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Thematic Analysis of Studies on Computational Thinking in Education in Turkey and Abroad*

Neslihan Usta
[1] *Associate Professor, Department of Educational Sciences, University of Bartin*

Nihal Düzalan
[2] *Graduate Student, Department of Educational Sciences, University of Bartin*
Corresponding Author: Nihal Düzalan

ABSTRACT: *The problems become very complex in today's world, where technological and scientific developments gain continuity. In the advancing world, the education systems are transformed into another form, as the problems become more complex every day. Computational thinking (CT) is one of the basic skills required by the 21st-century. This study aims to analyze the studies (papers) on computational thinking in education in Turkey and abroad in a thematic framework. In order to achieve this aim, the scanning model, one of the descriptive research methods, was used. This method was selected due to the nature of the study, in which the current situation was evaluated. The research data consists of 33 Turkish and 34 international papers on computational thinking in education, written in Turkish and English, conducted in Turkey and abroad, published in scientific journals between 2012 and 2020. The "Review Form for Studies on Computational Thinking" was used as the data collection tool. Descriptive analysis was used in the analysis of the data. The papers suitable for the study were analyzed using the classification analysis technique. The papers were classified according to publication year, methodology, sample group, sample size, data collection tools, educational field, and addressed topic. Some of the results of the study are as follows. Especially since 2017, there has been a significant increase in the number of studies addressing computational thinking, both in Turkey and abroad. In Turkey, the number of studies conducted in educational fields other than Computer Technologies is limited. Abroad, most studies were conducted in mathematics. Mostly used methods in the papers are quantitative methods in Turkey and qualitative methods abroad. Analyzing CT according to various variables is the most popular topic in Turkey and abroad.*

KEYWORDS: *Computational thinking (CT), thematic analysis, education, mathematics education.*

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I. INTRODUCTION

Today's societies emphasize that students should acquire the skills such as computational thinking (CT), problem-solving and critical thinking, which are called 21st-century skills. Therefore, the most important qualification expected from students in this century is acquiring and using knowledge. In this context, solving problems and expanding the thinking framework by combining CT and technology is important for students (Uğur, 2019).

CT is a comprehensive mindset that includes several steps such as understanding the problem, estimation, abstraction, and problem-solving (Sengupta, Kinnebrew, Basu, Biswas, & Clark, 2013). Selby (2014) expressed CT as a special type of problem-solving. According to Curzon (2015), CT means problem-solving for people. CT is defined as having the knowledge, skills, and attitudes necessary to use computers in finding solutions to the problems encountered in daily life (Korkmaz, Çakır, & Özden, 2015). CT has various components, such as being decisive when dealing with difficult problems, self-confidence in addressing complex situations, going from the whole to the parts, and making the problem understandable (Weintrop, Holbert, Horn, & Wilensky, 2016).

The International Society for Technology in Education (ISTE, 2016) states "being a computational thinker" as one of the seven qualities students should possess in line with 21st-century skills. Therefore, CT skills are also needed for the success of today's student-centered programs. The need for CT skills is increasing for everyone, not just for computer scientists (Wing, 2006). Therefore, CT should be integrated into curricula in schools, students' CT skills should be improved, and basic courses covering CT applications should be a part of the curricula (Barr & Stephenson, 2011). Various attempts have been made to integrate CT into pre-school education; however, little is known about teaching CT to children in this age group (McGinnis, Hestness, Mills,

Ketelhut, Cabrera, & Jeong, 2020). Lavigne, Lewis-Presser, and Rosenfeld (2020) reported that some countries integrated CT skills for K-12 students in their curriculum. In their study at the University of Chicago, Lavigne et al. (2020) reorganized the curricula of Computer, English, History, Latin, and Graphics and Art courses to allow middle school and high school students to acquire CT skills. As a result of the study, the activities and assessment and evaluation methods also changed with the reorganization of the curriculum; the rote-based teaching-evaluation system was replaced by performance-based teaching, measurement, and evaluation system. Thus, the type of activities, assessment, and evaluation used in the lessons has also changed. At the end of the study, the researchers reported that a performance-based teaching and evaluation system replaced rote-based teaching. Israel, Pearson, Tapia, Wherfel, and Reese (2015) investigated how primary school teachers could integrate CT into teaching with limited computer science experience. They concluded that primary school teachers could plan and prepare activities to include CT in their lesson plans. Gonzalez, Gonzalez, and Fernandez (2016) conducted a study to suggest a definition of CT suitable for mathematics and science education. They identified the titles of this definition as modeling, system design, simulation, and problem-solving with CT. The data of the study were collected from the relevant literature and interviews conducted with scientists. They concluded that CT skills should be included in the mathematics and science curriculum. In addition, Barr and Stephenson (2011) conducted a study for the definition of CT to fill the gap between CT skills and educators. The study was also part of a project identifying the resources needed to integrate CT into the K-12 curriculum. As a result of their study, Barr and Stephenson (2011) reported that interdisciplinary application of basic CT concepts is possible.

Lye and Koh (2014) investigated how programming can be included in the primary school curriculum, CT's performances, and approaches to train students with this idea. The review of the studies showed that the use of visual programming tools that act with drag-and-drop logic might be more effective. Finally, Voogt, Fisser, Good, Mishra, and Yadav (2015) prepared a draft curriculum with CT skills. This curriculum addressed how to handle CT in education and the challenges in defining this concept.

Kirwan, Costello, and Donlon (2018) investigated how secondary school teachers can successfully teach CT and online learning. They conducted a literature review addressing CT and online learning together. As a result, the latest knowledge on how CT is taught online was outlined. They concluded that it is possible to design games, play video games, use non-visual-based programming language, and perform various activities to increase success in the online environment with CT.

As the interest in CT has increased in recent years, and its importance has been better understood, researchers have started to focus on CT. The definition of CT and various studies on CT are given in the previous paragraphs. However, the main purpose of this study is to examine the studies (papers) on CT in education in Turkey and abroad in a thematic framework. In addition, it is thought that this study will be useful in helping to review the literature involving the studies on CT in education in Turkey. Developed and developing countries have included or are considering including CT in their curricula in recent years. Hence, it is thought that it is important for Turkey to prioritize this issue in education and to include CT at every level of the curriculum. Therefore, conducting studies on CT is necessary for both teachers and academics who train teachers. The papers published in Turkish are very important for teachers, who are an important component of the education system in Turkey. The papers allow them to access the information about CT studies more easily, to understand it better, to show the applicability of CT, to suggest learning and teaching approaches, and to shape their teaching methods in the light of the information given in the studies, (Türkdoğan, Güler, Bülbül, & Danişman, 2015). For this reason, this study examines the papers on education, written in both Turkish and English, published in scientific journals, and included CT as a subject. The study addresses the following question: "What is the content of the scientific papers on CT in education, published in Turkey and abroad?". The sub-problems created to elaborate the study are listed below:

1. What are the publication years of scientific papers on CT published in Turkey and abroad?
2. Which method/methods have been used in scientific papers on CT published in Turkey and abroad?
3. What are the sample groups of scientific papers on CT published in Turkey and abroad?
4. What are the data collection tools used in scientific papers on CT published in Turkey and abroad?
5. How are the papers on CT published in Turkey and abroad distributed according to educational fields/disciplines?
6. How are the papers on CT published in Turkey and abroad distributed according to subject/purpose?

