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Technology Integration into Science Education: Systematic Review and Mapping of Postgraduate Theses in Turkey*

Fen Eğitimine Teknoloji Entegrasyonu: Türkiye'de Lisansüstü Tezlerin Sistematik Alanyazın İncelemesi ve Haritalanması

Zekiye Tuba Özbek[a], Nilüfer Atman Uslu[a†]

[a]*Manisa Celal Bayar University, Manisa, Turkey*

Abstract

The main purpose of this study was to identify research trends of postgraduate theses about technology integration into science education conducted in Turkey between 2014-2019. The second purpose was to analyze the findings of the postgraduate theses designed by experimental method and make inferences about the role and potential of technology integration into science education. Accordingly, systematic mapping and systematic literature review approaches were used in this study. The review was carried out in the National Thesis Center of the Turkey Council of Higher Education and 234 graduate theses were examined. One-hundred and eighty-three of the theses were the master's theses and 51 of them were doctoral theses. Considering the distribution of postgraduate theses by years, it was seen that most research was done in 2018. It was found that mostly middle school students constituted the study group, and the quantitative research methods were preferred the most. The majority of the studies did not refer to integration models or frameworks. It was determined that experimental design was used in 151 of the postgraduate theses. Web applications, animation, simulation and robotics technologies were mostly used in experimental research. In the light of the findings of the research, suggestions were presented for future studies aiming to examine the technology integration into science education.

Keywords: Science education, technology integration, systematic mapping, systematic literature review.

Öz

Bu çalışmanın temel amacı, 2014-2019 yılları arasında Türkiye'de fen eğitimine teknoloji entegrasyonu ile ilgili yapılan lisansüstü tezlerin araştırma eğilimlerini belirlemektir. İkinci amaç, deneysel yöntemle tasarlanan lisansüstü tezlerin bulgularını analiz etmek ve teknoloji entegrasyonunun fen eğitimindeki rolü ve potansiyeli hakkında çıkarımlarda bulunmaktır. Buna göre, bu çalışmada sistematik haritalama ve sistematik alanyazın incelemesi yaklaşımları kullanılmıştır. İnceleme, Türkiye Yükseköğretim Kurulu Ulusal Tez Merkezi'nde gerçekleştirilmiş ve 234 lisansüstü tez incelenmiştir. Tezlerin 183'ü yüksek lisans, 51'i doktora tezidir. Lisansüstü tezlerin yıllara göre dağılımına bakıldığında en fazla araştırmanın 2018 yılında yapıldığı görülmüştür. Çalışma grubunu en çok ortaokul öğrencilerinin oluşturduğu ve en çok nicel araştırma yöntemlerinin tercih edildiği belirlenmiştir. Çalışmaların çoğu entegrasyon modellerine veya çerçevelerine atıfta bulunmamıştır. Lisansüstü tezlerin 151'inde deneysel tasarımın kullanıldığı tespit edilmiştir. Deneysel araştırmalarda daha çok web uygulamaları, animasyon, simülasyon ve robotik teknolojileri kullanılmıştır. Araştırma bulguları ışığında, fen eğitimine teknoloji entegrasyonunu incelemeyi amaçlayan gelecekteki çalışmalar için öneriler sunulmuştur.

Anahtar sözcükler: Fen eğitimi, teknoloji entegrasyonu, sistematik haritalama, sistematik alanyazın inceleme.

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**ADDRESS FOR CORRESPONDENCE: Zekiye Tuba Özbek, Department of Science Education, Manisa Celal Bayar University, Manisa,Turkey. E-mail address: tubaozbek993@gmail.com.ORCID ID: 0000-0002- 8021-5305.*

[b]*Nilüfer Atman Uslu, Department of Computer Education and Instructional Technology, Manisa Celal Bayar University, Manisa, Turkey, E-mail addres:atmanuslu@gmail.com. ORCID ID: 0000-0003-2322-4210.*

