The Impact of Scratch-Assisted Instruction on Computational Thinking (CT) Skills of Pre-Service Teachers

Ulaş İlic iD
Pamukkale University, Turkey

To cite this article:

The Impact of Scratch-Assisted Instruction on Computational Thinking (CT) Skills of Pre-Service Teachers

Ulaş İlic

Article Info	Abstract
	The present study aimed to determine the effect of Scratch-assisted expressions and applications on the Computational Thinking skills of pre-service teachers. For this purpose, the research was designed with an exploratory sequential design, a mixed research method. Thirty-three pre-service teachers participated in the study. Data were collected with Computational Thinking Scale before and after the applications conducted in the Instructional Technologies course, and with a survey form developed by the author and face-to-face interviews conducted with the participants at the end of the course. Based on the data obtained, it was determined that the applications conducted in the course improved the Computational Thinking skills of the participants. Although the improvement did not differ based on gender, it was determined that the differences were significant based on creativity, algorithmic thinking, and critical thinking sub-dimensions. Furthermore, it was observed that there was a positive and significant correlation between Computational Thinking and academic achievement. Also, pre-service teachers stated that Scratch applications contributed to the acquisition of Computational Thinking skills. It was suggested that the present study findings would contribute to future studies on Computational Thinking acquisition in similar courses.

Introduction

Our lives have accelerated with advances in information and communication technologies. Access to information, content production, and provision of content has become the wheels of these rapid advances. To cope with these advances, a need for processes to find solutions and make decisions about novel problems are significant. In this context, a new concept, Computational thinking (CT), was introduced.

Computational Thinking

CT was first proposed by Papert (1980). Wing (2006), on the other hand, pioneered the current significance of the concept. There is no consensus on the definition of CT, which is a complex concept (Haseski, İlic, & Tuğtekin, 2018). For instance, according to The National Research Council (NRC) (2010), CT is a structure that includes various cognitive habits and strategies in problem-solving. Carnegie Mellon (2014) defined CT as the

use of computers to support thinking and problem-solving processes. Kafai (2016) reported that computational thinking is a social practice. In a computer science-related definition, diSessa (2001) argued that CT is the use of computer science methods and perspectives by individuals. In general, the concept is accepted as a 21st-century skill where individuals propose solutions to the problems they encounter and employ the most suitable solutions (Denning, 2009; ISTE, 2016). In the present study, it was decided to use the final CT definition.

The concept became more popular due to the significance assigned by institutions such as Google for Education (2015) and ISTE (2016) and the number of studies on CT started to increase. In the literature, some studies aimed to improve CT skills with robots (Kafai & Burke, 2013) and software programming (Berland & Wilensky, 2015; Pellas & Peroutseas, 2016). Furthermore, other studies investigated ICT courses based on CT (Mercimek & Ilic, 2017), integrated CT into the curriculum and developed CT curriculum (Angeli et al., 2016; Bers, Flannery, Kazakoff, & Sullivan, 2014; Israel, Pearson, Tapia, Wherfel, & Reese, 2015). Furthermore, after the initial studies that focused on defining the concept, the studies started to focus more on the field of education (İlic, Haseski, & Tuğtekin, 2018; Özçınar, 2017). It was observed that various content analyzes were conducted in recent years to investigate these studies in detail (Haseski & İlic, 2019; Ilic et al., 2018; Shute, Sun, & Asbell-Clarke, 2017, Özçınar, 2017).

CT is a skill that everyone should possess, not just professional computer scientists (Ilic et al., 2018; National Research Council, 2010; Wing, 2006). It was reported that CT, which is significant in solving complex problems, could be effective in various fields such as geography, meteorology, archeology, engineering, and pharmaceutics (DeSchryver & Yadav, 2015). However, CT was mostly associated with computer science in most studies (Israel et al., 2015; Özçınar, 2017; Pellas & Peroutseas, 2016). Thus, the courses associated with computer sciences became important in the acquisition of CT skills to pre-service teachers. Hence, the Instructional Technologies course should be addressed in this context.

Instructional Technologies Course

Instructional Technologies course is a teacher training program course in the curriculum renewed in the 2018-2019 academic year. The course is designed as a 2 hours per week theoretical course. The Instructional Technologies course content was specified by YÖK (2018) as follows:

> *Information technologies in education; instructional process and classification of instructional technologies; theoretical approaches to instructional technologies; new approaches in learning; contemporary literacies; instructional technologies as instruments and materials; design of instructional materials; designing thematic instructional materials; creating field-specific object warehouse, assessment criteria of instructional material.*

As seen in the course content, the Instructional Technologies course that includes topics such as information technologies in education, new approaches in learning, instructional technologies as instruments and materials, and design of the instructional materials stands out as an important course. The course is also important since it replaced the Computer 2 course in the new curriculum since CT was associated with computer sciences (Israel

et al., 2015; Özçınar, 2017; Pellas & Peroutseas, 2016). Furthermore, as Tissenbaum, Sheldon, and Abelson (2019) noted, the course should not only aim to instruct the concepts but include production as well. Thus, the course is important as it contains topics such as material development. Thus, the replacement of the Computer 2 course with this course and further concentration on practice in addition to the instruction of theoretical content, the course was considered important for the acquisition of CT. Scratch software is significant due to ease of use and effectiveness in the acquisition of CT skills, which is one of the skills that pre-service teachers aim to acquire (Lye & Koh, 2014).

Scratch

Various visual programming languages such as Alice, Logo, Blockly, and Small with end-user appeal were developed in recent years. Scratch, developed by MIT Media Labs, is one of these programming languages. Scratch (Price & Barnes, 2015), which has reached a higher number of users due to its ease of use when compared to other tools, includes various components. In the application, which includes 4 panels, there is a field that contains code blocks on the far left of the screen. The codes in the blocks such as motion, events, sensing can be added to the space in the middle. Since these codes could be dragged and dropped, even the most novice users do not experience difficulties. In the panel at the bottom right, there are sprites and related features. The stage is located right above this panel. The screen produced by the codes with the selected sprites is displayed in this area. Furthermore, due to the multi-language feature and the ability of the code to run simply on a web browser, Scratch has high availability. The general structure of Scratch is called tinkerable. Thus, codes consisting of small chucks contribute to hands-on-learning (Maloney, Resnick, Rusk, Silverman, & Eastmond, 2010) and are easy to use (Resnick, Kafai, Maeda, Rusk, and Maloney, 2003). It was reported in the literature that Scratch is a simple and enjoyable tool (Genç & Karakuş, 2011). The opportunity it provides for the students to learn by doing is also effective for teachers (Tan & Kim, 2015). This demonstrated that the implementation is effective on creativity as well (Armoni, Meerbaum-Salant, & Ben-Ari, 2015; Korkmaz, 2016; Wolz, Stone, Pearson, Pulimood, & Switzer, 2011). Thus, it was reported that Scratch contributed to problem-solving, logical, and analytical thinking skills (Calder, 2010; Kaučič & Asič, 2011). Furthermore, Scratch is a useful tool in the acquisition of algorithmic thinking skills and CT related skills by learners (Berland & Wilensky, 2015; Maloney et al., 2010).

