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A Systematic Analysis on Graduate Theses Published in The Field of Computer Programming in K-12 Education Between 2018 and 2022

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This study is designed to reveal the research trends of graduate theses published in the field of computer programming in K-12 between 2018 and 2022. Document analysis was used for data collection in this study. The data was divided into 9 categories, and the results demonstrated that the scholars in the Departments of Computer Educational and Instructional Technologies (CEIT) at Atatürk University and Ondokuz Mayıs University of Türkiye mainly published master's theses in this field in 2019. Another result was that though CEIT is also the main department for doctoral theses, no difference exists in terms of years or universities. "Teaching, learning, and training programming" and "computational thinking" are the most frequently used keywords in graduate programs, respectively. While quantitative and mixed method (parallel, convergent), convenience sampling, and psychometric scales are preferred in master's theses, mixed method (explanatory, mixed), purposive sampling, interviews/focus group interviews, and psychometric scales are preferred in doctoral theses, respectively. Observation and semi-structured interview forms are used as data collection tools in the theses. Although quantitative methods are mainly utilized in data analysis, parametric and non-parametric statistical tests are also used, and content analysis is resorted to as part of qualitative methods. Whilst validity and reliability studies have been carried out measurement tools

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are employed in master's theses, scales have been developed in doctoral theses. The present study also offers some suggestions for future research on teaching computer programming.

Introduction

Rapidly developing technology has an important place in the field of education as well as in all areas of our lives. The inclusion of technology in the field of education has led to the inclusion of Information Technologies and Software and Computer Science courses among the courses taught in schools. The Information Technologies and Software course was added to the list of compulsory courses in secondary schools while the Computer Science course was added to the list of compulsory courses in high schools (MoNE, 2017). The curricula of these courses were updated in 2018, and most of the updated programs include algorithms and programming subjects (MoNE, 2018).

The skills that today's students should have been generally expressed as 21st-century skills. These skills can be listed as problem-solving, questioning, decision-making, collaborative work, entrepreneurship, and critical thinking (Engin & Korucuk, 2021). Rapid developments in technology have also required skills such as internet, media, and technology literacy in addition to the skills called 21st-century skills. Today's students are expected to be individuals equipped with these skills by using technology effectively and efficiently. Various studies emphasize the importance of providing students with these skills and that one of the methods that can be used to achieve these skills is computer programming courses (Akpınar & Altun, 2014; Çakıroğlu, Sarı & Akkan, 2011). Akpınar and Altun (2014) reported that computer programming courses enhance students' motivation for the course and their digital literacy levels.

As cited by Konan (2020), “*Programming not only allows computer technology to be used in solving a problem but also allows individuals to look at the problem from a larger perspective and come up with creative ideas for the solution*”. Programming skills come with knowledge and skills that make people's lives easier (Gülbahar, 2017). Teaching programming is highly crucial in gaining these skills, especially in today's world, where 21st-century skills are gaining importance. Studies show that programming contributes positively to the acquisition of skills such as computational thinking (Ünsal, 2020), problem-solving (Alp, 2019), critical thinking (Çelik, 2019), and creative thinking (Tiryaki, 2020).

The individual who learns how to program implements the problem-solving steps in his own mind while teaching the computer what to do. In such a process, the individual solves a problem step by step and could think algorithmically. Fesakis and Serafeim (2009) emphasize that a person who can write a computer program develops creative thinking skills by realizing systematic thinking, problem-solving, and relationships. In Türkiye, various programming activities are used intensively at primary, secondary, and high school levels, both within the framework of official curriculums and within the scope of supplementary activity courses. Currently, schools in Türkiye are designed in a manner to develop entrepreneurship skills as well as to ensure that children gain skills by using visual programming tools such as Small Basic, Scratch, Alice, and App Inventor. It is possible to say that important studies are carried out at all educational levels in fields such as programming, design, coding, robotics, etc. in Türkiye (Mumcu, Atman Uslu & Yıldız, 2022). In addition, students' efforts are supported by institutions such as Scientific and Technological Research Council of Türkiye (TUBİTAK), which reward successful students and teachers with various competitions and festivals (Kaya, Taşlı, Kök & Kuruöz, 2022). Therefore, computer programming is appreciated by state

administrators and all kinds of creative ideas and products thought to have the potential in contributing economically to the country in the future are honoured in different ways.

