of education (Butler, Pentoney & Bong, 2017). In fact, Korkmaz (2009) stated that this situation is a necessity in terms of professional competence of teachers.

Cıgrı Yıldırım (2005) identified teachers who support critical thinking as a teacher model who guides students to think critically, gives importance not only to the subject, but also to thinking, realizes different solutions than one’s own solution, is fair to his/her students, and establishes the democratic understanding in classroom management. Worley and Worley (2019) emphasize the importance of developing children's critical thinking skills at primary school and state that critical thinking should be a habit that starts at an early age. On the other hand, Alkın (2012) categorized the behaviors of teachers who support critical thinking as open-mindedness, high-level questioning, openness, questioning of the accuracy and reliability of information, and seeking cause-evidence (Alkın, 2012). Demir (2006) states that an authoritarian teacher who does not give importance to critical thinking skills in the classroom does not treat students fairly and ignores equality among students raises students who are afraid of taking responsibility, do not develop their critical and other thinking skills, shy, afraid to express their thoughts, worried about the future, cannot defend their rights when they are an individual in the society, cannot express their thoughts clearly, and cannot fulfill their responsibilities towards their family and society. In this context, we may say that teacher behaviors that support critical thinking are particularly important for future generations.

It is thought that teachers do various activities, practices and studies in their classes related to support critical thinking. It can be said that recently, activities such as coding and robotics have made significant contributions to students' 21st century skills. In this regard, Korkmaz, Altun, Usta, and Özkaya (2014) state that robotic activities contribute to students' computational thinking, creative thinking, and problem-solving skills. It is thought that the activities and practices made with educational robotic sets are used as important materials in the development of critical thinking skills.

The concept of robotic coding appears as a new and current concept in instructional technology field. As the name suggests, the basis of robotic coding is the merging of engineering science and programming. In general terms, robotic coding is expressed as "an integrated work platform that combines many disciplines such as machinery, computers, electricity, electronics, mechatronics, software automation control systems, nanotechnology, bioengineering, and space sciences" (Reader, 2019, p.53). Scaradozzi, Sorbi, Pedale, Valzano, and Vergine (2014) state that robotic coding is both fun and seen as a tool that contributes to the development of children's logical thinking skills by introducing information technologies.

Students who can do robotic coding can also comprehend abstract concepts more easily, there is a positive increase in the success of the students in their courses and it encourages them to learn by increasing their motivation (Karahoca, Karahoca, & Uzunboylu, 2011). According to Ceylan and Gündoğdu (2018), the fact that robotics and coding trainings are in the robotics and coding curricula in educational institutions will make particularly important contributions to the professions that students may choose in the future. In this context, educational robotics in-service training was given to the teachers in this study, and it was aimed to investigate the effect of robotics education on teachers' critical thinking dispositions and their critical thinking supportive teacher behavior, and teachers' views on robotic education. For this purpose, answers to the following research questions are sought:

(1) Does educational robot in-service training differentiate teachers' critical thinking disposition?
(2) Does educational robot in-service training differentiate teachers' critical thinking supportive behaviors?
(3) What do the teachers think about the use of educational robots in education?

## Method

### *Research Design*

This is an embedded design mixed method study. As Creswell (2008) stated, the advantages of both quantitative and qualitative research designs can be benefited from with the mixed research method. In the quantitative part of this research quasi-experimental research design with pretest-posttest control group was used, and then qualitative data collected through interviews with teachers.

## Working Group

The study group of this research consists of teachers from different subject areas who work in public schools affiliated to the MoNE in the province of Amasya in the spring term of 2018-2019 and have not received educational robotics applications before.

The experimental group of the research consists of 34 teachers out of 120 teachers working in Amasya and voluntarily included in the "Basic Robotics Education" in-service program. The control group of the research consists of 30 teachers who work in Amasya and voluntarily participate in the 'Educational Game Design' in-service program. The qualitative examples of the research consist of 10 voluntary teachers from the experimental group. The distribution of 64 teachers is summarized in Table 1.

