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Examination of Studies on Concept Teaching in the Field of Science Education

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Abstract: Concepts, as well as forming the basis of scientific knowledge, are also important in terms of their correct learning and understanding. Teaching the concepts of a subject in a way that they can understand, makes it easier for students to associate the concepts with their daily life and use them in their daily lives. This study aims to analyze the content of the studies conducted between 2010-2020 on analogies, conceptual change texts, concept cartoons, meaning analysis tables and concept maps used in teaching concepts in science education and in identifying and eliminating misconceptions in Turkey. In the study, 169 studies including 50 articles, 105 master theses and 14 doctoral dissertations on concept teaching were used. While document analysis method is utilized in the study, while the data are shown with the descriptive analysis method, analyzed results are displayed with tables and graphics using percentage and frequency values. The results of the study shows that while quantitative research are more commonly preferred, more master's theses are conducted compared to articles and doctoral dissertations, and while the research are more frequently conducted on the subject of "determination and elimination of misconceptions", secondary school students are more commonly preferred as sample groups and "conceptual comprehension test" is the most frequently used measurement tool. This study may suggest future researchers to conduct studies on concept teaching of teachers.

Keywords: Science education, Concept teaching, Studies about concept teaching.

Introduction

In science education, we aim to raise our students as scientifically literate individuals who can solve problems, question, have a critical perspective, adapt to their environment in change and development, and associate the knowledge they learn at school with daily life (Ministry of National Education, 2005). Raising such individuals can only be achieved by structuring the information about science in a meaningful way at the level of concepts and learning in accordance with the scientific definition. It is very important to learn the basic concepts correctly in the teaching of a subject. Teaching the concepts in the subject in an understandable way makes it easier for students to associate these concepts with and use them in their daily lives. According to Özmen (2005), with the acceleration of the developments in science and technology, knowledge accumulation also increases rapidly. It becomes increasingly difficult to convey all of this information to students and thus, concept teaching becomes more important. Therefore, while trying to teach a subject basic concepts should be emphasized effectively and in depth. Thus, the necessary basis is formed for the students to easily access information themselves (Akdeniz, Yıldız, & Yiğit, 2001). While the correct learning of the concepts has gained such importance, the wrong concepts that students bring to the classroom before entering the class make it difficult to carry out science education effectively. Concepts that are passed without being learned correctly cause students to develop alternative concepts in their ongoing education life and have difficulties in learning the other subjects. According to Bodner (1986), students may have alternative ideas different from the ones advocated by scientists in case of lack of basic knowledge. If the concepts formed in students' minds differ from the concept that the educator aims to give, students cannot associate these concepts with scientific explanations in their daily lives, and students face misconceptions (Aydoğan et al., 2003, Coştu et al., 2007). According to Piaget, misconceptions are like structures that add up on top of each other and create more and more gaps in learning. Learning activities carried out without paying attention to the concepts and misconceptions of students will increase their misconceptions (Büyükkasap et al., 2001). Science concepts are mostly abstract concepts, and the concepts that students acquire from their own lives are mostly unscientific concepts formed by their prejudices,

wrong beliefs and environmental influence. Misconceptions are deep and permanent, so the reasons for misconceptions should be investigated thoroughly. Studies have revealed that it is extremely difficult to reverse and correct a student's misconceptions.