Kert, Yeni, and Şahiner (2017) state that although the concept expressed as "computational thinking" in foreign literature has a long history, there are still uncertainties regarding its boundaries. Uncertainties about definition and evaluation also emerged in finding the Turkish equivalent of the concept, and a common consensus could not be reached. As a result, various Turkish translations are used in the national literature (e.g.,

Aldağ and Tekdal, 2015; Barut, Tuğtekin and Kuzu, 2016; Çınar and Tüzün, 2017; Demir and Seferoğlu, 2017; Kalelioğlu and Gülbahar, 2015; MoNE, 2016, 2017; Korkmaz, Çatlak, Tekdal and Baz, 2015; Şahiner and Kert, 2017). The existence of domestication efforts is quite natural. Because, as Piaget said (Bringuier, 1980), the definition of concepts comes after creating the terms in scientific studies. In this study, "Bilgi İşlemsel Düşünme" is used as the Turkish equivalent of the concept of "computational thinking."

II. METHODOLOGY

This study examined the papers on CT in education, published in Turkey and abroad between 2012 and 2020, from a thematic perspective. Since the study evaluates the current situation, the scanning model, one of the descriptive research methods, was adopted because of the nature of the study. Descriptive analysis was used in the analysis of the data. Furthermore, the criterion sampling method, one of the purposeful sampling methods, was used in the study. Criterion sampling acts according to several predetermined criteria, and the cases that meet these criteria are included (Yıldırım & Şimşek, 2012). Similarly, Büyüköztürk (2012) states that in criterion sampling, the sample consists of people, objects, events, or situations possessing the characteristics that are set to be relevant to the research problem. The sample consists of 33 Turkish and 34 international papers written in Turkish and English and published in scientific journals. The papers reached in the study were analyzed by classification analysis according to publication year, methodology, sample group, sample size, data collection tools, educational field, and addressed topic.

The criteria used to determine the studies to be included in the study were as follows; covering CT in education, being published in Turkish or English, the papers published in Turkish contain the keywords "bilgisayarca düşünme, bilgisayarımsal düşünme, bilişimsel düşünme, hesaplamalı düşünme ve komputastonel düşünme" and the papers published in English contain the keyword "computational thinking." Another criterion for the studies is being open to access in the databases. The Turkish sample, which was created in line with the specified criteria, was formed by searching the keywords in the ULAKBİM National Academic Network, Google Scholar databases, and Google search engine in Turkish. The English sample was formed by searching the Google Scholar databases, Education Resources Information Center (ERIC) online digital library, and Google search engine in English. The papers of some journals whose full text is not available and published online were not included in the study due to their limitations.

A measurement tool was prepared to reveal the descriptive characteristics of the studies on CT and used as the data collection tool. This data collection tool was the "Review Form for Studies on Computational Thinking." Expert opinions were taken to ensure the validity and reliability of the prepared measurement tool. The papers were classified according to publication year, methodology, sample group, sample size, data collection tools, educational field, and addressed topic and concepts. A data matrix was created from the studies, and then descriptive outlines of the studies were created.

In order to ensure the validity of the study, all steps were carefully explained, and the information of 67 studies, 33 from Turkey and 34 from abroad, was given in detail. To ensure reliability, the papers from Turkey were randomly numbered from 1 to 33, and the papers from abroad from 1 to 34. First, the researcher and an expert academician coded the studies separately. Then, they came together to compare their coding, reached a consensus on different codes, and finalized the coding.

III. DISCUSSION

Being aware of the studies on CT is important for teachers and teacher candidates to organize and develop their education and training activities. In this context, knowing the results of teaching activities based on CT is necessary for educators at all levels of education, provided that CT's theoretical foundations and conceptual framework are known. For this reason, the thematic review of studies on CT within the existing literature in Turkey and abroad constitutes the subject of this study. It is of great importance that students acquire the CT skill, one of the 21st-century skills. Hence, the results of studies on CT in education will guide education. In Turkey, there is no study on CT in mathematics education. The number of studies is not sufficient. Therefore, the studies could not provide a driving force in fulfilling important tasks such as integrating CT into education and raising awareness in this context. Therefore, there is a need for more studies on CT in education. In Turkey, most studies were performed in Computer Technologies, and there is no study in other disciplines such as mathematics, physics, chemistry, and biology. The review of the studies conducted in educational sciences, science, basic education, guidance, and psychological counseling according to sample type, the method used, and the subject, showed that the number of studies is insufficient. Also, there is no study in mathematics education in Turkey; researchers consider this an issue that needs consideration.

The analysis of the studies included in this research in terms of data collection tools showed that mostly quantitative data collection tools were preferred in Turkey and qualitative data collection tools abroad. The doctoral thesis of Weinberg (2013), a study conducted abroad, revealed that data for CT evaluation was collected from questionnaires containing scales. This research found that the quantitative data were collected

mostly from scales in Turkey and questionnaires abroad. Grover (2015) states that more than one data collection tool should be used for complex subjects such as CT in different disciplines, which he refers to "assessment system." However, this research showed that researchers in Turkey preferred to use a limited number of data collection tools.

As a result of this study, it is suggested to carry out conceptual or practical studies on CT in various educational fields, especially in mathematics education. This research suggests that studies related to CT should be carried out in other disciplines and fields, especially in mathematics education, apart from Computer Technologies in Turkey.

IV. FINDINGS

The findings obtained from the study were explained by addressing the criteria and sub-problems of the study and supported by graphs. Table I and Table II, created according to the sub-problems, are given below. The graphs were created from these tables.

Table I. Studies on CT in Turkey (The studies included in the study are marked with * in the references.)