Table 1. Distribution of teachers in the quantitative group by gender, professional experience, and age

| | **Experimental Group** | | **Control Group** | | **Total** | |
|---|---|---|---|---|---|---|
| **Gender** | N | % | N | % | N | % |
| Women | 18 | 52,9 | 20 | 66,7 | 38 | 59,4 |
| Male | 16 | 47,1 | 10 | 33,3 | 26 | 40,6 |
| Total | 34 | 100,0 | 30 | 100,0 | 64 | 100,0 |
| **Professional Experience** | | | | | | |
| 1-10 Years | 12 | 35,3 | 10 | 33,3 | 22 | 34,4 |
| 11-20 Years | 15 | 44,1 | 12 | 40,0 | 27 | 42,2 |
| 20+ Years | 7 | 20,6 | 8 | 26,7 | 15 | 23,4 |
| Total | 34 | 100,0 | 30 | 33,3 | 64 | 100,0 |
| **Age** | | | | | | |
| 20-40 Years | 23 | 67,6 | 16 | 53,3 | 39 | 60,9 |
| 40+ Years | 11 | 32,4 | 14 | 46,7 | 25 | 39,1 |
| Total | 34 | 100,0 | 30 | 100,0 | 64 | 100,0 |

In Table 1, it is seen that the study group consists of 64 people. It is seen that 58.4% (N=38) of this group consists of female and 40.6% (N=26) male. 52.9% (N=18) of the experimental group teachers were female, 47.1% (N=16) were male teachers, 66.7% (N=20) of the control group were female and 33.3% (N=10) were male teachers.

### *Data Collection Tools*

In this study, two scales were used to collect quantitative data. The first of these is the "Critical Thinking Disposition (CTD)" scale developed by Semerci (2016). Apart from demographic information, the scale consists of 49 items and 5 sub-dimensions (metacognition, flexibility, systematicity, tenacity-patience and open mindedness) to reveal the critical thinking dispositions of pre-service teachers and teachers. The total internal consistency coefficient of the scale was found to be .963. The scale is 5-point Likert type. The second one is the "Critical Thinking Supportive Teacher Behavior Inventory (CTSTBI)" developed by Alkın (2012). The scale consists of 80 items and 5 sub-dimensions (open mindedness (OM), questioning of the accuracy and reliability of information (QARI), seeking causes and evidence (SCE), high-level questioning (HLQ), and openness (O). The total internal consistency coefficient of the CTSB scale is 0.89. The scale is 5-point Likert type. To examine the research result in more depth, a semi-structured interview form was prepared by researchers and applied to collect qualitative data.

### *Experimental Process*

All the participants received the aforementioned training within the scope of an in-service training. Educational robotics applications and educational game design training were given to the teachers in the experimental and control groups for 2 weeks. Teachers in the experimental group were given five days of mBlock programming and five days of Lego Educations EV3 programming training. This training given to the experimental group corresponds to 20 lesson hours in total. The teachers in the control group were given training on Scratch for 20 lesson hours in 10 days. Likewise, the teachers in the control group were given training equivalent to 20 lesson hours. After the teaching of the experimental group teachers was completed, the teachers in the experimental group were informed about the research and they were allowed to participate in this research with their own consent.

At the beginning of the experimental process, the teachers were informed about the experiment and the Critical Thinking Disposition (CTD) and the Critical Thinking Supportive Teacher Behavior Inventory (CTSTBI) scales were applied to the experimental group teachers as a pre-test. Since there were two separate robotics training sets determined for the experimental process, the experimental group teachers were divided into two groups and teaching was carried out with educational robotics applications by using two different sets alternately, one week apart. While educational robotics applications were made with the Lego Educations EV3 and Makeblock mBot bluetooth kit under the name of ‘Basic Robotics Education' to the teachers in the experimental group, Scratch was taught to the teachers in the control group under the name of 'Designing educational games'. While Makeblock mBot bluetooth kit and Scratch training were given by the researcher, Lego Educations EV3 training was given by field experts.

