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Computational thinking within the context of professional life: Change in CT skill from the viewpoint of teachers

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Abstract
The goal of this study is to compare in-service and pre-service teachers' computational thinking skills and to take in-service teachers' opinions about the contribution of professional life to differentiation in this skill. The study was conducted in Turkey. The type of the study is mixed method. Quantitative data were obtained from 870 pre-service teachers enrolled to Van Yüzüncü Yıl University and from 143 in-service teachers working in Van province. Qualitative data were obtained from 10 in-service teachers. Quantitative data were collected with Computational Thinking Scales (CTS). Qualitative data were obtained through conducting focus group interview. Results revealed that in-service teachers significantly differentiate from pre-service teachers according to the common effect of the sub dimensions of CTS. On the other hand, according to the results of the comparison conducted based on the main effect of the total score and sub dimensions of the scale; there is no difference according to the sub dimension of problem solving. There is a differentiation on behalf of in-service teachers according to all measurements outside of that. Qualitative data also support these results. In addition, qualitative data present details concerning the reasons of the change in CT within the context of professional life.

Keywords Computational thinking · In-service teachers · Pre-service teachers · Professional life

1 Introduction

Student-centered approaches are available in today's educational environments. In parallel with this, there is a need for building the information according to the students'

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background. It is frequently stated that information acquired in this way will have a potential to solve daily life problems. Students utilizing such an educational environment should have some skills. Examining these skills which are expressed as skills to be specialized by students of the twenty-first century; it is possible to see that they refer to skills, specialities and literacies to be acquired for solving situations that might be encountered in daily life and work environment.

P21 (Partnership for twenty-first Century Skills), which is an organization with members from the U.S. and other countries in the areas of business, government and education, conducts global studies to improve evidence-based educational politics and practice, and make innovative education possible for everyone. As a result of their studies, they have revealed a framework for students of the twenty-first century (P21 Framework for twenty-first Century Learning). According to this framework, twenty-first century student outputs can be analyzed under four main topics, namely, Life and career skills, Learning and innovation skills, Key subjects & twenty-first century themes and Information, media and technology skills (P21, 2018a; P21, 2019).

In the context of Life and career skills, students should have information, skills and social skills that they may need in their daily life and work environment (P 21, 2018b). These skills include Flexibility and adaptability; Initiative and self-direction; Social and cross-cultural skills; Productivity and accountability; Leadership and responsibility (P21, 2019). Learning and innovation skills contain skills that might be used by students in their daily life and work environment which constantly get more and more complicated (P 21, 2018b). They include Creativity and innovation; Critical thinking and problem solving; Communication; Collaboration (P21, 2019). Key Subjects and twenty-first century themes comprise information, skills and specialities required for twenty-first century students to be successful in their working life and daily life (P 21, 2018b). Key subjects within this scope include English; Reading or language arts; World languages; Arts; Mathematics; Economics, Science, Geography, History, Government and civics (P21, 2019). Information, media and technology skills emphasize literacies at the point of accessing to information and keeping pace with the rapid change in technology. They can be expressed under three topics as Information literacy; Media literacy; ICT Literacy (P 21, 2018b). Computational Thinking (CT) is an important twenty-first century skill (Voogt et al. 2015). Among the twenty-first century student outputs, it is seen that especially Learning & innovation skills and Information media & technology skills substantially coincide with CT because CT is consistent with some conceps such as computer literacy, digital literacy, and algorithmic thinking (Moreno-León et al. 2018). Furthermore, CT embrances creativity, algorithmic thinking, critical thinking, problem solving, cooperativity & communication skills (Korkmaz et al. 2017; Doleck et al. 2017) and requires computer using knowledge, skill & attitudes (Korkmaz et al. 2017).

International Society for Technology in Education's (ISTE) standards, which were about students' technology literacy in 1998, were transformed into technological use in 2007 and have become transformative learning with technology since 2016. In other words, today's students should be trained by focusing on developing in the constantly evolving technological area. From this point of view, one of the standards for students is that they should be Computational thinkers. Students with this skill develop and use strategies to understand and solve problems using the power of technological methods (ISTE 2018). CT is considered directly or indirectly as an important skill which is not

only designated by organisations with various stakeholders like P21, but also presented by ISTE.

Studies on CT can be examined under the categories of Concepts, Practices and Perspectives (Brennan and Resnick 2012; Lye and Koh 2014; Román-González et al. 2017). The dimension of Concepts includes variables and loops, in other words it is related with the technical dimension of programming. The dimension of Practices examines problem solving procedures in the process of programming. The dimension of Perspectives requires students to develop an understanding for themselves and their relationships with others in the technological world (Lye and Koh 2014). Computer Science Teachers Association (CSTA) and ISTE offer a framework on how to train pre-service teachers within the context of CT. Methods of collecting, analyzing and summarizing data are described for science classes. In addition, students' CT can be developed with data collection, analysis and representation concerning social science (Yadav et al. 2017). In other words, CT have fields of application in all levels and areas of educational environments especially in the dimension of Perspectives.

CT has become a skill just like reading, writing and arithmetic (Wing 2006). In the literature, there are various studies aiming to bring this skill in pre-school students (Bers et al. 2014), elementary school students (Zhong et al. 2016; Chen et al. 2017; Tran 2018), high school students (Atmatzidou and Demetriadis 2016) K-12 students within the scope of math, science, social studies and language arts courses (Barr and Stephenson 2011), high school students within the context of math and science courses in a way to adapt to STEM courses (Weintrop et al. 2016), university students (Chao 2016; Cetin 2016; Günbatar and Bakırcı 2019) and in-service teachers (Marcelino et al. 2017; Angeli et al. 2016). As is aimed in these studies, CT is a skill to be brought in individuals at every age and educational level. Integration of CT into the system of education requires basic transformations in teaching role in the classroom and student experiences in the process of education. Students in this environment can obtain information from both the teacher and the technological environment (Basogain et al. 2018). That is way teachers must update themselves according to twenty-first century professional development (P21, 2019). Having CT skills has become an obligation for teachers who will establish this environment.