There has been an increasing number of academic studies on programming teaching in Türkiye recently (Gökçearslan & Alper, 2015; Kukul, Gökçearslan & Günbatar, 2017). Çatlak, Tekdal, and Baz (2015) scrutinized the use of Scratch software in programming teaching in their document review studies and analyzed 32 articles published between 2007 and 2015 through a literature review. Benzer and Erumit (2017) carried out an analysis of graduate theses related to teaching programming and collected 29 theses published between 2008 and 2017 through a review on the thesis centre of the Council of Higher Education (YÖK). Eryılmaz and Deniz (2019) examined the studies on teaching programming in Türkiye, including a total of 146 studies, 68 theses, and 78 articles published between 2008-2018, on the databases of YÖK thesis centre and TÜBİTAK-ULAKBİM and reported that most of the studies were carried out in 2018 and that the Information Technologies and Software course was mainly preferred with Scratch as the setting. Konan (2020) conducted a content analysis for teaching programming in his thesis in which SSCI, ERIC, Google Scholar, and ULAKBİM databases were searched and a total of 94 national and international articles published between 2008 and 2018 were examined. Yiğit (2021) assessed scientific trends in programming education research in his graduate thesis study, and a total of 305 international articles published between 2009 and 2020. Rovshenov (2020) examined the content analysis of research on programming education in his thesis including a total of 162 articles published between January 2012 and February 2020 searched in the Web of Science database in journals publishing in the field of Educational Sciences within the scope of SSCI index.

If the results of these systematic analysis studies are summarized, Türkiye and the USA are at the forefront of the researches, although the orientation and researches towards programming teaching are increasing. The demand for block-based programming tools is increasing. Quantitative research methods, scales as measurement tools, university student sample, Scratch program, problem-solving, logical and creative thinking are the prominent themes.

It is seen that the number of international academic studies on programming teaching has increased gradually, especially in the last ten years. Ouahbi et al. (2015) conducted an experimental study on teaching programming with 69 high school students. According to the research results, the motivation and academic achievement scores of those who learned programming with Scratch were statistically high. Similarly, Shin and Park (2014), in their study with 46 primary school students, concluded that the use of Scratch in programming teaching positively affected students' problem-solving skills. Sanjanaashree, Anand Kumar and Soman (2014) emphasized that Scratch can be used in foreign language teaching. In the study in which 204 secondary school students and eight teachers participated, Armoni, Meerbaum-Salant and Ben-Ari (2015) revealed the results of the successful use of Scratch in teaching computer science concepts.

It is stated that programming education is compulsory at primary and secondary school level and elective at high school level in England (Brown, Sentance, Crick, & Humphreys, 2014). Programming education in the country is given with an interdisciplinary approach and it is aimed to improve students' skills by using Scratch software, a block-based programming tool, together with various robotic tools (Allsop & Sedman, 2015). Students who learn the logic of programming with Scratch are taught programming languages such as Python and Javascript in the next step (Mason & Cooper, 2014). In Australia, it is seen that basic, visual, and object-



oriented programming trainings are given according to age groups (Falkner & Vivian, 2015).

One of the countries where studies on programming education have increased the most is the USA. K-12 level curriculums in programming education are implemented in different ways in many states in the United States Ravitz, Stephenson, Parker, & Blazeovski (2017). The general aims of providing programming education to students are to improve their skills in computer science and computational thinking (Gal Ezer & Stephenson, 2014). As in the USA, programming studies at the K-12 level are carried out at all levels in South Korea. Choi, An and Lee (2015) state that some levels of programming education in South Korea are compulsory and some are optional. It is seen that visual and easy-to-use tools such as Scratch, Turtle Graphs and Alice are preferred especially at primary school level. In Rovshenov (2020)'s master's thesis, it is stated that different tools or programming languages are taught at different levels related to programming education in Spain, Estonia, Russia, and India. As a result, studies in the literature reveal that each country implements and supports computer education, programming education, and technology education programs in schools.

This study has been designed to shed light on previous studies on programming by examining master's and doctoral theses on programming in K-12 education (preschool, primary, and secondary education institutions) published between 2018 and 2022. The curriculum in Türkiye was updated in 2018. Therefore, the present study takes as basis the year 2018, when the 'Information Technologies and Software' and 'Computer Science' courses were included in the most recent curriculum. Moreover, the literature review reveals that the master's and doctoral theses on programming in the field of education after 2018 have not been analyzed via content analysis. The significance of this study is that it reveals the effect of the updated curriculum on master's and doctoral studies as well as the research trends. In this context, the following research questions were addressed:

- (1) How is the distribution of master's and doctoral theses according to the universities?
- (2) How is the distribution of master's and doctoral theses according to the departments?
- (3) How is the distribution of master's and doctoral theses by year?
- (4) What are the keywords of master's and doctoral theses?
- (5) What are the methods used by master's and doctoral theses?
- (6) What are the sample characteristics of master's and doctoral theses?
- (7) What are the data analysis methods of master's and doctoral theses?
- (8) What are the data collection tools used by master's and doctoral theses?
- (9) Are any measurement tools developed in the master's and doctoral theses?

Method

Content analysis was used in the study. Büyüköztürk et al. (2021) describe content analysis as a systematic technique in which the words in the text are selected by making various coding according to certain criteria. The researchers employed document analysis, which is defined as a meaningful summary and interpretation of the data by systematically performing various operations to examine the identified resources (Bowen, 2009).

A total of 60 theses (master's theses: 52; doctoral theses: 8) were included in the current study. These theses were obtained from the YÖK Thesis Centre (<http://www.tez.yok.gov.tr>). In the thesis database, the thesis year was filtered as '2018-2022', the thesis name as 'programming', the thesis type as 'master's and doctorate', and the subject as 'education and training'. The theses on K-12 education written in Turkish were included in the study and the theses whose full text could not be accessed were excluded from the study. 9 categories were

created: university, department, year, keywords, method, sample, data collection tools, data analysis, and measurement tool development. Descriptive statistics were used for data analysis. While analyzing the data, frequency and percentage values were used for interpretation, and the findings were shown in tables and graphs.

