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Thematic Content Analysis of Studies Concerning Misconceptions in Science Education in Turkey

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Abstract

The current study aims to contribute to closing this gap in the literature by making a thematic content analysis. In this study, which was conducted to examine the studies on misconceptions in science education in Turkey by thematic content analysis according to their type, year, method, sample, sampling method, data collection tools, and topics, a total of 346 studies published between 2000–2022 and accessed through the YÖK Thesis Center, ERIC, and Google Scholar were analyzed. As a result of the research, it was determined that most of the studies on misconceptions in science education in Turkey were published in 2011 in the forms of articles, they mainly used the survey method, they were conducted generally at the primary education level, the most frequently used sampling method was convenience sampling, and they often utilized concept tests as data collection tools. In terms of the preferred topics, it was found that most studies aimed to detect misconceptions. It is a well-known fact that misconceptions prevent science learning. Although it is favorable that a substantial number of studies on misconceptions are conducted in Turkey, the fact that the vast majority of these studies are about detecting misconceptions is thought-provoking since it is equally important to determine the causes of misconceptions and to try to eliminate them. In addition, based on the conclusion that quantitative methods are mostly used in the studies analyzed, it is essential to increase the number of qualitative studies to gain in-depth information about misconceptions.

Keywords

Science education, misconceptions, Turkey, thematic content analysis.

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INTRODUCTION

Rapid developments in technology, science, and communication create a competitive environment. Competing countries have aimed to raise qualified individuals to cope with the changing and developing world. Training qualified individuals is generally the mission of direct instruction (Lynch et al., 2017; Miaoulis, 2009; Yıldırım & Selvi, 2016). The most common definition of education today is the conscious behavioral change that an individual acquires through his or her own experiences. Currently, societies can change and develop with individuals who not only own information but also know the ways to access information, can structure information in their own minds, associate it with other information, and solve problems by thinking creatively. Science education has a key role in raising individuals with these qualities (Ertürk, 1994). Science education enables individuals to understand the nature and the universe, question them in the face of a problem, establish a cause-effect relationship between events, and find different solutions by providing them with creative and scientific thinking skills (Hançer, Şensoy, & Yıldırım, 2003; Kılıç Alemisoğlu, 2014). An effective science education with this purpose can only be achieved by considering science at the conceptual level (Koray & Tatar, 2003).

'Concept' is the common name given to classes when any event, phenomenon, entity, person, or object is classified according to their similarity (Kaptan, 1998; Laçin Şimşek, 2019). According to Ülgen (2004), a concept is the individual's interpretation of the information he has acquired due to his own experiences in a way that represents their common characteristics in his own mind. The concepts that a person produces as a result of his experiences enable him to understand his environment and the world and to integrate these concepts with the world. With the help of concepts, we think, speak, and write. As the examples of a phenomenon increase, similar and different features are brought together, and the conceptualization process is started. In this process, where the individuals are, who is with them, their current ages, the opportunities brought by the situation they are in, and to what extent they have experienced these have crucial roles. As concepts may differ from person to person, the qualities of concepts may also change over time (Alwan, 2011; Laçin Şimşek, 2019). However, an individual's intuitive understanding of the world around them is usually insufficient to explain scientific concepts (Pine, Messer, & St. John, 2001). Most researchers agree that students do not come to class with a blank slate. Much of children's early science learning is informal, and some of these may hinder their further science learning (Vosniadou, 2013). Students come to school with concepts forming through their physical activities, talking to people around them, the media, their experiences in their lives, and these concepts are mostly far from being scientific (Driver, Guesne, & Tiberghien, 1998; Driver et al., 1999; Seloni, 2005; Stepans, 2003). These concepts, which are generated differently from the real definition, are called 'misconceptions.' Misconceptions are concepts that are resistant to change, cause difficulty in learning the subject, are mostly independent of culture, and are the source of resistance to scientific knowledge (Aygün & Hacıoğlu, 2022; Clement, 1982; Driver et al., 1999; Nik Daud et al, 2015; Schmidt, 2011; Sinatra, 2022), and even the universality of education does not prevent misconceptions (Nodzyńska, 2021). Misconceptions are not simple information deficiencies that can be corrected by presenting correct information. Therefore, they are extremely resistant to change (Shtulman & Valcarcel, 2012).

Misconceptions have been observed not only in today's children, but even in scientists and philosophers. Ideas developed without prior knowledge about any subject are not necessarily wrong. These are called alternative or original concepts or preconceptions. The preconceptions created by children often do not match today's scientific concepts. Increasingly, research results show that there are misconceptions in the formal education period (Driver et al., 1999; Potvin & Cry, 2017). Not all misconceptions can be attributed to preconceptions. Unfortunately, most of these are "school-made misconceptions" caused by inappropriate teaching methods and materials (Aydoğan, Güneş, & Gülçiçek, 2003; Barke, Hazeri, & Yitbarek, 2009.p.21-24; Coley & Tanner, 2012). Teachers who do not have sufficient content knowledge or who have misconceptions may unfortunately cause their students to form concepts that are not scientific and therefore to develop misconceptions (Görecek & Baybars, 2018; Kruger et al., 1992). Misconceptions experienced by students can also occur due to misinterpretation. The events they encounter at home, school, university, and in all areas of life, affect students' ability to understand and interpret the concept (Duda, 2016). On the other hand, Suprapto (2020) states the sources of misconceptions as students, teachers, teaching materials or literature, the context, and teaching methods.

Büyük (2017) lists the causes of misconceptions as follows:

- Teachers' insufficient knowledge about the subject to be taught
- Students' prejudices about the concept
- Use of rote-based, teacher-centered methods
- Not associating the taught concept with daily life
- Lack of information or inaccuracies in course resources and not updating them periodically.