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1. Introduction

Attempts to digitize the economy suggest that a different workforce structure will be needed compared to the previous century. According to the European Commission's report entitled "ICT for work: Digital skills in the workplace" (2014), a decrease was predicted in the demand for medium or low skilled jobs due to the automation with technologies such as robotics, numerically controlled machines, speech recognition, self-driving tools, e-commerce. According to the same report, a significant increase was expected in demand for highly skilled individuals equipped with cognitive skills and technical knowledge to cope with the tasks and procedures required by new technologies. For this reason, education systems are expected to train students for a workforce with digital skills. According to the "STEM Education Policies in Europe" report, it was a tendency towards STEM reforms for reasons such as the rise of the digital economy, the speed of technological change and the need to prepare citizens for the future (Scientix, 2018). In the light of these developments, there was an increase in macro and micro level initiatives for the integration of ICT into the subject field such as science, mathematics and fine arts in recent years. In this respect, many countries started to update their education programs by giving priority to ICT integration. When the education curriculum of countries such as Finland (Finnish National Board of Education, 2016), Singapore (Ministry of Education, Singapore, 2013) Australia (ACARA, 2017) was examined, ICT competence takes place as an important component. As technology transforms the daily life, communication and behavior of individuals, inevitably, bring about a change in learning and teaching processes. Many technologies such as virtual (Chang, Hsu, Chen, & Jong, 2020; Kersting, Steier, & Venville, 2020; Liu et al., 2020) and augmented reality (Chen, 2020; Wang, 2020), robotics (Chang & Chen, 2020; Guven et al., 2020), simulations (Develaki, 2019; Dunn & Ramnarain, 2020) and digital storytelling (Yilmaz & Sığirtmac, 2020) have been used in science education recently. In conclusion, the diversity of technologies in learning and teaching processes and the increase in the importance attributed to digital skills led to many studies on technology integration in science education. A systematic review and mapping of master's theses in Turkey about technology integration into science education were carried out in this study. In the following sections, initiatives related to the technology integration in Turkey and systematic review studies on the integration of technology into science education were given respectively.

1.1. Technology integration in Turkey

Technology integration is generally defined as a sustainable and permanent process in which technology helps students to learn (Belland, 2009; Wang & Woo, 2007). ICT can be used with various approaches in learning and teaching processes. Uslu and Usluel (2019) defined three types of usage in the conceptual framework that they put forward regarding the use of ICT in learning and teaching processes. These usage types are presented in Figure 1.

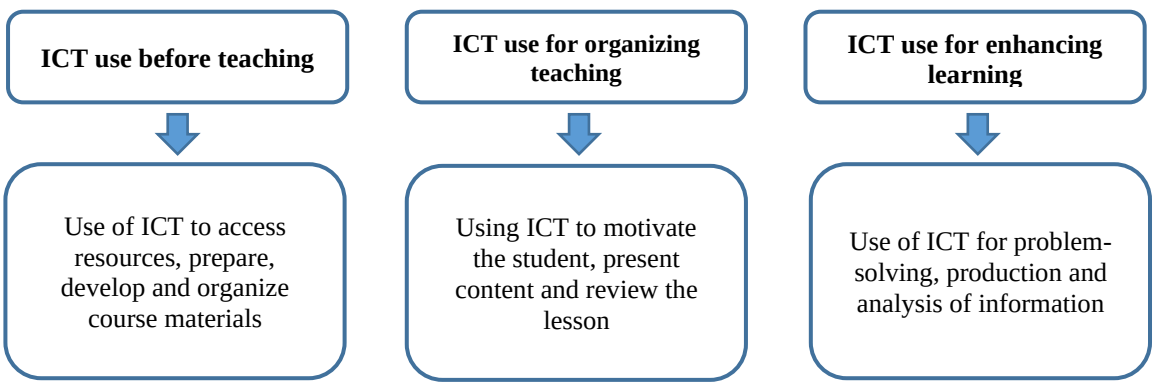

Figure 1. A conceptual framework for ICT use in education (Uslu & Usluel, 2019).

According to Figure 1, the use of ICT before teaching includes teachers' use of technology for searching resources, preparing lesson plans and materials, keeping student notes and data. The use of ICT to organize teaching includes activities such as motivating students, presenting content, reviewing, repeating, and reinforcing the topics. The use of ICT to improve learning includes activities that can be done to encourage students to develop their skills such as producing and analyzing information. In this kind of ICT usage, the responsibilities of teachers are considered as bringing ICT facilities to the classroom to improve student's skills such as information seeking and processing (Uslu & Usluel, 2019). Also, ICT is used for managerial and socio-cultural purposes, such as

supporting student-teacher-parent interaction, providing communication and information flow with other schools and ministry units, developing educational policies, and designing education programs, as well as its use for instructional purposes (Bardakçı & Keser, 2017).