Related Literature

Constructionism, developed by Papert, advocates that learners should produce an object or a design for a more effective learning process. Thus, learners learn more easily by designing (Kafai & Resnick, 1996). In this context, it seems necessary to encourage learners to produce (Peppler & Kafai, 2007). In constructionism theory, courses such as Instructional Technologies that prioritize material design in CT instruction and include basic topics associated with computer sciences are considered important. Furthermore, the inclusion of CT in teacher training was considered a requirement (İlic et al, 2018; Yadav, Mayfield, Zhou, Hambrusch, & Korb, 2014, Yadav, Hong, & Stephenson, 2016). There is only a limited number of studies on CT and pre-service teachers in the literature (Haseski & İlic, 2019). In these studies, it was observed that CT skills were not tackled in

conjunction with the Scratch and Instructional Technologies course. Furthermore, there is no specific educational program on CT instruction (Ertmer & Ottenbreit-Leftwich, 2010; Masterman & Manton, 2011; Moreno-León, Robles, & Román-González, 2015). Thus, the Instructional Technologies lesson, which is one of the common courses where the concept could be instructed, is significant in the introduction of CT to all pre-service teachers. Thus, it was suggested that pre-service teachers could allow their students to acquire this skill from preschool to high school in the future. It was considered that Scratch could be useful in achieving this goal due to its ease of use and effectiveness in CT instruction. Hence, the present study aimed to determine the effect of Scratch-assisted CT expressions and applications conducted in the Instructional Technologies course on CT skills of pre-service teachers.

Method

The Research Model

This study was conducted with an exploratory sequential design, a mixed research method. The designs where quantitative and qualitative data are collected, analyzed, and interpreted are called mixed designs (Onwuegbuzie & Leech, 2006). One of the mixed research methods is the exploratory sequential design, where qualitative data are collected secondly to support the quantitative data (Creswell, 2003). In this context, quantitative data were obtained with CTS, and then the survey form and interviews were used to explain the quantitative data. Thus, it was aimed to explain qualitative data with the CTS data.

The Study Group

The study group included 33 pre-service teachers attending a public education faculty during the 2019-2020 academic year. As seen in Table 1, the ages of pre-service teachers ranged between 18 and 33. Furthermore, about half of the participants were female (51.5%).

Table 1. The Distribution of Participants based on Gender

Age	*f*	%
18	5	15.2
19	10	30.3
20	9	27.3
21	4	12.1
22	2	6.1
24	1	3.0
28	1	3.0
33	1	3.0

The criterion sampling method was used to determine the study group. This method is used when it is necessary to study existing cases or that meet certain criteria determined by the researchers (Yıldırım & Şimşek, 2011). Thus, the selection criteria were determined as attending Pamukkale University, Faculty of Education,

enrollment in the Instructional Technologies course section instructed by the author during the 2019-2020 academic year fall semester. In addition to this, only volunteering students were enrolled in the study for ethical reasons. Also, care was taken to abide by the principle of confidentiality and the participant IDs were coded with a P, and the participant number in the present study.

Data Collection Instruments

In the present study, scales, survey forms, and interviews were employed to collect data. The "Computational Thinking Scale" (CTS), developed by Korkmaz, Cakir, and Özden (2017), which is a 5-point Likert-type scale with 29 items and 5 factors, was used in the present study. Out of the 5-factor structure, 6 items in the final factor were negative and the remaining items were in the scale. The Cronbach Alpha internal consistency coefficient of the scale developed for college students is .82. In the present study, the CTS internal consistency coefficient was calculated as .91 in the pre-test and .93 in the post-test. These findings demonstrated that the internal consistency of the scale was high (DeVellis, 2012; Kline, 2000).

The survey and interview forms were developed by the researcher. During the development of both tools, the opinions of 3 Computer Education and Instructional Technology experts were obtained. The experts were selected based on their contribution to the literature on CT. Then, the questions were examined by a linguist and an assessment and evaluation specialist. The survey and interview forms were finalized after the required editing. The survey form included one question. It included only one question since the author aimed to learn the general views of the pre-service teachers without steering them towards an idea. The survey form question was "Did the Instructional Technologies course have any contribution? If so, what were the contributions?" On the other hand, the following questions were included in the interview form developed for one-on-one interviews:

1. What are your views on CT?
2. Did the Instructional Technologies course contribute to your CT skills? If yes, what can you say about this contribution?
3. What do you think about Scratch?
4. Scratch was one of the significant topics covered in the Instructional Technologies course. Do you think this application had any impact on your CT skills? If so, what can you say about this impact?

In addition to these data collection instruments, demographic information such as age and gender of the participants was collected.

Procedure

The study group participated in a 13-week instructional technology course lectured by the researcher. In the first week of the course, the instructor applied the CTS as a pre-test without even before the introductions prevent biased findings due to the recognition of teaching staff. Fifty pre-service teachers participated in the pre-test. Based on the instructional technology course content, the instruction was started with topics such as the concept of technology and instructional technologies, historical developments, and classification of instructional

technologies. Next, the concept of the algorithm was discussed. At this stage, after the presentation of the concept and its significance, the topics of conditions, loops, and flow charts were addressed. In the next step, the concept of CT was instructed for 2 weeks. CT examples, steps, importance, and reflections of CT skills in life were discussed. To improve the comprehension of the topic, the example developed by Haseski, İlic and Tuğtekin (2017) to present the basic CT concepts to teachers was presented to the participants. The example included the steps included in ISTE standards, explanations of these steps, and solutions associated with steps about the problem of how to go from Ankara to Istanbul were instructed. Furthermore, sample assignments completed by pre-service teachers in previous courses were also presented to the participants. Next, pre-service teachers were asked to identify a problem in their daily lives and work on an assignment based on these problems. In this assignment, the researcher advised the participants starting from the step of problem identification until the completion of the assignment.

