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Research Trends on the Use of Technology in Early Childhood Science Education: Bibliometric Mapping and Content Analysis

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Abstract
The purpose of this study is to identify research trends from 2011 to 2020 through bibliometric mapping and content analysis of articles on the use of technology in early childhood science education. Articles published between 2011 and 2020, identified through the Web of Science database, constituted the data for the research. For bibliometric mapping and content analysis, this study accessed a total of 47 articles that met the inclusion criteria for science education, early childhood, and technology. The results revealed that the number of articles has increased over the years; that academic achievement,identifying the teaching environment features, and determining teacher experiences were the most examined variables; and that STEM hands-on activities, robotics-programming, and ICT tools such as tablets and computers have been the most- popular technology types. The studies on the use of technology in ECSE are at a developmental stage. Future studies may focus on different variables such as cognitive issues, collaborative activities, and interactions, and on various new technologies such as coding, augmented reality, digital apps, web 2.0, and e-portfolio. They may also focus on increasing the competence of pre-service teachers in the use of new technologies for pedagogical purposes.

Keywords: Early Childhood, ICT, Preschool, Science Education, STEM, Technology

Introduction

Science education and technology use in early childhood are topics that have recently attracted researchers' attention. Researchers have long been discussing whether technology should be used in Early Childhood Education (ECE) (Plowman & McPake, 2013; Zomer & Kay, 2016). Some researchers argue that technology use is not good for children's development as young children should use concrete materials to reinforce their knowledge (Healy, 2004; House, 2012). It is reported that extended screen time causes sensory loss (House, 2012), lack of concentration (Cordes & Miller, 2000), and adversely affects ocular health, muscular, and skeletal development in children (Cordes & Miller, 2000). Potential negative effects also include reduced literacy skills, imagination, social skills, and social exclusion (Cordes & Miller, 2000; Healy, 2004). Some researchers, on the other hand, argue that technological tools will support children's learning outcomes, such as academic achievement (Hillman & Marshall, 2009) and motivation (Sullivan & Bers, 2019), and will particularly develop literacy skills (Parette, Quensenberry, & Blum, 2010; Plowman, Stevenson, McPake, Stephen, & Adey, 2011) when used appropriately according to children's developmental levels. They also state that technology use in ECE can be effective in practicing student-centered learning activities (Inan & Inan, 2015), developing social skills through collaboration (Fridberg, Thulin, & Redfors, 2018; Shifflet, Toledo, & Mattoon, 2012), and overcoming many disadvantages of students (Hutinger & Johanson, 2000).

Rather than discussing whether technology should be used in ECE, early childhood educators have now focused on how technology can be effectively used to facilitate children's learning and development (Blackwell, Lauricella, & Wartella, 2014; Otterborn, Schönborn, & Hultén, 2019; Parette et al., 2010; Trundle, 2010). Meanwhile, one of the content areas that will be most affected by technology use in ECE is science.

Integration of Technology into Early Childhood Science Education

Children have a natural tendency to enjoy observing and thinking about nature and trying to learn about the world (Trundle, 2010), including also the technological world (Blackwell et al., 2014). The aim of early childhood science education (ECSE) is to provide experiences that can stimulate children's curiosity, motivate them to deal with their environment and the mechanisms of nature, and gain knowledge and skills about scientific concepts, methods, and processes (Bustamante, White, & Greenfield, 2018; Olgan, 2015; Trundle, 2010). Young children should be involved in learning about the world from a scientific viewpoint, starting from the first day of school (Inan & Inan, 2015). Early childhood teachers should also encourage students to explore and keep their interest in science alive (Inan & Inan, 2015). Moreover, children should be encouraged to ask questions, seek answers, and dream about nature (Akerson, Buck, Donnelly, Nargund-Joshi, & Weiland, 2011; Bustamante et al., 2018). Children also need to measure, collect, analyze, and interpret data as well as to make observations to learn science (Akerson et al., 2011; Trundle, 2010). In this way, they will gain knowledge and skills about science, scientific methods, and basic scientific processes (Akerson et al., 2011; Bustamante et al., 2018). The benefits of science for children in early childhood can be further enhanced with the help of technology. Technology can further increase the effectiveness of ECSE (Blackwell et al., 2014; Jennings, Hooker, & Linebarger, 2009). Williams and Easingwood (2003) states that children can take photos or shoot videos of the natural world and real-life events with tools such as cameras anduse the Internet extensively to access sources of information. Tools such as the Internet, harddisk, and others enable to collect, store, and modify data, facilitate scientifict hinking with simulation or modeling, answering the "What if?" questions with virtual experiments, and strengthen communication with other places, subjects, and people. In addition to supporting student learning, they also facilitate the teacher's work.