The effects of learning the concepts incorrectly can last throughout an individual's life (Svandova, 2014). In fact, some misconceptions are deeply rooted in students' psyche, and simply asking students to reject them may fail (National Research Council [NRC], 1996). For this reason teaching of the concepts and elimination of misconceptions has gained importance in recent years. Concepts should be concrete, logical and understandable by the student in order to learn the concepts correctly and to eliminate misconceptions. In concept teaching, many methods are used to identify and eliminate misconceptions. One of these methods is the analogy method. Studies on analogy-based teaching method show that analogies concretize abstract concepts as a result of associating them with real life events, facilitate understanding of concepts and provide permanence in learning (Sağırlı, 2002; Wong, 1993). Analogies form a bridge between concepts that students already know well and concepts they do not know and are going to learn. Meaning analysis tables are frequently used in concept teaching during and after the process for evaluation. While the objects or concepts whose properties are to be determined are written in one of the columns or rows of the table, the properties of these concepts are listed in another. During the preparation of these tools, the student develops new concepts by combining the meanings of the words being learned with concepts previously known (Çepni, 2006). Many studies have shown that meaning analysis tables are effective in teaching the descriptive and distinctive features of concepts (Aydın & Balım, 2005; Caner, 2008). According to Asubel (1968), the most important factor affecting learning is the knowledge of students. In order for meaningful learning to take place, new concepts to be learned should be associated with previous concepts. Concept maps serve as a bridge between new concepts to be learned and previous concepts, and are based on Ausubel's meaningful learning theory (Broggy & McClelland, 2008). Concept maps are defined as visualized, concrete graphs showing the relationship between concepts (Kaptan, 1998; Martin, Sexton, Wagner & Gerlovich, 1994). In our country, a lot of studies have been done in teaching concepts in science education and determining and eliminating misconceptions. This has led to the need to determine a general framework for the methods used in concept teaching. In order for meaningful learning to take place, new concepts to be learned should be associated with previous concepts. Concept maps serve as a bridge between new concepts to be learned and previous concepts, and are based on Ausubel's meaningful learning theory (Broggy & McClelland, 2008). Concept maps are defined as visualized, concrete graphs showing the relationship between concepts (Kaptan, 1998; Martin, Sexton, Wagner & Gerlovich, 1994). In our country, many studies have been done in teaching concepts in science education and determining and eliminating misconceptions, and this has led to the need to determine a general framework for the methods used in concept teaching.

In this context, the aim of the study is to create a content analysis, aiming to find answers for sub problems determined within the scope of the research, on master's theses and doctoral dissertations conducted and registered between the years 2010-2020 in the National Thesis Center of Institution of Higher Education and research papers in the database of ULAKBİM and obtained through the database of Google Scholar on analogies, conceptual change texts, concept cartoons, meaning analysis tables and concept maps used in concept teaching, which holds an important place in science education in our country, and in detection and elimination of misconceptions.

For this reason, studies conducted on analogies, conceptual change texts, concept cartoons, meaning analysis tables and concept maps used in teaching of concepts and detection and elimination of misconceptions are reviewed ad thought to be useful for the future studies in the discipline of science education. With the information obtained as a result of the investigations made, it was aimed to determine the deficiencies in this field and to present a research that will constitute a source for future studies with the idea that it can give preliminary information to researchers.

Within this aim, following are the research questions concerning the teaching of concepts in the field of physics, chemistry, biology and science education between the years 2010-2020:

1. What is the distribution of the studies in terms of the type of publication?
2. What is the distribution of the studies according to the publication type and years?
3. What is the distribution of studies according to the type of tool and publication used in teaching concepts?
4. What is the distribution of studies according to the type of publication and research method?
5. What is the distribution of the research methods of the studies by years?
6. What is the distribution of the studies according to the type of publication and sample group?

7. What is the distribution of studies according to the type of publication and data collection tool?
8. How is the distribution of studies according to the type of publication, sample group and subject studied?

Methodology

Research pattern

The "Document Analysis" method was used in order to find answers to the research questions determined in this study. Document Analysis covers the examination of written materials containing data about the phenomena determined within the scope of the research (Yıldırım and Şimşek 2006). Document review is an effective method to obtain data in a short time and is highly efficient (Koyuncu et al., 2018).

Data collection process

The universe of the study consists of articles, master's theses and doctoral dissertations published between 2010-2020 on analogies, conceptual change texts, concept cartoons, meaning analysis tables and concept maps used in teaching concepts in science education and detecting and eliminating misconceptions in our country. The literature review was made on Thesis database of the Institution of Higher Learning for master's and doctoral theses and ULAKBİM Database and Google Scholar databases for national articles. During the search, the keywords "concept teaching", "concept map", "concept cartoons", "conceptual change texts", "analogy", "meaning analysis table" were used. With these criteria, 169 publications including 50 articles, 105 master theses, 14 doctoral dissertations were included in the study.

Analysis of data

The analysis of the data obtained in this study was made by the descriptive analysis method, where the data are shown as they are. In content analysis, it is important to organize and interpret similar data by gathering them around certain criteria and in a clear way for readers. The researcher can make predictions by interpreting the findings obtained (Yıldırım & Şimşek, 2006). In the research, master's and doctoral dissertations were analyzed in terms of the criteria given in the problems. The data obtained as a result of the investigations were organized and grouped according to the criteria created and the data were shown with appropriate tables and graphics.