In subsequent classes, the Scratch application was discussed for 3 weeks. It was identified that Scratch was a very effective tool especially for beginners although several instruments could be employed in the acquisition of CT skills. Furthermore, it was stated that the use of Scratch software could contribute to students of all grades from preschool to higher education. Then, the basic components of the software such as code blocks, writing area for these blocks, and the stage were addressed. The whole process was conducted with the constructivist approach. In the process, before the discussion of algorithmic thinking and CT concepts, the participants were asked about the solution to the problem. Then, sample code blocks were presented by the author to assist the pre-service teachers. Throughout the process, the feedback was provided for both individuals and groups, creating an environment that allowed group discussions that could lead to collaborative learning. Dialog activities, which are among the main building blocks in English language instruction, were designed by the participants. In this process, as seen in Figures 1 and 2, the presence of structures such as loops and if-then clauses are presented after the use of simple components. Each student was asked to design activity and the assignments were evaluated by the author and feedback was provided.
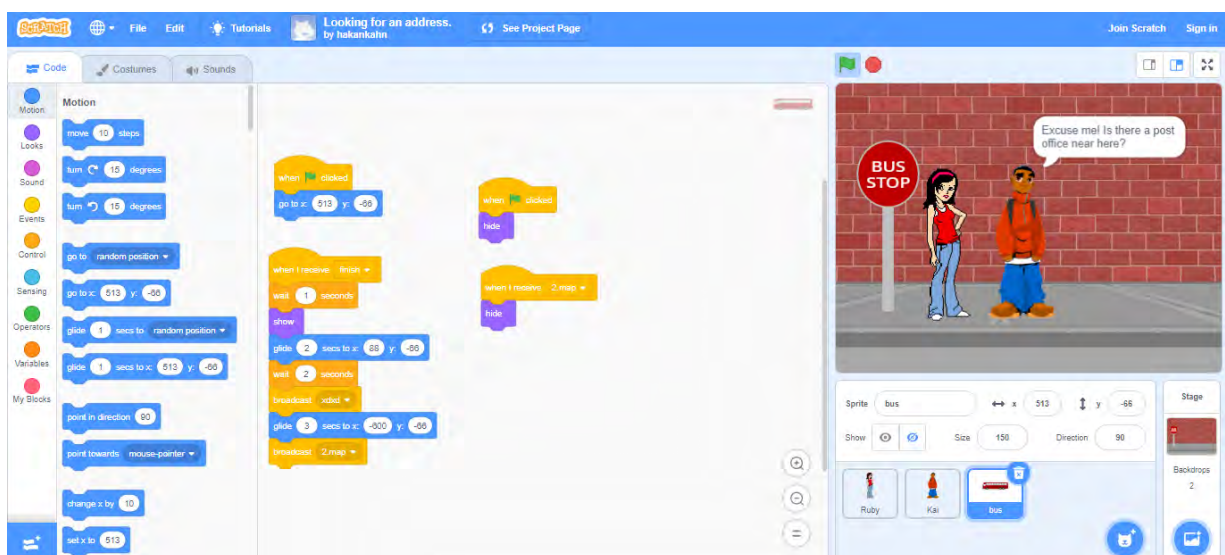

Figure 1. A Screenshot from a Student Activity with Code Blocks

Figure 2. A Screenshot from a Student Activity

In the final activity, pre-service teachers were asked to design a short quiz including correct and incorrect answers. As seen in Figures 3 and 4, procedures such as giving feedback to the user after an incorrect answer, increasing the points after a correct answer, and increasing the question level after a certain score is reached were employed.
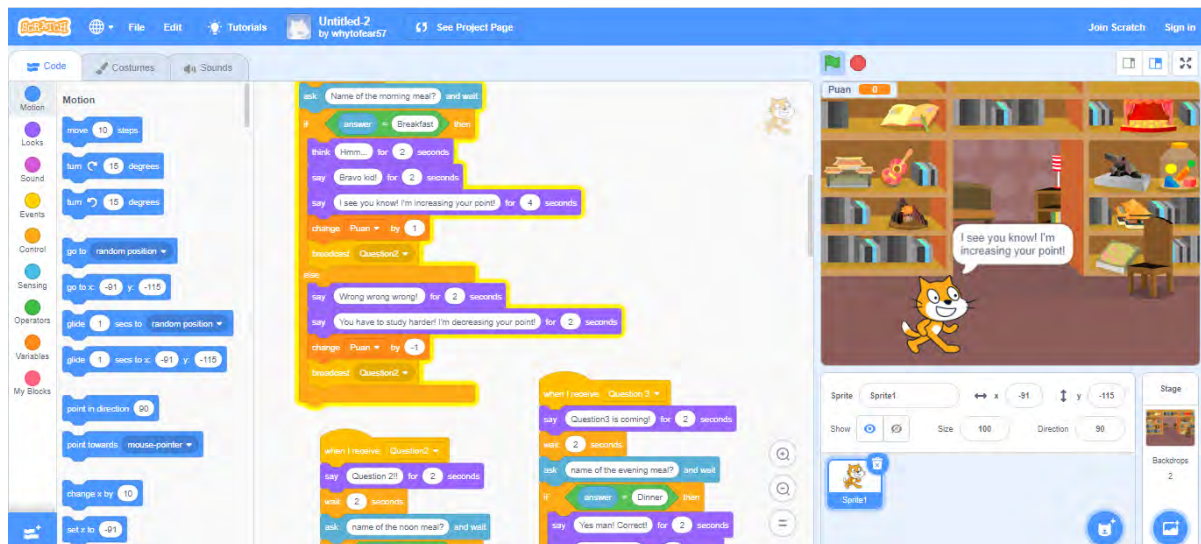
Figure 3. A Screenshot from a Student Activity with Code Blocks

After the instruction of the above-mentioned topics, the post-test data were collected with CTS in the final class. Thirty-four students participated in the post-test. The difference between the participants in the pre-test and post-test was since certain students changed their sections during the course. The next step was conducted online. The single-question survey form about the contributions of the course was sent to the students online. After the analysis of the data collected with both data collection instruments, face-to-face interviews were conducted with 4 participants who stated that the course contributed to their skills and volunteered for the interview. These interviews were conducted in the author's office between 26.12.2019 and 31.12.2019. The

interviews lasted between 3:28 and 8:19 minutes.