In order to increase the quality of ECSE, researchers have used several technological tools, such as tablets (Fridberg et al., 2018), computers, and several ICT tools (Hu & Yelland, 2017; Mertala, 2020; Samuelsson, 2019; Sundqvist & Nilsson, 2018), digital apps (Kim, Asher, Burkhauser, Mesite, & Leyva, 2019), coding (Çiftci & Bildiren, 2020) robotic kit (Sullivan & Bers, 2018, 2019) programming (Master, Cheryan, & Meltzoff, 2017; Otterborn et al., 2019; Papadakis & Kalogiannakis, 2019), STEM (Chen, Huang, & Wu, 2020; Yıldırım, 2020; Zhao & Guo, 2019) and other technologies such as e-portfolio (Franklin & Smith, 2015; Habeeb & Ebrahim, 2019), augmented reality (Ozdamli & Karagozlu, 2018) and web 2.0 (Alkhayat, Ernest, & La Chenaye, 2020). In addition, some researchers have focused on identifying teachers' use of technologies in their classrooms (Hu & Yelland, 2017; Otterborn et al., 2019; Sundqvist & Nilsson, 2018), their beliefs (Chen et al., 2020; Mertala, 2020; Master et al., 2017; Park, Dimitrov, Patterson, & Park, 2017), their perceptions (Habeeb & Ebrahim, 2019), and examining the effects of these technologies on students' learning outcomes such as academic achievement, motivation, attitude, student engagement, retention, and problem-solving (Bustamante et al., 2020; Zhao & Guo, 2019). With the opportunities offered by technologies such as coding, programming and other tools, children have started to come up with new designs and ideas (Çiftci & Bildiren, 2020; Master et al., 2017; Otterborn et al., 2019; Papadakis & Kalogiannakis, 2019). As a result, STEM, which integrates science, technology, engineering, and mathematics, has gained popularity in ECSE teaching, as in other levels of education. Science and technology are among the basic elements needed in STEM skills today, and STEM is an important part of a young child's education in the 21st-century classroom (Chen et al., 2020; Yıldırım, 2020). In the past, science and mathematics education did not include technology and engineering subjects. In the 21st century, however, science and technology are almost intertwined.

In this context, the use of technology in ECSE differs in terms of technology, pedagogy, and sampling, however, it is rather a new subject in the literature. Children are exposed to many new forms of technology in their daily lives and classrooms at a young age. Due to rapid development and change in technology, it is important to periodically review the studies about the use of technology in ECSE to provide a reference for both researchers and teachers in their future studies and applications revealing the current situation.

Rationale for the Study

Some review studies focus on the use of technology generally in early childhood education (ECE) but not on a particular discipline (Hsin, Li, & Tsai, 2014; Jack & Higgins, 2019; Khodabandelou, Mehran, & Nimehchisalem, 2018; McCarrick & Li, 2007; Murcia, Campbell, & Aranda, 2018; Yelland, 2005; Zomer & Kay, 2016). These studies focused on identifying the effects of technologies on learning outcomes such as creativity and critical thinking (McCarrick & Li, 2007; Yelland, 2005), social interaction (McCarrick & Li, 2007; Zomer & Kay, 2016), active participation in teaching activities, cognitive development and motivation (McCarrick & Li, 2007), and the problems and challenges for educational applications in the early years (Murcia et al., 2018). However, they did not address methodological trends. Furthermore,some review studies focused on the use of technology in a particular discipline in ECE, such as literacy (Burnett, 2010; Eutsler, Mitchell, Stamm, & Kogut, 2020; Lankshear & Knobel, 2003; Papadakis, Kalogiannakis, & Zaranis, 2018; Zucker, Moody, & McKenna, 2009), mathematics (Verbruggen, Depaepe, & Torbeyns, 2021), or foreign language teaching (Yilmaz, Topu, & Takkaç-Tulgar, 2019). Other studies have focused on the use of specific technologies in ECE, such as touchscreen mobile devices (Liu & Hwang, 2021) orrobots (Toh, Causo, Tzuo, Chen, & Yeo, 2016). Few of these studies offer systematic reviews (Eutsler et al., 2020; Khodabandelou et al., 2018; Verbruggen et al., 2021; Yilmaz et al., 2019). However, no study has focused specifically on the use of technology to teach science in ECE.

Recently, ECSE has begun to attract more attention from researchers, as the technologies used in education have been updated. The absence of a review study on science education creates a need in this field. Presenting research trends related to the studies focusing on the use of technology in ECSEis important to give a complete picture and reveal gaps in the current knowledge of the field. Doing so can encourage researchers to fill in research gaps and address issues that are not fully explored or supported by evidence. Such a study will also ultimately support the development of a technology-integrated science curriculum. The purpose of this study is to identify research trends between 2011 and 2020 by conducting bibliometric mapping and content analysis of articles related to the use of technology in ECSE. For this purpose, the research questions are listed below. In the articles on the use of technology in ECSE,

1. What is the distribution of the most used keywords?
2. What is the distribution of the most used words in abstract section?
3. Who are the most cited authors(citation and co-citation)?
4. Which are the most cited journals(citation and co-citation)?
5. What is the distribution of the number of articles over the years?
6. What were the examined variables?
7. Which technology types were used?
8. What were the methodological trends?
9. What were the most preferred data collection tools?
10. What were the most preferred sampling methods, sample populations and sample sizes?
11. What were the most preferred data analysis methods?