It is considered that it will be easier for teachers to find solutions in teaching science concepts when the types and causes of students' misconceptions in understanding science are well-known. Misconceptions prevent students from both understanding the newly learned concepts correctly and establishing a connection between the new and previously learned concepts. For this reason, it is important to first determine whether the students have misconceptions (Alwan, 2011; Baysari, 2007). There are many studies in Turkey about misconceptions in science education. However, from 2000, when these studies started, to 2022, only four content analyses were found in the literature (Ayvacı & Altınok, 2019; Mesin et al., 2019; Taş, 2017; Yanarateş, 2022). Two of them are analyses of studies on detecting misconceptions on specific subjects (Ayvacı & Altınok, 2019; Mesin et al., 2019), one is a content items analysis (Taş, 2017), and the other is a content analysis of theses on misconceptions (Yanarateş, 2022). In other words, even though content analyses of studies on any subject may guide field researchers, a content analysis of studies on misconceptions in the Turkish context was not made between the specified dates.

If the aspects of misconceptions have been examined in science education and the type of methodology that has been used it is known, the deficiency in this area can be understood more clearly, and more research can be done to overcome these deficiencies. With the current study, this gap in the literature will be tried to be closed by making a thematic content analysis of the studies on misconceptions in science education. Therefore, the aim of this research is to examine the studies on misconceptions in science education in Turkey between the years 2000–2022 with a thematic content analysis.

In this study, answers to the following sub-problems were sought:

1) What kind of academic publications have been made about misconceptions in science education in Turkey?

2) What is the distribution of the studies on misconceptions in science education in Turkey by years?

3) What are the methods of the studies on misconceptions in science education in Turkey?

4) What are the samples of the studies on misconceptions in science education in Turkey?

5) What are the sampling methods of the studies on misconceptions in science education in Turkey?

6) What are the data collection tools of the studies on misconceptions in science education in Turkey?

7) What are the subjects of the studies on misconceptions in science education in Turkey?

METHOD

In this study, the meta-synthesis (thematic content analysis) method was used as a type of content analysis. In meta-synthesis research, it is possible to interpret the studies on the same subject with a critical perspective through themes or templates (Çalık & Sözbilir, 2014).

The procedure followed in the study is as follows:

1) Determination of the criteria: The studies to be included in the content analysis needed to be published between 2000–2022, originated in Turkey, written in Turkish, be one of the types of theses, articles, or presentations, and the full texts had to be accessible. Since studies on misconceptions in Turkey started with two studies (Eryılmaz & Tatlı, 2000; Yuruk & Çakır, 2000) in 2000, the date range of 2000–2022 was determined for the studies to be examined in this research.

2) Identifying key words: The keywords in Turkish were "fen eğitimi + kavram yanılgıları," while they were determined as the keywords "science education + misconceptions" in English.

3) Selection of databases: The publications in the Higher Education Institution (YÖK) Thesis Center, ERIC, and Google Scholar databases were searched. "Higher Education Institution Thesis Center" is the national thesis center of Turkey, and theses about misconceptions can be accessed from this institution. Google Scholar is known as one of the largest open-access databases. ERIC, on the other hand, is among the field indexes acknowledged by the Inter-University Board (ÜAK). The reason why other indexes or databases such as WoS or Scopus were not selected is the low number of relevant publications in some of them and the difficulty in accessing some of them due to corporate subscription requirements.

4) Eliminating duplicate studies

5) Analyzing the studies according to the determined variables

A total of 346 studies meeting the determined criteria were coded as S1, S2, S3, …, and S346, and in the next stage, the studies were classified according to their publication year, type, method, sample, sampling method, data collection tools, and subjects. As a result of the thematic content analysis, seven themes were identified.

Long-term interaction for credibility, which means validity in qualitative studies, is very important in terms of confirming whether the collected data are periodic or not (Yıldırım & Şimşek, 2008). Each study was examined repeatedly at various time intervals for the credibility of this study. In these reviews, for example, some changes were made in the subject theme, and its final form was given. For the consistency of the study, the consensus of the codes of 20% of the data was checked to measure the reliability between the two encoders. For this, Miles and Huberman's (1994) formula (Reliability = Consensus / (Agreement + Disagreement) was used. The inter-coder reliability was calculated as .90.

The terms related to the variables examined in the studies were used directly, regardless of their accuracy or inaccuracy. For example, although there is no 'simple random sampling' scientifically, the sampling method of a study written as simple random sampling was taken as stated in the study. If no information about the investigated variable was specified, for instance, if the sampling method was not specified, it was coded as "none."