CT can be considered a series of problem solving processes that can be applied in all areas and a cognitive skill that is expected to be acquired by an average person (Yadav et al. 2017). It is a process of generating a solution using computers and computational technology when a problem is faced (Grover and Pea 2013). Computer programming is an important tool to develop CT. But according to some computer science educators to develop CT, programming is not essential (Voogt et al. 2015). It is a thinking skill set that does not have to result in computer programming. Thus, it focuses on principles of computing rather than computer programming skills (García-Peñalvo and Mendes 2018). It includes formulating problems so that solutions can be offered with computational steps and algorithms (Aho 2012). When daily life problems are solved using computational tools, students will be able to use technology efficiently besides having a technological literacy (Yadav et al. 2016). It is recommended to design environments that are appropriate for constructivist approach, which is among today's educational approaches, and may support learning based on problem solving and computational perspectives (Lye and Koh 2014). Similarly, CT can be gained through making students comprehend the steps to be followed in the context of an open-ended problem

concerning any area (Anderson 2016; Angeli et al. 2016). CT which can be brought in students as long as the educational content is supportive and sufficient time has passed (Atmatzidou and Demetriadis 2016). It may also be developed by adult individuals in the process of solving problems faced in professional life.

There are various thoughts for bringing CT in future teachers within the context of curriculum reform (García-Peñalvo and Mendes 2018) due to the fact that CT is a skill used in the context of professional life. Individuals who are unable to acquire this skill adequately at the end of the processes of education will have to develop the skill in their daily life and professional life (Korkmaz et al. 2015). However, there is not enough evidence in the lietrature that the professional life has improved this skill. Given the lack of evidence, it is required to determine the level of in-service and pre-service teachers who will help students develop CT, a skill required by our era. Moreover, it is also essential to determine whether or not in-service teachers have developed the CT through their professional life by making comparisons their results with pre-service teachers' data.

1.1 What is CT?

CT is the new literacy of the twenty-first century (Wing 2011) and has recently been centered upon as an important skill of the twenty-first century for all students (Yadav et al. 2016; Senin and Nasri 2019). However, the concept is not new; it dates back to the 1960s. During these years, it was asserted that university students from all areas needed to learn programming (Grover and Pea 2013) and CT was presented as algorithmic thinking. It was proven to be related with automizing this process with computer by using regular and consecutive steps when necessary (Yadav et al. 2017). The skill used to be defined as thinking like a computer scientist in case of facing a problem has been altered afterwards (Román-González et al. 2017) and is moving to other disciplines now (Anderson 2016; Shute et al. 2017). It has started to be stressed among the twenty-first century literacies after non-computer scientists began to use computational approaches in the problem solving process (Mohaghegh and McCauley 2016). The reason that it used to be interpreted in this way is probably due to using the term "computer" instead of "study of computers" within computer science. Computer science uses computers and computational technology to solve problems (Mohaghegh and McCauley 2016). Thus, CT can be suggested as a universal thinking skill for not only computer scientists, but also for everyone (Weinberg 2013). CT emphasizes conceptualizing. It requires more than writing a computer program (Wing 2006; Voogt et al. 2015). It needs a multi-level abstraction. It is a fundamental skill that contains the things fulfilled by everyone in modern society rather than rote skills. It is people's way of problem solving; in other words, a way of thinking as a person rather than a computer. It completes and combines mathematical and engineer thinking. It is not only an artifact of software and hardware, but also ideas. It is available everywhere for everyone as long as it is integrated with human effort (Wing 2006).

In the literature, there is a tendency concerning six main elements for CT in operational definition that are decomposition, abstraction, algorithm design, debugging, iteration, and generalization (Shute et al. 2017; Román-González et al. 2018). These categories can be explained respectively as; separating the problem into manageable steps using computer and other tools; Analyzing and arranging the

data logically; Presenting the data with summarizations like models and simulations; Designing the solution in a systematic way by algorithmic thinking; Identifying, analyzing and applying possible solutions to reach the combination of the most productive and effective steps and sources; Generalizing and transferring this problem solving process to problem statuses that show a large variety (Israel et al. 2015; Román-González et al. 2017; ISTE and CSTA 2011; Csizmadia et al. 2015). The process comprising these statuses can be carried out using thinking skills like Logical Thinking, Algorithmic Thinking, Efficiency and Innovative Thinking which all have strong aspects and applications (Mohaghegh and McCauley 2016). Thus, over time there has been a consensus that CT is a thinking skill related to processing data and proceeding step by step in the problem solving process (Román-González et al. 2017). CT is a solving complex problem by efficient, effective, algorithmically and fairly way (Lu and Fletscher 2009). The definition of CT has not been maturated enough (Román-González et al. 2018b). But, if we need to suggest an up-to-date definition for CT, which has been brought forward once again by Wing (2006) and defined in various ways since then; "Computational Thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent" (Wing 2011).

1.2 Aim

The goal of this study is to compare in-service and pre-service teachers' CT and if there is a differentiation, reveal the opinions of teachers concerning the possible contribution of professional life to that differentiation. Within the scope of this goal, the research questions are:

RQ1: Is there a significant difference between in-service and pre-service teachers' CT?

What are the opinions of in-service teachers about the changes of;

RQ2: creativity,
RQ3: algorithmic thinking,
RQ4: cooperativity,
RQ5: critical thinking,
RQ6: problem solving,
RQ7: communication skill in the context of professional life?

2 Method

2.1 Research design

Mixed research method was used in the study. The study design is explanatory design. Explanatory design firstly uses quantitative method and then qualitative method to follow up and refine the results obtained (Freankel and Wallen 2009). Within the scope

of this study, in-service and pre-service teachers' CT and the sub dimensions of these skills were compared quantitatively in the first place. As a result of comparisons, it was determined that there were differentiations in favour of in-service teachers. Qualitative data were obtained for the purpose of revealing the reasons of development within the context of professional life and augmenting the results.

2.2 Sample

Quantitative data within the scope of the study were obtained from 870 pre-service teachers and 143 in-service teachers. Qualitative data, on the other hand, were obtained from the interviews conducted with ten in-service teachers. The pre-service teachers were enrolled to Van Yüzüncü Yıl University Faculty of Education in the fall semester of 2017–2018. It was tried to reach as many pre-service teachers as possible from different fields (e.g., social studies education, science education, etc.). Among the pre-service teachers; 540 were female and 311 were male. 19 participants did not specify their gender. Data were obtained from pre-service teachers receiving education in different classes from eight fields. Two people did not specify their graduate level (see Table 1).

On the other hand, the participant in-service teachers work at government organizations in Van province during the fall semester of 2017–2018. It is tried to reach as many in-service teachers as different branches and characteristics. 73 were female, 67 were male and 3 did not specify their gender. Data were collected from the in-service teachers with different seniorities from 20 branches. Five teachers did not specify their branches and two teachers their seniority year (see Table 2).