Results

In this section, articles, master's and doctoral theses published in Turkey between the years 2010-2020 on teaching of concepts in the field of science education are analyzed by publication type, publication year, methods used in teaching of concepts, research methodology, sample group, sample number, subject studied and data collection tool and the results are shown with tables and graphs.

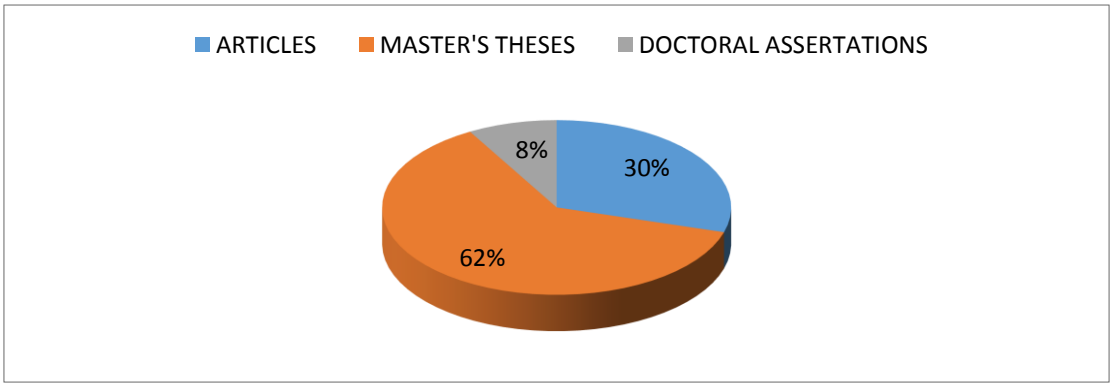

Figure 1. Distribution of studies on concept teaching between 2010 and 2020 by type of publication

Distribution of studies by type of publication

In Figure 1, the distribution of the publication type of the studies on concept teaching is given. In Figure 1, it is seen that the most studies in science education related to concept teaching are master's theses (67%), then the article type (32%) and the least number of publication is made as doctoral theses (1%).

Distribution of studies by publication type and years

Figure 2 shows the distribution of the studies on concept teaching according to the publication type and years.

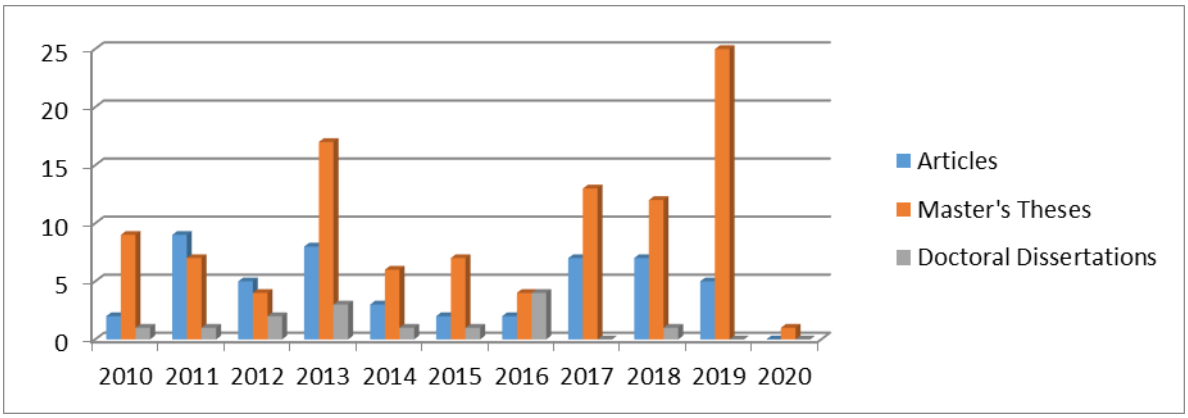

Figure 2. Distribution of studies on concept teaching by publication type and years

When Figure 2 is examined, it is seen that the most studies on concept teaching between 2010 and 2020 are in 2019 (f: 30). In addition, it is seen that there is a significant increase in the studies carried out in 2013 (f: 28), 2017 (f: 20) and 2018 (f: 20). When the years in which the broadcasting types were made according to the years are examined; It is seen that the article type was made in 2011 (f: 9), the master type in 2019 (f: 25) and 2013 (f: 17), and the doctoral type in 2016 (f: 4).