No	Author and publication year	Methodology	Sample Group	Sample Size	Data collection tools	Educational field	Addressed Topic and Concepts
1*	İbili & Günbatar (2020)	Quantitative	Secondary school students	332	The Self-Efficacy Perception Scale for Computational Thinking Skill	Computer Sciences	CT and self-efficacy perception
2*	Gülbahar, Kalelioğlu, Doğan & Karataş (2020)	Qualitative	Secondary school students	97494	Bilge Kunduz (Bebras) activities	Computer Sciences	Learning approach/ teaching process
3*	Kaya, Korkmaz & Çakır (2020)	Quantitative	Secondary school students	51	Reflective Thinking Skill towards Problem Solving Scale, Computational Thinking Scale.	Computer Sciences	The effect of programming, software and models on CT skills
4*	Oluk, Korkmaz & Oluk (2018)	Quantitative	Secondary school students	62	Computational Thinking Scale, Algorithm Development Achievement Test	Computer Sciences	The effect of programming, software and models on CT skills
5*	Aydoğdu (2020)	Quantitative	University students	29	Computer Programming Self-Efficacy Scale, Computational Thinking Skill Scale	Computer Sciences	The effect of programming, software and models on CT skills
6*	Adsay, Korkmaz, Çakır & Uğur Erdoğmuş (2020)	Mixed	Secondary school students	202	Self-efficacy Perception Scale of Block Based Programming, Computational Thinking Ability Levels Scale and Basic STEM Skill Levels Scale, semi-structured interview form	Computer Sciences	CT skill levels
7*	Erümit, Şahin & Karal (2020)	Qualitative	Secondary school students	38	Computational Thinking Scale	Computer Sciences	The effect of programming, software and models on CT skills
8*	İbili, Günbatar & Sırakaya (2020)	Quantitative	High school students	591	Computational Thinking Scale	Computer Sciences	Analysis of CT according to various variables
9*	Akgün (2020)	Quantitative	University students	365	Preservice Teacher's Information and Communication Technology Competencies Scale, Computational Thinking Scale	Educational Sciences	Analysis of CT according to various variables
10*	Tosik Gün & Güyer (2019)	Qualitative	-	-	47 studies (These studies were examined in detail according to i) the most	Computer Sciences	Analysis of CT according to various variables

					evaluated CT components, ii)data collection methods, iii)data analysis methods, iv)content of data collection tools, v)audience, and vi)validity and reliability studies.)		
11 *	Batı, Çalışkan & Yetişir (2017)	Qualitative	-	-	-	Natural Sciences	Analysis of CT according to various variables
12 *	Atman Uslu, Mumcu & Eğin (2018)	Mixed	Secondary school students	55	Computational Thinking Skill Scale, semi-structured interview form	Computer Sciences	The effect of programming, software and models on CT skills
13 *	Üzümcü & Bay (2018)	Qualitative	-	-	12 theses, 35 scientific publications (articles and papers) In this study, in which the document review method was preferred, data obtained from reliable sources such as relevant articles, theses and websites of world-renowned institutions and organizations were used.	Basic Education	Analysis of CT according to various variables
14 *	Gülbahar, Kert & Kalelioğlu (2019)	Quantitative	Secondary school students	692	Self-efficacy Perception Scale For Computational Thinking Skill	Computer Sciences	Scale development/adaptation
15 *	Akçay, Karahan & Türk (2019)	Qualitative	Primary school	30	Semi-structured interviews, Participant Observation Reports	Educational Sciences	Learning approach/ teaching process
16 *	Yağcı (2018)	Qualitative	High school students	445	Computational Thinking Skills Scale	Computer Sciences	Analysis of CT according to various variables
17 *	Özçınar & Öztürk (2017)	Qualitative	University students	378	The Scale Of Self-efficacy Perception Towards Teaching Computational Thinking	Computer Sciences	Scale development/adaptation
18 *	Korkmaz, Çakır, Özden, Oluk & Sarıoğlu (2015)	Qualitative	University students	1306	Computational Thinking Skills Scale	Computer Sciences	Analysis of CT according to various variables
19 *	Çakır & Yaman (2018)	Quantitative	Secondary school students	53	Computational Thinking Scale, Academic Achievement Test	Natural Sciences	CT skill levels
20 *	Şahiner & Kert (2016)	Qualitative	-	-	22 papers	Computer Sciences	Analysis of CT according to various variables
21 *	Kirmit, Dönmez & Çataltaş (2018)	Quantitative	Secondary school students	59	Computational Thinking Skills Scale	Computer Sciences	Analysis of CT according to various variables
22 *	Oluk & Çakır (2019)	Quantitative	University students	237	Computational Thinking Skill Levels Scale, Logical Mathematical İntelligence Self-perception Scale, Problem-solving İnventory	Computer Sciences	Analysis of CT according to various variables
23 *	Güler & Dinci (2019)	Quantitative	Secondary school students	292	Computer Thinking Scale (For Secondary Level), Kolb Learning Style Inventory	Computer Sciences	Analysis of CT according to various variables
24 *	Dolmacı & Akhan (2020)	Qualitative	University students	510/ 254	Computational Thinking Skills Scale	Educational Sciences	Scale development/adaptation
25 *	Çiftci, Çengel ve Paf (2018)	Quantitative	University students	166	Preservice Teacher's Information and Communication Technology Competencies Scale, Computational Thinking Scale	Computer Sciences	CT and self-efficacy perception
26 *	Korkmaz, Çakır & Özden (2015)	Qualitative	Secondary school students	241	Computational Thinking Levels Scale	Computer Sciences	Scale development/adaptation

27 *	Özçınar (2017)	Quantitative	-	-	451 Papers (document co-citation analysis, author co-citation analysis and word frequency analysis)	Computer Sciences	Bibliometric analysis
28 *	Kert, Yeni & Şahiner (2017)	Qualitative	-	-	Relational Model Sheme (based on interational literature review)	Computer Sciences	Analysis of CT according to various variables
29 *	Kılıç, Korkmaz, Çakır & Uğur Erdoğmuş (2019)	Mixed	High school students	106	Computational Thinking Skills, Perception Oriented STEM Skill Levels, Self-Efficacy Perception Oriented Programming	Computer Sciences	Identifying the perception of CT skills, programming, and STEM skill levels
30 *	Çakır, Adsay & Akgül Uğur (2019)	Mixed	Secondary school students	64	Activity Experience Scale, Computational Thinking Skills Scale, Spatial Visualization Test	Computer Sciences	The effect of programming, software and models on CT skills
31 *	Alsancak Sırakaya (2019)	Quantitative	University students	54	Computational Thinking Scale	Computer Sciences	The effect of programming, software and models on CT skills
32 *	Sarıtepeci (2017)	Quantitative	High school students	122	Computational Thinking Skills Scale, Problem Solving Scale	Educational Sciences	Analysis of CT according to various variables
33 *	Yünkül, Durak, Çankaya & Mısırlı (2017)	Quantitative	Secondary school students	69	Computational Thinking Scale, Exam of the Course of Information, Communication Technologies and Software	Computer Sciences	The effect of programming, software and models on CT skills

Table II. Studies on CT abroad (The studies included in the study are marked with * in the references.)