With ten volunteer teachers interviews were conducted. Among the in-service teachers from whom the qualitative data were collected; eight were male and two were female. The branch of one of the female teachers is Hand Arts Education and the branch of the other is Computer Education and Instructional Technology. The branch of one of the male teachers is Elementary Mathematics Education, the branch of four is

Table 1 Pre-service teachers' demographic profiles

Departments	Graduate level					Total
	Freshmen	Sophomore	Junior	Senior	5th grade and above	
Biology education	0	1	12	0	0	13
Computer Education and Instructional Technology	2	16	29	18	1	66
Elementary Science Education	34	34	55	57	7	187
Elementary Mathematics Education	28	7	16	9	1	61
Mathematics Education	33	17	3	7	0	60
Early Childhood Education	32	46	16	48	0	142
Classroom Instruction Education	28	66	37	40	0	171
Social Sciences Education	39	35	51	43	0	168
Total	196	222	219	222	9	868

Table 2 In-service teachers' demographic profiles

Branches	Seniority					Total
	1–3 year	4–6 year	7–10 year	11–15 year	16 year and above	
Computer Education and Instructional Technology	6	0	1	0	0	7
Elementary Science Education	2	2	0	0	0	4
Physics Education	0	1	0	0	0	1
English Language Education	4	3	1	1	0	9
Elementary Mathematics Education	3	1	0	0	0	4
Mathematics Education	5	1	1	0	0	7
Music Education	1	2	1	1	0	5
Early Childhood Education	4	3	1	0	0	8
Guidance and Psychological Counseling	4	3	0	0	1	8
Art Education	0	3	1	0	0	4
Classroom Instruction Education	7	11	12	3	5	38
Social Sciences Education	0	4	0	1	0	5
History Education	1	0	0	1	0	2
Turkish Language Education	2	2	4	1	0	9
Turkish Language and Literature Education	0	1	0	0	0	1
Sport Sciences Education	8	7	1	0	0	16
Fashion Design Education	1	1	0	1	0	3
Hand Arts Education	2	0	0	1	0	3
Philosophy Group Education	0	0	0	1	0	1
Special Education	0	0	0	1	0	1
Total	50	45	23	12	6	136

Computer Education and Instructional Technology, the branch of two is English Language Education and the branch of one is Music Education. They have a professional life ranging from 2 to 13 years.

2.3 Data collection instruments

2.3.1 Computational thinking scales (CTS)

Computational Thinking Scale developed by Korkmaz et al. (2017) was used to determine CT of participants. The five-point Likert-type scale consists of 5 factors and 29 items. For each item, the participant picks one of the following options: "Always (5)", "Generally (4)", "Sometimes (3)", "Rarely (2)", "Never (1)". The first factor, Creativity, consists of 8 items. Factor loading values of the first factor varies between 0.708 and 0.548. The second factor, Algorithmic thinking, consists of 6 items. Factor loading values of the second factor vary between 0.827 and 0.666. The third factor, Cooperativity, consists of 4 items. Factor loading values of the third factor vary between 0.842 and 0.685. The

fourth factor, Critical thinking, consists of 5 items. Factor loading values of the fourth factor vary between 0.764 and 0.533. The fifth factor, Problem solving, consists of 6 items. Factor loading values of the fifth factor vary between 0.720 and 0.494. The scale explains 56.12% of the variance. The Cronbach's Alpha internal consistency coefficient is $\alpha = 0.843$ for the first factor, $\alpha = 0.869$ for the second factor, $\alpha = 0.865$ for the third factor, $\alpha = 0.784$ for the fourth factor, $\alpha = 0.727$ for the fifth factor, and $\alpha = 0.822$ for the whole scale. Goodness of fit index values are within the boundaries of excellent fitness ($X^2/sd < 3$; $0 < RMSEA < 0.05$; $0 < S\text{-}RMR < 0.05$; $0.97 < NNFI < 1$; $0.97 < CFI < 1$; $0.95 < GFI < 1$; $0.95 < AGFI < 1$; $0.95 < IFI < 1$).

2.3.2 Teacher interview form

Comparing the in-service and pre-service teachers according to CTS; it was seen that in-service teachers' CT measurements and four sub dimensions concerning these measurements were statistically higher than pre-service teachers'. On the basis of this data, an interview form was prepared for determining whether or not professional life contributed to teachers' CT and if it did, it would help reveal the possible reasons. According to ISTE (2015), CT is a common reflection of "creativity, algorithmic thinking, critical thinking, problem solving, cooperative thinking and communication skills". From this point of view, the interview form was prepared based on the aforementioned skills. The form consists of six questions and probe questions concerning each question were used when necessary. Questions and probe questions within this scope were prepared in the light of the literature. Questions were provided in Appendix Table 10.

2.4 Data collection procedure and analysis

The data were collected with the aforementioned data collection instruments. CT of in-service and pre-service teachers were obtained via CTS in the fall semester of 2017–2018. Measurements of in-service and pre-service teachers concerning CTS and its sub dimensions were compared by running MANOVA analysis. According to the MANOVA results, there were statistically significant differences among pre-and in-service teachers. Then the qualitative data were obtained on the basis of the question, "What might be the reasons of these differences which are in favor of in-service teachers within the context of professional life?" Qualitative data were obtained conducting two different focus group interviews with teacher interview form in the spring semester of 2017–2018. Focus group interviews were voice-recorded and transcribed verbatim. Transcribes were analyzed through content analysis method. By this way, qualitative data of the study were obtained. Codes were determined for the qualitative data concerning the change in CT, themes were presented on the basis of these codes and expression examples regarding the themes were presented in tables.

3 Findings

3.1 RQ1: Is there a significant difference between in-service and pre-service teachers' CT?

MANOVA analysis was conducted to determine whether the in-service and pre-service teachers differentiated according to the common effect of the sub dimensions of CTS or not. According to the common effect of the sub dimensions of CTS; the in-service and pre-service teachers differentiate significantly ($F_{(1,1011)} = 3.78$, $p = 0.001$; Wilks' Lambda( ) = 0.978; Partial eta squared = 0.022). This differentiation is in favor of in-service teachers. In addition, Table 3 shows the data concerning the comparisons that were made according to the sub dimensions of the scale and total scale scores.

Tablo 3 includes the ANOVA data examining dependent variables separately according to being an in-service or a pre-service teacher. Accordingly, the participants show a significant difference according to all measurements, except for the sub dimension of Problem Solving ($p < 0.05$). In-service teachers' Creativity, Algorithmic Thinking, Cooperativity, Critical Thinking and Total Scale measurements are significantly higher than those of pre-service teachers.