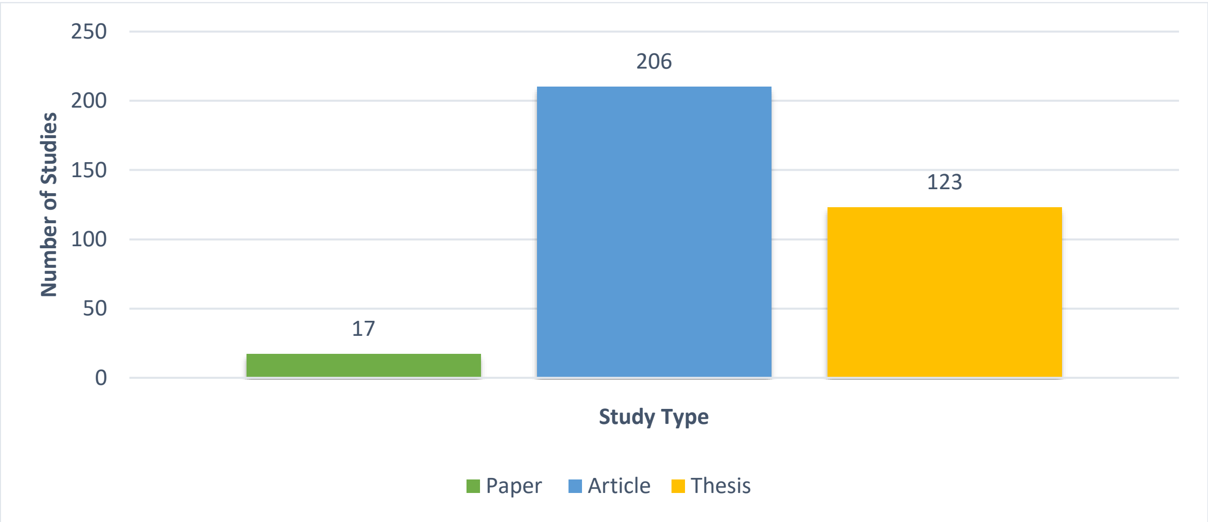
FINDINGS

Findings regarding the first sub-problem

The results regarding the type of studies (articles, papers, theses) about misconceptions in science education in Turkey are shown in Figure 1.

Figure 1

Type of studies on misconceptions in science education in Turkey



As shown in Figure 1, of the 346 studies on misconceptions in science education, 206 were articles, 123 were dissertations, and 17 were papers. It was seen that most of the studies on misconceptions were in the form of articles and the least in the form of papers.

Findings regarding the second sub-problem

The results of the distribution of studies on misconceptions in science education in Turkey by years are shown in Figure 2.

Figure 2

Distribution of studies on misconceptions in science education in Turkey by years

As demonstrated in Figure 2, when the distribution of the studies on misconceptions in science education was analyzed by years, 2011 was the year in which the highest number of studies were published. A total of 34 out of 346 studies were conducted in this year. With respect to the highest number of studies by years, it was seen that 2011 was followed by 2015 with total 29 studies, by 2010 with 26 studies, 2009 with 21 studies, and 2016 with 21 studies. The year in which the fewest number of publications were issued was 2000. It was seen that there were fewer studies on misconceptions in the year 2000 with two studies, in 2001 with three studies, and in 2002 with four studies.

Findings regarding the third sub-problem

The results of the analysis according to the methods of the studies on misconceptions in science education in Turkey are shown in Table 1.

Table 1

Distribution of Studies on Misconceptions in Science Education in Turkey by Research Methods

Research Method	*f*	%
Survey	86	24,8
Experimental	75	21,6
Descriptive	53	15,3
Quasi-Experimental	50	14,4

Qualitative	27	7,8
Mixed	19	5,5
Case Study	12	3,47
Trial	6	1,8
Unspecified	4	1,2
Special Case	3	0,8
Phenomenology	3	0,8
Developmental Research	2	0,6
Correlational	2	0,6
Cross-Sectional Survey	2	0,6
Controlled Trial	1	0,3
Action Research	1	0,3
Total	346	100

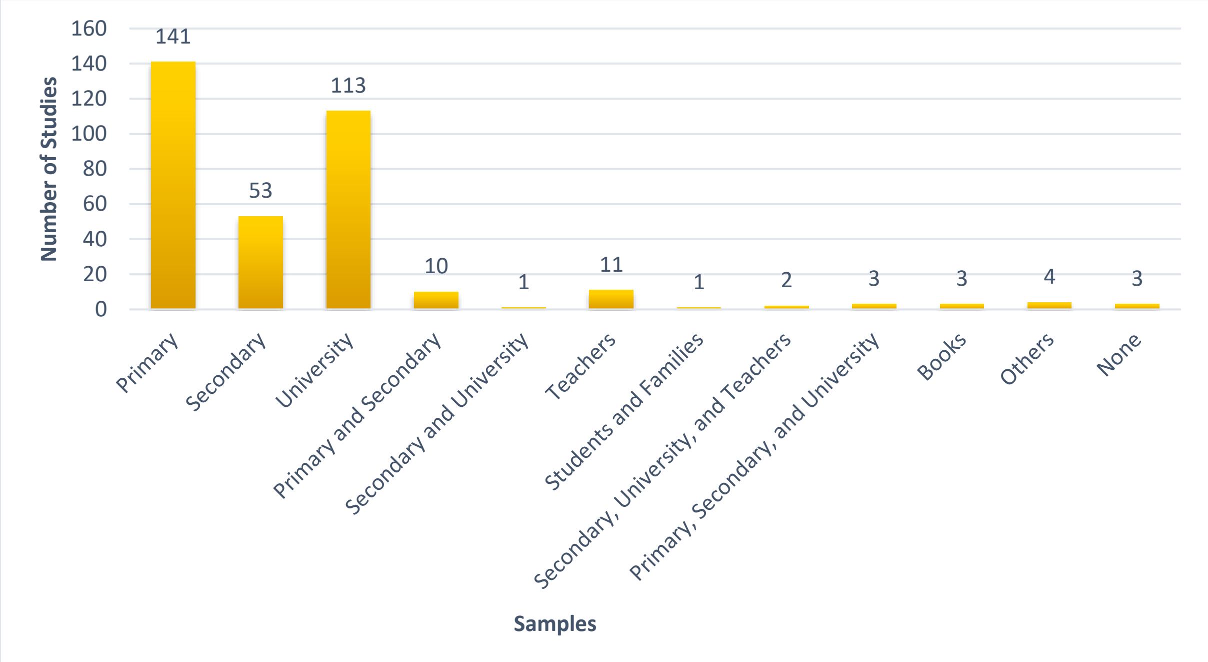
As presented in Table 1, the analysis of the research methods of the studies on misconceptions in science education revealed that the most used research method in 346 studies was the 'survey' method. When the table was examined, it was seen that quantitative research designs such as the survey method (n = 86), experimental method (n = 75), descriptive method (n = 53), and the quasi-experimental method (n = 50) were utilized most frequently in the studies. On the other hand, the least used research methods in the studies were generally qualitative research designs such as case studies, phenomenology, and action research.