Figure 4. A Screenshot from a Student Activity Asking a Question

Data Analysis and Interpretation

Before the data analysis, the responses given to the negative items in the CTS were reverse coded. Missing responses were investigated in the data set and it was determined that there was no missing data as well. The 50 students who participated in the pre-test and 34 students who participated in the post-test were determined. The data collected with both tests were analyzed and the participants who did not participate in one of the tests were excluded from the analysis. Thus, the data collected from 33 pre-service teachers, who participated in both pre- and post-tests were analyzed.

To use parametric tests, the sample size should be at least 15 for in-group comparisons (Pallant, 2001). Thus, it was observed that the criterion was met. Almost all skewness and kurtosis values for both participants and genders were in the range of -2 - +2. According to George and Mallery (2011), these values were sufficient to determine the normal distribution of the data. For females, Kurtosis$_{criticalpre}$ was 2.041 and kurtosis$_{criticalpost}$ was 2.002 and kurtosis$_{criticalpost}$ was 2.369 for males. Kolmogorov-Smirnov test is used in groups with 30 or more participants to determine the normal distribution (Akbulut, 2010). Accordingly, it was determined that all but one value exhibited normal distribution. This value demonstrated that that the collaboration post-test scores of females did not exhibit normal distribution (D (17) = .217, p = .33).

However, according to Çokluk, Şekercioğlu, and Büyüköztürk (2010), more than one case should be employed in the determination of the normal distribution. Thus, the histogram and quartile graph were also used. Based on these analyses, all variables exhibited a normal distribution. In this context, it was decided to use parametric paired samples t-test and independent samples t-Test. The research problems determined based on the study aim and the analyses employed to solve these problems are presented in Table 2.

The analyses presented in Table 2 were conducted with statistical analysis software. The significance level was taken as .05 in statistical analysis. Spreadsheet software was used to analyze qualitative data. In this software, the responses of each participant were written on a separate line. Codes and themes were obtained based on these responses analyzed with content analysis. Furthermore, to ensure the transferability of the study, direct quotes of the participant statements were also presented.

Table 2. The Research Problems and the Analyses Employed to Solve These Problems

Research questions	Type of Analysis
1. Overall CT score and sub-dimension scores differ across pre-test and post-test results?	Paired samples t-test
2. Overall CT score and sub-dimension scores based on pre-test and post-test differ across gender?	Independent Samples t-test
3. Is there a correlation between CT pre-test, CT post-pest, and achievement scores?	Pearson Coefficient of Correlation

Validity and Reliability

Various steps were taken to ensure the validity and reliability of the study. For instance, data triangulation was conducted to improve the internal validity of the study. The data triangulation method allows the control, comparison, and verification of different types of data (Patton, 1990). Thus, in addition to the data collected with pre-test and post-test CTS application, the data collected with the survey form and one-on-one interviews were used.

The students were informed about their rights about participation in the study. Long-term interaction was maintained with the students during the 13-week course instruction to collect in-depth data. Furthermore, qualitative data were presented using direct participant quotes to improve the reliability of the study. Cronbach Alpha values for the development of the scale and internal consistency coefficients obtained for the pre-test and post-test data are presented to the readers as well.

Limitations

The present study has several limitations. In the present study, the exploratory sequential design was employed. Therefore, the study group included a small population. Furthermore, due to the employment of the criterion sampling method, individuals who met the specified criteria could be assigned to the study group. Another limitation was the data collection instruments. Interview questions, which were used especially to collect the qualitative data were a limiting factor in the study. The final limitation of the study was the scope and quality of the course. The Instructional Technologies course content that was determined by YÖK and implemented by the author was another limitation in the study.

Findings

The findings obtained with the analyses conducted based on the research problems are presented under three main topics. First, the CT pre-test and post-test and sub-dimension scores of the pre-service teacher are presented. Then, all pre-test and post-test scores of the participants were analyzed based on gender and the findings are presented in the second section. Finally, the correlations between CT pre-test, post-test, and achievement scores are presented.

Findings on Overall CT and CT Sub-Dimension Data

To determine the pre-test post-test scores of the pre-service teachers based on overall CT score and sub-dimension scores, paired-samples t-test was used. Furthermore, the responses given by the participants to the survey questions and the data obtained with face-to-face interviews were also employed. Paired samples t-test results are as presented in Table 3.

Table 3. Paired Samples t-test Results

Pre-Test - Post-Test	Group	$\overline{x}$	Ss	t	Sd	p
	Female	-2.000	3.021	-2.730	16	.015*
Creativity	Male	-1.438	2.632	-2.184	15	.045*
	Total	-1.727	2.809	-3.532	32	.001*
	Female	-2.941	3.508	-3.457	16	.003*
Algorithmic Thinking	Male	-2.688	3.301	-3.257	15	.005*
	Total	-2.818	3.358	-4.821	32	.000**
	Female	-0.353	3.408	-.427	16	.675
Cooperativity	Male	-1.563	3.119	-2.004	15	.064
	Total	-0.939	3.278	-1.646	32	.110
	Female	-1.765	2.796	-2.603	16	.019*
Critical Thinking	Male	-1.188	2.713	-1.751	15	.100
	Total	-1.485	2.729	-3.126	32	.004*
	Female	-0.059	3.561	-.068	16	.947
Problem Solving	Male	-0.438	5.354	-.327	15	.748
	Total	-0.242	4.451	-.313	32	.756
	Female	-5.118	7.607	-2.774	16	.014*
Overall CT	Male	-5.875	9.054	-2.595	15	.020*
	Total	-5.485	8.216	-3.835	32	.001*

Based on the results presented in Table 3, it was determined that there were significant differences between CT pre-test and post-test scores of all participants ($t_{(32)}$ = -3.835, p <. 05), male participants ($t_{(15)}$ = -2.595, p <.05) and female participants ($t_{(16)}$ = -2.774, p <.05). Similarly, there was a significant difference between creativity

and algorithmic thinking pre-test and post-test scores of all groups. Based on the mean scores, it was observed that the mean post-test score was higher when compared to the mean pre-test score ($\overline{x}_{\text{post-test}} > \overline{x}_{\text{pre-test}}$).