The experiment process was continued with the activity plan prepared by the researcher for these teachings. In this activity plan, which robot will be built on which day, which sensors will be taught, and which programming will be done are expressed in detail. In line with the prepared robotic activity plan, the lessons were implemented as given below:

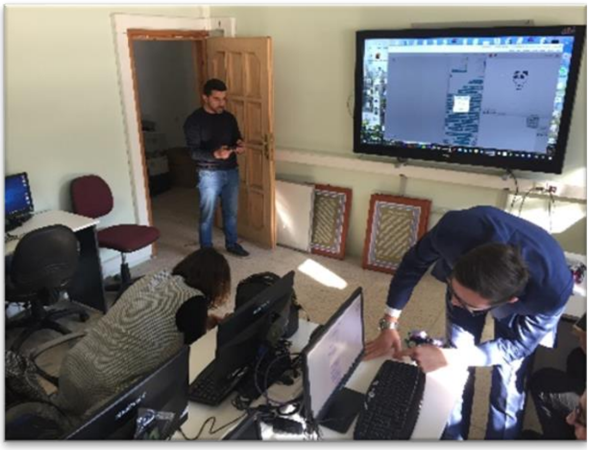
(1) The course content given to the experimental group teachers

- First Lesson (introductory activity, program content introduction, introduction to coding),
- Second Lesson (block logic, color and sound sensor, motors),
- Third Lesson (distance, touch and gyro sensors),
- Fourth Lesson (line follower and light sensor, mechanical design),
- Fifth Lesson (coding, project design and presentation)
- Course content prepared for control group teachers
- First Lesson (introductory activity, program content introduction, introduction to coding),
- Second Lesson (block logic)
- Third Lesson (sound, events and control blocks)
- Fourth Lesson (control blocks)
- Fifth Lesson (detection and operators blocks)

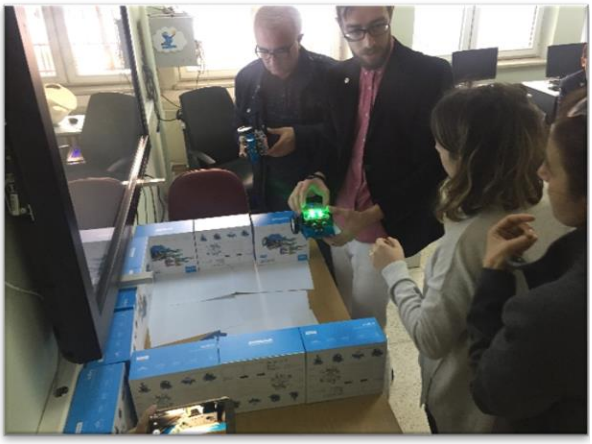
- Sixth Lesson (variables and plugins)
- Seventh Lesson (coding, game design and presentation)

Some pictures of the experimental process are presented in Picture 1,2,3, and 4.

Picture 1



Picture 2



Picture 3

Picture 4

After the experimental process was over, the control group teachers were also applied as post-test to CTD and CTSTBI.

***Analysis of Data***

In this research, the collected data were transferred to the computer environment and analyzed with the SPSS 25 package program. Skewness-Kurtosis values were found to be between -1,500 and +1,500 and it was assumed that the values showed normal distribution. Hence, paired-Samples T-Test was applied. The results obtained from the semi-structured interview form were analyzed with a content analysis method.

**Results**

Results of this study presented according to research questions.

### *Quantitative results*

*Is there a significant difference between the pretest scores of the Experimental and Control Groups on Critical Thinking Dispositions and their sub-factors?*

An Independent-Samples T-Test was conducted to investigate whether there was a significant difference between the total and sub-factors pretest scores of the critical thinking dispositions of the experimental and control group teachers. Test results are presented in Table 2.