Findings regarding the fourth sub-problem

The samples of studies on misconceptions in science education in Turkey are shown in Figure 3.

Figure 3

Distribution of studies on misconceptions in science education in Turkey by sample levels



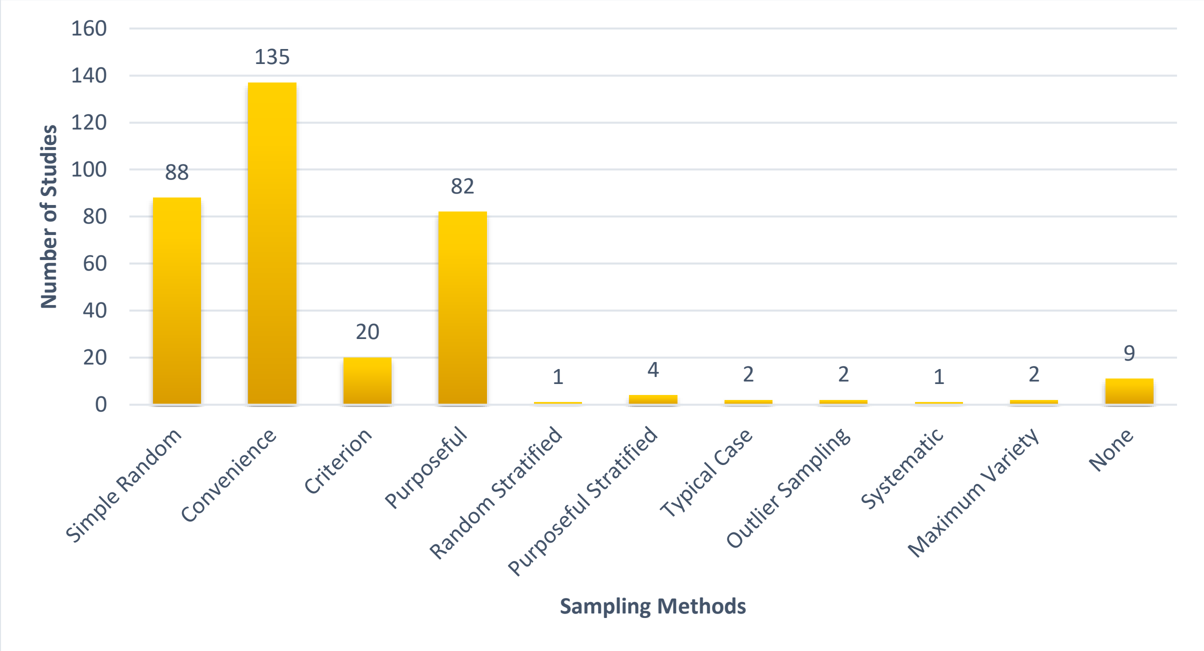
As demonstrated in Figure 3, the distribution of studies on misconceptions in science education according to their samples revealed that the most commonly sampled levels were the primary education level with 141 studies, followed by 114 studies at university level, and 53 studies at the secondary education level. The least used sample level in studies was a single study carried out with the students and families and another study with secondary education and university.

Findings regarding the fifth sub-problem

The sampling methods of studies on misconceptions in science education in Turkey are shown in Figure 4.

Figure 4

Distribution of studies on misconceptions in science education in Turkey according to sampling methods



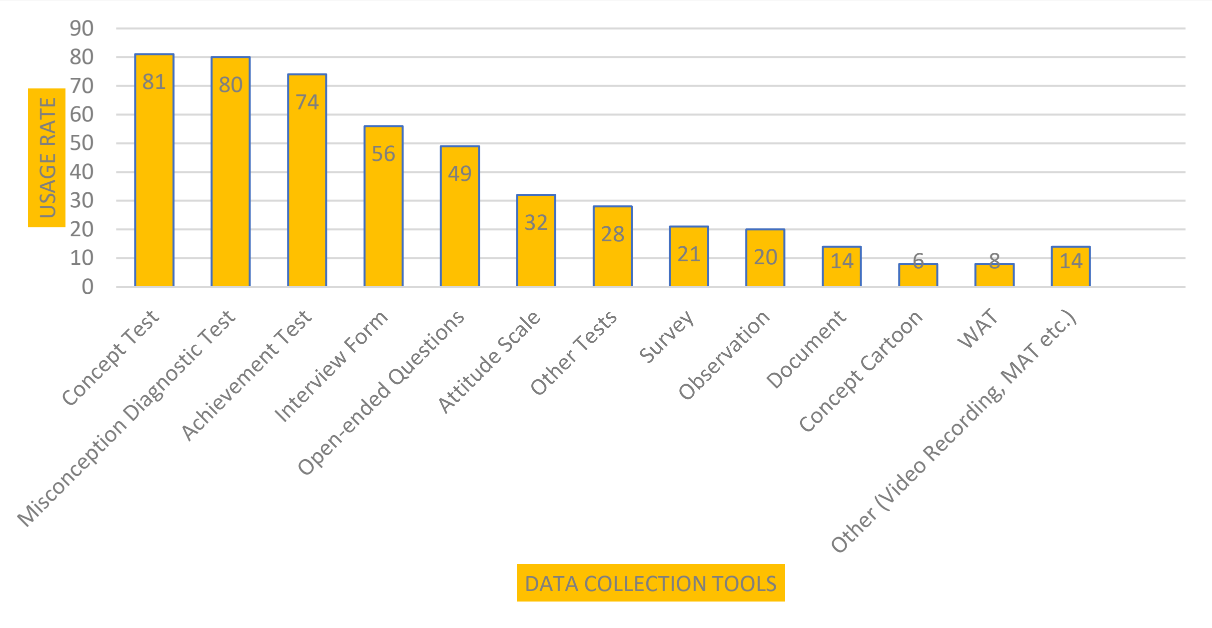
As a result of the analysis regarding the sampling methods of the studies on misconceptions in science education, it was seen that the most used sampling method in 346 studies was the convenience sampling method (Figure 4). Concerning the distribution of the number of studies by sampling methods, it was seen that 135 convenient sampling methods, 88 simple random sampling methods, and 82 purposive sampling methods were used, while the least employed sampling methods were the random stratified sampling method (n = 1), systematic sampling method (n = 1), typical case sampling method (n = 2), outlier sampling method (n = 2), and the maximum variety method (n = 2).