3.2 RQ2: What are the opinions of in-service teachers about the creativity changes of them in the context of professional life?

The question, "Do you think you have made any progress in suggesting distinctive ideas against any problem after going into your professional life?" was asked concerning the change in participants' creativity. Participants' opinions about this

Table 3 Mean, standard deviation values and ANOVA results of pre-service and in-service teachers according to CT

Measurements	Group	N	$\bar{x}$	Ss	Sd	F	p	Partial Eta Squared
Creativity	Preservice	870	4.10	0.73	1	9.57	0.02*	0.009
	Inservice	143	4.30	0.65				
Algoritmic thinking	Preservice	870	3.22	1.06	1	4.25	0.04*	0.004
	Inservice	143	3.41	1.02				
Cooperativity	Preservice	870	3.78	1.07	1	13.46	0.00*	0.013
	Inservice	143	4.13	0.91				
Cricical thinking	Preservice	870	3.59	0.82	1	15.80	0.00*	0.015
	Inservice	143	3.88	0.73				
Problem solving	Preservice	870	3.71	0.87	1	3.76	0.053	0.004
	Inservice	143	3.86	0.89				
Total scale	Preservice	870	3.70	0.47	1	16.83	0.00*	0.016
	Inservice	143	3.93	0.42				

matter were separated into themes and analyzed. Figure 1 briefly shows the themes and frequencies of expressions concerning the relevant theme.

When examining Fig. 1; it is possible to see that there are seven themes concerning the change in participant teachers' creativity. Six of these themes refer to the positive contribution of professional life, whereas one refers to its negative effect. Theme 1, "Contribution of the process of education" was expressed six times, which is the highest frequency. Theme 7, "Negative contribution of managerial problems" was expressed twice. Expressions concerning the positive contribution of professional life were explained 23 times in total; whereas expressions concerning the negative effects once. The following Table 4 shows the themes and relevant expression examples.

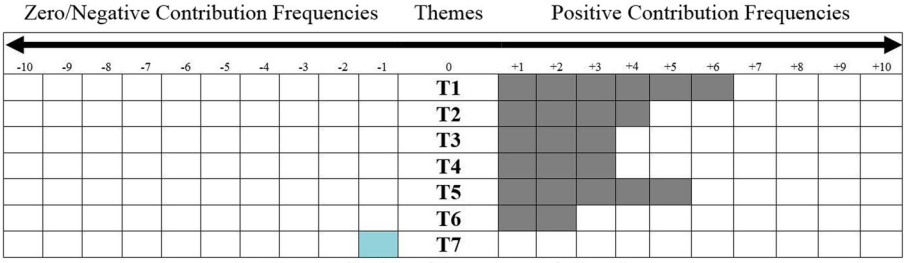
3.3 RQ3: What are the in-service teachers' opinions about the algorithmic thinking changes of them in the context of professional life?

The question, "Do you think you have made any progress in acting determined or patient at the point of realizing the procedures to be conducted step by step after going into your professional life?" was asked concerning the change in participants' algorithmic thinking. Figure 2 briefly shows the themes and frequencies of expressions concerning the relevant theme.

When examining Fig. 2; it is possible to see that participant teachers' opinions about algorithmic thinking are examined under four themes. Expressions concerning the positive contribution of algorithmic thinking were mentioned 10 times; whereas expressions concerning the zero/negative effects were mentioned four times. The following Table 5 shows the themes and relevant expression examples.

3.4 RQ4: What are the in-service teachers' opinions about the cooperativity changes of them in the context of professional life?

The question, "Do you think you have made any progress in your ability of conducting a common project/work with people of different characteristics



T1: Contribution of the process of education
T2: Contribution of problems arising from students
T3: Contribution of problems arising from limited opportunities
T4: Contribution of technical problems
T5: Contribution of technological oppurtunities
T6: Contribution of problems arising from the administration
T7: Negative contribution of problems arising from the administration

Fig. 1 Summary display of themes for creativity

Table 4 Themes related to the changes in creativity

Theme	Expression examples (P: Participant)
T1: Contribution of the process of education	P1: It develops with examples produced for concretizing the content while teaching. P5: We need to find examples from daily life while teaching abstract concepts. P6: It develops with the effort of teaching in a distinctive and practical way while teaching. I develop my own methods.
T2: Contribution of problems arising from students	P3: Undergraduate study was theoretical. Problems arising from students in the classroom contribute to my creativity. I think it develops with professional experience. These problems contribute to my creativity. P7: The things planned in the classroom may not always go right. I think facing such situations develops my creativity in time.
T3: Contribution of problems arising from limited opportunities	P2: Problems being faced stimulate creativity. Limited opportunities stimulate my creativity. I have made progress at this point. Conditions of profession require developing this feature. P9: There might be a lack of equipments while teaching. I overcome such problems within the context of crisis management in a short time.
T4: Contribution of technical problems	P4: When there are technical troubles, I need to find solutions immediately. For example, when a prepared educational material has deficiencies, they need to be removed immediately. When the power goes out, we need to continue the lesson without the educational material. P5: When there are technical troubles, we need to change the teaching method.
T5: Contribution of technological oppurtunities	P7: As long as there is an internet opportunity, I am able to conduct more creative activities during lessons. P9: I make researches using technology and get insprired by different studies for original ideas.
T6: Contribution of problems arising from the administration	P3: Undergraduate study was theoretical. My creativity develops by generating solutions to problems arising from the administration. P7: The things we plan may not always go right (in situations involving the administration). We may be left without a solution unless we add a different point of view. I believe that this skill develops as we face such situations in the course of time.
T7: Negative contribution of problems arising from the administration	P3: For example, utilization of materials in the classroom may be restricted by the Ministry of National Education, which consequently affects my creativity negatively.

(ability/skill/personality)?" was asked concerning the change in participants' cooperativity. Figure 3 briefly shows the themes and frequencies of expressions concerning the relevant theme.

When examining Fig. 3; it is possible to see that opinions of participant teachers about cooperativity are examined under five themes. Expressions concerning the positive contribution of professional life were explained 11 times; whereas expressions concerning the negative effects four times. The following Table 6 shows the themes and relevant expression examples.