Table 2. Experimental and control group pretest scores of teachers' critical thinking dispositions

| | | Group | *N* | *X* | *SS* | *t* | *SD* | *p* |
|---|---|---|---|---|---|---|---|---|
| **Critical Thinking Disposition** | **Metacognition** | Experiment | 34 | 61.76 | 5.84 | -2.96 | 62 | .004* |
| | | Control | 30 | 65.83 | 5.01 | | | |
| | **Flexibility** | Experiment | 34 | 47.02 | 5.63 | -3.49 | 62 | .001* |
| | | Control | 30 | 51.40 | 4.14 | | | |
| | **Systematicity** | Experiment | 34 | 58.88 | 6.69 | -4.04 | 62 | .000* |
| | | Control | 30 | 64.83 | 4.78 | | | |
| | **Tenacity-Patience** | Experiment | 34 | 33.79 | 3.65 | -4.16 | 62 | .000* |
| | | Control | 30 | 37.40 | 3.21 | | | |
| | **Open mindedness** | Experiment | 34 | 12.79 | 1.71 | -2.65 | 62 | .010* |
| | | Control | 30 | 13.86 | 1.47 | | | |
| | **Total** | Experiment | 34 | 214.26 | 21.19 | -4.00 | 62 | .000* |
| | | Control | 30 | 233.33 | 16.22 | | | |

When Table 2 is examined, it is observed that there is a significant difference between the pretest total scores of the experimental and control group teachers' critical thinking dispositions ($t(62)= -4.00$, $p<0.05$). In terms of sub-factors, respectively, a significant difference is observed in metacognition ($t(62)= -2.96$, $p<0.05$), flexibility ($t(62)= -3.49$, $p<0.05$), systematicity ($t(62)= -4.04$, $p<0.05$), perseverance – patience ($t(62)= -4.16$, $p<0.05$) and catholicity ($t(62)= -2.65$, $p<0.05$) factors. According to these results, it can be said that the groups differed before the experimental process and the difference in the levels of critical thinking disposition in total and sub-factors was in favor of the control group.

*Is there a significant difference between the posttest-pretest difference scores of the experimental and control groups in terms of the total and sub-factors of the Critical Thinking Disposition?*

As summarized in Table 2, since the experimental and control groups were not equal, instead of looking at the difference between the posttest scores, it was examined whether the increase in the pretest-posttest difference scores of the experimental and control groups provide a significant difference to understand whether the experimental process was effective or not. For this reason, the Paired-Samples T-Test was conducted to investigate whether there is a significant difference between the critical thinking dispositions and sub-factors post-test-pretest difference scores of them. Test results are presented in Table 3.

Table 3. The differentiation between the CTD posttest-pretest difference scores of the experimental and control group

| | | Group | *N* | *Posttest -Pretest Difference (X)* | *SS* | *t* | *SD* | *p* |
|---|---|---|---|---|---|---|---|---|
| **Critical Thinking Disposition** | **Metacognition** | Experiment | 34 | .79 | 5.223 | -1.12 | 62 | .264 |
| | | Control | 30 | -1.63 | 6.407 | | | |
| | **Flexibility** | Experiment | 34 | 1.61 | 4.270 | -.65 | 62 | .514 |
| | | Control | 30 | -1.93 | 5.685 | | | |
| | **Systematicity** | Experiment | 34 | -2.41 | 6.11 | -.90 | 62 | .371 |
| | | Control | 30 | -6.93 | 6.56 | | | |
| | **Tenacity-Patience** | Experiment | 34 | 1.23 | 3.62 | -.90 | 62 | .369 |
| | | Control | 30 | -1.50 | 4.07 | | | |
| | **Open mindedness** | Experiment | 34 | .35 | 1.54 | -.12 | 62 | .905 |
| | | Control | 30 | -.66 | 1.97 | | | |
| | **Total** | Experiment | 34 | 1.58 | 18.30 | -.92 | 62 | .357 |
| | | Control | 30 | -12.66 | 23.10 | | | |

According to Table 3, it is observed that there is no significant difference in the posttest-pretest difference scores of the experimental and control group teachers' CTDs (t (46) = -.92, p>0.05). In terms of sub-factors, no statistically significant difference is also observed. Accordingly, although the averages of the teachers in the experimental group were higher than the averages of the teachers in the control group, it was seen that robotic education did not have a significant effect on the critical thinking disposition of the teachers.