While analysing the theses and interpreting the data, the categories and frequencies were determined systematically (Figure 1). The studies examined were coded by three different researchers working in the field of Educational Technology and holding doctorate degrees. The coders used the Publication Classification Form (Göktaş et al., 2012) distributed to them for coding processes and previously determined by the researchers. It was observed that the agreement between the codes of three different researchers was 90%. Miles and Huberman (1994) report that %70 is the acceptable level of agreement among coders.

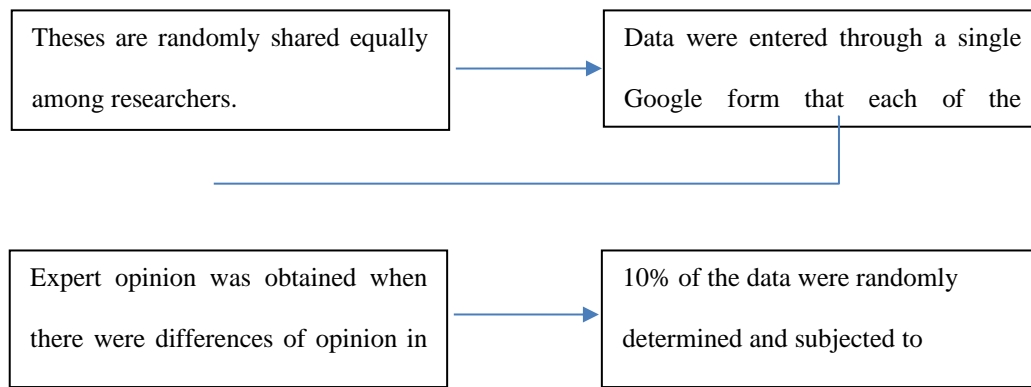


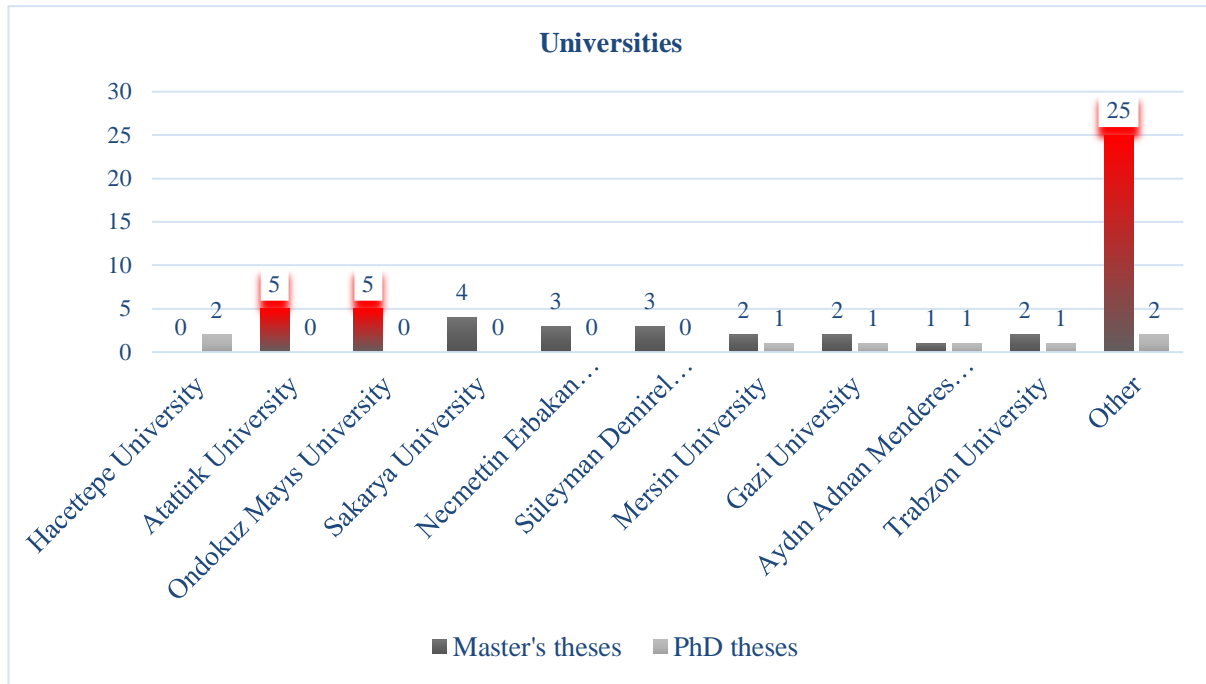
Figure 1. Validity and reliability studies

Findings

This section includes the findings obtained as a result of content analysis.

1. Universities with Graduate Theses

Universities with graduate theses are given in Graph 1.