There were many macro and micro level attempts for technology integration into learning and teaching processes in Turkey. FATIH Project (Movement to Increase Opportunities and Technology) was seen as the most well-known of the initiatives with the provision of technology integration in Turkey in the last decade. The project was launched by the Ministry of Education in 2010 aiming at reducing inequality of opportunity and increasing the quality of education by using ICT in the classrooms. Within the scope of the project, providing interactive whiteboards and an internet connection to the classrooms, distributing tablet computers to teachers and students, developing e-contents and uploading them to a portal called Educational Information Network (EBA) was planned. In addition, in-service training to use the system effectively was planned for teachers. Accordingly, the project consists of four components: hardware, infrastructure, in-service training and the creation of e-contents. However, obstacles such as the problems experienced in the in-service training component, and the low-level computer literacy of teachers, parents and students were seen as obstacles to the expected impact of the project (Eryılmaz & Uluyol, 2015). In this context, it can be said that taking steps to provide the hardware infrastructure with the FATIH project alone is not enough to ensure integration.

More recently, the 2023 Education Vision Document was published by the Ministry of Education (2018). The 2023 Vision aims to raise individuals who are equipped with the skills of the era and the future and who can use this equipment for the good of humanity, who are interested in science and culture. Within the scope of this vision, it was targeted that students use information technologies as a means of "production", "developing solutions to problems" and "realizing their dreams" in online and offline environments. In addition, training for teachers who acquired a culture of effective use and development of digital content was decided. In this context, a protocol was signed to establish 100 technology laboratories in 81 provinces by the end of 2020. These laboratories, called "Try to Do Atelier", were located in 30 provinces. Students which are 4^{th}, 5^{th}, 8^{th} and 9^{th} graders attend the ateliers if they are found successful in written exams and project designs. Training in ateliers consists of three terms and each of them lasts 12 months. In the first term, basic training is given on subjects such as robotics coding and the internet of things. In the second term, students specialize in their subject area. In the third term, they form teams and participate in national and international technology competitions. In summary, attempts were made in recent years to encourage students to pursue a career in STEM and to be interested in these fields.

1.2. Previous review studies on technology integration into science education

With the importance attributed to digital skills, there was an increase in the research on the use of technology in science education. In this context, systematic mapping and compilation studies were carried out in which the articles were examined. In a systematic review study on virtual laboratories in science education, 40 studies in the Web of Science database were included and it was found that most of the studies were conducted on university level and physics (Tho et al., 2017). Another study examining studies related to mobile applications in science education included 66 studies between 2000 and 2016. It was shown that studies were mostly conducted with students between the ages of 5 and 11 in the context of informal learning (Crompton, Burke, Gregory, & Gra, 2016). The increasing interest in STEM brought many review studies on this subject. In a systematic review study examining 798 articles on STEM published in 36 journals between 2000 and 2018, it was determined that the international importance of STEM research increased and more than half of the reviewed articles were published in the last three years (Li, Wang, Xiao, & Froyd, 2020). Moreover, systematic reviews were conducted on gender-specific differences in STEM education. In a systematic review study examining gender-related differences in STEM student experience, ERIC, PsycInfo, ProQuest and Scopus databases were searched and 36 articles meeting the specified criteria were included (Camilla, Fisher, Thompson, & Brooks, 2020). It was concluded that the most important issue for female students was low self-efficacy perception. Also, it was suggested that gender-specific experiences should have been considered in order to ensure the permanence of female students in STEM degrees. Prieto-Rodriguez, Sincock, and Blackmore (2020) reviewed empirical studies on female students' participation in STEM. In 21 of the 32 studies included in the systematic review, the interventions were carried out in a short time frame between 20 minutes and two weeks. It was found that more than half of the studies involving long-term interventions failed to show that they encouraged STEM participation. Besides, systematic reviews on a variety of technologies such as mobile applications (Gao, Lin, & Sun, 2020), immersive virtual reality (Pellas, Dengel, & Christopoulos, 2020), robotics (Ferrada-Ferrada, Carillo-Rosua, Diaz-Levicoy, & Silva-Diaz, 2020) in STEM education were conducted in the last years. When previous studies were examined, it was noteworthy that review studies were limited to a specific technology. A similar situation was seen in review studies in Turkey. A meta-analysis study on web-based instruction in science education and a meta-synthesis study on STEM (Herdem & Ünal, 2018) were conducted

recently. Namdar and Küçük (2018) approached holistically to the subject and examined the articles on technology integration in science education. On the other hand, in the study in which 32 articles were reviewed, postgraduate theses were not examined and experimental findings were not analyzed.

1.3. Purpose of the study

This study examining the postgraduate theses on technology integration into science education has two purposes. The first purpose of this study was to determine the direction of the trends in the literature by examining the postgraduate theses about technology integration into science education. The second purpose was to make inferences about the role of technology by examining experimental studies. Two research questions were formulated:

RQ1: What are the current trends in postgraduate theses examining the technology integration into science education between 2014 and 2019?

a. How is the distribution according to the years?
b. How is the distribution according to the study group?
c. How is the distribution according to the research methods?
d. How is the distribution according to data collection tools?
e. How is the distribution according to the integration model and frameworks taken as a basis?