*Is there a significant difference between the pretest scores of the experimental and control groups on the critical thinking supportive teaching behaviors and its sub-factors?*

An independent-samples t-test was conducted to investigate whether there was a significant difference between the pretest scores of experimental and control group teachers' critical thinking supportive teaching behaviors and its sub-factor. Test results are presented in Table 5.

Table 5. Differences between pretest scores of CTSTBI

| | | Group | *N* | *X* | *SS* | *t* | *SD* | *p* |
|---|---|---|---|---|---|---|---|---|
| **Teacher Behaviors Inventory Supporting Critical Thinking** | **O** | Experiment | 34 | 61,76 | 5,42 | -3.01 | 62 | .004* |
| | | Control | 30 | 65,83 | 5,32 | | | |
| | **HLQ** | Experiment | 34 | 54,88 | 7,72 | -2.41 | 62 | .019* |
| | | Control | 30 | 59,03 | 5,75 | | | |
| | **QARI** | Experiment | 34 | 73,23 | 10,61 | -1.76 | 62 | .082 |
| | | Control | 30 | 77,93 | 10,62 | | | |
| | **SCE** | Experiment | 34 | 66,02 | 13,82 | -2.50 | 62 | .015* |
| | | Control | 30 | 74,73 | 13,96 | | | |
| | **OM** | Experiment | 34 | 75,47 | 10,23 | -2.73 | 62 | .008* |
| | | Control | 30 | 81,93 | 8,39 | | | |
| | **Total** | Experiment | 34 | 329,26 | 46,85 | -2.88 | 62 | .005* |
| | | Control | 30 | 361,13 | 40,76 | | | |

When Table 5 is examined, it is observed that there is a significant difference in the pretest scores of the critical thinking supportive teaching behavior (t (62) = -2.88, p<0.05). In terms of sub-factors, there are significant differences in open-mindness (t (62) = -3.01, p<0.05), high-level questioning (t (62) = -2.41, p<0.05), seeking causes and evidence (t(62) -2.50, p<0.05) and open-mindedness (t(62)= -2.73, <0.05) factors. When the pretest average scores of the teachers in the experimental and control groups to support critical thinking are examined, it is observed that the average score of the teachers in the experimental group is X=329.26, and the average score of the teachers in the control group is X=361.13. According to this, it can be said that there is a significant difference in favor of the control group in the levels of supporting critical thinking of the teachers participating in the research before the experimental process.

*Is there a significant difference between the posttest-pretest difference scores of the experimental and control groups in the critical thinking supportive teaching behavior scores of teachers?*

As summarized in Table 5, since the experimental and control groups were not equal, instead of looking at the difference between the posttest scores, it was examined whether the increase in the posttest-pretest difference scores of the experimental and control groups created a significant difference in order to understand whether the experimental process was effective or not. Accordingly, the Paired-Samples T-Test was conducted to investigate whether there was a significant difference between the critical thinking supportive teaching behaviors of the teachers participating in the and their sub-factors post-test-pretest difference scores. Test results are presented in Table 6.

Table 6. The differentiation between the critical thinking supportive teaching behavior of the experimental and control Group teachers in the posttest-pretest difference scores