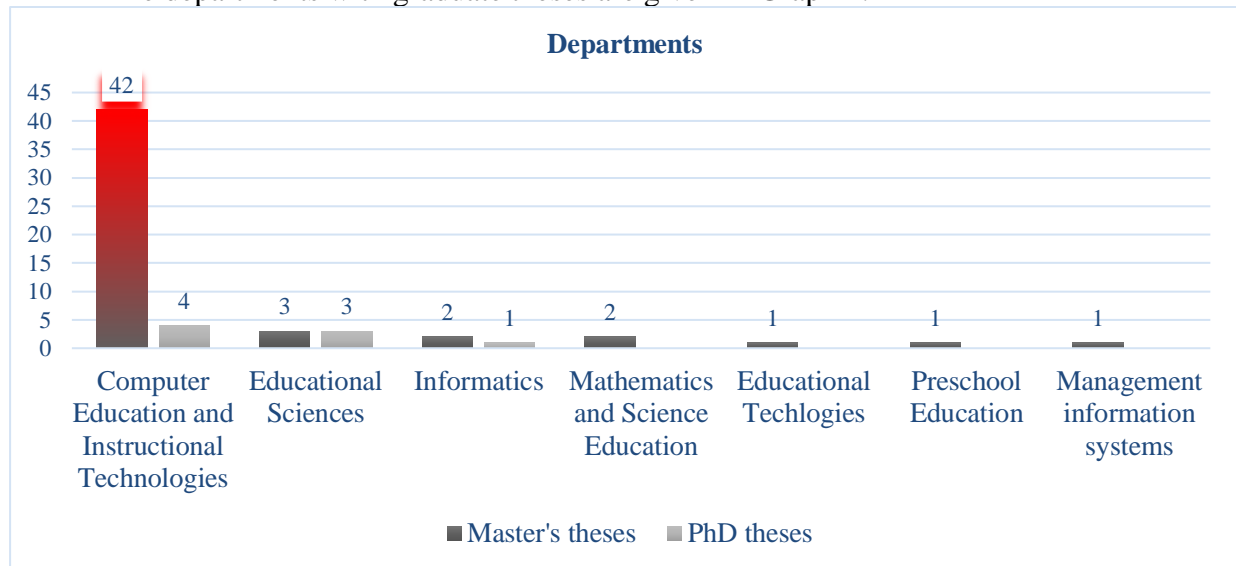


Graph 1. Universities with graduate theses

Graph 1 shows that the universities with most master's theses are conducted at Atatürk University and Ondokuz Mayıs University (5 theses), while Hacettepe University is ranked the first with 2 doctoral theses. Graph 1 also highlights that programming is studied by many different universities.

2. Departments

The departments with graduate theses are given in Graph 2.

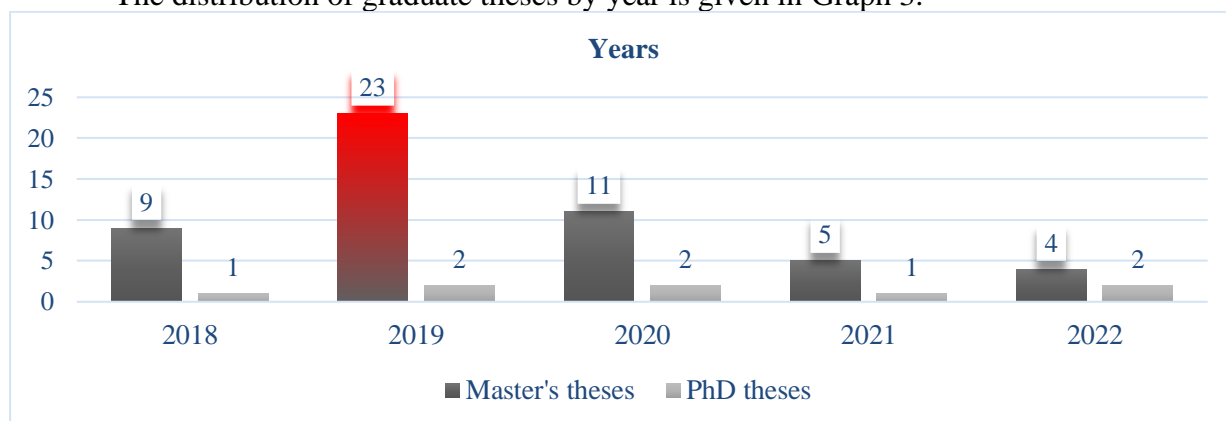


Graph 2. The departments with graduate theses

Graph 2 shows that that the department with most graduate theses is Computer Education and Instructional Technologies (42 master's theses and 4 doctoral theses; 46 studies in total).

3. Distribution by year

The distribution of graduate theses by year is given in Graph 3.