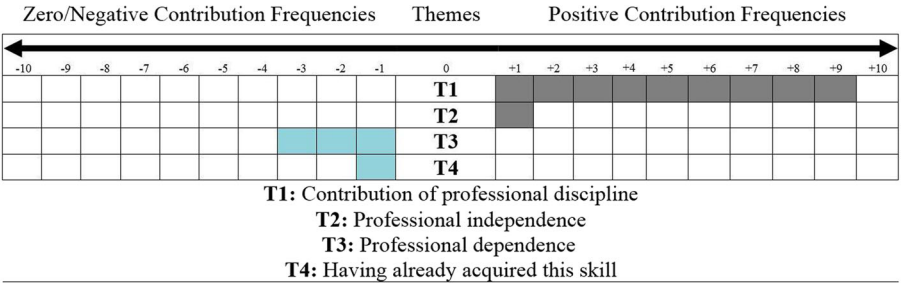


Fig. 2 Summary display of themes for algorithmic thinking

3.5 RQ5: What are the in-service teachers' opinions about the critical thinking changes of them in the context of professional life?

The question, "Do you think you have made any progress in your critical thinking skill, in other words at the point of arriving at a judgment or decision based on your own thoughts evaluating the analysis and measurement results after going into your

Table 5 Themes related to the changes in algorithmic thinking

Theme	Expression examples (P: Participant)
T1: Contribution of professional discipline	P1: I think I have acquired algorithmic thinking. I have to do things step by step. There will be no result unless there is a plan. P3: Professional life contributes to achieving the steps to be followed in a work. P4: We conduct monthly projects with students at school. When I see the project subjects for the first time, I fictionalize the things to be done step by step. Because we proceed on the basis of projects, we plan everything step by step. By this way, there has been a progress unlike before. P8: In my area (Music teaching), there are works to be done step by step such as playing a musical piece step by step and at the end, combining it. I have had the opportunity of applying this in my professional life. I have tended towards new and complex areas (Turkish music) after going into my professional life and created new fields of application for this.
T2: Professional independence	P6: I have made progress because I am able to plan the content of education by myself. When I was a student, I didn't have that chance. I had to complete the projects/homeworks in a short time.
T3: Professional dependence	P2: We may sometimes have interruptions in proceeding the things step by step. When the school administration interrupts my classes, this spoils my systematic and bothers me. This attitude of the school administration has affected me negatively. P5: In general, the things can not be done as planned due to problems arising from people and other factors. I am generally able to make plans, but fail in applying them properly. It has always been like this; even after going into my professional life.
T4: Having already acquired this skill	P10: I have algorithmic thinking skill due to my branch (CEIT). I don't think the skill has increased after going into my professional life. I use it while transferring an information or a skill to another person. I used to use the skill as a student, but I use it more attentively in my professional life. I use it while teaching.

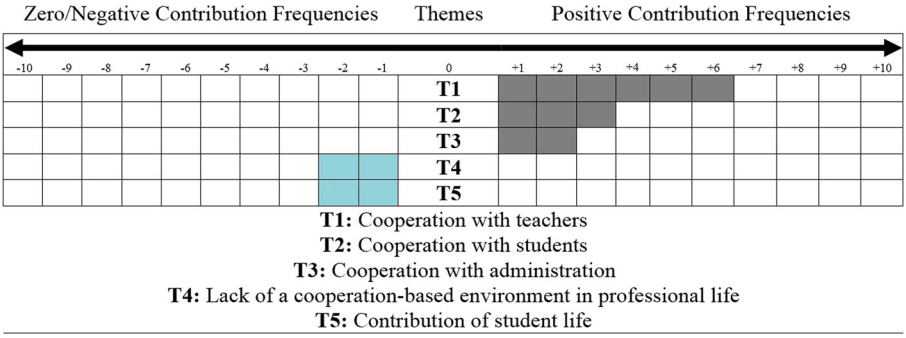


Fig. 3 Summary display of themes for cooperativity

Table 6 Themes related to the changes in cooperativity

Theme	Expression examples (P: Participant)
T1: Cooperation with teachers	P2: Profession of teaching necessitates a cooperation-based study. I used to prefer working individually as a student. I would take personal projects. In professional life, on the other hand, we have to work on some projects collectively. It is a little tiring but we show understanding. We complete each other's deficiencies. Professional life definitely brings along that skill. P7: We apply new methods while teaching. We exchange opinions with our colleagues while identifying these methods. I can say that this skill has developed along with my professional life by doing so. P8: I conduct some activities with my colleagues. By this way, I get the opportunity of knowing people with different characteristics/skills.
T2: Cooperation with students	P7: I think it contributes. We exchange opinions with students. We apply new methods while teaching. P8: I encourage students with different characteristics to use different instruments. Professional life gives the opportunity of working with different people.
T3: Cooperation with administration	P8: One of the stakeholders in professional life is administration and the projects are conducted with them. P9: We need to be in touch with superiors while conducting any work/project. Our professional life necessitates working in cooperation. It brings along this speciality.
T4: Lack of a cooperation-based environment in professional life	P3: I don't have much experience in cooperation-based study in my professional life. Generally everyone attends their own classes. Professional life has not contributed so much in this sense. P5: As we are in a group, we need to express an opinion and make an evaluation. Cooperation-based studies are conducted when necessary. On the other hand, we don't use this way so much the other way around. Thus, I don't think professional life contributes so much to this skill.
T5: Contribution of student life	P3: I used to conduct cooperation-based studies also before my professional life. My student life has brought this skill in me. P4: I had started cooperation-based studies when I was a student. I still conduct these studies in my professional life, which has partially had an effect.

professional life?" was asked concerning the change in participants' critical thinking. Figure 4 briefly shows the themes and frequencies of expressions concerning the relevant theme.

When examining Fig. 4; it is possible to see that opinions of participant teachers about the effect of professional life on critical thinking are examined under four themes. Expressions concerning the positive contribution of professional life were explained 12 times; whereas expressions concerning the negative effects once. The following Table 7 shows the themes and relevant expression examples.

3.6 RQ6: What are the in-service teachers' opinions about the problem solving changes of them in the context of professional life?

The question, "Do you think you have made any progress in your problem solving skills after going into your professional life?" was asked concerning the change in participants' problem solving. Figure 5 briefly shows the themes and frequencies of expressions concerning the relevant theme.

When examining Fig. 5; it is seen that expressions concerning the positive contribution of professional life to problem solving were mentioned four times under two themes; whereas expressions concerning the negative effects were mentioned 11 times under two themes. The following Table 8 shows the themes and relevant expression examples.

3.7 RQ7: What are the in-service teachers' opinions about the communication skill changes of them in the context of professional life?