In other words, it could be suggested that the overall CT score, creativity, and algorithmic thinking scores of the participants improved after the application. The qualitative data also supported this finding. Based on the survey data, most participants (93.94%) stated that the course contributed to various skills. Four students stated that the course had a direct contribution to CT skills, etc. For example, P19 stated the following: "...I learned software that I have not heard of before, I improved my knowledge and CT." In the interviews, all pre-service teachers stated that the course contributed to their CT skills. For example, P1 stated the following: "In the course, certain definitions were presented about the concept of CT. This was something I want to apply in my life. I learned this in the course. I did not know it before the course. I started to think more that it was important in courses and should be used by teachers and students." Furthermore, in one-on-one interviews, P1 stated the following reflecting algorithmic thinking: "We can achieve a more successful result when we break down the problem into parts and write down adequate solutions, then select the most adequate one, and apply it to other events. I think this is a very practical method."

On the other hand, no significant difference was determined between the cooperativity and problem-solving sub-dimension scores of all groups. Despite this finding, certain students stated in the survey that the course improved their problem-solving skills. For example, P33 stated the following: "I think it would be beneficial for the determination of the paths to choose in rapid problem-solving." In one-on-one interviews, P4 stated that the course improved CT skills: "We have a problem. This is something to be resolved. We need something about how to solve this. CT is useful in this context. It gave me an idea. I can use this method in the events that I will encounter in my daily life in the future." The participant also stated that this skill could also be used to solve problems. The lack of a difference between the cooperativity sub-dimension scores could have been since only individual activities were conducted in the course. Unlike the above-mentioned findings, there was a significant difference between the critical thinking scores of all participants ($t_{(32)} = -3.126$, $p < .05$) and female participants ($t_{(16)} = -2.603$, $p < .05$), while the difference between the scores of male participants was not significant ($t_{(15)} = -1.751$ $p = .100$).

All study participants expressed positive views about Scratch. Two students stated that the application had an interesting structure. For example, P3 stressed the intended use of the application: "... useful software. It can also be of interest. We can narrate stories and make games with it. It is very good in terms of attracting interest. Great achievements can be acquired when used adequately." P1, on the other hand, stated that the application had its advantages in algorithmic thinking as follows: "It allows both the teacher and the individual who develop the application to acquire planned thinking skill. I can see that." It was determined that pre-service teachers expressed different views about the contribution of Scratch to CT skills. While 2 participants were undecided on the issue, 2 students stated that Scratch was effective in the development of CT skills. P2, one of the undecided students stated the following: "I cannot recognize a connection between the two. Because I was not very active on Scratch." One of the students who thought Scratch was effective, P4 stated the following: "It did. It was like this: There is something that needs to be explained or transmitted. Or there is an event that needs to be resolved.

Scratch is also a method. So, we can use this method. It had such a benefit for CT with me."

The Findings on the Differences between Overall CT and CT Sub-Dimension Scores

Independent samples t-test was employed to determine the differences between the pre-test and post-test overall CT and CT sub-dimension scores of the participants. The t-test results are presented in Table 4.

Table 4. Independent Samples t-test Results

	Group	n	$\bar{x}$	Ss	Sd	t	p
Creativity Pre-test	Female	17	33.059	3.526	31	-.281	.781
	Male	16	33.438	4.211			
Creativity Post-test	Female	17	35.059	3.211	31	.137	.892
	Male	16	34.875	4.410			
Algorithmic Thinking Pre-test	Female	17	12.824	6.217	31	-.852	.401
	Male	16	14.750	6.768			
Algorithmic Thinking Post-test	Female	17	15.765	6.280	31	-.665	.511
	Male	16	17.438	8.099			
Cooperativity Pre-test	Female	17	14.235	3.456	31	-.247	.806
	Male	16	14.563	4.131			
Cooperativity Post-test	Female	17	14.588	2.399	31	-1.586	.123
	Male	16	16.125	3.138			
Critical Thinking Pre-test	Female	17	16.765	2.905	31	-1.125	.271
	Male	16	18.250	4.465			
Critical Thinking Post-test	Female	17	18.529	4.625	31	-.522	.605
	Male	16	19.438	5.354			
Problem Solving Pre-test	Female	17	23.235	3.073	31	.569	.574
	Male	16	22.438	4.746			
Problem Solving Post-test	Female	17	23.294	3.460	31	.315	.755
	Male	16	22.875	4.161			
Overall CT Pre-test	Female	17	67.059	10.244	31	-.630	.533
	Male	16	70.000	16.108			
Overall CT Post-test	Female	17	72.176	12.759	31	-.715	.480
	Male	16	75.875	16.808			

As seen in Table 4, there was no significant difference between the pre-test and post-test overall CT and CT sub-dimension scores based on the gender variable. Thus, it could be suggested that the pre-application levels of the participants were similar. Also, it could be suggested that the improvements experienced after the application were close.

The Findings on the Correlation between CT Pre-Test, CT Post-test and Achievement Scores

Pearson Correlation coefficient was employed to determine the correlation between the achievement, CT pre-test, and CT post-test scores of the pre-service teachers. The conducted analysis is presented in Table 5.

Table 5. The Correlation between the Achievement, CT Pre-test and CT Post-test Scores of the Pre-service Teachers

Test (n=247)	Post-Test	Achievement Score
Pre-Test	.833**	.458**
Post-Test	-	.410[*]

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

As seen in Table 5, it was determined that there were significant and positive correlations between all variables ($p < .05$). According to Cohen (1977), the correlation between CT pre-test and CT post-test scores was high ($p < .01$, $r = .833$) and the correlation between CT pre-test and achievement scores was moderate ($p < .01$, $r = .458$). In other words, as the CT pre-test scores of the students increased, their CT post-test scores increased. Furthermore, as the CT pre-test score increased, the course achievement score increased as well. The correlation between the CT scores and the achievement scores of the students was moderate ($p < .05$, $r =, 410$). It could be suggested that course achievement improved as the CT post-test score increased, similar to the other findings.

The analysis of the correlations based on gender revealed a positive and high correlation between CT pre-test and CT post-test for both female ($p < .01$, $r = .803$) and male ($p < .01$, $r = .850$) students. Similarly, a high and significant correlation was determined between CT pre-test and achievement scores of male students ($p < .05$, $r = .536$). However, there was no significant correlation between the same scores of female students ($p = .062$). Similarly, there was a moderate correlation between CT post-test and achievement scores of male students ($p < .05$, $r = .569$). On the other hand, this correlation was not true for female students ($p = .233$).