Method

Bibliometric analysis is the use of statistics to determine certain characteristics of publications in any field (Pritchard, 1969). In bibliometric analysis, publications are examined according to specific characteristics such as distribution of the number of publications over the years, the most studied topics; and other findings are made about scientific publications. Content analysis (thematic) critically reveals trends in publishes of an area by creating themes or templates, and it provides a rich resource for researchers studying in the relevant area and having limited access to all publishes (Çalık & Sözbilir, 2014). Because this study proposes to reveal research trends in the articles on the use of technology in ECSE published in the journals in the Web of Science (WoS) database between 2011 and 2020, the bibliometric analysis and the thematic content analysis was preferred.

Data Collection and Purification Process

The data were collected from the WoS database, as it allows to access easily all SSCI, and other important indexed journals. The study was initially planned for studies involving only the use of digital technology. However, the number of articles accessed in the database is low (n=20), STEM studies were also included to increase the number of reviewed articles. Studies on the use of technology for education have recently been widely carried out with STEM. The relevant articles were collected from combining after scanning the below two different keywords groups: *((kindergarten* OR "early child*" OR preschool* OR "early year*" OR "young child*") AND (technolog* OR computer* OR "information and communication* technology" OR ICT OR *media OR digital* OR electronic* OR mobile OR internet OR tablet OR software OR reality OR robotic* OR screen OR coding OR programming OR "web 2.0" OR "educational app*") AND ("learning for science" OR "education in science" OR "scientific project*" OR "science reading" OR "science center*" OR "science game*" OR "teaching science" OR "science class*" OR "earth science" OR "natural science" OR "museum science*" OR "science education" OR "science course*" OR "science learning" OR "learning science" OR "science teaching" OR "science content*" OR "science laborator*"))and ((kindergarten* OR "early child*" OR preschool* OR "early year*" OR "young child*") AND ("stem" OR "steam" OR "science technolog* engineering math*" OR "science technolog* engineering and math*" OR "science technolog* engineering art math*" OR "science technolog* engineering art and math*"))* in the topic section, using the advanced search function. These were preferred to facilitate the review of the articles as the word "science" is too all-enveloping and were obtained by the researcher expanding the keywords used in previous review studies on science education or the use of technology in early childhood (Arıcı, Yildirim, Caliklar, & Yilmaz, 2019; Eutsler et al., 2020; Jack, & Higgins, 2019; Verbruggen et al., 2021). The time span was limited to the period from 2011 to 2020. The language was selected as "English" and the document type was determined as "journal articles" for consistent quality. As a result of this scan, a total of 234 articles were accessed in the "education/educational research category" (Access date: April 2021).

Subsequently, these collected articles were checked for eligibility according to the inclusion and exclusion criteria to examine whether they are really related to the use of technology in ECSE. The first inclusion criterion was whether the article was about science education. The second criterion was whether the article covered early childhood. This included children in early childhood, early childhood teachers, or technology use in early childhood. The third criterion was whether the article contained technology (also STEM). For this purpose, the title, summary, and keywords of all articles in the pool were checked one by one. At the end of these checks, articles not related to the sample group of early childhood were removed from the data pool. For example, articles were about 4-5th grade students, or were included in the pool due to the use of expressions such as from kindergarten to university in the abstract section, but were not about kindergarten, were removed from the pool. The articles in which the word technology was used in the text, butwas not used in the context of pedagogy were removed from the pool, as they only used technology for data collection purposes, or to explain the characteristics of the present time. The articles that were included in the pool due to containing words, such as computer science, but were not related to science education were removed from the pool. At the end of the purification process, a total of 47 articles were found to be suitable for the purpose of this study.

After the articles included in the study were determined, the same articles were found searching the WoS database as in the first search in May 2021. Then, full records and cited references were downloaded in tab-delimited (Win) file format. The mappings were created by uploading the file to VOS Viewer.

Data Analysis

To create bibliometric maps, VOS Viewer software was used to visualize the networks of the words and keywords most frequently used in the abstracts of 47 articles, their distribution over the years, and the most cited authors and journals.

Then, to conduct a content analysis, the Publication Classification Form developed by Goktas et al (2012) was used to analysis of 47 articles whose full texts were accessed. The form consisted of five sections: 1.Study and author's name and journal name, 2.Methods, 3.Data collection tools, 4.Samples and 5.Data analysis methods. Also, the examined variables and the types of used technological tools in the articles were also identified. The data analysis process was carried out twice by the researcher 3 weeks apart. The consistency value between the two analyzes was calculated as 0.91. The articles were re-examined, and inconsistencies were resolved.