| | | Group | *N* | *Posttest -Pretest Difference (X)* | *SS* | *t* | *SD* | *p* |
|---|---|---|---|---|---|---|---|---|
| **Teacher Behaviors Inventory Supporting Critical Thinking** | **O** | Experiment | 34 | 1.91 | 5.07 | .10 | 62 | .917 |
| | | Control | 30 | -2.30 | 5.88 | | | |
| | **HLQ** | Experiment | 34 | .88 | 7.66 | -.59 | 62 | .557 |
| | | Control | 30 | -2.16 | 7.18 | | | |
| | **QARI** | Experiment | 34 | 2.26 | 10.05 | -.52 | 62 | .605 |
| | | Control | 30 | -.93 | 12.95 | | | |
| | **SCE** | Experiment | 34 | 4.73 | 10.15 | .14 | 62 | .886 |
| | | Control | 30 | -4.43 | 15.38 | | | |
| | **OM** | Experiment | 34 | -1.52 | 8.70 | .31 | 62 | .756 |
| | | Control | 30 | -8.76 | 11.09 | | | |
| | **Total** | Experiment | 34 | 10.38 | 37.95 | -.11 | 62 | .912 |
| | | Control | 30 | -20.26 | 49.57 | | | |

According to Table 6, it is observed that there is no significant difference in the posttest-pretest difference scores of teachers' critical thinking supportive teaching behavior (t(46)= -.11, p<0.05). When the post-test average scores of the teachers participating in the research to support critical thinking were examined, it was determined that the posttest-pretest difference of the experimental group was X=10.38, and the posttest-pretest difference of the control group was X=-20.26. In terms of sub-factors, it is observed that there is no significant difference. It can be said that there is no statistically significant difference in terms of the level of support of the teachers participating in the research for critical thinking after the experimental process. According to this, although the average of the teachers in the experimental group is higher than the average of the teachers in the control group, it is observed that there is no statistically significant difference in the level of teachers' tendency to support critical thinking in the experimental application.

### *Qualitative Results*

The first theme that emerged according to the results of the content analysis is the "definition of critical thinking". Under this theme, teachers provided definitions of critical thinking and different examples of critical thinking disposition. However, it was observed that some teachers could not give examples about critical thinking. In addition, it was seen that teachers approached the definition of critical thinking from different aspects. For example, K1 defines it as "thinking from different angles and reaching a conclusion in the face of a problem". The example K1 gives about critical thinking is “the child's prejudice against coding and the solutions produced to eliminate this prejudice”. K10, on the other hand, states that “individuals who question the knowledge instead of blindly accepting it and start doing research in line with it” have critical thinking. It is seen above that the participants gave different definitions about critical thinking. As a result, many of the participants expressed what critical thinking is from different perspectives. However, they had difficulty in giving examples on this subject.

Another theme that emerged as a result of qualitative analysis is "how to support critical thinking in schools". What can be done to support critical thinking in schools, and an example of this is teachers' views on their classroom work to support critical thinking. Participants state that they do different activities in their classrooms for the development of children's critical thinking skills. K3 expressed his opinion about the studies he had done in the classroom on the behaviors of supporting critical thinking as "I always try to make them work their brains from different directions and find solutions from different directions". K6 gave examples of teachers' work in the classroom to support critical thinking as follows. “There should not be a classroom environment where students are actively questioning in their lessons and the teacher does not give the students the right to speak, teachers should not silence the students. Teachers should give up traditional education and teachers should avoid raising monotonous individuals”. K9, on the other hand, expresses that “children should not be limited, and we need to leave them to their own horizons a little more”. Above, teachers' views on how to do activities to help students develop critical thinking skills are given. From this point of view, it was concluded that teachers should have a democratic classroom environment, students should actively participate in the lessons, and the students should be trained considering the personal characteristics of each of them.