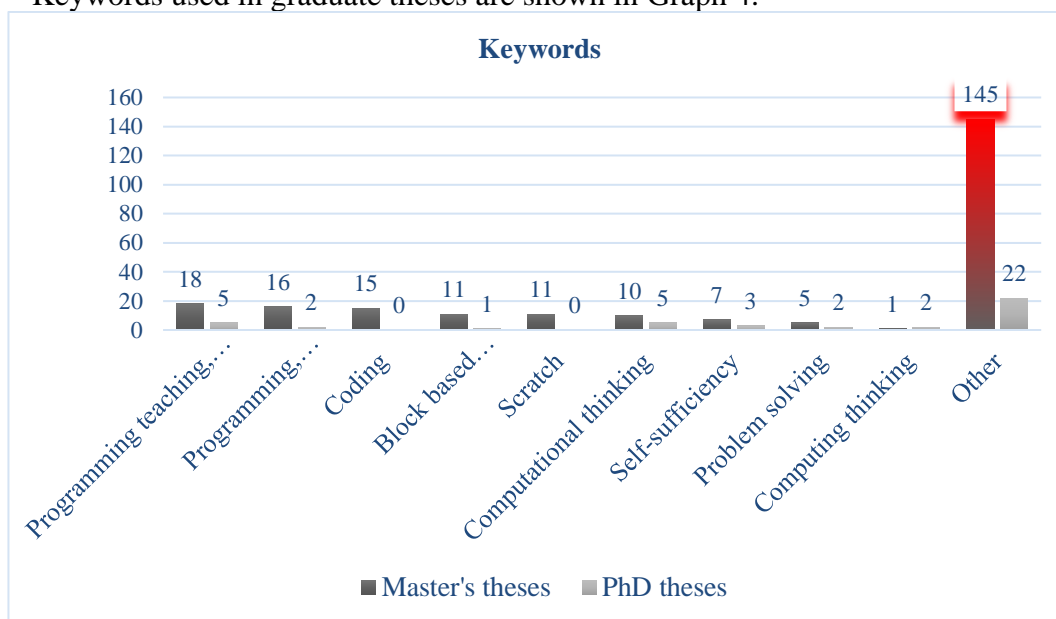


Graph 3. The distribution of graduate theses by year

Graph 3 shows that the year with most master's theses is 2019, while the year with more doctoral theses differs. The distribution of graduate theses varies depending on years.

4. Keywords Used in Graduate Theses

Keywords used in graduate theses are shown in Graph 4.



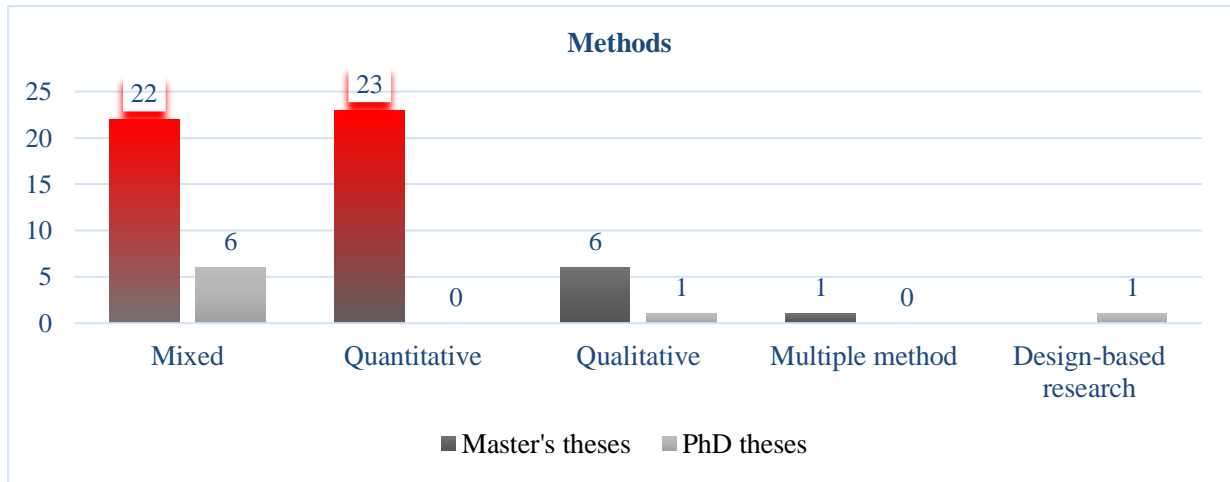
Graph 4. Keywords used in graduate theses

Graph 4 shows that the most frequently used keywords in graduate theses are the concepts related to “programming education and training”. The other most frequently used keyword in doctoral theses is “computational thinking”. The graduate theses reveal that various keywords such as programming-related coding, block-based programming, Scratch, self-efficacy, problem-solving, and computational thinking are used.

5. Methods Used in Graduate Theses

The distribution of the methods used in graduate theses is given in Graph 5.





Graph 5. The distribution of the methods used in graduate theses

Graph 5 shows that the mixed method is frequently used in graduate theses on computer programming in K-12 education. And this method followed by quantitative, qualitative, multi-method, and design-based research methods, respectively.

The type of mixed method used in graduate theses is given in Table 1.