Distribution of techniques and studies used in studies by type of publication

Figure 3 shows the distribution of the studies conducted between 2010-2020 according to the technique used in concept teaching and the type of publication.

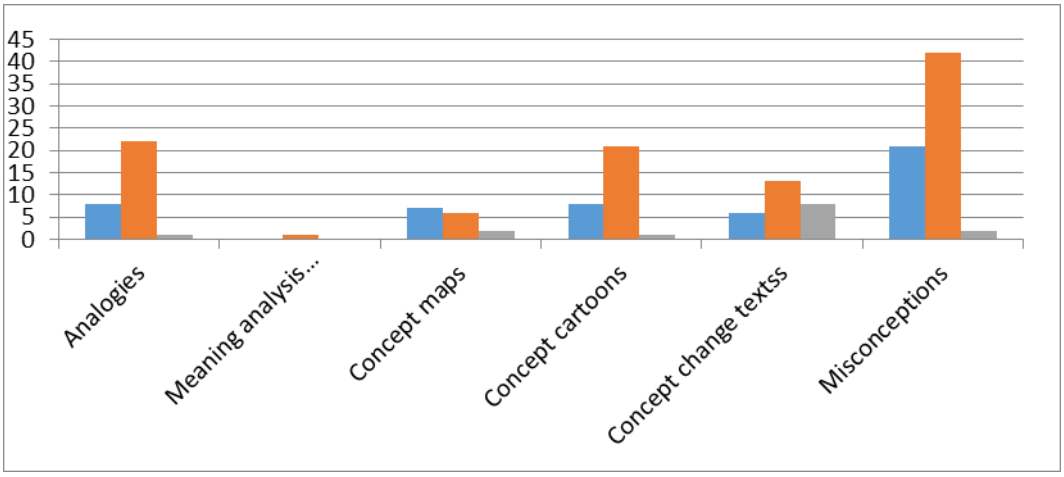

Figure 3. Distribution of the techniques and studies used in the studies by type of publication

When Figure 3 is examined, it is seen that the most studies were made on misconceptions (f = 65) in concept teaching between 2010-2020. In addition, it is seen that the most studies are done by using analogies, determining misconceptions and concept cartoons techniques in concept teaching. When the studies conducted are examined, it is seen that the most conceptual change texts are used in doctoral dissertations according to the

type of publication (f = 8), while studies on the detection and elimination of misconceptions are the most in master's theses and articles. It is seen that concept cartoons technique is mostly studied in master's theses. Doctoral dissertations have not been found in studies conducted solely on the detection and elimination of misconceptions. The semantic analysis tables technique used in concept teaching has been studied very little in master's theses, and these techniques have not been found in articles and doctoral dissertations.

Distribution of studies by type of publication and research method

Figure 4 shows the distribution of the studies according to the type of publication and research method.