The question, "Do you think you have made any progress in your communication skills after going into your professional life?" was asked concerning the change in participants' communication skills. Figure 6 briefly shows the themes and frequencies of expressions concerning the relevant theme.

When examining Fig. 6; it is seen that expressions concerning the positive contribution of professional life to communication skills of participant teachers were explained nine times in total; whereas expressions concerning the negative effects twice. The following Table 9 shows the themes and relevant expression examples.

To summarize the qualitative data of the study, in-service teachers mentioned the contribution of people (i.e., administrative personel and students), education process and technology in relation to creativity changes. For algorithmic thinking

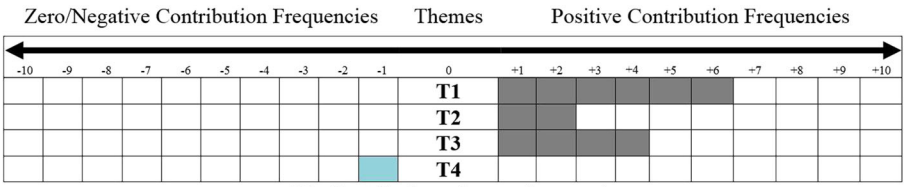
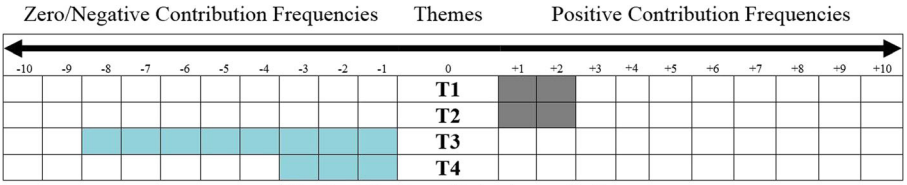


Fig. 4 Summary display of themes for critical thinking

Table 7 Themes related to the changes in critical thinking

Theme	Expression examples (P: Participant)
T1: Contribution of managing people	P2: We have to consider events in the classroom from different perspectives. We have to consider why students are indifferent to the class. We have to think about their psychology. We have to evaluate them multidimensionally. P7: I am better at understanding my students compared to the first years. I can interpret their statements more properly. I can understand what they say better (I can discern whether they are lying or telling the truth). P10: I have made progress in approaching to things from the perspective of students. I use my critical thinking skill to give students the correct information. I didn't have such a concern before (as a student).
T2: Psychology of being a teacher	P6: I have begun to approach to things from the perspective of a teacher after going into my professional life. I used to criticize my teachers, but now I can understand the reasons of their behaviors. P7: I have begun to understand my teachers after becoming a teacher myself. My empathy has developed.
T3: Being open to different opinions	P5: When you receive the opinions of other people and exchange opinions with them concerning students, your opinions may change. You may be convinced by more reasonable explanations. When you meet the administration or teachers from different disciplines, you may have a different point of view. P8: I certainly believe that it contributes. Everyone has their own ways/methods. In order to succeed, we need to be open to novelties and take the suggestions of other people into consideration. I can develop myself by considering different people, different thoughts and interpretations.
T4: A little change	P6: I don't think it makes so much change.

changes, they emphasized the positive contributions of the professional discipline and professional independence. Some of them also talked about professional dependence as negative effect; having already the skill also as zero contribution. For cooperativity changes, they mentioned the positive contribution of cooperation with other people (i.e., colleagues, administration and students), on the other hand they mentioned about zero contribution by lack of cooperativity in working environment and obtaining the skill during undergraduate education. For critical thinking changes, they predominantly mentioned the positive contributions of communication with other people as a teacher. For problem solving changes,



T1: Contribution of intraclass activities
T2: Contributions from other people
T3: A previous personality trait (opportunity of application in professional life)
T4: Limitations arising from other people

Fig. 5 Summary display of themes for problem solving

Table 8 Themes related to the changes in problem solving

Theme	Expression examples (P: Participant)
T1: Contribution of inclass activities	P8: Yes, I believe that my professional life has contributed to my problem solving skill. I find individual solutions to some problems that I face in the classroom, such as pulling a string while playing the violin. At first, I made the students pull a string by reclining them against a wall in order to do it right. P9: We frequently have to solve problems in the classroom by the nature of our professional life. You get the ability of solving greater problems by solving minor problems. It is a matter of accumulation which has mainly developed with my professional life. It is a personality skill developing in professional life even further.
T2: Contributions from other people	P5: Professional life has made both positive and negative contributions. Any problem in the educational environment has a number of stakeholders. There are many variables to be considered. It can make positive and negative contributions to your problem solving approach against such conditions and enable you to develop your idea. P6: It enables me to find rapid solutions in the profession of teaching. I use it in my professional life.
T3: A previous personality trait (opportunity of application in professional life)	P1: I don't have any trouble with problem solving; I can solve and deal with them. It's in my personality. P2: We face more complex problems. I think it is one of the hardest competences to be brought in a person. It should be available in personality. P3: I can solve problems but I haven't acquired this competence in my professional life. I was a very active student and could solve problems. P4: I don't think the professional life has a contribution. It's in my personality. Nothing has changed in my professional life. I have always done the necessary thing and reached in case of facing a problem. P6: I had acquired the skill before going into my professional life. P7: Professional life has made no contribution. The skill is in my personality. I solve problems with my infrastructure. P10: Compared to my student life, I have faced different problems in my professioanl life. It's related to personality. I have had the opportunity of applying it in my professional life.
T4: Limitations arising from other people	P1: I have begun to consider decisions more frequently after going into my professional life. Our administrators tell us what to do and we do it. We just do instead of thinking. Professional hierarchy restricts us. P5: Any problem in the educational environment has a number of stakeholders. There are many variables to be considered. It can make positive and negative contributions to your problem solving approach. It can have an adverse effect unless you are able to use your solution. It can make you feel insufficient.

they mosly emphasized neutral contributions. They mentioned about it as a previous personality trait and they think that limitations arising from other people hinder the development of problem solving skill. They also think some positive contributions of professional life to problem solving skill. They mentioned inclass activities and limitations arising from other people but it is in low rate. For communication skill changes they mostly think official communication with people (i.e., students and others) has positive contribution.