Table 1. The type of mixed method used in graduate theses

	Descriptive	Triangulation (parallel, convergent)	Exploratory	Not specified
Master's Degree Theses	9	12	0	1
Doctoral Theses	3	2	0	1

Table 1 shows that the most commonly used mixed method type in master's theses is triangulation (parallel, convergent), and exploratory method in doctoral theses. Experimental quantitative methods used in graduate theses are given in Table 2.

Table 2. Experimental quantitative methods used in graduate theses

	True Experimental	Quasi-Experimental	Weak Experimental	Not specified
Master's Degree Theses	2	27	7	4
Doctoral Theses	3	3	0	0

Table 2 shows that the quasi-experimental design is mostly preferred in graduate theses on computer programming in K-12 education. The other preferred method in doctoral theses is the true experimental design. Correlational quantitative methods used in graduate theses are given in Table 3

Table 3. Correlational quantitative methods used in graduate theses

	Correlational	Survey	Correlational + Survey
Master's Degree Theses	2	3	1
Doctoral Theses	0	0	0

Table 3 shows that the most frequently used correlational quantitative method in master's theses is the survey. Table 3 also highlights that correlational quantitative methods are not preferred in doctoral theses. The qualitative methods used in graduate theses are given in Table 4.

Table 4. The qualitative methods used in graduate theses

	Case Study	Action Research	Not specified
Master's Degree Theses	10	1	17
Doctoral Theses	4	1	1

Table 4 shows that the qualitative method most frequently used in graduate theses is the case study.

6. Characteristics of Samples in Graduate Theses

Levels of samples in graduate theses are given in Table 5.

Table 5. Levels of samples in graduate theses

	Preschool	Primary School	Secondary School	Primary School + Secondary School	High School
Master's Degree Theses	1	2	40	1	8
Doctoral Theses	0	1	5	0	2

Table 5 shows that secondary school is the most frequently studied level for sampling in graduate theses on computer programming in K-12 education. The sample size in graduate theses is given in Table 6.

Table 6. Sample size in graduate theses

	1-100	101-200	201-300	301-400	401-500	501-600
Master's Degree Theses	38	9	2	1	0	2
Doctoral Theses	4	3	0	1	0	0

Table 6 shows that the most frequently studied sample size in graduate theses ranges between 1 and 100. Analyses of sample selection in graduate theses are given in Table 7.

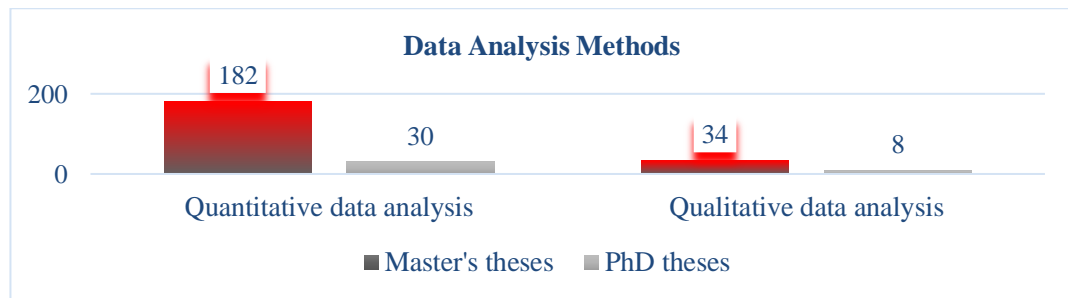
Table 7. Sample selection in graduate theses

	Convenience Sampling	Purposive Sampling	Random	Not specified
Master's Degree Theses	17	9	2	24
Doctoral Theses	2	3	2	1

Table 7 shows that the most preferred sample selection in master's theses is convenience sampling, and purposive sampling in doctoral theses.

7. Data Analysis Methods Used in Graduate Theses

Data analysis methods used in graduate theses are given in Graph 6.



Graph 6. Data analysis methods used in graduate theses

Graph 6 shows that the most frequently used data analysis method in graduate theses is quantitative data analysis methods.

7.1. Quantitative Data Analysis

7.1.1. Descriptive Statistics

Descriptive statistics used in graduate theses are given in Table 8.

Table 8. Descriptive statistics used in graduate theses

	Mean / Standard deviation	Frequency /Percentage	Graphical Representation	Mean / Standard deviation+Graphical Representation
Master’s Degree Theses	48	8	2	0
Doctoral Theses	5	1	1	1

Table 8 shows that that the most frequently used descriptive statistics method in graduate theses education is the mean/standard deviation.

7.1.2. Predictive Statistics

The predictive statistics used in graduate theses are given in Table 9.

Table 8. Predictive statistics used in graduate theses

	Non-Parametric Tests	Parametric Tests	t-test	Anova/Ancova	Correlation	Manova/Mancova	Regression	Factor Analysis	Others
Master’s Degree Theses	52	0	31	24	8	5	2	1	1
Doctoral Theses	10	7	3	1	0	1	0	0	0

Table 9 shows that the most frequently used predictive statistics method in graduate theses is non-parametric tests.

7.2. Qualitative Data Analysis

Qualitative data analyzes used in graduate theses are given in Table 10.