RQ2: What are the characteristics and findings of the interventions conducted in experimental studies examining the technology integration into science education between 2014 and 2019?

a. What kind of subjects are focused on?
b. What kind of technologies are used?
c. What are the dependent & independent variables and findings of experimental studies?

Considering that technology was used in most of the researches in science education, determining the current situation in the studies is important in terms of shedding light on trends for future research and presenting suggestions.

2. Methodology

Systematic mapping (SM) and systematic literature review (SLR) approaches were combined and used in this study respectively. A SM study provides for categorizing the structure of published research reports and results and usually provides a visual summary with a map of the results (Petersen, Feldt, Mujtaba, & Mattsson, 2008; Petersen, Vakkalanka, & Kuzniarz, 2015). SM studies generally require less effort while providing an overview of the research area (Petersen et al., 2008). On the other hand, the SLR studies synthesize the results of studies considered to be relevant to research questions (Budgen, Brereton, Drummond, & Williams, 2018). Kitchenham & Charters (2007) described the SLR studies as a secondary form of research that uses a well-defined methodology to describe, analyze and interpret all available evidence on a particular research question in an unbiased and reproducible manner. This study aimed to examine the postgraduate theses on technology integration into science education by following the SM steps. Within the scope of the SM study, postgraduate theses were examined according to years, study group, research methods, data collection tools and the integration model. Experimental studies were determined after a general picture of the postgraduate theses were presented. The postgraduate theses about technology integration into science education and designed with an experimental method were analyzed by following the SLR steps. Within the scope of SLR, the topic, technologies, dependent and independent variables and findings in the interventions were examined in theses using experimental design. In the following sections, search strategy, study selection, coding and analysis stages were explained respectively.

2.1. Search strategy and study selection

Within the framework of the search strategy, the keywords and the database were selected. The database was determined as Council of the Turkey Higher Education Thesis Center. It was decided to conduct the review between 2014 and 2019 to identify the latest up-to-date trends. The title of “Education and Training” was chosen as the subject in the review. Thus, attention was paid to reach the theses about science education in different institutes and departments. “Science” was selected as a keyword and the search was carried out in July 2019. After the search, inclusion and exclusion criteria were determined to evaluate the theses in terms of their eligibility for research. These criteria are presented in Table 1.

Table 1. Inclusion and Exclusion Criteria in Study Selection

Inclusion Criteria	**Exclusion Criteria**
Studies in the field of science education (physics, chemistry, biology)	Review studies
Studies in one of the education level (kindergarten, primary school, secondary school, high school, undergraduate and graduate)	Lack of permission to access research
Having access to study	Studies not including the use of technology
Studies conducted in Turkey	
Studies using technology in science education	

After the search, 2568 theses were reached. The titles and abstracts of these theses and, if necessary, the entire thesis were examined in detail and evaluated in line with the inclusion and exclusion criteria. Theses that do not have access and review studies were excluded from the study. The remaining theses were evaluated in detail, and those that are not using technology were also excluded. The number of post graduate theses meeting all inclusion criteria included and analyzed in the research was 234.

2.2. Coding and analysis

The features to be coded for each research question were determined in this process. Within the scope of the first research question, it was decided to code the year, methodology, research design, study group, data collection tools and integration models. Experimental studies were determined after the SM process was over. Accordingly, 151 experimental studies were found. Then, topic, the technology, independent and dependent variables and supporting status of the hypotheses were coded (Figure 2). A spreadsheet program was used in this process. In order to reach a common understanding about the classification options in the coding process, some of the theses were extracted together by the two authors. Care was taken to ensure the objectivity of the form to be used in this way and to reduce the threat of descriptive validity. After the encodings were completed, the data were described using frequency and percentage.