Findings

Bibliometric Mapping Analysis Findings

The Most used Keywords in the Articles

The co-occurrence analysis was used, and author keywords were selected in VOS Viewer to create a map based on text data for the most used keywords. The minimum number of occurrences of a keyword was set as 2 and the number of keywords to be selected was automatically taken as 20. Since the number of keywords used in the data collection process of this study was high, the minimum number of repetitions was selected as 2, to reveal the variables investigated in the studies. The map for the most used keywords in the articles is given in Fig. 1, and the map for their distribution over the years in Fig. 2.

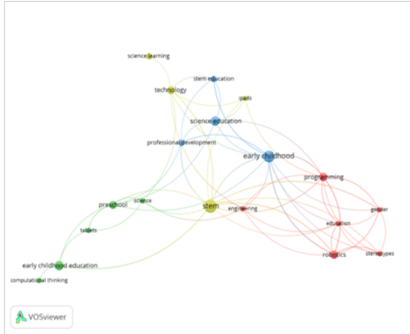

Figure 1 The Most used Keywords in the Articles

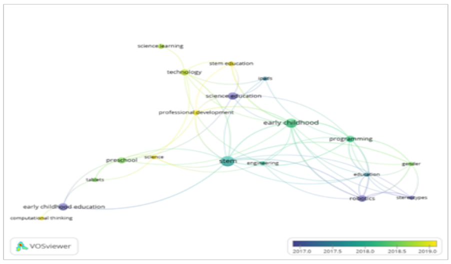

Figure 2 Distribution of the Number of Used Keywords in the Articles Over the Years

Fig. 1 shows that there are 4clusters, and the most used keywords are STEM (f=12), early childhood (f=9), early childhood education (f=6), science education (f=6), programming (f=5), robotics (f=5), preschool (f=4), and technology (f=4). These results clearly show that the articles published between 2011 and 2020 years mostly focus on STEM education and robotic programming in ECE. It can also be seen in Fig. 2, that the articles published towards 2020 focuses on professional development and STEM education in science education, the articles published in 2018 focuses on STEM, robotic programming, and early childhood education. Also, the number of co-words used has been higher in recent years.

The Most Used Words in the Abstract Sections

The WoS bibliographic database file was uploaded to the software to create a map based on text data for the most used words in the abstracts of articles. Then, abstract and binary counting method were selected as the field. The minimum number of occurrences of a term was set as 4 and the number of terms to be selected was automatically set to 50.

Figure 3 Most used Words in the Abstract

The map is given in Fig. 3 that shows there are 3 clusters and the most used words in the abstracts are education (f=17), mathematics (f=14), understanding (f=13), development (f=12), use (12), learning (f=10), and process (f=10). These results indicate that the articles mostly focus on understanding students' concept, development of students or in/pre-service teachers, their use of technology and process STEM education. The distribution of the most used words in the abstract over the years is given in Fig. 4.

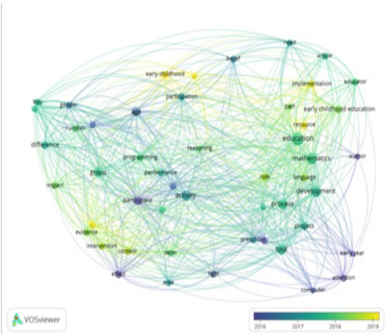

Figure 4 Distribution of the Most Used Words in the Abstracts Over the Years

The most recent articles mainly focus on the benefits of approaches such as programming, play, and STEM training applied for early childhood while the previous articles focus on children's attention and beliefs processing of a certain context.

The Most Cited Authors

Citation analysis and authors were selected to create a map for the most cited authors. The minimum number of documents by a particular author was set as 2 and the minimum number of citations of an author was determined as 10. The number of authors to be selected was automatically given as 3. The map is given in Fig. 5 indicating that the most cited authors in this area were Bers and Sullivan (Citations[cit]=151, Documents[doc]=5), Gaskins, Geddes, Haden, Hoffman, Jant and Marcus (cit=44, doc=1).

Figure 5 The Most Cited Authors (Citation Analysis)

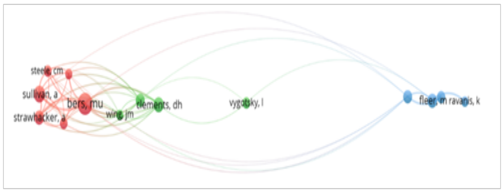

Figure 6 Most Cited Authors (Co-Citation Analysis)

Furthermore, co-citation analysis and cited authors were selected. The minimum number of citations of an author was set as 6 and the number of authors to be selected was automatically given as 17. The map is given in Fig. 6 which shows most cited (co-citation) authors in this area were Bers (26 cit), Sullivan (14 cit), and Clement (12 cit).