Findings regarding the sixth sub-problem

The data collection tools of studies on misconceptions in science education in Turkey are shown in Figure 5.

Figure 5

Distribution of data collection tools used in studies on misconceptions in science education in Turkey



As seen in Figure 5, when the data collection tools used in the studies on misconceptions in science education were examined, it was seen that the most frequently used data collection tools in 346 studies were the concept test (*n* = 81), the misconception diagnosis test (*n* = 80), and the achievement test (*n* = 74), respectively. It was determined that the least used data collection tools in the studies examined were the data collection tools gathered under the title of 'other' (e.g., video recordings, *n* = 2; meaning analysis table [MAT]).

Findings regarding the seventh sub-problem

The results of the analysis according to the subjects of the studies on misconceptions in science education in Turkey are shown in Table 2.

Table 2

Distribution of Studies on Misconceptions in Science Education in Turkey by Subject

Categories	*f*	%
Topics in which misconceptions were detected	285	76.2
Methods used to eliminate misconceptions	61	16.31
Methods used in detecting misconceptions	22	6.6
Analysis of studies on misconceptions in Turkey	3	0.81
Opinions on misconceptions	2	0.54

Raising awareness of science teacher candidates on detecting misconceptions	1	0.27
Total	374	100

Note. The reason why the sum of the codes (374) in the table is more than the studies analyzed is that some studies include more than one subject. For example, in the same study, both misconceptions might have been identified, and a method might have been used to eliminate the identified misconceptions.

As a result of the analysis, it was seen that in the studies conducted on misconceptions, the subjects in which the misconceptions were detected were mostly studied (n = 285), and the subject of raising the awareness of the pre-service science teachers about the detection of misconceptions (n = 1) were the least studied (Table 2).

The distribution of the topics in which misconceptions were detected within the most studied subjects theme is presented in Table 3.

Table 3

Distribution of Topics in Which Misconceptions Were Detected in the Most Studied Subjects Theme

Category	Codes	Study codes	*f*	%
	Mechanical	S1, S22, 135, S338	4	1.4
	Oxygen and deoxygenated respiration	S2	1	0,35
	Heat and temperature	S3, S15, S39, S59, S69, S81, S131, S144, S158, S159, S165, S196, S221, S234, S238, S242, S243, S244, S273, S278, S279, S316, S318, S336, S170	25	8,75
	Chemical bonds	S4, S52, S54, S55	4	1.4
	Greenhouse effect	S7, S127, S187, S218	4	1.4
	Light	S8, S13, S120, S124, S200, S235, S301, S323	8	2,8

	Multiple basic concepts of chemistry	S9, S91, S142, S177, S290	5	1.75
	Mass and weight	S14, S37, S189, S321, S331	5	1.75
	Simple electric circuit	S17, S78, S116, S197	4	1.4
	Chemical balance	S20, S133, S141, S214	4	1.4
	Photosynthesis and respiration	S19, S26, S143, S184, S191, S267, S277	7	2,45
	Electricity	S23, S48, S71, S82, S150, S157, S161, S168, S169, S179, S270, S334, S287	13	4,55
	Diffusion and osmosis	S24, S138, S164, S230	4	1.4
	Erosion	S25	1	0.35
	Mitosis-meiosis-cell division	S27, S58, S139, S176, S186, S205, S299, S303, S344	9	3,15
Topics in Which Misconceptions Were Detected	Matter	S28, S68, S73, S89, S92, S136, S162, S163, S166, S203, S212, S231, S248, S265, S268, S340	16	5,16
	Protein synthesis-enzymes	S30, S50, S61, S70, S174	5	1.75
	Seasons	S341	1	0.35
	Lightening	S31	1	0.35
	Structure of the atom	S32, S60, S120, S146, S193, S220, S253	7	2,45

Gravity	S34, S125, S156, S189	4	1,4
Mixture	S35, S236, S6, S283	2	0,7
Genetics	S38, S53, S102, S107, S298, S176, S205, S254, S329, S335	10	3,5
Biodiversity and classification	S42, S126, S147, S307, S332, S77, S284, S216, S292, S310, S11, S84, S312	13	4,55
Force and motion	S43, S85, S90, S132, S137, S175, S183, S259, S320, S44	10	3,5
Physical and chemical change	S45, S181, S215, S106	4	1,4
Pressure	S47, S291, S319, S328	4	1,4
Sound	S63, S79, S124, S192, S219, S227, S247	7	2,45
Change of state	S65, S80, S81, S222, S36, S339	6	2,1
Humidity	S67	1	0,35
Gases	S108, S109, S130, S134, S199, S206, S260, S261	8	2.8
Solutions	S10, S96, S119, S153, S311, S324, S326, S66	8	2,8
Melting and dissolution	S180, S262, S274, S66	3	1,05
Energy	S103	1	0.35