Discussion, Conclusion, and Recommendations

The present study aimed to determine the impact of Scratch-assisted CT expressions and applications on CT skills of pre-service teachers. Consistent with this aim, the levels of 33 pre-service teachers were analyzed. It was considered that the present study findings would contribute future studies on the CT skill levels of pre-service teachers in courses such as Scratch-assisted Instructional Technologies. Furthermore, the study was also considered important since the study group included pre-service teachers, who will instruct the skill at different school levels in the future.

In the study, it was concluded that the CT skills of the pre-service teachers improved. This finding was consistent with the study findings on the same target group (Cetin, 2016; Gabriele, Bertacchini, Tavernise, Vaca-Cárdenas, Pantano, & Bilotta, 2019; Kim, Choi, Han, & So, 2012). Furthermore, considering Scratch is a

beneficial tool in the acquisition of algorithmic thinking and CT skills (Berland & Wilensky, 2015; Maloney et al., 2010), it could be suggested that this finding was expected. On the other hand, it was determined that there was an improvement in the algorithmic thinking skills of the pre-service teachers. This finding was in line with the studies in the literature (Cetin, 2016; Gabriele et al., 2019; Kim et al., 2012) and the studies which demonstrated that algorithmic thinking was an important part of CT skills (Korkmaz et al., 2017; Yadav et al., 2016).

The findings on creativity were similar to CT and algorithmic thinking findings. It was reported that CT was a problem-solving process where creative thinking is important (Snalune, 2015; Voskoglou & Buckley 2012). Thus, it was observed that the present study findings were consistent with the literature. According to Paul (1990), there is an important correlation between creative thinking and critical thinking. It was determined that the critical thinking skills, which are associated with creativity, of the participants, improved in the present study. While this improvement was significant in all participants and female participants, it was not significant in males. It could be argued that the above-mentioned finding for males was due to the study group size.

Critical thinking is an important component of CT (Ater-Kranov, Bryant, Orr, Wallace, & Zhang, 2010). It could be argued that Scratch contributes to logical thinking and analytical thinking skills (Calder, 2010; Kaučič & Asič, 2011), benefiting the learners in critical thinking. Thus, the study findings were consistent with the literature. On the other hand, it was reported in the literature that Scratch contributed to learners' problem solving, logical thinking, and analytical thinking skills (Calder, 2010; Kaučič & Asič, 2011). However, in the present study, a significant difference could not be determined in the problem solving and cooperativity dimensions between the pre-service teachers. This finding on cooperativity skills could be due to the fact that only individual activities were conducted in the Instructional Technologies course. The present study findings on problem-solving were unexpected. As reported in the literature, CT is a problem-solving process (Kazimoglu, Kiernan, Bacon, & MacKinnon, 2012; Yağcı, 2019). Thus, the course was expected to improve this skill. However, it was suggested that this finding was due to the sample size. On the other hand, the qualitative findings demonstrated that the process contributed to the problem-solving skills of pre-service teachers. Finally, it was determined that the overall CT and CT sub-dimension scores did not differ by gender. This finding was consistent with the studies which reported that there was no significant correlation between CT levels and gender (Werner, Denner, Campe, & Kawamoto, 2012). However, these findings contradicted with other study findings (Prottsman, 2011; Roman-Gonzalez, Perez-Gonzalez, & Jimenez-Fernandez, 2017).

A significant and positive correlation was determined between CT and academic achievement. In the literature, it was reported that CT concepts and applications are based on computer sciences (Korkmaz et al., 2017; Sengupta, Kinnebrew, Basu, Biswas, & Clark, 2013; Wing, 2008). It could be suggested that the topics instructed in the Instructional Technologies course in the present study were effective in CT skills. Furthermore, it was reported that academic achievement in information technologies was associated with CT skills (Durak & Saritepeci, 2018). Thus, it could be argued that the study findings were consistent with the findings reported in the literature. However, considering that CT is a problem-solving process beyond technological literacy (Yadav et al., 2016), it was observed that further research is required on Instructional Technologies and similar courses.

It was determined that the Scratch application utilized in the present study was effective on CT and algorithmic thinking skills. This finding was consistent with previous studies, which reported that the application had an impact on algorithmic thinking and CT skills of pre-service teachers (Cetin, 2016; Gabriele et al., 2019; Kim et al., 2012). In general, it was reported that Scratch contributed to problem-solving, logical, and analytical thinking skills (Calder, 2010; Kaučič & Asič, 2011). Furthermore, Scratch was reported as a beneficial tool in the acquisition of algorithmic thinking and CT skills by the learners (Berland & Wilensky, 2015; Maloney et al., 2010). It was also reported in the literature that Scratch is a pleasant application (Genç & Karakuş, 2011). Thus, it was observed that the present study findings were consistent with the literature.

In conclusion, it was determined that the CT skills of pre-service teachers improved with the algorithm, CT concept, and Scratch application topics instructed in the Instructional Technologies course. This finding was similar in all dimensions except for problem-solving and collaboration dimensions. There was no difference between the development of CT skills based on gender. There was a positive correlation between CT skills and academic success. Furthermore, it was concluded that the Scratch application, which was mostly employed in applied classes, was effective in CT skills. It could be observed that these findings were consistent both with the literature mentioned above and the reports of the authors who developed related measurement tools (Kazimoglu et al., 2012; Yağcı, 2019). There is no curriculum on the instruction of CT for pre-service teachers (Ertmer & Ottenbreit-Leftwich, 2010; Masterman & Manton, 2011; Moreno-León et al., 2015). Thus, it was considered significant that the present study was conducted within the context of a product-oriented course such as Instructional Technologies, where topics such as Scratch, etc. were instructed. However, there is a need for further studies on the topic in the literature. Thus;

- Future studies could be conducted with different designs in the Instructional Technologies course.
- Studies could be conducted on various courses that could contribute to the CT skills of the teachers.
- The levels of pre-service teachers in CT sub-dimensions could be studied with larger samples.
- The effect of Scratch and similar applications on the CT skills of pre-service teachers could be determined with future experimental studies.
- According to the literature, the CT skills of in-service teachers are more developed when compared to those of the pre-service teachers (Günbatar, 2019). Thus, future longitudinal studies could monitor the CT development of learners after graduation.
- Future studies that would include ethnic/racial demographics could be beneficial.

References

Akbulut, Y. (2010). *Sosyal bilimlerde SPSS uygulamaları: Sık kullanılan istatiksel analizler ve açıklamalı SPSS çözümleri*. İstanbul: İdeal Kültür Yayıncılık.