Another theme that emerged in line with qualitative analyzes is the theme of "received robotics training". Under this theme, there are opinions about the general effect of the robotics training received in the experimental process, the positive and negative results of the training received on the teachers, and the opinions about the gains of the training received to the teachers. Teachers expressed positive and negative opinions about the in-service training that they attended. While the teachers who expressed positive opinions stated that the education produced beneficial results in terms of their individual development, they stated that these trainings should be planned better in terms of time and that there were studies on ready-made sets about the negative aspects. For example, K6 said, “I can make unique robotic designs and coding after this training. I think that algorithmic thinking skills and problem-solving skills have improved”. K1 “It has been a good professional experience for us. My prejudices on this matter have been broken.” K8 “I think the 21st century skills have improved, and I have learned about different robotic sets". K9 stated that "This training has positive results for us because I couldn't help children about robotics and coding before, but after this training, I can guide children more easily." K3 states that "the short duration of this training and the attempt to upload so much information in such a short time is a negative aspect of education". K10 said, "I think it's the wrong time in terms of timing, it's very difficult for us to get out of class and catch up." expressed an opinion. K9, on the other hand, stated that the high number of people reduced the efficiency of education. Based on the information above, we can conclude that teachers are able to make original designs, their algorithmic thinking and problem-solving skills have improved, their prejudices about robotic education have been broken, they have learned about different robotic sets, and they have improved themselves. Teachers also stated that the training period was short, and the schedule was not in an appropriate time frame.

According to the results of the research, the last theme that emerged is the "ideal robotic education" theme. Under this theme, the teachers' expressions about how robotic coding training should ideally be given and their views on the deficiencies they experienced are included. The views of each of the teachers on how education should be planned show diversity. Although they express some common views, their views differ in general. For example, K10 states that "I think education should have been in a wider environment. I think it would be better if it was done as extracurricular activities and by sending the works of people participating in such projects to competitions". K2, on the other hand, "had to be longer term. It can be done very easily in applications with the support of informatics teachers, and teachers had to be separated according to level groups in teacher training. I think it could have been better that way". K3 stated that "A long-term program should be designed in such projects and there should be continuity". K6, on the other hand, said that "education should be focused on problem solving, original robotic studies should be carried out, and students should be given studies in which they can reach a solution instead of robotic studies with specific steps. Students need to research and find the problem and use robotics as a tool, not an end. They should know that they will use interdisciplinary robotics and they should include robots and critical thinking with a focus on problem solving in their other lessons. I think it will be better this way".

In addition, teachers talked about the deficiencies they experienced. For example, K2 said, "For example, we had a lot of trouble in terms of materials. Since the teacher does not have materials, we can stay away from such activities and maybe it will be beneficial for both the students and us. K5, on the other hand, stated that "the computer environment is not suitable, even the internet environment is very weak, and the absence of interactive whiteboards in most classrooms is a shortcoming for them". It has been observed that teachers have difficulties in doing such activities because of the deficiencies they have experienced. As a result, it can be concluded that teachers use different ways to develop skills such as critical thinking disposition for their students. Based on the opinions expressed by the participants above, they stated that ideal robotics training should be a long-term project in wider environments, and it would be better with level groups. They also state that there should be continuity, it should be problem-solving oriented, that students should research and reach problems on their own, and that they should see robotics as a tool rather than an end.

To sum up, according to the qualitative results each of the teachers gave a different definition about critical thinking. They think that the in-service training they received had positive and positive results for them. Additionally, they consider that robotics education increased their critical thinking skills and there were differences in their students after this education. Teachers stated that they were more patient because of the training they received, they are pleased to have this training. They stated that the ideal robotics education should have a wider environment, be longer-term, be given by experts in the field. Also, the readiness levels of the trainees should be close to each other, the training should be continuous and there should be applications that will contribute to the development of skills such as problem solving. In addition, teachers listed the inadequacy of time, the unsuitability of the environment, and the lack of various opportunities as the negative effects of education.

## Discussion

According to the results of the research, it was seen that educational robotics applications did not cause a significant difference in the critical thinking dispositions and sub-factors of teachers. In other words, educational robotics applications have no effect on critical thinking disposition. However, according to the results obtained from the qualitative findings, the in-service educational robotics practice course taken by the teachers positively affected their critical thinking disposition. They stated that because of the robotic coding training given to the teachers, they realize the importance of patience, determination and persistence. Teachers stated that these educational robotics applications are a job that requires determination and patience. As stated in the literature, decision making or problem solving (Ennis, 1985; Halpern, 1998; Willingham, 2007) processes are related to critical thinking skills. In this context, although the quantitative findings show the opposite, teachers think that educational robotics applications have a positive effect on their critical thinking dispositions.