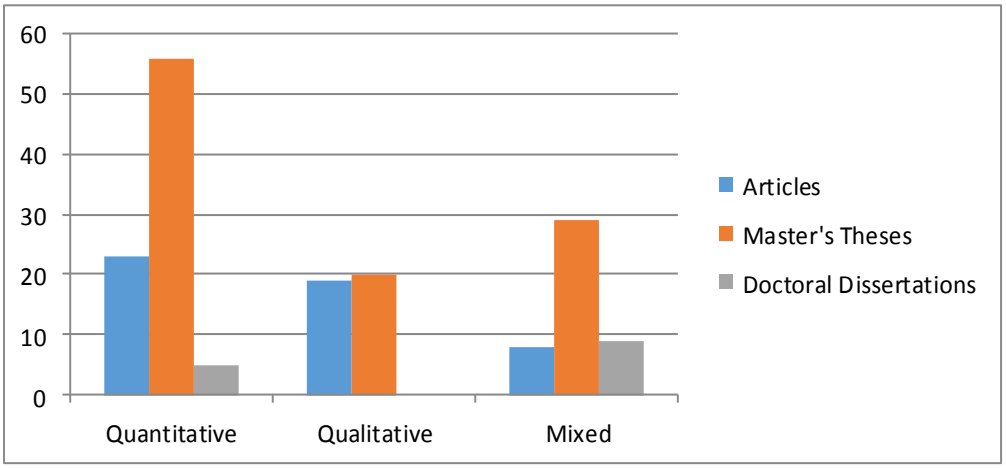

Figure 4: Distribution of studies by type of publication and research method

Between 2010 and 2020, 49.7% of the studies on concept teaching were done by quantitative research, 23% by qualitative research and 27.3% by mixed research methods.

Distribution of the publication type and research method of the studies by years

Table 1 includes the distribution of the type of publication and research method by years.

Table 1 shows that quantitative research methods (f = 84) are preferred more frequently. In addition, it is seen that the quantitative research method is mostly preferred for articles and master theses. However, the most preferred year is 2019 (f = 18), most of which are master theses (f = 15). The most preferred method afterwards was the mixed search method (f = 46). In 2013, it is seen that the mixed method is preferred more (f = 11). In doctoral dissertations, especially the mixed method (f = 9) was preferred more.

Table 1: Distribution of publication type and research method by years

		Quantitative research			Qualitative research			Mixed research		
Years		A	M	D	A	M	D	A	M	D
2010		-	5	-	2	1	-	-	3	1
2011		3	2	1	4	2	-	2	3	-
2012		3	2	1	2	2	-	-	-	1
2013		5	8	1	3	2	-	-	8	3
2014		1	3	1	2	1	-	-	2	-
2015		1	3	1	-	1	-	1	2	-
2016		2	3	-	-	1	-	-	-	3
2017		1	12	-	3	-	-	3	1	-
2018		4	3	-	2	5	-	1	4	1
2019		3	15	-	1	3	-	1	6	-
2020		-	-	-	-	1	-	-	-	-
TOTAL	f	23	56	5	19	19	-	8	29	9
	%	50			22,62			27,38		

(A: Articles, M: Master's Theses, D: Doctoral Dissertations)

The change of the research methods of the studies by years is given in Figure

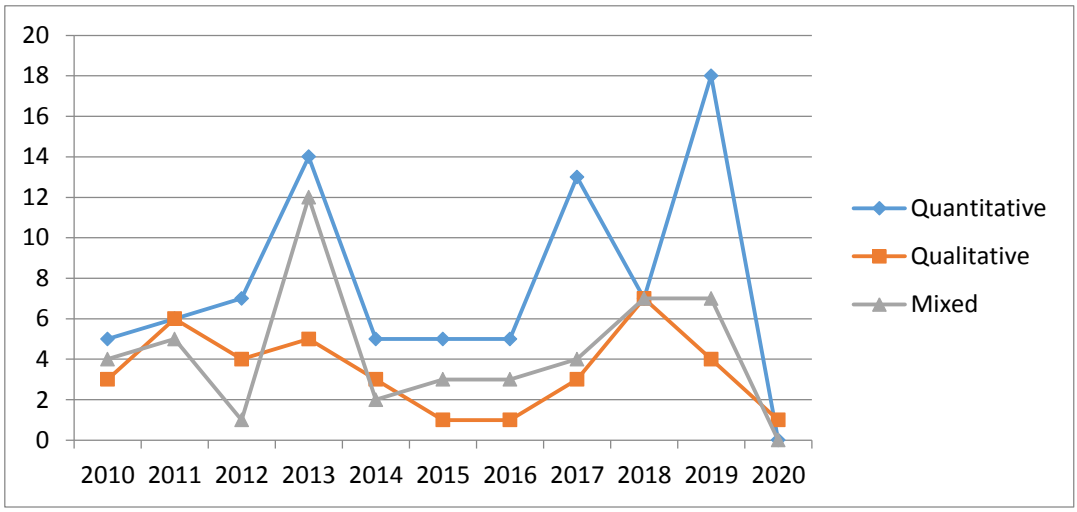

Figure 5. Distribution of publication type and research methods by years

When Figure 5 is examined, it is seen that the studies using the quantitative research method were carried out most in 2019. Qualitative research methods are seen to be the most in 2018. Studies using the mixed method were the most in 2013, and no increase was observed afterwards.