Angeli, C., Voogt, J., Fluck, A., Webb, M., Cox, M., Malyn-Smith, J., & Zagami, J. (2016). A K-6 computational thinking curriculum framework: Implications for teacher knowledge. *Educational Technology & Society, 19*(3), 47–58.

Armoni, M., Meerbaum-Salant, O., & Ben-Ari, M. (2015). From Scratch to "real" programming. *ACM Transactions on Computing Education (TOCE), 14*(4), 1-15.

Ater-Kranov, A., Bryant, R., Orr, G., Wallace, S., & Zhang, M. (2010). Developing a community definition and teaching modules for computational thinking: Accomplishments and challenges. In *Proceedings of the 2010 ACM conference on information technology education* (pp. 143–148). ACM.

Berland, M., & Wilensky, U. (2015). Comparing virtual and physical robotics environments for supporting complex systems and computational thinking. *Journal of Science Education and Technology, 24*(5), 628–647.

Bers, M. U., Flannery, L., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers & Education*, *72,* 145-157.

Calder, N. (2010). Using Scratch: An integrated problem-solving approach to mathematical thinking. *Australian Primary Mathematics Classroom*, *15*(4), 9-14.

Carnegie Mellon. (2014, December 11). *Carnegie Mellon center for computational thinking*. Retrieved from http://www.cs.cmu.edu/~CompThink/

Cetin, I. (2016). Preservice teachers' introduction to computing: Exploring utilization of Scratch. *Journal of Educational Computing Research*, *54*(7), 997-1021.

Cohen, J.W. (1977). *Statistical power analysis the behavioral sciences.* NY, SF, London: Academic Press.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative and mixed methods approaches* (2nd. Ed.), California, CA: Sage.

Çokluk, Ö., Şekercioğlu, G. ve Büyüköztürk, Ş. (2010). *Sosyal bilimler için çok değişkenli istatistik SPSS ve Lisrel uygulamaları*. Ankara: Pegem Akademi Yayıncılık.

Denning, P. J. (2009). The profession of IT beyond computational thinking. *Communications of the ACM, 52*(6), 28–30.

DeSchryver, M. D., & Yadav, A. (2015). Creative and computational thinking in the context of new literacies: Working with teachers to scaffold complex technology-mediated approaches to teaching and learning. *Journal of Technology and Teacher Education, 23*(3), 411-431.

DeVellis, R. F. (2012). *Scale development: Theory and applications*. Los Angeles: Sage Publications.

diSessa, A. (2001). *Changing minds: Computers, learning, and literacy*. MA: MIT Pres

Durak, H. Y., & Saritepeci, M. (2018). Analysis of the relation between computational thinking skills and various variables with the structural equation model. *Computers & Education*, *116*, 191-202.

Ertmer, P., Ottenbreit-Leftwich, A. (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture intersect. *Journal of Research on Technology in Education, 42*(3), 255–284

Gabriele, L., Bertacchini, F., Tavernise, A., Vaca-Cárdenas, L., Pantano, P., & Bilotta, E. (2019). Lesson planning by computational thinking skills in Italian pre-service teachers. *Informatics in Education*, *18*(1), 69-104.

Genç, Z. & Karakuş, S. (2011). Learning through design: Using scratch in instructional computer games, design. *5 th International Computer & Instructional Technologies Symposium*, 22-24 September. Fırat University, Elazığ, p: 981-987.

Google for Education (2015, March 31). *Exploring computational thinking*. Retrieved from https://edu.google.com/resources/programs/exploring-computational-thinking/

George, D. & Mallery, M. (2011). *SPSS for windows step by step: A simple study guide and reference.*

Thousand Oaks, CA: Sage.

Günbatar, M. S. (2019). Computational thinking within the context of professional life: Change in CT skill from the viewpoint of teachers. *Education and Information Technologies*, *24*(5), 2629-2652.

Haseskı, H. I., & İlıc, U. (2019). An investigation of the data collection instruments developed to measure computational thinking. *Informatics in Education*, *18*(2), 297.

Haseski, H. İ., İlic, U., Tuğtekin, U. (2017). Computational thinking in educational digital games: An assessment tool proposal. In H. Ozcinar, G. Wong, & H. T. Ozturk (Eds.), *Teaching computational thinking in primary education* (pp. 256–287). USA: IGI Global.

Haseski, H. İ., Ilic, U., & Tugtekin, U. (2018). Defining a new 21st century skill-computational thinking: Concepts and trends. *International Education Studies*, *11*(4), 29-42.

Ilic, U., Haseski, H. İ., Tugtekin, U. (2018). Publication trends over 10 years of computational thinking research. *Contemporary Educational Technology, 9*(2), 131–153

Israel, M., Pearson, J.N., Tapia, T., Wherfel, Q. M., & Reese, G. (2015). Supporting all learners in school-wide computational thinking: A cross-case qualitative analysis. *Computers & Education, 82*, 263-279.

ISTE. (2016, January 12). *CT leadership toolkit*. Retrieved from http://www.iste.org/ docs/ct-documents/ct-leadershipt-toolkit.pdf?sfvrsn=4

Kafai, Y. B. (2016). Education from computational thinking to computational participation in K-12 education seeking to reframe computational thinking as computational participation. *Communications of the ACM, 59*(8). https://doi.org/10.1145/2955114

Kafai, Y. B. & Burke, Q. (2013). Computer programming goes back to school. *Phi Delta Kappan*, *95*(1), 61-65.

Kafai, Y. B., & Resnick, M. (1996). *Constructionism in practice: Designing, thinking, and learning in a digital world*. Routledge.

Kalelioglu, F. (2018). Characteristics of studies conducted on computational thinking: A content analysis. In M. S. Khine (Ed.), *Computational thinking in the STEM disciplines* (pp. 11–29). Cham, Switzerland: Springer.

Kaučič, B., & Asič, T. (2011, May). Improving introductory programming with Scratch?. *2011 Proceedings of the 34th International Convention MIPRO* (pp. 1095-1100). IEEE.

Kazimoglu, C., Kiernan, M., Bacon, L., & MacKinnon, L. (2012). Learning programming at the computational thinking level via digital game-play. *International Conference on Computational Science*, 4-6 June. Omaha, Nebraska. 522–531.

Kline, P. (2000). *The handbook of psychological testing* (2nd ed.). London: Routledge.

Kim, H., Choi, H., Han, J., & So, H. (2012). Enhancing teachers' capacity for 21st century learning environment: Three cases of teacher education in Korea. *Australasian Journal of Educational Technology, 28*(6), 965–982.