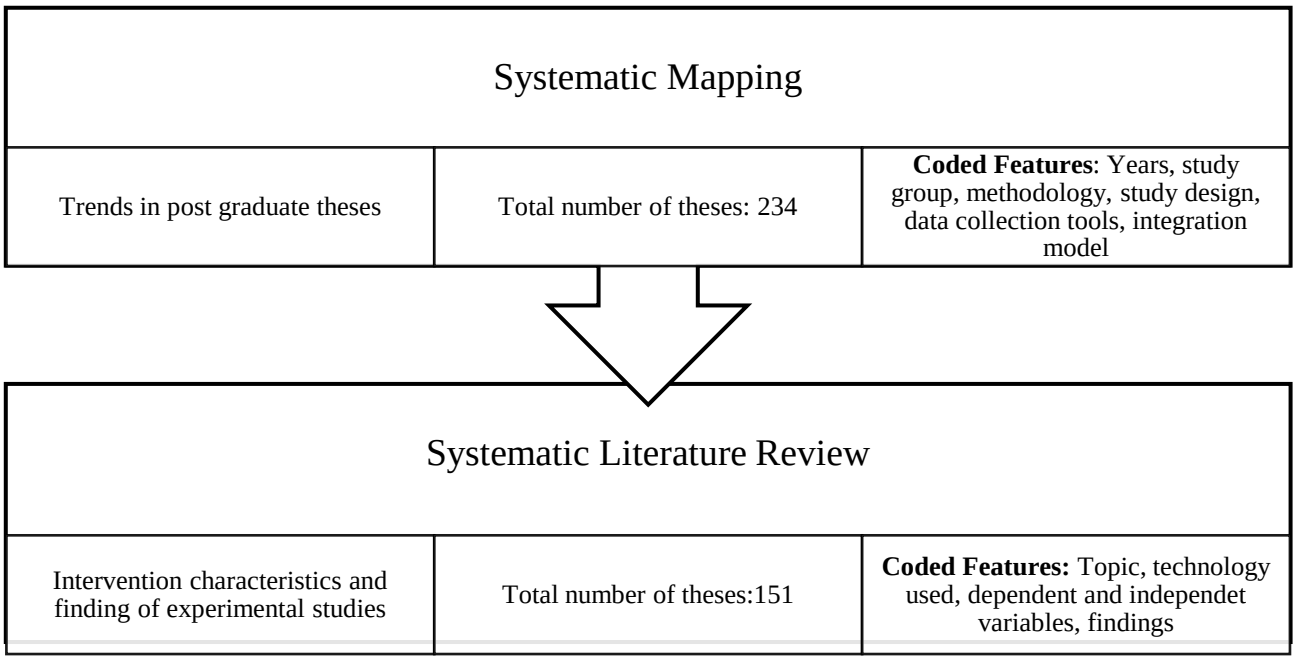

Figure 2. Coded features in coding and analysis

3. Findings

3.1. Findings of the Systematic Mapping

3.1.1. The Distribution According to Years

The distribution of 234 post graduate theses, which are included in the systematic mapping process is presented in Table 2 according to years.

Table 2. The Distribution of Postgraduate Theses According to Years

Years	Master	Doctorate	Total (f)	%
2014	16	2	18	7.69
2015	22	13	35	14.96
2016	15	9	24	10.26
2017	25	6	31	13.25
2018	52	15	67	28.63
2019	53	6	59	25.21
Total	183	51	234	100

As seen in Table 2, most of the research was conducted in 2018 (f = 67). This corresponds to 28.63% of the postgraduate theses examined. Considering that the search took place in the middle of 2019, it can be said that there is an increasing trend in studies examining the use of technology in science education. This increasing trend can be seen in Figure 3.

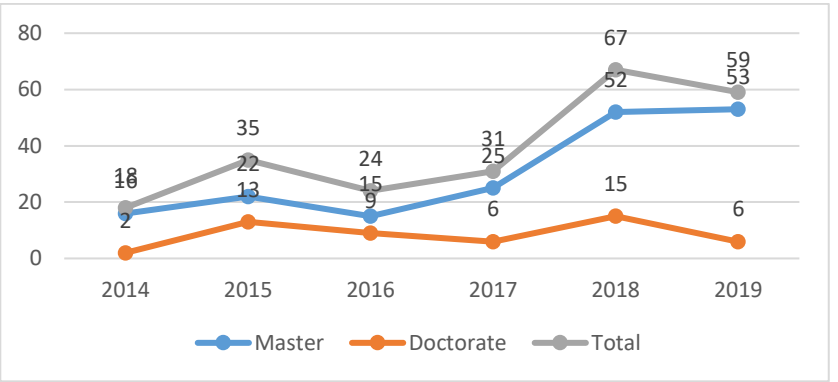

Figure 3. The Distribution of Postgraduate Theses According to Years

3.1.2 Study Groups

The distribution of 234 post graduate theses, which are included in the systematic mapping process is presented in Table 3 according to study groups.