Distribution of studies by type of publication and sample group

Figure 6 shows the distribution of the studies conducted according to the type of publication and sample group.

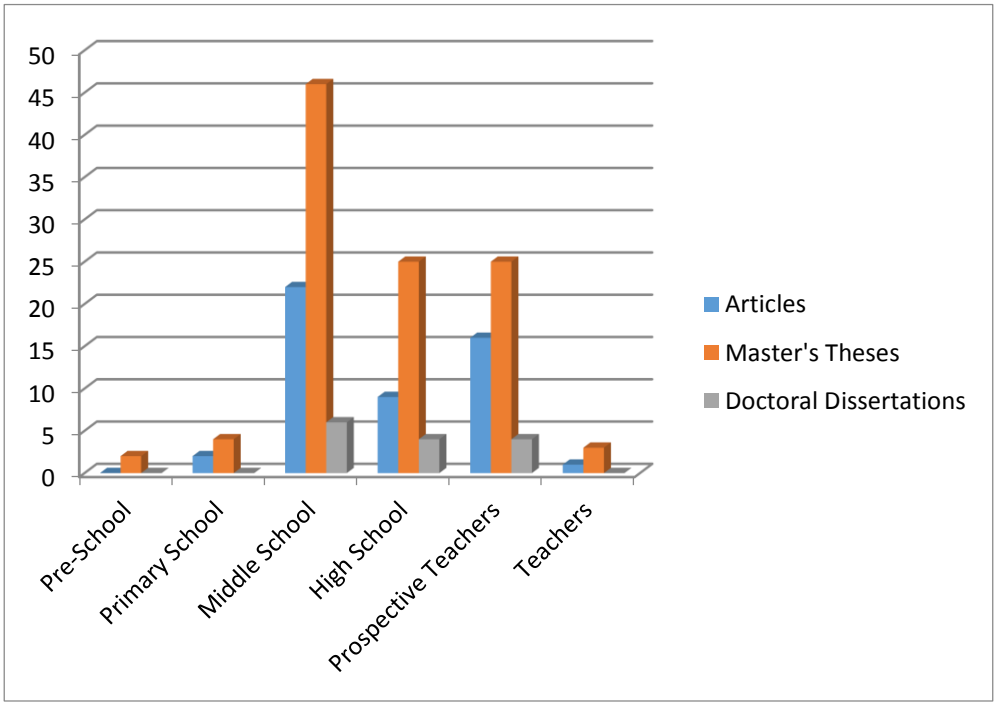

Figure 6: Distribution of studies by type of publication and sample group

When Figure 6 is examined, it can be seen that, in the total of types of publications, mostly secondary school students are worked with (43.7%). Then comes the studies conducted with prospective teachers (26.6%). When the studies are examined, it is seen that studies are carried out mostly with secondary school students in the type of master's, doctorate and article publication.

Distribution of studies by type of publication and data collection tools

Table 2 includes the distribution according to the type of publication and data collection tools.

Table 2. Distribution of studies by type of publication and data collection tools

Data collection tool	Articles f	Master's theses f	Doctoral dissertations f	Total F	%
Conceptual comprehension tests	12	36	11	59	19,87
Conceptual diagnistoc tests	7	14	-	21	7,07
Academic achievement tests	14	28	5	47	15,82
Attitude scales	4	21	9	34	11,45
Interviews	11	26	7	44	14,81
Polls	9	20	-	29	9,76
Document analysis	4	6	1	11	3,70
Logical thinking skill tests	4	4	2	10	3,37
Motivation scales	3	3	-	6	2,02
Observations	1	2	-	3	1,01
Scientific process skill tests	1	4	3	8	2,69
Word association tests	-	3	-	3	1,01
Concept map technique	3	4	1	8	2,69
Analogical thinking tests	1	1	-	2	0,67
Material evaluation forms	-	1	-	1	0,34
Concept cartoons technique	2	3	-	5	1,68
Worksheets	1	1	-	2	0,67
Kolb learning style inventory	-	1	-	1	0,34
Student diaries	1	1	-	2	0,67
Video recording	-	1	-	1	0,34

When Table 2 is examined, it is seen that the most preferred data collection tool in studies conducted between 2010 and 2020 for concept teaching is conceptual comprehension tests (19.87%). Afterwards, the most preferred data collection tool was academic achievement tests (15.82%). In the third row, interview forms were used and an interview (14.81%) was conducted. In the fourth place, attitude scales (11.45%) were used. When we look at the types of publications, the most preferred data collection tool in the article type is academic achievement tests (f = 14), conceptual understanding tests in master theses (f = 36), and the most preferred data collection tool in doctoral dissertations is conceptual understanding tests (f = 11).