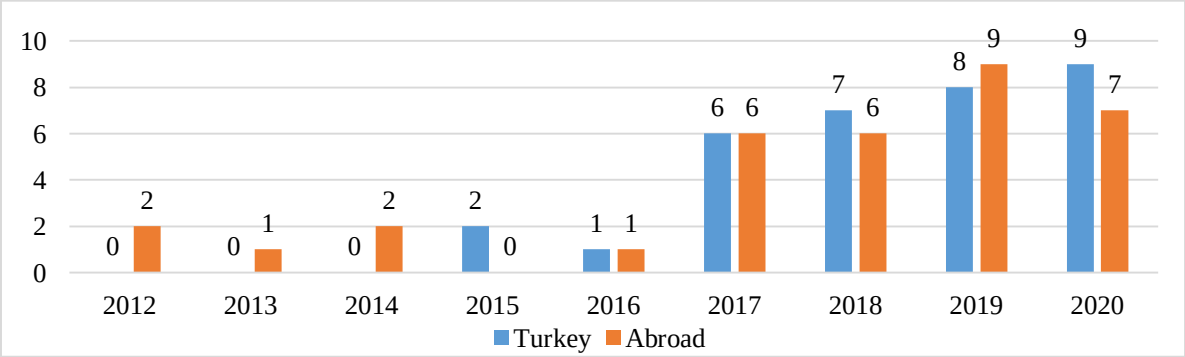
No	Author and Publication Year	Methodology	Sample Group	Sample Size	Data collection tools	Educational field	Addressed Topic and Concepts	Country
1*	Maharani, Nusantara, As'ari & Qohar (2019)	Qualitative	University students	3	Observation	Mathematics	Analysis of CT according to various variables	Indonesia
2*	McGinnis, Hestness, Mills, Ketelhut, Cabrera & Jeong (2020)	Qualitative	University students	39	Documents, activities, interview	Computer Sciences	Belief about CT	America
3*	Barcelos & Frango Silveira (2012)	Qualitative	-	-	-	Mathematics	Learning approach/ teaching process	Brazil
4*	Lavigne, Lewis-Presser & Rosenfeld (2019)	Qualitative	Pre-school students	25	Observation	Basic Education	Analysis of CT according to various variables	America
5*	Rodríguez-Martínez, González-Calero & Sáez-López (2018)	Quantitative	Secondary school students	47	Computational Thinking Test, Mathematical Knowledge Test	Mathematics	Analysis of CT according to various variables	Spain
6*	Lee, Han & Cho (2014)	Qualitative	-	-	-	Mathematics	Model development/project design	Korea
7*	Sanford & Naidu (2017)	Qualitative	-	-	71 Articles	Mathematics	Analysis of CT according to various variables	America
8*	Barcelos, Munoz, Villarroel, Merino & Silveira (2018)	Qualitative	-	-	42 Articles	Mathematics	CT and math	Brazil & Chile
9*	Voskoglou (2013)	Quantitative	University students	85	10 Problems	Mathematics	Model development/project design	Greece
10 *	How & Looi (2018)	Qualitative	-	-	Python Programming Language	Mathematics	The effect of programming, software and models on CT skills	Singapore
11	Sinclair & Patterson	Qualitative	Secondary	10	Project datas	Mathematics	CT and math	Canada

*	(2018)		and high school students					& India
12 *	Israel & Lashb (2019)	Qualitative	Teachers	13	Lesson Plans	Mathematics	Model development/project design	America
13 *	Pei, Weintrop & Wilensky (2018)	Qualitative	High school students	16	Video recording, Pre-post semi-structured interview	Computer Sciences	Analysis of CT according to various variables	America
14 *	Rich, Yadav & Schwarz (2019)	Qualitative	Teachers	12	Semi-structured interview	Basic Education	Analysis of CT according to various variables	America
15 *	Gadanidis, Cendros, Floyd & Namukasa (2017)	Qualitative	University students	143	Training of the participants in classroom and training of the participants by means of a homework	Mathematics	CT and problem solving	Brazil
16 *	Gadanidis, Clements & Yiu (2018)	Qualitative	Teachers and secondary school students	19-415	Photos, written reflections by children, written reflections by teachers, and parent comments	Mathematics	Model development/project design	London & America
17 *	Aminger, Hough, Roberts, Meier, Spina, Pajela, McLean & Bianchini (2020)	Qualitative	University students	6	edTPA (teacher performance assessment) lessons—including their written commentaries, video-recorded lesson excerpts,	Natural Sciences	Analysis of CT according to various variables	America
18 *	Sari, Marwan ve Hajidin (2019)	Qualitative	Religious school students	106	Various tests, observation	Mathematics	CT and problem solving	Endonezya
19 *	Mardi (2020)	Qualitative	Postgraduate students	-	Survey	Mathematics	Model development/project design	America
20 *	Costa, Campelo & Sampaio Campos (2019)	Quantitative	-	-	402 math questions	Computer Sciences	Model development/project design	Brazil
21 *	Maharani, Kholid, Pradana & Nusantara (2019)	Qualitative	University students	30	A math problem	Mathematics	CT and problem solving	Indonesia
22 *	Liu, Zhi, Hicks & Barnes (2017)	Quantitative	Secondary school students	22	Survey, activities	Computer Sciences	CT and problem solving	America
23 *	Bagley & Rabin (2016)	Qualitative	University students	8	Observation	Mathematics	CT and problem solving	America
24 *	Promraksa, Sangaroon & Inprasitha (2014)	Qualitative	Primary school students	-	Observation, videotape analysis	Mathematics	Analysis of CT according to various variables	Thailand
25 *	Rich, Spaepenb, Strickland & Moran (2020)	Qualitative	Pre-school and primary students	-	K-5 Common Core State Standards for Mathematics	Computer Sciences	Analysis of CT according to various variables	America
26 *	Weese & Feldhausen (2017)	Quantitative	Secondary school students	381	Survey	Computer Sciences	Analysis of CT according to various variables	America
27 *	Romero, Lepage, & Lille (2017)	Quantitative	University students	120	Activities	Computer Sciences	Analysis of CT according to various variables	America
28 *	Chongo, Osman & Nayan 2020	Quantitative	Secondary school students	128	Survey, various tests	Mathematics	Analysis of CT according to various variables	Malaysia
29 *	Benakli, Kostadinov, Satyanarayaa & Singh (2017)	Quantitative	University students	-	Survey	Mathematics	Promoting the use of CT	America
30	Bråting & Kilhamn	Qualitative	Primary	-	Activities	Mathematics	CT and math	Sweden