Table 3. The Distribution of Postgraduate Theses According to Study Groups

	Master	Doctorate	Total (f)	%
Middle school students	92	21	113	46.69
Pre-service teachers	45	16	61	25.21
Teachers	23	7	30	12.40
High school students	9	5	14	5.79
Elementary school students	5	3	8	3.31
Kindergarten students	4	0	4	1.65
Parents	1	0	2	0.83
Principals	1	0	1	0.41
Adults	1	0	1	0.41
Academics	1	1	1	0.41
Gifted Students	1	0	1	0.41
Not reported	5	1	6	2.48

As seen in Table 3, most of the study groups in the research were middle school students (f = 113). This corresponds to 46.69% of the postgraduate theses examined. It was seen that the frequencies of the studies conducted with pre-service teachers (f = 61) and teachers (f = 30) were also high.

3.1.3. Research Methodologies

The distribution according to the research methods in postgraduate theses is presented in Table 4.

Table 4. The Distribution of Postgraduate Theses According to Research Methodologies

	Master	Doctorate	Total (f)	%
Quantitative	97	11	108	46.15
Mixed	66	34	100	42.74
Qualitative	20	6	26	11.11

As seen in Table 4, the most used research methodology was quantitative methods (f=108). This corresponds to 46.15% of the postgraduate theses examined. It was seen that the frequencies of the studies conducted with mixed methods were also high (%42.74). The least used method was the qualitative method (f=26).

3.1.4. Data Collection Tools

The distribution of 234 postgraduate theses, which are included in the systematic mapping process is presented in Table 5 according to data collection tools.

Table 5. The Distribution of Postgraduate Theses According to Data Collection Tools

Instrument*	Master	Doctorate	Total (f)	%
Scale	107	34	141	27.98
Achievement Test	99	30	129	25.60
Interview Form	50	34	84	16.67
Questionnaire	29	11	40	7.94
Observation Form	14	17	31	6.15
Diary	14	8	22	4.37
Video recordings	6	6	12	2.38
Concept map form	1	10	11	2.18
Document	3	7	10	1.98
Inventory	8	2	10	1.98
Rubric	2	4	6	1.19
Focus group form	4	1	5	0.99
Other	1	2	3	0.60

According to Table 5, the most used data collection tool in both master's and doctoral theses was scale (f = 141). This value corresponds to 27.98% of the data collection tools used. Afterwards, it was determined that the achievement test (f = 129) and interview form (f = 84) were among the most used data collection tools, respectively.

3.1.5. Technology integration models and frameworks

Postgraduate theses were examined according to which technology integration models and frameworks are based. It was found that 206 of the 234 theses were not cited to a framework related to technology integration. The integration models based on the theses are presented in Table 6.

Table 6. The Distribution of Postgraduate Theses According to Integration Model or Framework

Integration Model or Framework	**Total (f)**	**%**
TPACK	24	10.1
Systematic Planning Model	1	0.004
Diffusion of innovations	1	0.004
Activity Theory	1	0.004
Technology Integration Matrix	1	0.004
Not reported	204	86.4

In studies based on integration models, relational designs were used mostly. Accordingly, the relationships between TPACK, attitude towards technology (Altunoğlu, 2017), self-efficacy (Öztürk, 2017; Bal, 2017; Bağrıyanık, 2015) and teaching styles (Kabaran, 2016) were examined. Additionally, TPACK levels were described (Avcı, 2014) and relationships between TPACK sub-dimensions were examined (Gündüz, 2018). In this respect, it was noteworthy that studies on TPACK are mostly focused on identifying the existing situation and examining the relationships with various variables.

3.2. Findings of the systematic literature review

It was determined that 151 of 234 post graduate theses included experimental studies and the subject focused on learning, technology and the interventions in these studies were examined with the SLR approach.

3.2.1 Topics

The distribution of the topics taught in experimental studies is given in Table 7.

Table 7. Topics taught in experimental studies

Topic	**Total (f)**	**%**
Force and Motion	18	11.9
Electricity in Our Lives	16	10.6
Light and Sound	12	7.95
Solar System	12	7.95
Systems in our body	9	5.96
Structure and Properties of Substance	8	5.30
Heat	6	3.97
Force and Energy	5	3.31
Reflection and Light Absorption in Mirrors	5	3.31
Simple Machines	4	2.65
Living Beings	3	1.99
Other	53	35.1

According to Table 7, force and motion have the highest frequency according to topics in the experimental studies. Also electricity, light and sound are other topics frequently focused on in the postgraduate theses.

3.2.2. Technologies

The distribution of technologies used in experimental studies is presented in Table 8. According to Table 8, web applications were the most used technology (%24.5). Simulation, animation and robotics were found other frequently used technologies.