Distribution of studies by type of publication, sample group and subject studied

Table 3 includes the topics that researchers frequently work on regarding concept teaching. Table 3 contains the topics that researchers frequently worked on between the years of 2010-2020. When the table is examined, it is seen that the most studies were carried out with secondary school students at the primary education level (43.7%) and within the unit of "Structure and Properties of Matter" (f = 17). After the Structure and Properties of Matter, the most preferred subject is the "Systems in Our Body" unit. Following the students from the second stage of the primary education, prospective teachers are the group which the studies are most frequently carried out with (26.6%). Most of the studies were conducted with the prospective teachers within the unit of Structure and Properties of Matter (f = 6). In the third row, a study was conducted within the scope of the "Force and Motion" unit (f = 11). When the table is examined, it is seen that in doctoral dissertations, most of the studies are worked with primary school students within the scope of the Structure and Properties of Matter unit (f = 3).

Conclusion, Discussion

In this section, general research criteria are presented and the hypothesis results for each variable are discussed, and recommendations are made for future research to be conducted with concept teaching. The following results have been reached with the content analysis of the studies on concept teaching, which has a large place in the researches in the field of science education between 2010 and 2020.

Table 3: Distribution of studies by type of publication, sample group and subject studied

Sample Group	Subject	A	M	D	Total	
		f	f	f	F	%
Pre-School	Simple Electric Circuit	-	1	-	1	0,65
	Science and Nature Activities	-	1	-	1	0,65
	Electric Tools	-	1	-	1	0,65
	Light and Sound	-	1	-	1	0,65
Primary School	Scientific Concepts	1	-	-	1	0,65
	Let's Solve The Puzzle of our Body	1	-	-	1	0,65
	Introduction to Matter	1	1	-	2	1,29
	Force and Motion	1	1	-	2	1,29
	Classification of Living Things	-	1	-	1	0,65
Secondary School	Force and Motion	-	4	2	6	2,58
	Electric and Electrostatic	-	1	1	2	1,29
	Classification of Living Things and Biodiversity	3	1	-	4	2,58
	Light and Sound	1	3	-	4	2,58
	Nutrients	-	2	-	2	1,29
	Biodiversity	1	-	-	1	0,65
	Systems in Our Body	3	7	-	10	6,45
	Cell	1	-	-	1	0,65
	Structure and Properties of Matter	2	12	3	17	10,97
	Reproduction, Growth and Development in Plants and Animals	1	2	-	3	1,94
	Human and Environment	1	1	-	2	1,29
	Solar System and Beyond	-	3	-	3	1,94
	Cell Division and Inheritance	3	1	-	4	2,58
	Nature of Science	-	1	-	1	0,65
	Earthquakes	-	1	-	1	0,65
	Structure and Properties of Matter	2	3	1	6	3,87
	Nature of Science	-	1	-	1	0,65
	Systems	1	3	-	4	2,58
	Force and Motion	1	2	1	3	1,94
	Classification of Living Things and Biodiversity	1	2		3	1,94
	Osmosis- Diffusion	-	2	-	2	1,29
	Water and Its Properties	-	1	-	1	0,65
	Organic and Inorganic Substances	-	2	-	2	1,29
High School	Electrical Current	1	1	1	3	1,94
	Environment	-	2	-	2	1,29
	Photosynthesis	-	1	-	1	0,65
	Solutions	-	1	1	2	1,29
	Electrochemistry	-	-	1	1	0,65
	Modern Atomic Theory	-	1	-	1	0,65
	Heat and Temperature	-	1	-	1	0,65
	Evolution	1	-	-	1	0,65
	Radioactivity	-	-	1	1	0,65
	Structure and Properties of Matter	2	2	2	6	3,87
	General Chemistry	1	2	-	3	1,94
	Electric Current and Electrification	3	1	-	4	2,58
Prospective Teachers	Heat and Temperature	2	3	-	5	3,23
	Living Things and Life	1	1	-	2	1,29
	Work	1	1	-	2	1,29
	Electrochemistry	1	-	-	1	0,65
	Photosynthesis and Respiration	1	1	-	2	1,29
	Science Concepts	1	3	-	4	2,58
	Pressure	-	4	-	4	2,58
	General Chemistry	1	2	-	3	1,94
	Osmosis - Diffusion	-	1	-	1	0,65
	General Biology	-	1	-	1	0,65
	Solutions	-	2	-	2	1,29
	Density	-	1	-	1	0,65
	DNA Replication	-	1	-	1	0,65
	Mechanical Waves	1	-	-	1	0,65
Teachers	Science Concepts	1	3	-	4	2,58