*	(2020)		and secondary school students					
31	Waterman, Goldsmith & Pasquale (2019)	Qualitative	-	-	-	Basic Education	Analysis of CT according to various variables	America
32 *	Reichert, Barone & Kist (2020)	Qualitative	Teachers	28	observation, logbook records, recordings, photographs	Mathematics	Analysis of CT according to various variables	Brazil
33 *	Gero, Tsybulsky & Levin (2019).	Qualitative	-	-	-	Mathematics	CT and math	Israel
34 *	Soman, Krishnan & Sowmya (2012)	Qualitative	-	-	-	Mathematics	Improving CT	India

The general information of 67 studies is shown in Table I and Table II in a general framework. Some studies were based on literature review, environment design, model development, modeling, document review, document analysis, publication co-citation analysis, author co-citation analysis, and word frequency analysis. Therefore, their sample group and sample sizes are not shown. The analysis results of the sub-problems are given below.

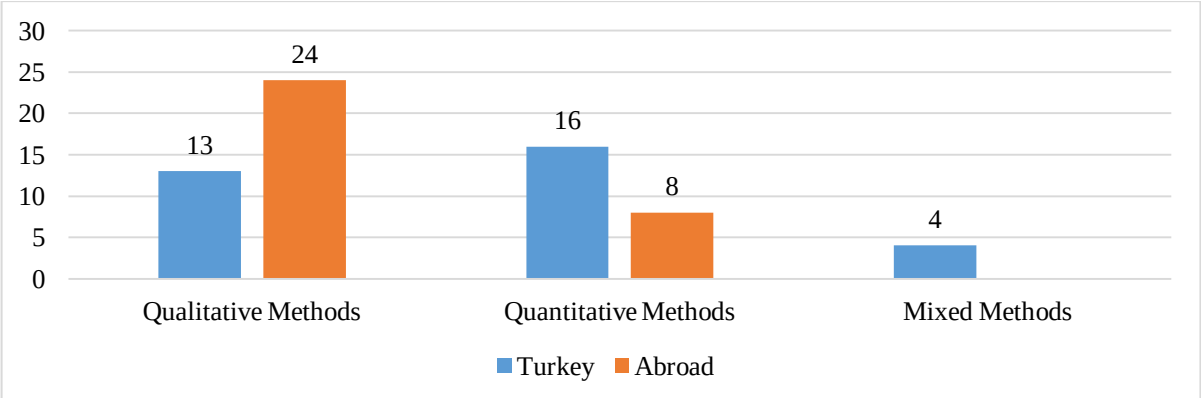
1. What is the publication year of scientific papers on CT published in Turkey and abroad?



Graphic 1. Publication year of published in Turkey and abroad

Graphic 1 shows the publication years of scientific papers published in Turkey and abroad. The first study on this subject in Turkey belongs to 2015. Regarding Graphic 1, the number of studies on CT in Turkey has tended to increase in recent years. There were 3 studies in 2015 and 2016 in Turkey, whereas 30 were found between 2017 and 2020. On the other hand, it can be seen from Graphic 1 that studies on CT have started earlier abroad. There are 5 studies conducted abroad on the subject between 2012-2014 and 1 between 2015-2016. 28 studies were found between 2017 and 2020, almost equal to the number of studies in Turkey between these years. This fact shows that CT has been studied abroad in recent years and has been researched more in Turkey.

2. Which method/methods have been used in scientific papers on CT published in Turkey and abroad?

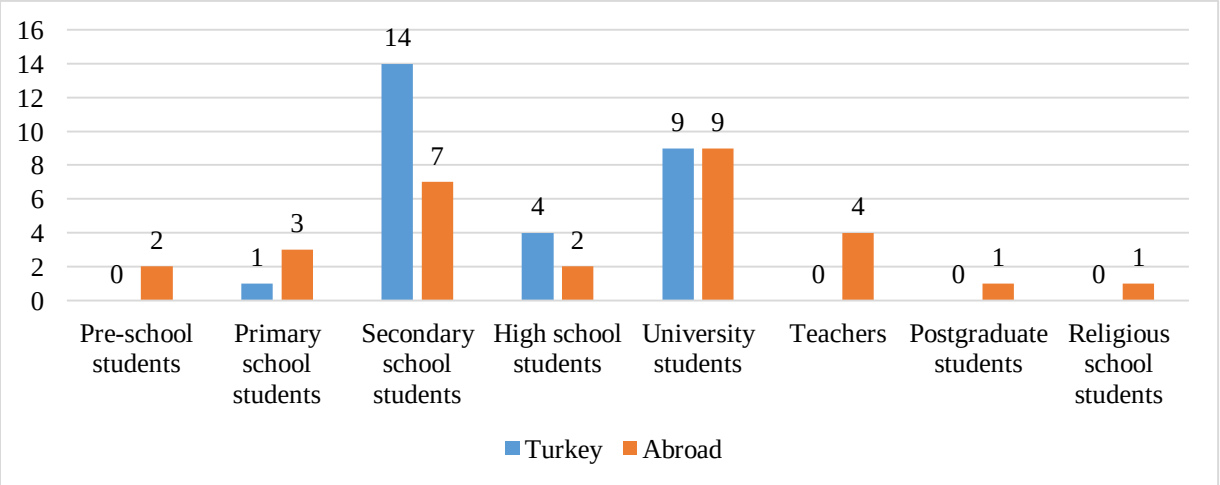


Graphic 2. The method/methods used in scientific papers published in Turkey and abroad

Graphic 2 shows the methods used in papers on CT published in scientific journals. According to Graphic 2, the most used method in Turkey and abroad is qualitative methods with 37 papers. Quantitative methods were used

in 24 papers, and mixed methods were used in 4 papers. Qualitative methods were more used abroad, and quantitative methods in Turkey. No study using mixed-method and conducted abroad was found within the ones meeting specified criteria.