The Most Cited Journals (Citation and Co-Citation)

Citation analysis and sources were selected to create a map for the most cited journals. The minimum number of documents of a source was set as 2 and the minimum number of citations of a source was also set as 2. The number of sources to be selected was automatically given as 10. The map is given in Fig. 7 shows that the most cited journals are International Journal of Technology and Design Education (148 cit., 4 doc.), British Journal of Educational Technology (59 cit., 3 doc.), Early Childhood Research Quarterly (46 cit., 2 doc.), and Journal of Science Education and Technology (35 cit., 3 doc.).

In addition, co-citation analysis and cited sources were selected. The minimum number of citations of a source was set as 15 and the number of sources to be selected was automatically set to 12. The map is given in Fig. 8 shows that the most cited journals are International Journal Science Education (34 co-cit.), Computer and Education (31 co-cit.), and Child Development (46 co-cit.).

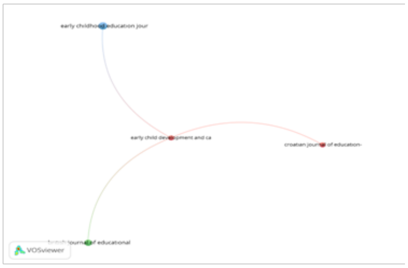

Figure 7 The Most Cited Journals (Citation Analysis)

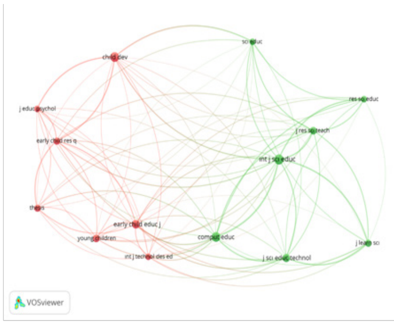

Figure 8 The Most Cited Journals (Co-Citation Analysis)

Content Analysis Findings

Distribution of the Number of Articles Over the Years

The distribution of the number of related articles over the years are given in Figure 9.

The results revealed that the number of articles has increased over the years, as well as it has increased more rapidly since 2017.

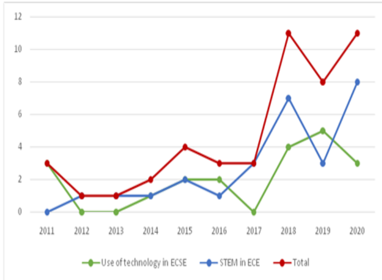

Figure 9 Distribution of the Number of Articles Over the Years

Examined Variables

The frequencies of examined variables the articles are given in Table 1. The results revealed that the primary examined variables in the articles are academic achievement (f=18) and identifying the teaching environment features(f=11). Furthermore, many other variables such as determining the benefits and harms of education, engaging time, gender, technological skills, teacher beliefs, teacher opinions, transfer to daily life, attitude and others were all examined in the reviewed articles.

Table 1 Frequency of the Examined Variables in the Articles

Examined Variables	Number of articles*	Percentage (%)
Academic achievement	18	38,30
Identifying the teaching environment features	11	23,40
Determining the benefits and harms of education	6	12,77
Engaging time	6	12,77
Gender	5	10,64
Technological skills	5	10,64
Teacher beliefs	3	6,38
Teacher opinions	3	6,38
Transfer to daily life	3	6,38
Attitude	3	6,38
Determining teacher experiences	2	4,26

Self-efficacy	2	4,26
Reflective thinking	2	4,26
Concern	1	2,13
Problem solving	1	2,13
Retention	1	2,13
Professional development	1	2,13
Computational thinking	1	2,13
Preferences on STEM activities	1	2,13
Career choice	1	2,13

Types of Used Technology

Types of used technology in the articles are given in Table 2. It revealed that STEM studies with hands-on activities (f=10) and with robotics-programming (f=9) were the most-preferred types. The most used technologies were ICT tools (f=5) such as tablet, computer, common technologies,simulation (f=3) and web 2.0 (f=3). Augmented reality, digital apps, digital books are other types of used technology in the articles. Additionally, some articles referred to the use of e-portfolio, video, educational games (STEM) and common technologies.

Table 2 Frequency of Technology Types Used in ECSE As Stated in the Articles

Technology Types		Number of articles	Total number of articles	Percentage (%)
ICT	Tablet, iPad	3	5	10,64
	Computer	1		
	Common tech.	1		
Simulation		3	3	6,38
Web 2.0		3	3	6,38
AR/VR		2	2	4,26
Digital apps (games)		2	2	4,26
Digital books		2	2	4,26
Tech-other	e-portfolio	1	3	6,38
	Video	1		
	Virtual classroom	1		
STEM	Hands-on	10	10	21,28
STEM (Robotics-Programming)	Robotics	8	9	19,15
	Programming	1		
STEM-other	Undefined	4	8	17,02
	Common tech.	2		
	Educational games	1		
	e-books	1		

Distribution of the number of articles using the technology types over the years are given in Fig. 10.In Fig. 10, there is an increase in the types of technology used due to the increase in the number of articles over the years. However, there has been an increase in diversity of type of used technologies STEM hands-on, robotics-programming, augmented reality, and web 2.0 in the articles since 2018.