(A: Articles, M: Master's Theses, D: Doctoral Dissertations)

It has been observed that the studies on concept teaching in science education are mostly conducted as master's theses and at least as doctoral dissertations. When the types of studies conducted by years are examined; It has been determined that the least number of studies on concept teaching were carried out in 2014, 2015 and 2016, and the maximum number of studies was conducted in 2019, with a significant increase between 2013 and 2019. It was also stated in previous studies that most of the students used the correct concepts presented by their teachers during the lesson, but they insisted on their own misconceptions when asked about the subject after the instruction (Mcdermott & Shafer, 1992; Küçüközer, 2003; Akgün, 2005). The fact that the studies conducted with concept teaching frequently gain momentum shows that concepts are the basic building blocks of teaching. The investigated studies reveal that most of the studies have been done to identify and eliminate misconceptions. Conceptual change texts were used most frequently for elimination of misconceptions. In addition to the fact that misconceptions in the field of science education is a frequently studied topic (Tatar & Tatar, 2008), this study also supports the finding that misconceptions in learning are studied too much. In addition, analogies and concept cartoons, which are effective in concept teaching, have been used quite a lot. There are very few studies on meaning analysis tables in concept teaching.

While the research management quantitative research design based on the studied studies is mostly preferred for articles and master theses, it is followed by qualitative research designs. The most widely used research methods in science have been "quantitative research methods" (Yıldırım, 1999). In the findings, it was seen that the most preferred method was quantitative research method. This finding is similar to previous studies (Çalık et al., 2008; Göktaş et al., 2012; Sözbilir and Kutu, 2008). It can be said that quantitative research methods have been frequently preferred in science education for years. The reason for this situation can be attributed to factors such as the ease of analysis of numerical data, the ability to generalize the results obtained from the studies, the large sample group reached and the low expenses (Göktaş et al., 2012). It was determined that the number of studies in which mixed research design was preferred is quite low. However, it is seen that while mixed research design is preferred in doctoral dissertations, qualitative research design is not preferred. In line with this finding, orientation towards mixed research in science education is among the recommendations of this study. While the sample group of the studies conducted with concept teaching in science education between the years of 2010-2020 was mostly composed of secondary school students; It was determined that there are very few studies in which primary school students were selected in sample groups.

In the researches, it was determined that conceptual understanding tests, followed by academic achievement tests and interviews were the most preferred data collection tools in master's theses and doctoral dissertations. In article publication types, mostly academic achievement tests and then conceptual comprehension tests were preferred. In addition, the abundance of studies examining the affective dimension (motivation, attitude, opinion, etc.) in concept teaching shows that the affective dimension has gained importance in science education in recent years according to the studies examining the effect of concept teaching on success. This finding is similar to previous studies (Sözbilir & Kutu, 2008). In summary, in order to determine the status and development of concept teaching in Turkey, we recommend similar studies to be conducted regularly in the coming years.

Suggestions

In this respect, in the light of the results of the study, some suggestions for researchers who will carry out future studies in this field are listed as follows;

Studies on the teaching concept in Turkey and abroad can be examined in comparative manner.
Studies on teaching concepts, especially at doctorate level, should be increased.
Studies can be carried out on the effectiveness of meaning analysis tables in the field of teaching science concepts.
Studies in which quantitative and qualitative data collection methods are used together and mixed research method should be increased in order to make in-depth analysis.

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