Global environmental issues	S105, S117, S263, S293, S297	5	1.75
Ascending force	S110, S208, S346	3	1,05
Digestive system	S100, S112, S140, S256, S295	5	1.75
Electrochemistry	S114, S115, S195	3	1,05
Nature of science	S121, S285 S342	3	1,05
Waves	S122	1	0.35
Mirrors	S13, S128	2	0.7
Reproduction-growth-development	S145, S171, S12	3	1,05
Uniform circular motion	S149	1	0.35
Acid and base	S152, S172, S241, S330	4	1.4
Electrification	S154, S327	2	0.7
Water	S173, S308	2	0.7
Work	S182, S249	2	0.7
Transport and circulatory system	S190, S271, S269	3	1,05
Adhesion-cohesion	S194	1	0.35
Science books	S123, S237, S322, S337	4	1.4
Evolution	S251	1	0.35
Magnetism	S258	1	0.35
Speed and rate	S302	1	0,35

	Astronomy concepts	S5, S63, S98, S151, S198, S211, S282, S305, S315	9	3,15
	Multiple basic biology concepts	S49, S333	2	0.7
	Earth and universe	S275, S232, S325, S185, S343, S101	6	2,1
	Radioactivity	S264	1	0.35
	Total		285	100

As shown in Table 3, among the subjects in which misconceptions were detected from the theme of the most studied subjects, the topics of heat and temperature, matter, and electricity were the most frequent, respectively, followed by aerobic and anaerobic respiration, erosion, seasons, lightning, humidity, energy, waves, adhesion, cohesion, smooth circular motion, evolution, magnetism, speed and rate, and radioactivity.

The distribution of the methods used to eliminate the misconceptions within the theme of the most studied subjects is shown in Table 4.

Table 4

Distribution of the Methods Used to Eliminate Misconceptions in the Most Studied Subjects Theme

Category	Codes	Study Codes	*f*	%
Methods Used to Eliminate Misconceptions	4-E Learning Cycle	S48	1	1,64
	Creative Drama	S296, S317	2	3,28
	Predict-Observe-Explain Technique	S213, S280, S289	3	4,92
	Constructivist Theory	S29	1	1,64
	Concept Map	S21, S207, S228, S250, S217	5	8,2
	Active Learning	S57	1	1,64
	Event-Based Web Material	S300	1	1,64

	Concept Cartoon	S72, S155, S229, S252, S309, S74	6	9,84
	Problem-Based Teaching	S83	1	1,64
	Multiple Intelligence	S94	1	1,64
	5E Model	S56, S86, S118, S345	4	6,56
	Worksheets	S95, S202	2	3,28
	Storytelling Technique	S246	1	1,64
	Open-Ended Experimental Method	S233	1	1,64
	Conceptual Change Text	S40, S75, S87, S111, S204, S209, S210, S224, S226, S240, S245, S257, S266, S272	14	22,96
	Dominant Intelligence Areas	S148	1	1,64
	Learning Stages	S33	1	1,64
	Inquiry	S178, S86, S288	3	4,92
	Scenario	S51	1	1,64
	Learning at Stations	S201	1	1,64
	Model-Based Learning	S225	1	1,64
	Simulation	S255	1	1,64
	Explanatory Story	S99	1	1,64
	Cooperative Learning Method	S276	1	1,64
	Total		61	100

According to Table 4, the most commonly used method to eliminate misconceptions was conceptual change texts (*n* = 14).

The distribution of the methods used in the detection of misconceptions within the theme of the most studied subjects is shown in Table 5.

Table 5

Distribution of the Methods Used in the Detection of Misconceptions in the Most Studied Subjects Theme

Category	Codes	Study Codes	*f*	%
Methods Used in the Detection of Misconceptions	Predict-Observe-Explain Technique	S223	1	4,76
	Concept Map	S42, S76	2	9,52
	Project-Based Learning	S46, S88	2	9,52
	Concept Cartoon	S93	1	4,76
	Worksheets	S16, S39	2	9,52
	Word Association Test	S104, S304	2	9,52
	Diagnosis Test	S18, S239, S281, S306	4	19,04
	Constructivist Approach	S41, S97	2	9,52
	Computer-Aided Learning	S62,	1	4,76
	Conceptual Change Text	S52	1	4,76
	Meaningful Learning Method	S113, S167	2	9,52
	Games	S188	1	4,76
	Total		21	100

According to Table 5, the most common method for detecting misconceptions was diagnostic tests (*n* = 4), and the least used methods were concept cartoons (*n* = 1), computer-assisted teaching (*n* = 1), conceptual change texts (*n* = 1), and games (*n* = 1).

The distribution of the studies that analyzed the research conducted on misconceptions under the theme of the most studied subjects is shown in Table 6.

Table 6

Distribution of Studies Analyzing Studies on Misconceptions

Category	Codes	Study Codes	*f*	%
Analysis of Studies on Misconceptions in Turkey	Content Analysis	S314, S347, S330	3	75
	Content Elements Analysis	S294	1	25
	Total		4	100

As shown in Table 6, three of the four studies that analyzed the research on misconceptions under the theme of the most studied subjects were content analyses, and the other was content elements analysis.

The distribution of the studies that identified the views on misconceptions in the theme of the most studied topics is shown in Table 7.

Table 7

Distribution of Studies Determining Views on Misconceptions

Category	Codes	Study Codes	*f*	%
Opinions on Misconceptions	Insufficient information of teachers	S129	1	50
	Mental models of pre-service science teachers	S313	1	50
	Total		2	100

As can be seen in Table 7, there were two studies that identified opinions on misconceptions in the theme of the most studied subjects. One of them was about teachers' insufficient knowledge, and the other was about the mental models of pre-service science teachers.