Table 8. Technologies used in experimental studies

Technology*	**Total (f)**	**%**
Web	37	24.5
Simulation	27	17.89
Animation	26	17.22
Robotics	17	11.26
Interactive Whiteboard	15	9.93
Video	13	8.61
Computer	12	7.95
Educational Software	12	7.95
Augmented Reality	12	7.95
Mobile Apps	8	5.30
3D computer models	6	3.97
Digital games	5	3.31
Digital story	5	3.31
Multimedia	2	1.32
Scratch	2	1.32
Other	5	3.31
Not reported	18	11.92

* Some studies used more than one technology

3.2.3. Variables and Findings of the Studies

The distribution of independent variables in the interventions and study groups are presented in the Table 9.

Table 9. The Distribution of independent variables, study groups and frequencies

Independent Variable	**Study Group**						**f**
	Kindergarten	Elementary	Middle	High School	Pre/in-service teachers	Gifted	Total
STEM/STEAM	4	2	28	3	10	2	49
Computer Assisted Learning, Web-based learning	2		32		3		37
Animation & simulation		1	14	2	4		21
Augmented Reality			6	1			7
Programming (robotics, block-based programming)			4		3		7
Interactive whiteboard			5		1		6
Mobil applications			3		2		5
Digital games	1		4				5
Blended Learning					4		4
Flipped classroom			1		2		3
Training for TPACK competences					3		3
3D design			2				2
Digital storytelling tools			2				2
Total	7	3	101	6	32	2	151

As seen in Table 9, STEM activities have the highest frequency (f = 49, 32.4%) among the independent variables. 3D design and digital storytelling and the development of pre-service teachers' TPACK competencies were independent variables with low frequency among experimental studies. More than half of the experimental studies (f = 101, 66.8%) were conducted with secondary school students. The frequency of experimental studies conducted with university students was found to be 32 (21.1%). On the other hand, studies conducted with gifted students, primary school, high school and kindergarten students were found to have lower frequencies compared to other sample groups.

In the 151 experimental studies examined, 319 hypotheses were proposed. Dependent variables were found to be related to academic achievement, attitude and motivation, skill, self-efficacy and retention. It was also found that hypotheses about perceptions were put forward. Explanations about the support status of the hypotheses are given in Table 10. Accordingly, academic achievement was the most dependent variable in the studies. Of the 319 hypotheses, 115 were related to academic achievement. The rest of these hypotheses, except for five, were supported. According to this finding, it can be stated that technology in science education has the potential to increase academic achievement. After the academic achievement variable, it was determined that 95 hypotheses were related to attitude, motivation and interest. While 72 of these hypotheses were accepted, 23 were not accepted, and 57 hypotheses were put forward for skill. Higher-order thinking skills such as critical thinking, problem solving, science process, computational thinking, systems thinking, and creativity and design skills were proposed in 47 hypotheses. Among these hypotheses, 43 of them were accepted and 14 of them were not. On the other hand, although STEM activities were included in many studies, two hypotheses related to design skills were put forward but rejected.

Table 10. The Distribution of the Hypotheses

Dependent Variable		Accepted hypothesis	Rejected hypothesis	Total
Achievement		110	5	115
Attitude and motivation		72	23	95
Skills	Problem-solving	13	1	14
	Science process skills	13	4	17
	Creativity	11	2	13
	Design skills	-	2	2
	Critical thinking	2	-	2
	Computational thinking	1	1	2
	Reflective thinking in problem-solving	1	-	1
	Meta-cognition	1	-	1
	Other	5	4	9
Self-efficacy		10	1	11
Retention		6	3	9
Other		24	8	32
Total		265	54	319

It was observed that relatively few hypotheses about self-efficacy (10 supported, one unsupported) were put forward and tested. Nine of the hypotheses put forward were related to retention. It was determined that six of them were supported and three of them were rejected. In line with these findings, achievement, attitude and motivation in science education were mostly investigated variables, on the other hand, more studies are needed on higher-order thinking skills.