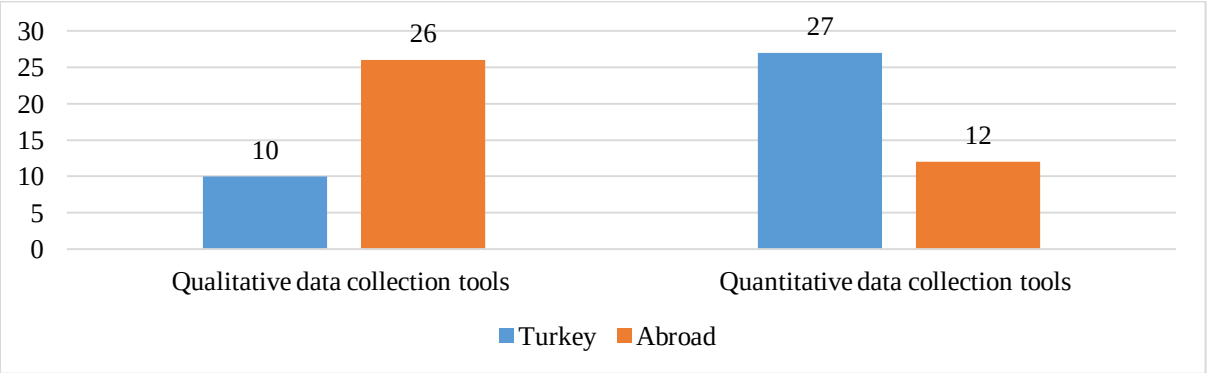
3. What are the sample groups of scientific papers on CT published in Turkey and abroad?



Graphic 3. Sample groups of scientific papers published in Turkey and abroad

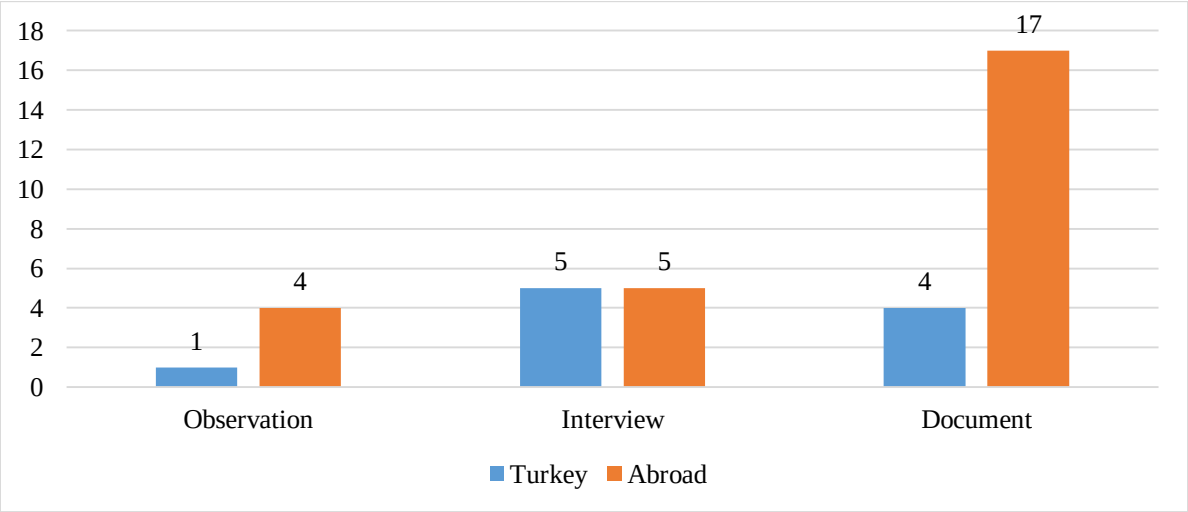
Graphic 3, shows the sample groups of the scientific papers published on CT in education. Regarding the sample groups, the studies were mostly conducted with secondary school students. According to Graph 3, 21 studies, 14 from Turkey and 7 abroad, were conducted with secondary school students. 18 studies, 9 from Turkey and 9 abroad, were conducted with university students. 5 studies from Turkey and 3 abroad were conducted with teacher candidates in the sample group of university students (see Table I and Table II). 4 studies were carried out with teachers abroad; however, no study was conducted with teachers in Turkey. Similarly, few studies were conducted with postgraduate, religious school, and pre-school students abroad; however, no studies were conducted with students representing these sample groups in Turkey. According to Graphic 3, the sample group in which most studies were conducted in Turkey is secondary school students, followed by university and high school students. On the other hand, Graphic 3 shows that various studies are carried out abroad with students at all levels of education, mostly with secondary school, university, and high school students, and with a small number of teachers.

4. What are the data collection tools used in scientific papers on CT published in Turkey and abroad?



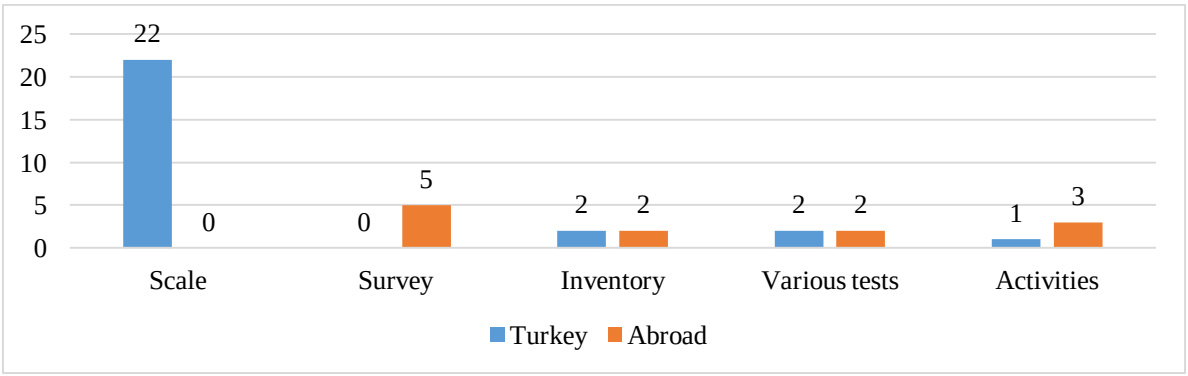
Graphic 4. Data collection tools used in scientific papers published in Turkey and abroad

Graphic 4 shows the data collection tools used in scientific papers on CT in education published in Turkey and abroad. Accordingly, 36 qualitative data collection tools were used, 10 in Turkey and 26 abroad. Similarly, 39 quantitative data collection tools were used, 27 in Turkey and 12 abroad. More quantitative data collection tools were used in scientific papers published in Turkey, whereas qualitative data collection tools were more used abroad. Besides, some studies used more than one data collection tool (see Table I and Table II). Especially in qualitative studies, more than one research method is used to prove the validity of the data and the accuracy of the results, depending on the characteristics of the sample group and the research topic (Yıldırım and Şimşek, 2008: 88). Qualitative and quantitative data collection tools used in scientific papers are detailed in Graphic 5 and Graphic 6.