The distribution of studies on raising the awareness of pre-service science teachers on the detection of misconceptions in the most studied subjects is shown in Table 8.

Table 8

Distribution of Studies on Raising Pre-Service Science Teachers' Awareness on Detection of Misconceptions

Category	Codes	Study Codes	*f*	%
Raising Awareness of Pre-Service Science Teachers on Detection of Misconceptions	Training to detect misconceptions	S160	1	100
	Total		1	100

According to Table 8, only one study was conducted on raising the awareness of pre-service science teachers about the detection of misconceptions within the most studied subjects.

RESULTS, DISCUSSIONS, AND SUGGESTIONS

In this research, which was conducted to examine the studies on misconceptions in science education in Turkey according to their types, year, method, sample, sampling method, data collection tool, and topics by thematic content analysis, 346 studies published between 2000–2022 and reached through YÖK Thesis Center, ERIC, and Google Scholar were analyzed. Accordingly, it was determined that most of the 346 studies were published as articles, the highest number of publications were made in 2011 and 2015, and the number of publications decreased gradually. These results are in line with the results of some studies in the literature. As a result of the analysis of the studies examining the misconceptions about gases, Mesin et al. (2019) concluded that the studies were mostly in the article type. Although in a specific area, as a result of their content analysis of the studies on misconceptions about heat-temperature in Turkey, Tamkavas et al. (2016) also stated that despite decreases in some years, there was an increase towards 2015 in general. Likewise, in the study of Aydoğan and Köksal (2017), it is seen that most studies were conducted between the 2005–2012 education years. In another study examining the articles published in the field of science education between 2010 and 2020, it was found that the studies on misconceptions have decreased in recent years. The reason for this tendency has been suggested to be the decrease in interest in the constructivism paradigm in recent years (Karampelas, 2021). The constructivist approach emphasizes student activities that help achieve conceptual understanding. Students build knowledge by matching new concepts they have acquired in the classroom with mental models based on the experiences they have gained in their lives, and constructivist learning begins (Gomez, 2016). In other words, in constructivist learning, the preconceptions that are effective in the formation of misconceptions are highly important. The decrease in the interest in the constructivist approach may have directly affected the number of studies on misconceptions. It is stated that the study subjects in any field vary according to the new terms developed in that field. For example, with the development of the term 'science literacy' in recent years, many of the studies in the field have shifted to the field of science literacy (Chang et al., 2009; Lin et al., 2018; Martin et al., 2012; NGSS, 2013; OECD, 2019).

Concerning the methods of the studies on misconceptions in science education in Turkey, it was determined that three methods, namely, survey methods (87), experimental methods (75), and descriptive methods (53), were used the most, while phenomenology and action research were used the least. Thus, it can be said that quantitative research designs are predominantly preferred. The reason for this inclination is that the planning, data collection, analysis, and reporting stages of quantitative research designs such as surveys, experimental, and descriptive methods are easier than those of the qualitative research designs such as phenomenology or action research. Some studies arrived at similar findings in the literature (Gül & Köse, 2018; Kula Wassink & Sadi, 2016; Sözbilir & Kutu, 2008). For example, Kula Wassink and Sadi (2016) evaluated studies conducted between 2005 and 2014 through content analysis and concluded that the most used methods are quantitative methods as a result of their research to determine the science education orientation in Turkey.

When the samples of the studies on misconceptions in science education in Turkey are considered, it is seen that the most common samples consist of the primary education level, university level, and secondary education level, and as a result of the analysis of sampling methods, it was determined that the convenience sampling method was preferred the most. The least used method is the random stratified sampling method and the systematic sampling method. As a result of their analysis of the articles on misconceptions in science education between 2000 and 2014, Aydoğan and Köksal (2017) concluded that the subject was mostly studied with 7th and 8th grade students. Bostan Sarıoğlan, Dolu, and Yılmaz (2021) stated that the most preferred sample types are secondary school students and university students after examining the articles published on science education in a journal they determined. On the other hand, by making a content analysis of the studies on misconceptions in physics education, Gül and Köse (2018) found that researchers mostly work with undergraduate students. According to Büyüköztürk et al. (2011), convenience sampling provides practicality to the researcher due to the limitations of other sampling methods in terms of time, money, and labor. Due to this feature, it is natural that it is one of the most preferred methods.

According to another result obtained in the present research, the data collection tools in studies on misconceptions in science education in Turkey were mostly concept tests, misconception diagnosis tests, and achievement test, whereas video recordings and MAT were used the least. Concept tests and misconception diagnostic tests (two-stage diagnostic tests, three-stage diagnostic tests, etc.) are tests that require students to explain their answers to the questions in their own words. Although achievement tests containing multiple choice questions are more useful in terms of their ease of application, evaluation, and reaching wider audiences, they are insufficient in detecting misconceptions because even if the students choose the right option, it can never be known whether they chose it intentionally or randomly. Therefore, concept tests and misconception tests may be the most frequently used tests. There are studies supporting these conclusions in the literature (Caleon & Subramaniam, 2010; Jimoyiannis & Komis, 2003; Kırbulut, Geban & Beeth, 2010; Loh, Subramaniam, & Tan, 2014; Yanarateş, 2022). For example, Yanarateş (2022), as a result of the thematic content analysis of the postgraduate theses on the misconceptions encountered in science education published between 2000–2021, determined that concept tests were used most commonly as data collection tools, followed by interviews and achievement tests. The reason for not using video recordings as a data collection tool may be the difficulties experienced in the analysis of the recordings. Again, the reason why MATs are rarely preferred may be that these tables are insufficient to detect misconceptions since MATs are tables in which there are events/objects/concepts in one dimension and features in the other dimension, and they ask the student to mark the feature of the event/object/concept. There is no part where the students can explain their thoughts about the given situation. Therefore, whether they have a misconception or not cannot be determined.