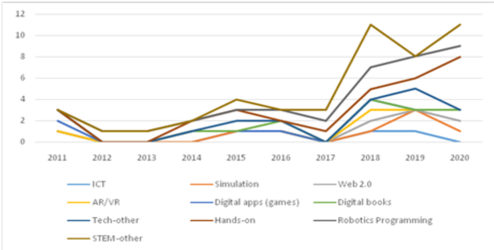

Figure 10 Distribution of used the Technology Types Over the Years

Method Trends

Method trends are given in Table 3 and Fig. 11. Table 3 shows that 29.8% of the articles used qualitative design, 29.8% quantitative design, 14.9% mixed design, and 25.5% systematic-analysis and other research. Among all methods, triangulation was the most preferred design (22%). Quasi-experimental was the most preferred among experimental quantitative methods. Case study was the most preferred among qualitative methods.

Table 3 Method Trends in Articles

Research Methodologies		Research Methods	f / (%)	∑f / (%)
Quantitative	Experimental	True experimental	3 (6.38)	14 (29.8)
		Quasi-experimental	4 (8.51)	
		Pre experimental	3 (6.38)	
		Total	10 (21.30)	
	Non-experimental	Descriptive	2 (4.26)	
		Comparative	2 (4.26)	
		Total	4 (8.51)	
Qualitative		Phenomenological Study	3 (6.38)	14 (29.8)
		Case Study	9 (19.10)	
		Concept analysis	1 (2.13)	
		Ethnographic analysis	1 (2.13)	
Mixed		Triangulation	7 (14.90)	7 (14.9)
Other		Systematic analysis/ Design-Based Research	5 (10.60)	12 (25.5)
		Undefined	7 (14.90)	
Total				47 (100)

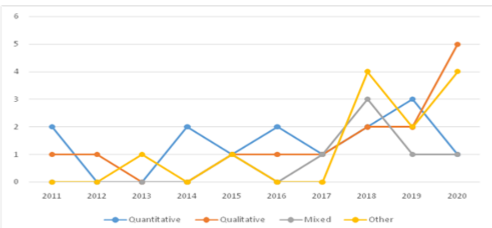

Figure 11 Distribution of Research Method Over the Years

Fig. 11 shows that, regarding the distribution of research methods over the years, the use of qualitative and mixed methods increased in the period from 2017 to 2020. Qualitative design was most commonly used in 2020, mixed design decreased after 2018, and systematic analyses/others began to be used in 2018.

Data Collection Tools

The frequencies of the data collection tools are given in Figure 12 and their distribution over the years are given in Figure 13.

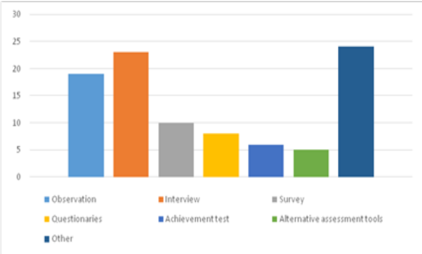

Figure 12 Frequencies of the Data Collection Tools

The findings show that interviews (F=23), observations (f=19), surveys (f=10), questionnaires (f=8) and achievement test (f=6) were commonly used in the articles. Regarding the distribution of data collection tools over the years, interview,observations and questionnaires increased throughout the period. Interviews and surveys were most commonly used in 2020.

Sampling Methods, Sampling Groups, and Sample Sizes

The frequency of use of the sampling groups is given in Table 4 which shows young children (63.04%) were commonly preferred as a sample group. In-service teachers (32.61%) and pre-service teachers (4.35%) were chosen as other sampling groups.

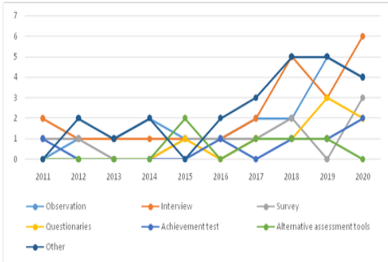

Figure 13 Distribution of the Data Collection Tools Per Year

Table 4 Frequency of the Use of Sampling Size According to Sampling Groups*

Sampling Groups	Sample Size				Sampling Method				Total	%
	1-10	11-30	31-100	101-300	Randam	Conventient	Purposive	Undefined		
Children	3	8	11	7	1	19	4	5	29	63.04
In-service teachers	9	3	1	2	1	7	3	4	15	32.61
Pre-service teachers	-	-	1	1	-	2	-	-	2	4.35
Total	12	11	13	10	2	28	7	9	46	100
%	26.09	23.91	28.26	21.74	4.35	60.87	15.22	19.56	100	

*The total number is 5 more since both teachers and children were used as the sampling group in 5 study. 6 articles are about material development or learning environment design.