Graphic 5. Qualitative data collection tools used in scientific papers published in Turkey and abroad

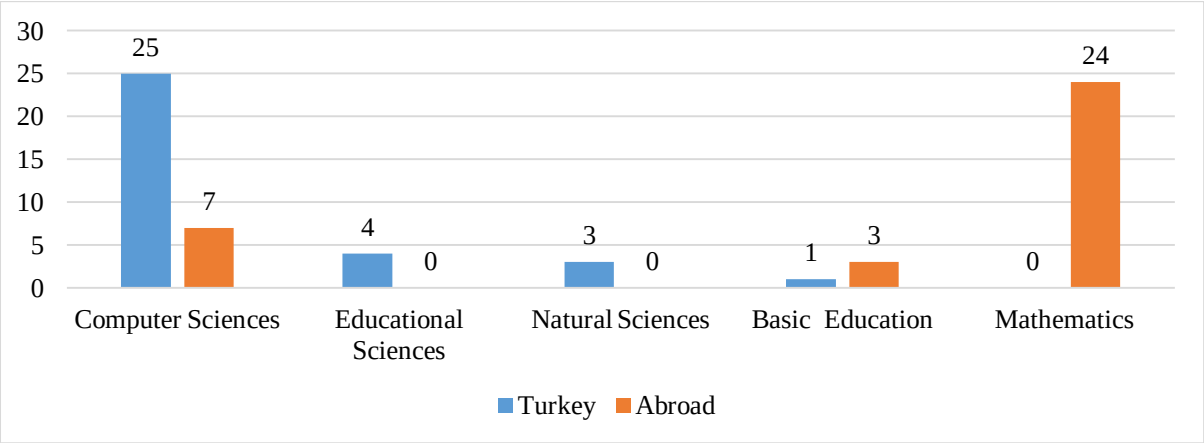
Graphic 5 shows the qualitative data collection tools used in scientific papers published in Turkey and abroad. The most common data collection tools in qualitative research were observation, interview, and document (Karataş, 2015). Marshal (2016), Savenye & Robinson (2004) grouped all documents, including printed materials, visual and audio documents, web pages, and blogs, as documents in a general framework. Therefore, data collection tools such as software programs, photographs, end-of-term exams, concept maps, and lesson plans were included in the document category. The interview method was used more in Turkey, and documents were mostly used abroad. There is only 1 study in Turkey where the observation method was used, whereas there were 4 studies abroad. Similarly, document analysis, a qualitative data collection tool, was quite rare in Turkey; however, according to Graphic 5, qualitative studies conducted abroad mostly used this method.



Graphic 6. Quantitative data collection tools used in scientific papers published in Turkey and abroad

Graphic 6 shows the quantitative data collection tools used in scientific papers published in Turkey and abroad. Accordingly, many scale development/adaptation studies were performed in Turkey, whereas there was no scale development/adaptation study among the papers from abroad. As shown from Graphic 5 and Graphic 6, mostly qualitative data collection tools were used abroad. On the other hand, quantitative data collection tools were limited to surveys, inventory, various tests, and activities.

5. How are the papers on CT published in Turkey and abroad distributed according to educational fields/disciplines?



Graphic 7. The distribution of the papers on CT published in Turkey and abroad according to educational fields/disciplines

Graphic 7 shows the number of studies on CT conducted in different educational fields/disciplines in Turkey and abroad. Accordingly, most of the studies conducted in Turkey belong to computer science. In contrast, there is no study in mathematics education. Regarding the studies conducted in computer sciences, 7 studies have been carried out in educational sciences and natural sciences. Abroad, most studies were conducted in mathematics education, followed by computer science. Graphic 7 shows that there are not many studies on CT in Turkey in different fields of education other than computer science. Information Technologies and Software Curriculum (2018), which has been put into practice in 2018 for secondary schools in Turkey, includes the concepts and dimensions of CT, which may be one reason why most studies have been performed in computer science in Turkey. Besides, the definition and concepts of CT are not included among the achievements of the Secondary School Mathematics Curriculum in Turkey (2018). This may be an obstacle to attracting the attention of researchers and mathematics educators to CT. In addition, although the concept of CT was based on the views of Seymon Papert (1980), it has attracted attention for the last two decades with the definition of Wing (2006). Since this concept has not yet gained the place it deserves in education programs, sufficient studies on CT have not been carried out in Turkey. These statements reflect a perspective that emerges from the researchers' studies and observations. Further studies investigating the reasons for the lack of adequate studies in education on CT in Turkey and presenting evidence-based data are recommended.

6. How are the papers on CT published in Turkey and abroad distributed according to subject/purpose?

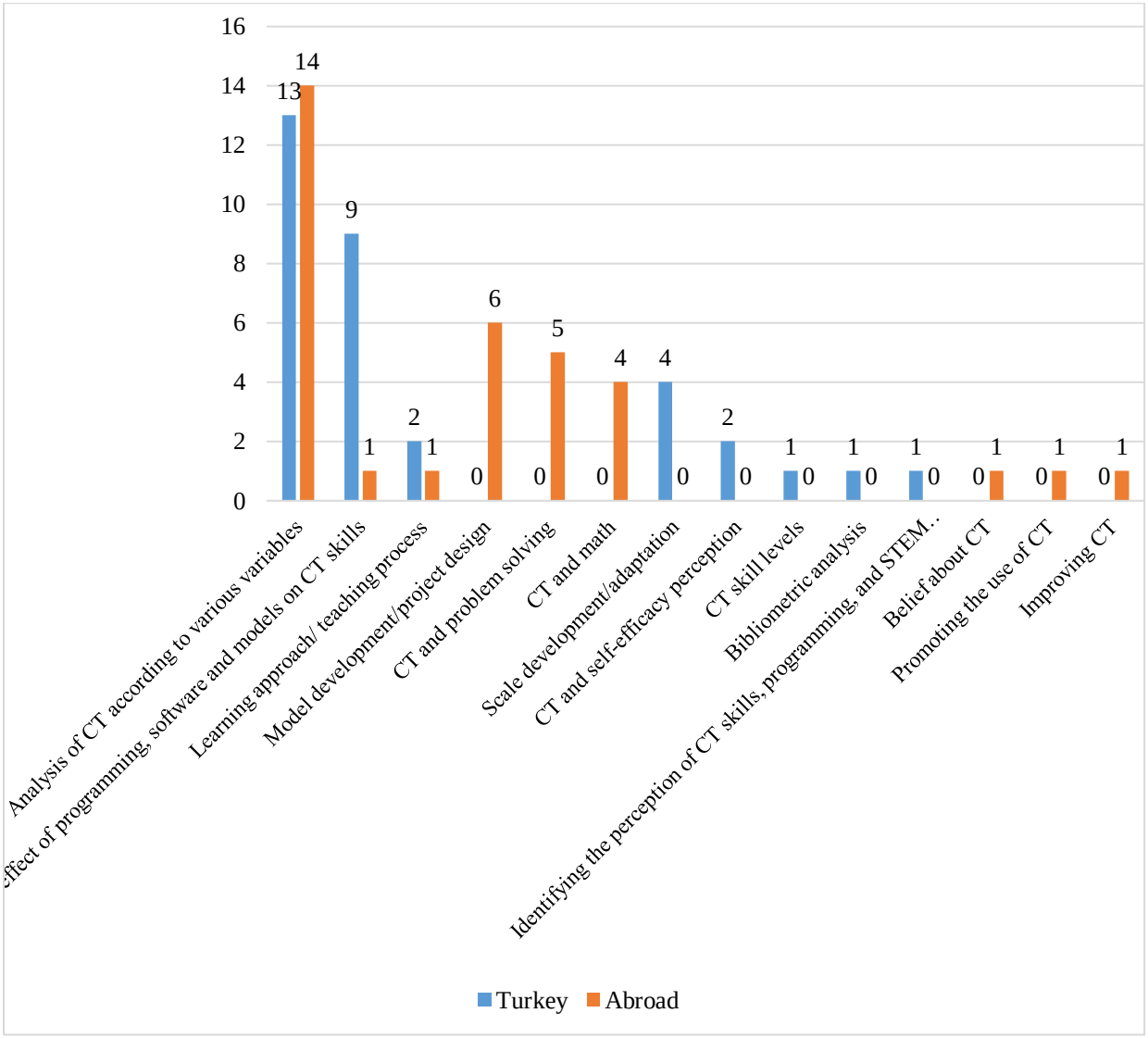
Table III. The distribution of the papers on CT published in Turkey and abroad according to subject/purpose