4. Discussion and Conclusion

In this study, 234 postgraduate theses on technology integration into science education were examined using SM and SLR approaches. Considering the distribution of postgraduate theses by years in the study, it was concluded that postgraduate theses examining the use of technology in science education learning and teaching processes tend to increase. Accordingly, it was determined that the most research was conducted in 2018. Considering the review carried out in July 2019, it can be said that there has been an increase in research examining the use of technology in

science education in recent years. In the literature review studies on science education, it was seen that similar results were obtained with the findings of this study (Alemli, 2019; Koca, 2019; Gürel et al., 2017). The reason for this increase in recent years can be attributed to the diversity of technologies that can be used in learning and teaching processes. Increasing attempts to digitalize the industry with the developments in ICT can be shown as one of the reasons for this situation. It was concluded that among the postgraduate theses examined in this study, mostly middle school students constituted the study group. It was found that the frequencies of studies conducted with pre-service and in- service teachers were also high. Literature review studies on science supported the findings of this study (Koca, 2019; Sarı, 2018; Doğru et al., 2012).

Among the research methods, the quantitative methods were used the most, followed by the mixed methods, and the least qualitative research method was used. There were similar findings in the literature regarding the frequent use of quantitative methods (Gürel et al., 2017; Yavuz, 2016; Wassink & Sadi, 2016). In this study, it was determined that experimental designs were in majority among quantitative research methods. However, it can be stated that more qualitative research is needed on how this effect occurs, as well as examining the effectiveness of learning and teaching processes using technology. It was observed that the frequently used data collection tools in studies were scale and test. Similar findings were also found by Namdar and Küçük (2018). The reason for this situation can be attributed to the examination of academic achievement and attitude as dependent variables, especially in experimental studies. Theoretical frameworks and models related to technology integration were given a little place in the reviewed postgraduate theses.

Experimental method was used in 151 of the theses. Experimental studies mostly focused on the subjects included in the middle school curriculum. Accordingly, most of the experimental studies were conducted with middle school students. In experimental studies, it was determined that web, animation, simulation and robotic technologies were mostly used. It was seen in many studies that more than one technology was used. Technologies to be used in science education may change over time with the advances in ICT. Therefore, evaluations should be made in the selection of ICT in order to achieve the target outcomes of the learning and teaching process. As a matter of fact, it was stated that technology should be positioned as a tool, not an end, according to instrumentalist perspectives in the integration of ICT (Surry, 1997).

When the interventions in experimental studies were examined, it was seen that the effect of STEM activities was tested the most. Considering that STEM activities were examined as independent variables in 49 of the 151 experimental studies, it was clearly seen that there is a trend to STEM in the field of science education. Computer-assisted learning and web-based learning, animation and simulations were frequently included in the research as independent variables. 3D design and digital storytelling and the development of pre-service teachers' TPACK competencies were independent variables with low frequency among experimental studies. When the topics in experimental research were examined, it was seen that the focus was mostly on physics, while the frequency of topics related to biology was low. This finding was similar to previous review studies (Namdar & Küçük, 2018). It has been revealed that biology classes at the high school level in Turkey are perceived as low in terms of teacher support and high in terms of task orientation (Den Brook, Telli, Cakiroglu, Taconis, & Tekkaya, 2010). Therefore, the effective use of technology in biology courses can be considered for its potential in transforming the classroom climate.

Academic achievement was mostly examined as the dependent variable and most of the hypotheses related to this were supported. However, it should be kept in mind that the resulting effect may not only be related to technology. In addition, there were unsupported hypotheses about retention. This situation raised the question of whether the technology causes an innovation effect or not. After the academic achievement variable, it was determined that the number of experimental studies examined attitude, interest and motivation as the dependent variable was high. However, considering the continuing emphasis on the use of technology in production and problem-solving processes, it can be said that more research is needed that focuses on the creativity and problem-solving skills of students. Namdar and Küçük (2018) also concluded that few studies are focusing on the development of higher-order thinking skills. As a matter of fact, it can be stated that the ultimate goal in the integration of ICT into learning and teaching processes should focus on the development of 21st century skills in addition to subject area learning and affective characteristics. As a result of the research, it was tried to determine the trends in the postgraduate theses on this subject and to present suggestions for future research:

- It was concluded that experimental studies were predominant in studies examining the use of technology in science education. However, it was recommended to conduct qualitative studies that examine the role of technology in the learning and teaching process in depth.
- In this study, it was determined that the studies were mostly conducted with middle school students. Studies with different study groups were recommended.

- It was concluded that the most used data collection tools in the studies were achievement tests and scale. Accordingly, it was recommended to use alternative data collection tools and to use various data collection tools together.
- In experimental studies, it was determined that mostly the effects of interventions on academic achievement and attitude are examined. It was recommended that more empirical research into higher-order thinking skills should be planned in the future.

5. Declaration of Conflict of Interest and Contribution

Each author contributed equally in the preparation of the article. The authors declare that there is no conflict of interest.

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Note: The postgraduate theses examined are located in Turkey Council of Higher Education National Thesis Center.