Table 4 shows the 31-100 samples (28.26%) were the most preferred sample size in the articles. However, other sample size groups were almost equally as 1-10 samples(26.09), 11-30 samples (23.91%), and 101-300 samples (21.74%).Table 4 shows the most commonly used sampling method is convenient sampling (60.87%). In addition, the distribution of sampling methods over the years is given in Fig. 14.

It shows the use of convenient sampling increased rapidly after the 2015. The use of random sampling method decreased throughout the period. The use of purposeful sampling method was not regularly throughout the period.

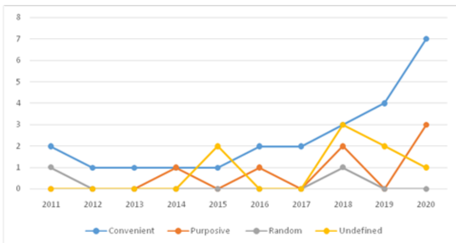

Figure 14 Distribution of the Use of Sampling Method in Articles Over the Years

Data Analysis Methods

Data analysis methods are given in Table 5 which shows that the data analysis method most conducted was content (66.67%). Secondly the techniques most used were frequencies, percentages, tables (40.48%), means, and standard deviations (23.81%). The most commonly used inferential techniques were t-tests (21.43%).

Table 5 Distribution of Data Analysis Methods in the Articles

Analysis Methods	Analysis Techniques	f	%
Descriptive analyses	Frequencies, percentages, tables	17	40,48
	Means, standard deviations	10	23,81
	Graphs	9	21,43
Inferential analyses	T-tests	9	21,43
	Non-parametric tests	8	19,05
	ANOVA/ANCOVA	7	16,67
	Correlations	3	7,14
Qualitative Analyses	Content Analysis	28	66,67
	Descriptive Analysis	1	2,38

Discussion

The number of articles on the use of technology in ECSE increased from 2011 to 2020 and increased more rapidly from 2017. Possible reasons for this trend include, first, that ECSE is gaining in popularity, as the use of technology in science education reaches saturation at other educational levels, such as primary or secondary schools. The second is the widespread use of new types of technologies such as robotics, augmented reality, and web 2.0 in education. This trend also suggests that ECSE will become more popular in the future.

Bibliometric analysis results revealed that the articles on ECSE from 2011 to 2020 primarily focused on STEM education and programming. More recent articles focused mainly on professional development and STEM education in ECSE. Bibliometric analysis of the most commonly used words in abstracts and content analysis that examined variables consistently demonstrated that these articles mostly focused on understanding students' academic achievement, revealing the development of students or in/pre-service teachers by identifying features of the teaching environment, and examining the use of technology in STEM education. Examining academic achievement and identifying features of the teaching environment were expected results because they are the most common variables in previous research (Arıcı et al. 2019; Chang, Hsu, & Wu, 2016; Çiftci & Bildiren, 2020; Goktas et al. 2012;Habeeb & Ebrahim, 2019; Küçük, Aydemir, Yildirim, Arpacik, & Goktas, 2013). These results may reflect the undefined nature of how technology is used for pedagogical purposes in ECSE and the lack of experience of in-service/pre-service teachers in using technology. This conclusion is supported by other studies, which have found that teachers have deficiencies in using technology in their teaching (Ching, Hsu, & Baldwin, 2018; Çalik, Özsevgec¸ Ebenezer, Artun, & Küçük, 2014; Kjällander & Frankenberg, 2018; Konstantinidis, Theodostadou, & Pappos, 2013; Otterborn et al., 2019; Sadaf, Newby, & Ertmer, 2012; Strawhacker, Lee, & Bers, 2018). This study's content analysis findings indicate that the number of new types of technology used in ECSE has increased. For this reason, it is natural for researchers to investigate how technologies are used in ECSE and their effects on student learning outcomes and teacher competencies. These results showed that studies of the use of technology in ECSE are at a developmental stage, and new studies are needed in the future.

An analysis of citations and co-citations revealed that Amanda Sullivan and Marina Umaschi Bers were the most frequently cited authors in this field. They have studied robotics in ECSE and are also the most frequently published authors with five articles within the bounds of this study. This finding indicates that robotics and programming have begun to gain importance in ECSE. This result is also supported by the finding that programming is one of the most often used keywords in articles. The most cited journals were the International Journal of Technology and Design Education, British Journal of Educational

Technology, Early Childhood Research Quarterly, and Journal of Science Education and Technology. These journals are the most prominent on technology or early childhood or science education.