Number of Studies		**Subject of Studies**
Turkey	**Abroad**	
13	14	Analysis of CT according to various variables
9	1	The effect of programming, software and models on CT skills
2	1	Learning approach/ teaching process
-	6	Model development/project design
-	5	CT and problem solving
-	4	CT and math
4	-	Scale development/adaptation
2	-	CT and self-efficacy perception
1	-	CT skill levels
1	-	Bibliometric analysis
1	-	Identifying the perception of CT skills, programming, and STEM skill levels
-	1	Belief about CT
-	1	Promoting the use of CT
-	1	Improving CT

Table III shows the distribution of scientific papers on CT in education published in Turkey and abroad between 2012 and 2020 according to their subjects/purposes. Regarding Table III, the studies conducted in Turkey and abroad generally examine CT according to various variables, examine the effects of programming, software, and models on CT skills, evaluate learning approaches towards CT and the CT teaching process. Accordingly, most of the scientific papers published in Turkey and abroad focused on analyzing CT according

to certain variables. The papers satisfying specified criteria generally analyzed CT skills of gifted students and primary, secondary, and high school students according to school type and department, grades and graduation, ages, genders, access to technology, daily technology usage, and problem-solving skill levels. On the other hand, some studies in Turkey examined the relationship between learning styles and CT skills and university students' CT skills within the framework of logical-mathematical intelligence and problem-solving skills (see Table I). There are very few studies that include a systematic literature review about evaluating CT skills in Turkey. Again, Table III shows that the studies examining the effects of various programs, software, and models on CT skills (mostly performed in computer science) are quite high compared to other subjects. The effect of the gamified educational robot, visual programming and block-based programming activities on CT skills, the effect of flipped classroom model and web 2.0 software on CT skills, the effect of Scratch software on CT skills, the effect of programming training and PAP teaching model on CT skills were examined in Turkey. Regarding abroad, only 1 study investigated the effect of Scratch on CT.

On the other hand, the studies involving learning approaches related to CT, model development or project designs, and explaining the teaching process of CT were conducted abroad more than in Turkey. In addition, the studies associating problem-solving skills, which is considered one of the basic skills of the 21st century and necessary, and CT skills were conducted abroad, which can be considered one of the indicators of the importance given to CT. Today, some studies revealed the relationship between CT and mathematics education, indicating that CT is an interdisciplinary field closely related to other fields such as mathematics (see Table II). Moreover, various studies in which CT is encouraged, focusing on the development of CT and the beliefs about CT, were performed abroad. Some examples of them are the studies involving the activities that support CT, examining students' mathematical predictions and the characteristics of CT, evaluating the synergies and differences between CT and mathematical thinking, comparing the dimensions of mathematical thinking with the dimensions of CT, assessing the confidence level of STEM program regarding CT skills, analyzing the relationship of CT skills with gender and mathematics achievement. Graphic 8 shows the subject areas of the studies on CT in education in Turkey and abroad.



Graphic 8. Subject areas of the scientific papers on CT in education published in Turkey and abroad

As can be seen from Graphic 8 there are 2 studies involving the learning approach/teaching process in Turkey and 4 studies abroad. According to Graph 8, the subjects of the studies conducted in Turkey are as follows: 4 scale development/adaptation studies, 2 self-efficacy perceptions studies, 1 study on CT skill level, 1 bibliometric analysis, and 1 perception determination study for CT and programming and STEM skills. However, there is no study abroad on these subjects.

Again, according to Graphic 8, the subjects of the studies conducted abroad are as follows: 6 studies on model development/project design, 5 CT and problem-solving studies, 4 CT and mathematics studies, 1 study on beliefs about CT, 1 study on promoting the use of CT and 1 study on improving CT. However, there is no study conducted in Turkey on these subjects. Finally, the studies on CT and learning mathematics, exploring dynamic geometry environments, creating difference equations with a spreadsheet, and examining the relationship between CT and algebraic thinking have been conducted abroad (see Table II).

V. CONCLUSION

This study examined the studies on CT in education in Turkey and abroad in a thematic framework. The study's data source consisted of 33 Turkish and 34 international papers on CT in education written in Turkish and English and published in scientific journals between 2012 and 2020. The papers were classified according to publication year, methodology, sample group, sample size, data collection tools, educational fields, and addressed topics. The results of the research can be outlined as follows:

- There is a significant increase in the number of studies on CT both in Turkey and abroad, especially since 2017.

- Most of the studies on CT in mathematics have been carried out abroad.
- In Turkey, the number of CT studies in other fields other than Computer Technologies is very few.
- The methods mostly used in the papers published in scientific journals on CT in education are quantitative methods in Turkey and qualitative methods abroad.
- Examining CT in terms of various variables is at the top of the common topics in Turkey and abroad.

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