Some studies in the literature mention the positive effects of receiving educational robotics training as well as critical thinking skills. For example, in the qualitative study conducted by İnce (2018), the contribution of coding education to the personal and academic development of students is expressed. Mıhcı-Türker and Pala (2018) stated that teachers' coding activities are beneficial for them. It is thought that in this study the reason why the quantitative and qualitative findings do not overlap with each other may be due to the fact that the teachers did not give sincere answers when filling out the questionnaires, the questionnaire items were too many, and the deficiencies in the experimental process. In addition, teachers had difficulties in defining critical thinking. Teachers' difficulties in defining critical thinking and their inability to give examples of critical thinking suggest that they may have had difficulties while filling out the scale.

According to another result of this study, it was seen that robotic coding education did not create a significant difference in the critical thinking supportive teaching behavior of teachers. These findings contradict the qualitative findings of the study. According to the results obtained from the qualitative findings, the teachers think that the educational robotics applications they have received have positive effects on their tendency to support critical thinking. After the educational robotics applications, the teachers stated that there was a noticeable increase in the self-confidence of the children. Aybek (2006) states that because teachers doing various activities related to critical thinking disposition, students actively participate in their critical thinking processes. Similarly, in a study conducted by Beşoluk and Önder (2010), teachers' support of critical thinking in their classrooms provides a positive increase in students' attitudes towards critical thinking disposition and they state that it contributes to students' cognitive development. Moreover, Numanoğlu and Keser (2017) stated that the use of mBot in robotic coding education has an impact on the development of 21st century skills such as children's creativity, critical thinking skills, problem solving skills and innovation.

In the light of qualitative findings, the teachers who participated in the research stated their suggestions and opinions about how to teach critical thinking skills in schools and how to design ideal robotic education. Teachers think that it is important to avoid raising monotonous individuals in schools, not to interfere with children's imaginations, and to produce solutions by looking at the existing problems from different perspectives in terms of students' critical thinking skills. As teachers have stated, being open-minded is defined as one of the characteristics of a critical thinking individual in literature (Bailin et al., 1999; Ennis, 1985; Facione 1990; Halpern, 1998; Kökdemir, 2000). Teachers who participated in the studyalso underlined that these skills should be supported in schools to raise individuals with critical thinking skills. It has been stated that such training should be longer-term, more frequent, and progress from simple to difficult. For a better in-service robotic education, it was stated that the training environment should be in a wide environment. It was also mentioned that the materials to be used in education should be sufficient in number. However, the fact that most of the sets that can be used in educational robotics training are expensive or not suitable for beginners pose a problem for the implementation of educational robotics training (Mariappan, Sing, & Nadarajan, 2015). In this context, it would be appropriate to pay attention to these issues before training on educational robotics applications.

## Conclusion and Recommendations

Considering the results of the study robotic coding education does not make a statistically significant difference in the critical thinking disposition and critical thinking supportive teaching behaviors of teachers. However, according to the qualitative findings, the teachers think that the robotic coding activities have positive results for them, their critical thinking skills have developed, and they could not help the children about robotics and coding before, but after this training, the children are more easily guided. It is important for teachers to develop their critical thinking skills and support students in this regard. As Korkmaz (2009) stated, this situation is a requirement for teachers' professional competence. Based on the findings of the study, suggestions for future research and practice are listed below.

- According to the results of the research, it was seen that educational robotics applications training did not have a significant effect on the tendency of teachers to think critically and to support critical thinking. However, teachers think that this training has a positive effect on them in this respect. In addition, teachers made suggestions about how educational robotics applications should be given. In this context, it is thought that it would be beneficial to give in-service educational robotics applications training? in a more planned and comprehensive way, considering the suggestions of the teachers.
- It is suggested that such in-service trainings should be planned in a way that supports critical thinking dispositions.

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