Many articles in the scope of this study have focused on STEM hands-on activities and robotics-programming. Other topics include ICT tools such as tablets and computers, simulations, and web 2.0. Augmented reality, digital apps, digital books, e-portfolios are rarely mentioned as technology types. STEM studies, which have been popular in all levels of education in recent years (Brenneman, Lange, & Nayfeld, 2019; Murphy, MacDonald, Danaia, & Wang, 2018), have also affected ECE. ICT tools are more commonly used in ECSE because they are more common and accessible in daily life. Arıcı et al. (2019) and Chen, Liu, Cheng, and Huang (2017) found that scholars preferred to focus on these technologies due to their widespread use around the world. The number of articles that used a specific type of technology, such as programming, robotics, coding, augmented reality, digital apps, digital books, or e-portfolio, has been increasing in recent years. Computational thinking skills have become more accepted as basic skills, like mathematics and literacy (Bocconi, Chioccariello, Dettori, Ferrari, & Engelhardt, 2016; Papadakis & Kalogiannakis, 2019), because citizens' ability to use digital technologies critically and creatively is considered to be a necessary skill in many countries, especially those in Europe (Papadakis, 2016; Redecker, 2017). These types of technology may have been more preferred in recent years because they enhance computational thinking (Papadakis & Kalogiannakis, 2019).

These trends, which are compatible with the findings of this study, suggest that there has been a transition in recent studies from having children use computers or tablets to robotics, coding, augmented reality, and digital applications. For this reason, researchers tend to define the classroom environment in terms of technology and call for teachers to integrate technology into their teaching. The fact that the most examined variables in this study are identifying features of the teaching environment and determining teacher experience supports this reasoning. Yilmaz et al. (2019) found that recent studies of early childhood foreign language teaching primarily focused on teacher education. Increasing the competence of teachers is critical (Wong, 2016), as teachers are vital for young children's science development.

This study found that the frequency of use of various research designs was very close. This result conflicts with those of other reviews of educational technology studies (Arıcı et al., 2019; Küçük et al., 2013). They found that researchers most frequently used quantitative research designs. One reason for this discrepancy may be that researchers prefer qualitative sources to collect in-depth data because of the illiteracy of young children. The articles in this study focused on mostly young children as their sample groups, unlike many other studies. The choice of triangulation as the most common methodological design also supports this interpretation. Another reason may be a growing preference for qualitative methods among researchers (Goktas et al., 2012).

This study found that interviews, observations, surveys, questionnaires, and achievement tests were the most commonly used data collection tools. This result is not surprising because the number of studies that used quantitative, qualitative, and mixed methods was also very close. The number of studies using interviews, surveys, and observations increased throughout the period. These findings are consistent with those of previous studies (Altınpulluk, 2018; Arıcı et al., 2019). They found that surveys and interviews were the most frequently used data collection tools. Chen et al. (2017) observed that tests, interviews, video observations, and surveys were the most preferred methods in the studies they examined. Korucu Usta, and Yavuzarslan (2016) reported that the most used tools, in decreasing frequency, were documents, surveys, interviews, and achievement tests. The findings of this study are largely in line with those of these previous studies.

The results of this study showed that convenience sampling was the most common sampling method in the studies. This observation is also consistent with that of other reviews (Arıcı et al. 2019; Goktas et al., 2012; Küçük et al., 2013). Researchers prefer this method because they can access the sample group easily (Baydas, Küçük, Yilmaz, Aydemir, & Goktas, 2015). Sample sizes varied, with 1-10, 11-30, 31-

100, and 101-300 as the most common. Sample size largely depended on whether researchers were using quantitative, qualitative, or mixed designs in their studies. Küçük et al. (2013) found that a sample size of 31–100 was most often used in quantitative and mixed studies, while a sample of 11–30 was most common in qualitative studies. Quantitative studies sometimes used larger samples to generalize.

The most preferred data analysis methods were content analysis, frequencies/percentages/tables, and means/standard deviations. Arıcı et al. (2019) found that the most frequently used data analysis methods were content analysis, frequencies/percentages/tables, and means/standard deviations. Some researchers prefer content analysis over descriptive analysis because it offers more detailed results (Creswell & Clark, 2017). Researchers often employed content analysis to explain the in-depth data they obtained.

The following recommendations are based on the results of this study.

- The studies on the use of technology in ECSE are at a developmental stage. Future studies should focus more comprehensively on the different pedagogical benefits of various new technologies.
- A few studies on new technologies in ECSE exist that explore such topics as coding, augmented reality, digital apps, web 2.0, and e-portfolio. Future studies should focus on the effects of these new technologies on students' learning outcomes and assessing teacher competencies with new technologies.
- Future studies should focus on other variables such as cognitive issues, collaborative activities, and interactions, along with identifying the features of the teaching environment, academic achievement, and teacher competencies.
- Few studies use pre-service teachers as a sample group. Future studies should be carried out to determine how to increase the competence of pre-service teachers, especially in the use of new technologies for pedagogical purposes.
- Researchers used quantitative and qualitative data collection tools and analysis methods with roughly equal frequency. Future studies should use them together for triangulation and gathering in-depth information.
- This study is based on articles that focused on the use of technology in ECSE from the WoS database. Future studies should expand this study by including larger samples from other databases and include conference proceedings and book chapters for more extensive coverage.

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