Korkmaz, Ö. (2016). The effect of scratch-based game activities on students' attitudes, self-efficacy and academic achievement. *I.J. Modern Education and Computer Science, 1*, 16-23.

Korkmaz, Ö., Cakir, R., & Özden, M. Y. (2017). A validity and reliability study of the computational thinking scales (CTS). *Computers in Human Behavior*, *72*, 558-569.

Lye, S. Y., & Koh, J. H. L. (2014). Review on teaching and learning of computational thinking

through programming: What is next for K-12?. *Computers in Human Behavior, 41*, 51-61.

Maloney, J., Resnick, M., Rusk, N., Silverman, B., & Eastmond, E. (2010). The Scratch programming language and environment. *ACM Transactions on Computing Education (TOCE)*, *10*(4), 1-15.

Masterman, E., & Manton, M. (2011). Teachers' perspectives on digital tools for pedagogic planning and design. *Technology, Pedagogy and Education*, *20*(2), 227–246.

Mercimek, B., & İlic, U. (2017). An evaluation for update suggestıon of informatıon technologies and software course curriculum. *Academia Educational Research Journal, 2*(1), 1–9.

Moreno-León, J., Robles, G., & Román-González, M. (2015). Dr. Scratch: Automatic analysis of scratch projects to assess and foster computational thinking. *RED. Revista de Educación a Distancia,* (46), 1-23.

National Research Council. (2010). *Report of a workshop on the scope and nature of computational thinking*. Washington DC: The National Academies Press.

Onwuegbuzie, A. J., & Leech, N. L. (2006). Linking research questions to mixed methods data analysis procedures 1. *The qualitative report*, *11*(3), 474-498.

Özçınar, H. (2017). Bibliometric analysis of computational thinking. *Educational Technology Theory & Practice, 7*(2), 149-171.

Pallant, J. (2001). *SPSS survival manual*. Maidenhead, PA: Open University Press.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. NY: Basic Books.

Patton, Q. M. (1990). *Qualitative Evaluation and Research Methods* (2nd ed.), London: Sage Publication.

Paul, R. (1990). *Critical thinking*. In Rohnert Park. California: Sonoma State University

Pellas, N., & Peroutseas, E. (2016). Gaming in Second Life via Scratch4SL: Engaging high school students in programming courses. *Journal of Educational Computing Research, 54*(1), 108-143.

Peppler, K. A., & Kafai, Y. B. (2007). From SuperGoo to Scratch: Exploring creative digital media production in informal learning. *Learning, Media and Technology, 32*(2), 149-166.

Price, T. W., & Barnes, T. (2015). Comparing textual and block interfaces in a novice programming environment. *11th annual international conference on international computing education research* (pp. 91–99). Neveda, US: ACM.

Prottsman, C. L. L. (2011). *Computational thinking and women in computer science*. (Unpublished doctoral dissertation). University of Oregon.

Resnick, M., Kafai, Y., Maeda, J., Rusk, N., & Maloney, J. (2003). A networked, media-rich programming environment to enhance technological fluency at after-school centers in economically-disadvantaged communities. *Proposal to National Science Foundation*.

Roman-Gonzalez, M., Perez-Gonzalez, J. C., & Jimenez-Fernandez, C. (2017). Which cognitive abilities underlie computational thinking? Criterion validity of the Computational Thinking Test. *Computers in Human Behavior, 72*, 678-691.

Sengupta, P., Kinnebrew, J. S., Basu, S., Biswas, G., & Clark, D. (2013). Integrating computational thinking with K-12 science education using agent-based computation: A theoretical framework. *Education and Information Technologies, 18*(2), 351-380.

Shute, V. J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying computational thinking. *Educational Research Review, 22*, 142-158.

Snalune, P. (2015). The benefits of computational thinking. *ITNOW, 57*(4), 58–59.

Tan, L., & Kim, B. (2015). Learning by doing in the digital media age: The contention of learning in adolescents' literacy practices. In Lin, T., Chen, V., & Chai, C.S. (Eds.), *New media and learning in the 21st century: A sociocultural perspective* (Education Innovation in Singapore Series) (pp.181-197). Singapore: Springer.

Tissenbaum, M., Sheldon, J., & Abelson, H. (2019). From computational thinking to computational action. *Communications of the ACM*, *62*(3), 34-36.

Voskoglou, M. G., & Buckley, S. (2012). Problem solving and computers in a learning environment. *Egyptian Computer Science Journal, 36*(4), 28–46.

Werner, L., Denner, J., Campe, S., & Kawamoto, D. C. (2012). The fairy performance assessment: Measuring computational thinking in middle school. *43rd ACM technical symposium on computer science education* (pp. 215-220). ACM.

Wing, J. M. (2006). Viewpoint: Computational thinking. *Communications of the ACM, 46*(3), 33–35.

Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society of London a: Mathematical, Physical and Engineering Sciences, 366*(1881), 3717-3725.

Wolz, U., Stone, M., Pearson, K., Pulimood, S. M., & Switzer, M. (2011). Computational thinking and expository writing in the middle school. *ACM Transactions on Computing Education (TOCE)*, *11*(2), 1-22.

Yadav, A., Hong, H., & Stephenson, C. (2016). Computational thinking for all: Pedagogical approaches to embedding 21st century problem solving in k-12 classrooms. *TechTrends*, *60*(6), 565-568.

Yadav, A., Mayfield, C., Zhou, N., Hambrusch, S., & Korb, J. T. (2014). Computational thinking in elementary and secondary teacher education. *ACM Transactions on Computing Education (TOCE)*, *14*(1), 5.

Yağcı, M. (2019). A valid and reliable tool for examining computational thinking skills. *Education and Information Technologies*, *24*(1), 929-951.

Yıldırım, A., & Şimşek, H. (2011). *Qualitative research methods in social sciences* (8th ed.). Ankara: Seçkin.

YÖK (2018, March 14). *Rehberlik ve psikolojik danışmanlık lisans programı.* Retrieved from https://www.yok.gov.tr/Documents/Kurumsal/egitim_ogretim_dairesi/Yeni-Ogretmen-Yetistirme-Lisans-Programlari/Rehberlik_ve_Psikolojik_Danismanlik_Lisans_Programi.pdf

Author Information

Ulaş İlic

https://orcid.org/ 0000-0003-4213-8713

Pamukkale University

Turkey

Contact e-mail: *uilic@pau.edu.tr*