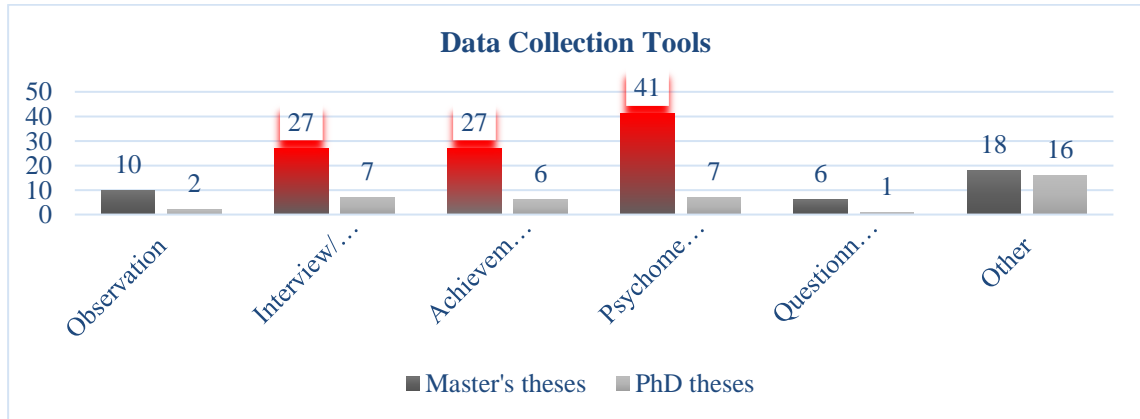
Table 10. Qualitative data analyzes used in graduate theses

	Descriptive Analysis	Content Analysis	Content Analysis + Descriptive Analysis	Protocol Analysis	Eye Tracking	Not Specified
Master’s Degree Theses	11	21	0	1	1	0
Doctoral Theses	0	6	1	0	0	1

Table 10 shows that the most frequently used qualitative data analysis method in graduate theses is content analysis.

8. Data Collection Tools Used in Graduate Theses

Data collection tools used in graduate theses are given in Graph 7.



Graph 7. Data collection tools used in graduate theses

Graph 7 shows that the most preferred data collection tool in graduate theses is psychometric scales. Interview/focus group is the other preferred data collection tool in doctoral theses. The type of observation used in graduate theses is given in Table 11.

Table 11. Type of observation used in graduate theses

	Participant observation	Non-participant observation
Master's Degree Theses	1	9
Doctoral Theses	0	2

Table 11 shows that the most frequently used type of observation in graduate theses is non-participant observation. The interview/focus group type used in graduate theses is given in Table 12.

Table 12. Interview/focus group type used in graduate theses

	Structured	Semi-structured	Unstructured	Focus group
Master's Degree Theses	6	18	1	2
Doctoral Theses	1	3	0	3

Table 12 shows that the most frequently used interview/focus group type in graduate theses is the semi-structured interview. Focus group is the other preferred type of interview in doctoral theses. Achievement tests used in graduate theses are given in Table 13.

Table 13. Achievement tests used in graduate theses

	Multiple Choice	Open-ended	Mixed
Master's Degree Theses	19	2	6
Doctoral Theses	4	0	2

Table 13 shows that the most frequently used achievement test in graduate theses is the multiple-choice test. The psychometric scales used in graduate theses are given in Table 14.

Table 14. Psychometric scales used in graduate theses

	Likert	Multiple Choice	Others
Master's Degree Theses	38	2	1
Doctoral Theses	6	1	0

Table 14 shows that the most frequently used psychometric scale in graduate theses is the Likert type. Alternative data sources used in graduate theses are given in Table 15.

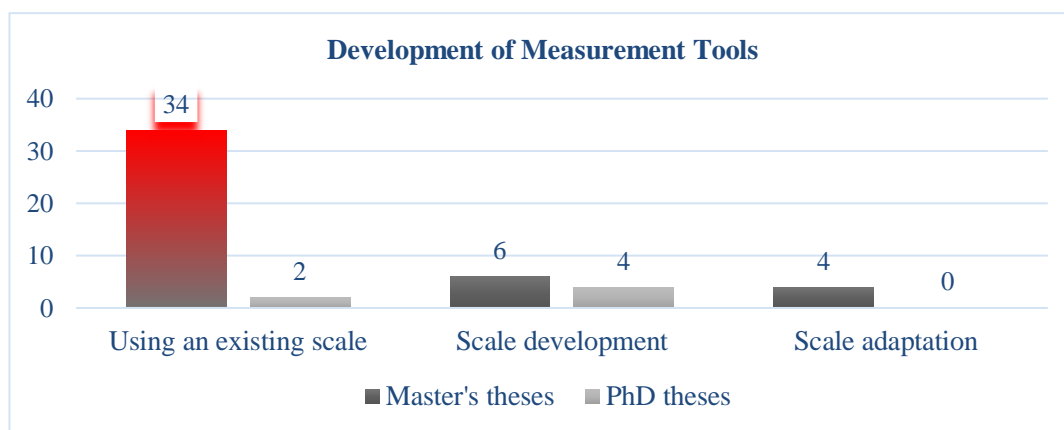
Table 15. Alternative data sources used in graduate theses

	Performance Tests	Eye Tracking Tool	Screencast	Video Recording	Thinking Loud	Homework	Others
Master's Degree Theses	11	2	2	1	1	1	0
Doctoral Theses	6	0	1	1	1	0	7

Table 15 shows that the most frequently used alternative data source in graduate theses is performance tests while various data collection tools such as clinical interviews, student diaries, worksheets, and field studies are preferred in doctoral theses.