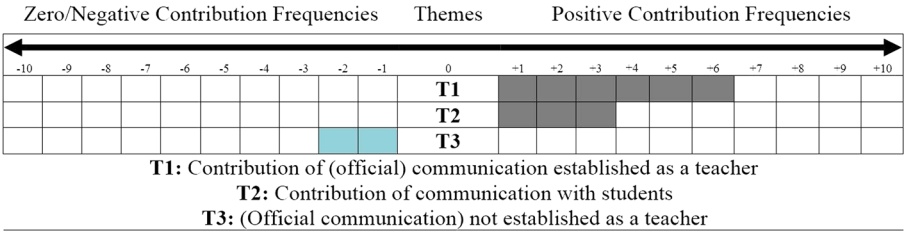


Fig. 6 Summary display of themes for communication skills

4 Discussion and conclusion

Many studies conducted in the literature emphasize that CT is necessary for all educational grades. It is a skill to be acquired by people from all areas (Bers et al. 2014; Chen et al. 2017; Atmatzidou and Demetriadis 2016; Barr and Stephenson 2011; Weintrop et al. 2016; Chao 2016; Marcelino et al. 2017; Ling et al. 2017). In the study, CT development was examined within the context of professional life. Because CT is defined based on several concepts and becomes increasingly popular (Haseski et al. 2018), suggestions were offered for future studies based on the results obtained. According to the findings of this study, regarding common effect of the sub dimensions of CTS, it was determined that in-service teachers' measurements were significantly

Table 9 Themes related to the changes in communication skills

Theme	Expression examples (P: Participant)
T1: Contribution of (official) communication established as a teacher	P2: I have developed a skill of establishing official communication. I had communication skills before. I have learned that we need to establish communication with different people (workers and students) in different ways in professional life. P6: I was too shy as a student. I couldn't establish communication with my teachers. But now I can establish communication with my colleagues. I have gained a self-confidence due to my position and developed this skill. P8: I certainly believe that it contributes. We need to establish communication with different people in different ways in professional life. We create different ways of addressing as we communicate with people from all strata.
T2: Contribution of communication with students	P4: I believe that it contributes to my communication skills. I have lectured students from almost all age groups. At first, I had a difficulty in communicating with certain age groups. In the course of time, my communication skills have developed. You can make students do anything with a good communication. P7: I believe that teaching contributes to communication skills. We perform our profession by communicating. It also develops the ability of rhetoric. The better the communication is, the better we will teach.
T3: (Official communication) not established as a teacher	P3: I am not sure whether the teaching life contributes so much. I can't communicate with the administration. Because I can't establish communication with people who are closed to communication, I am never sure of the contribution of professional life. P5: I don't think it contributes to the communication with my colleagues.

higher than those of pre-service teachers. So, the professional life may probably bring this skill to teachers, which is a desired result in one aspect because teachers have an important position bringing CT to students. There have been studies in the literature supporting this finding. For instance, Senin and Nasri (2019) revelaed that teachers are interested in how to apply CT in teaching environment. Likewise, Kong et al. (2017) stated that teachers' CT content knowledge can be improved. Furthermore, if the required technological infrastructure is provided and supported, teachers' pedagogical capabilities of CT can be improved (Bower et al. 2017).

As a result of comparisons made for the basic effect of the sub dimensions of the scale and total scale scores, it was also observed that there were differences in favor of in-service teachers according to all measurements, except for the sub dimension of Problem Solving. In order to reveal the possible reasons of this result in detail, focus group interviews were conducted with in-service teachers. Teachers were interviewed concerning whether professional life contributed to Creativity, Algorithmic Thinking, Cooperativity, Critical Thinking, Problem Solving and Communication skills or not.

The themes obtained after analyzing the qualitative data were examined. Concerning the contribution of professional life to Creativity; the in-service teachers indicated that activities conducted in the process of education made positive contributions to some problems that they faced with. In addition, they believe that opportunities provided by technology also make a positive contribution. This result consistent with the literature regarding that today's problem solving and technology terms come forward concerning CT (Haseski et al. 2018). A few of the participants believe that limitations arising from the administration hinder the development of creativity. In the general sense, they think that professional life helps to develop their creativity. As a result of comparing the creativity of in-service and pre-service teachers quantitatively with CTS; it was also determined that in-service teachers had higher levels of creativity. Thus, the qualitative data obtained within the scope of the study concerning this dimension support the quantitative data. This differentiation between the in-service and pre-service teachers might be associated with the aforementioned professional life experiences. In other words, some problems faced by teachers in their professional life, practical solutions that they generate in the process of education and technological opportunities develop their creativity. The spread of technological access has made CT skill a skill to be acquired in all disciplines and age groups (Kalelioglu et al. 2016). In addition, IT usage experience is one of the variables that can estimate CT (Durak and Saritepeci 2018). But CT is more than technology literacy. It requires using computational tools to solve problems (Yadav et al. 2016), and individual creativity is crucial for organisational innovation (Amabile 1988). On the basis of this result, it is recommended to compare CT skills in terms of the dimension of Creativity according to the technological infrastructure in the working environment of future studies.

According to the interviews conducted with in-service teachers concerning whether the Algorithmic Thinking skill develops within the process of professional life or not; working with discipline and managing the tasks independently, which are required by professional life, contribute to this skill. On the other hand, it is thought that there are no progresses in Algorithmic Thinking skill

within the context of professional life according to the interruption of individual plans as a result of the intervention of superiors from the outside and the state of having already had the skill. Algorithmic thinking is also necessary to find solutions to daily life problems (Mumcu and Yıldız 2018). It is usual to undevelopment of the skill because of obstacles. Considering the qualitative data, it is possible to see that the thoughts about the positive contribution of professional life are expressed two times greater than the thoughts about no contribution. According to this comparison, it is possible to state that professional life contributes to algorithmic thinking. The quantitative data obtained from CTS also show that this skill is higher in in-service teachers than in pre-service teachers. In other words, the qualitative data support the quantitative data in this respect. In-service teachers believed that the power of independently conducting the disciplines provided by professional life and the works contributes to Algorithmic Thinking, which is one of the most important skills for CT (Kalelioglu et al. 2016). According to Román-González et al. (2018), there is a significant correlation between Conscientiousness, which is related with dimensions like autonomy, dependability, orderliness, precision, persistence and fulfilling of commitments, and CT skills ($r = 0.27$). In other words, Conscientiousness can be considered a sense of responsibility. A similar result was obtained as in the finding of this study, "Professional responsibilities provide a progress within the scope of the sub dimension of Algorithmic thinking in CT".