9. Development of Measurement Tools

Information about developing measurement tools in graduate theses is given in Graph 8.



Graph 8. Information about developing measurement tools in graduate theses

Graph 8 shows that valid and reliable scales are mostly used in master's theses on computer programming in K-12 education, while scales are developed in doctoral theses.

Conclusion, Discussion and Recommendations

According to the findings of the study, the Departments of Computer Education and Instructional Technologies at Atatürk University and Ondokuz Mayıs University conducted most graduate theses in 2019. While scholars at the Department of Computer Education and Instructional Technologies constitute the main research group in doctoral theses, there is no noticeable difference in terms of years and universities. The reason why the relevant theses were mostly written in 2019 is possibly the update in the Information Technologies course curriculum in 2018. Keywords used in theses at the master's degree level include teaching, learning, and training programming, the concept of programming, coding, and block-based programming, while computational thinking, programming education, and self-efficacy are included in keywords in doctoral theses. Rovshenov (2020) scanned the Web of Science database for the journals published in the field of Educational Sciences within the scope of SSCI index between 2018-2020 to find out that studies on teaching programming were mostly carried out in the United States and Türkiye and that there has been an increase in these studies since 2015.

The analysis of master's theses revealed that the quantitative method is frequently studied in doctoral theses, while the mixed method is frequently used in both types of thesis. The triangulation (parallel, convergent) method was mainly used in the master's theses, while the explanatory method was used in the doctoral theses. Eryılmaz and Deniz (2019) and Rovshenov (2020) reported that quantitative research methods were preferred more in articles and graduate theses. Rovshenov (2020) also reported that studies are conducted with the quantitative research method followed by the mixed research method. It is noteworthy that the number of qualitative research on computer programming is quite low. Konan (2020) analysed the SSCI, ERIC, Scholar, and Ulakbim databases for the 2008-2018 period and obtained similar results. Semi-experimental type is frequently preferred in master's theses. The case study approach is also the most frequently used qualitative method in master's and doctoral theses.

Convenience sampling and sample size between 1 and 100 is preferred for sample selection in the master's theses, while purposive sampling is mainly employed in the doctoral theses. Since 2012, computer programming in Türkiye has been introduced in primary and secondary

schools after the 5th grade within the scope of the “Information Technologies and Software” course (Demirer & Nurcan, 2016). While the Information Technologies and Software course is compulsory at the secondary school level, the Computer Science course is compulsory only in the Science and Social Sciences high schools and included in the curriculum as an elective course in other high schools. The fact that the number of secondary schools is much higher than the number of science and social sciences high schools can be considered as the reason why secondary school students are selected as the sample. Eryılmaz and Deniz (2019) suggested that the low number of studies at preschool and primary school (1-4) levels is because there is not much space for programming education in the curriculum.

The commonly used data collection tool in master's theses is psychometric scales. Other types of measurement tools in doctoral theses are interviews/focus group interviews and psychometric scales, respectively. It was also observed that the use of scales is also preferred in the studies on teaching programming conducted in the literature by Benzer & Erümit (2017) and Çatlak et al. (2015). Non-participant observation and semi-structured interviews are also often preferred in the theses. Achievement tests used in theses are often multiple-choice, and psychometric scales are of the Likert type. Performance tests are frequently used as an alternative data source in theses. Although the quantitative method is mainly used in data analysis, mean and standard deviation are frequently preferred. In addition, non-parametric statistical tests and content analysis are used in qualitative methods. Ready-made measurement tools are used in master's theses while scales are developed in doctoral theses.

In conclusion, this study was designed to shed light on master's theses and doctoral theses on computer programming in K-12 education in terms of different categories. This study is expected to also shed light on research on computer programming in the K-12 setting. Although it is foreseen that research on computer programming teaching will increase in the future, it is still necessary to work with different and specific variables on how to teach computer programming. Although there are courses related to computer programming in the CEIT curriculum (Dağ, 2019), the increase in the courses and activities on how to teach programming from the K-12 level will increase the research on the teaching of computer programs. The development of assessment tools related to teaching computer programming at the K-12 level has also diversified recently (Kukul, Gökçearslan & Gunbatar, 2017; Hu, Lin, Wu, & Chen, 2022; Yalcin, Kahraman, & Yılmaz, 2020; Yalçın, Kahraman, & Yılmaz, 2020). It can be implied that studies on technologies such as the internet of things, machine learning, artificial intelligence, and Blockchain will also diversify and become specialized. Qualitative research is also recommended for an investigation into teaching programming in the future.

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