During the interviews that were carried out for the sub dimension of Cooperativity in CTS, the in-service teachers mainly used positive expressions concerning the contribution of professional life. Expressions concerning the positive contribution of professional life to cooperativity were approximately three times greater than expressions concerning no contribution. The in-service teachers believed that common working and idea exchange environment with colleagues, students and administration provided by professional life contributed to cooperativity. On the other hand, they expressed that there was no cooperation-based environment in the working environment and professional life made no contribution to this skill which is gained in student life. These results support the quantitative data.

There is a significant correlation between Openness to Experience, which corresponds to the broadness or narrowness of cultural interests especially in school environment, and CT ($r = 0.41$). This feature signifies the interest especially in other people (Román-González et al. 2018) and can also be expressed as communication established in school environment. Teachers who are accustomed to collaborative environments can reflect this to their lessons (Veenman et al. 2002). According to the teacher views obtained from the study; the common working and idea exchange environment that can be provided within the scope of professional life also makes a positive contribution to cooperativity and thus, CT. Considering these results, the future studies can compare teachers' CT skills in terms of the dynamics (i.e., communication with administration and colleagues) in school environment.

During the interviews conducted with the teachers, they stated that professional life made a positive contribution to Critical Thinking. They believed that the skill developed based upon managing students and other colleagues, the role attributed to them by their profession and considering the thoughts of other

people. Only one person stated that their critical thinking did not develop so much compared to their undergraduate years. However, there is a consensus that professional life makes a positive contribution to critical thinking. The data acquired show a parallelism with the quantitative data acquired from the sub dimension of Critical Thinking in CTS.

According to teacher views obtained from the study; Critical Thinking and consequently CT may develop as a result of the effort of managing the colleagues and other people and understanding their thoughts. In parallel with this result, Román-González et al. (2018) report that Extraversion which is related with dimensions like sociability, activity, enthusiasm, assertiveness, and self confidence is significantly related with CT skills. Thus, teachers' behavioural patterns displayed in their professional life and their attitudes of understanding other people are important for CT skill. Future studies can focus on comparing teachers' CT skills based on their personality traits.

As a result of the interviews, it was determined that professional life did not make sufficient contribution to Problem Solving in general. This condition shows a consistency with problem solving sub-factor measurement of CTS. In other words, the teachers believed that they had as much problem solving skill as they did in their undergraduate years. They revealed that they had acquired the skill long before and it could not develop due to the limitations by other people. On the other hand, they believed that inclass activities and communication with other people made some positive contributions to their problem solving skills. However, they generally stated that (i.e., almost three times greater than positive expressions) the skill did not develop.

Even though there is a consistent increase in the popularity of the concept of CT which can be considered a process of thinking including the formulization of problems (Aho 2012), there is no sufficient number of experimental studies on this subject (Weinberg 2013). One of the most important variables for CT is Problem solving (Kalelioglu et al. 2016). There is a significant relationship between CT and problem solving ability (problem solving ability; $r = 0.67$) (Román-González et al. 2017) and CT can provide the competence of solving not only practical problems, but also theoretical problems (Shute et al. 2017). Considering these data, CT is considered as a variable that may affect problem solving skill. Thus, the fact that in-service and pre-service teachers who do not differentiate in terms of problem solving ability but differentiate in terms of CT skill should be embraced carefully. Future studies can reveal the effect of CT on problem solving skill.

Evaluating the effect of proffessional life on CT skill in general; it is believed that profession of teaching contributes to CT development by establishing communication with other people. Thus, communication is considered as an important variable for CT. Qualitative data were collected concerning the change in Communication skills, although it is not a sub dimension of CTS. Regarding this point, teachers emphasized the positive contributions of professional life. They indicated that they developed an official communication skill with people due to the effect of teaching role provided by professional life and also due to their communication with students. On the other hand, a few of them stated that insufficient communication with administration and colleagues in work environment could not maintain this skill.

Appendix

Table 10 Teacher interview questions and probe questions

Aim	Question
Receiving opinion about the change in creativity	Do you think you have made any progress in suggesting distinctive ideas (beyond an average idea) against any problem after going into your professional life?
Probe questions concerning creativity	✓ *Do you use the information you have learned during your undergraduate study as it is,* ✓ *Do you develop different methods against new situations (problems),* ✓ *What is the place of technology among these methods,* ✓ *Do you think this is your personality trait or does it develop while generating solutions to problems that you face in your professional life,* ✓ *Does your working environment contribute to your creativity,* ✓ *Does your working environment hinder your creativity.*
Receiving opinion about the change in algorithmic thinking	Do you think you have made any progress in acting determined (patient) at the point of realizing the procedures to be conducted step by step after going into your professional life?
Probe questions concerning algorithmic thinking	✓ *Do you picture the steps to be followed when starting a work in a short time,* ✓ *Have you observed any progress in this situation after going into your professional life,* ✓ *Do you get help from computer programs,* ✓ *Let's suppose that someone else will apply the procedure steps that you have designated. Can these procedure steps be applied without making an extra explanation,* ✓ *If you observe a progress in these skills; does it have anything to do with the interaction with your students. If yes, what is the extent,* ✓ *What do you think about using an algorithm designated by someone else? What might be the reason of the progress in your professional life and in this.*
Receiving opinion about the change in cooperativity	Do you think you have made any progress in your ability of conducting a common project/work with people of different characteristics (ability/skill/personality)?
Probe questions concerning cooperativity	✓ *Do you conduct studies with other teachers,* ✓ *How is your interaction with school administration (Taking charge in administration, giving support in some matters),* ✓ *Do you conduct studies based on a cooperation with social environment provided by your professional life.*
Receiving opinion about the change in critical thinking	Do you think you have made any progress in arriving at a judgment or decision based on your own thoughts evaluating the analysis and measurement results?
Probe questions concerning critical thinking	✓ *Can you regard events from different perspectives,* ✓ *Do you try to understand different perspectives,* ✓ *Do you prove the validity (accuracy) of any idea before accepting it,* ✓ *Do you collect information (evidences) about a matter that you don't know sufficiently and try to learn it,* ✓ *Do you question the source of any information.*

Table 10 (continued)

Aim	Question
Receiving opinion about the change in problem solving	Do you think you have made any progress in your problem solving skills after going into your professional life?
Probe questions concerning problem solving	✓ *Do you think you have made any progress in generating options for problem solving,* ✓ *Do you think you have made any progress in planning for problem solving,* ✓ *Do you think you have made any progress in making other people accept your problem solving method while working with them.*
Receiving opinion about the change in communication skills	Do you think you have made any progress in your communication skills after going into your professional life?
Probe questions concerning communication skills	✓ *What might be the reason of this.*

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