The last finding reached in the current research is that, as a result of examining the studies on misconceptions in science education in Turkey according to their subjects, six categories were determined, which are "the topics in which misconceptions are detected," "methods used in eliminating science misconceptions," "methods used in the detection of misconceptions," "analysis of studies on misconceptions in Turkey," "opinions on misconceptions," and "raising awareness of prospective science teachers about detecting misconceptions."

The most preferred subject in 346 studies is "the topics in which misconceptions are detected." Diagnosing misconceptions can help educators develop teaching-learning activities to overcome them (Cardoso et al., 2020). In the literature, it is seen that studies on misconceptions in science education are mostly aimed at detecting misconceptions (Ecevit & Özdemir Şimşek, 2017). Soeherto et al. (2019), as a result of examining 111 articles published between 2015–2019, stated that the studies conducted focused mostly on detecting misconceptions.

The second most studied issue is the elimination of misconceptions with a rate of 16%. Permatasari, Rahayu, and Dasna (2022) concluded that only 7% of the studies examined were conducted to eliminate misconceptions as a result of their systematic analysis of studies using multiple representations in chemistry learning between 2012–2021. The most commonly used method to eliminate misconceptions is conceptual change texts. The reason for this may be the effects of conceptual change texts in creating conceptual change by making students aware of existing misconceptions and the aspects of these structures that conflict with scientifically accepted knowledge. There are many studies in the literature on conceptual change texts that yielded successful results in conceptual change (Banawi et al., 2022; Chambers & Andre, 1997; Hynd, 2001; Jacobson et al., 2021; Sinatra, 2022; Şahin, Bülbül & Durukan, 2013). For example, Şahin, Bülbül, and Durukan (2013) concluded that conceptual change texts were effective in eliminating students' misconceptions about celestial bodies. Jacobson et al. (2021) and Sinatra (2022) reported in their studies that conceptual change texts are effective in eliminating misconceptions. As a result of the analysis of postgraduate theses on misconceptions in the field of physics, Taşkın (2022) maintained that the effect of conceptual change texts was mostly investigated in eliminating misconceptions. Another conclusion reached is that the most used method in the detection of misconceptions is gradual diagnostic tests. After examining 111 articles, Soeharto et al. (2019) stated that multi-stage diagnostic tests are mostly utilized in the diagnosis of misconceptions. In their study with primary school teacher candidates, Bayuni, Sopandı, and Sujano (2018) concluded that the five-stage diagnostic test can be used successfully to detect misconceptions.

The least preferred topics in studies on misconceptions are content analyses about misconceptions, opinions on misconceptions, and raising the awareness of pre-service teachers to eliminate misconceptions, respectively. Shulman (1986) stated 37 years ago that there was a need for studies to enable teachers and prospective teachers to gain awareness of students' misconceptions and the necessary practices to overcome them. However, when we look at the findings of the present study, this seems clearly not to have happened.

In summary, in this research, it was determined that the highest number of studies on misconceptions in science education in Turkey were carried out in 2011, the studies were mostly in the form of articles, they mostly used the survey method, they generally targeted the primary education level, convenient sampling was the most frequent method for sampling, and mostly concept test were used as data collection tools. In terms of preferred topics, it is found that there are studies on the topics in which the most misconceptions are detected. In order for the science concepts to be learned to be meaningful and permanent, the newly learned concepts and existing concepts must be in a meaningful unity (Osborne & Wittrock, 1983; Yağbasan & Gülçiçek, 2003). Since the concepts are related to each other, an incorrectly learned concept will directly affect the correct understanding of other concepts to which it is related. For this reason, how the concepts are structured and what they mean for the student, as well as the detection of misconceptions, are very important in terms of the learning and planning processes (Alwan, 2011; Laçin Şimşek, 2019). It is a well-known fact that misconceptions prevent science learning (Soeharto et al., 2019) because even if there is a misconception of knowledge, if learning has taken place, the student has associated it with his previous knowledge and placed it in a logical framework in his mind. Eryılmaz and Sürmeli (2002) state that students with misconceptions argue that these structures are correct and try to explain them with their own reasons. Therefore, they are resistant to changing the existing misconception with the correct one. However, this procedure is more difficult than it seems. If there is a misconception, it is one of the most important tasks of the teacher to eliminate the misconception that existed before the concept teaching (Alwan, 2011; Baysari, 2007). In this context, studies on misconceptions are of great importance for field researchers, for meaningful learning, and for teachers, who are one of the most important elements of the learning process. Although it is a favorable situation that a substantial number of studies on misconceptions are conducted in Turkey, the fact that the vast majority of studies are about detecting misconceptions is thought-provoking as it is important to determine the causes of misconceptions and to try to eliminate them. Based on this result, working on the causes and elimination of misconceptions can be some suggestions for future research. In addition, it is important to increase the number of qualitative studies to gain an in-depth understanding about misconceptions, based on the conclusion that the quantitative research design is the mostly employed method in the studies. According to the results of the study, it is seen that the number of studies on misconceptions has decreased in recent years. Hence, it is recommended to increase the number of studies to be conducted on this subject, which is highly important in terms of the learning process.

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Author Contributions

Both authors planned and modeled the study. First author collected, analyzed, and interpreted the data. Second author analyzed the data again and interpreted the data. The present study is derived from the first author's thesis. However, the translation into an article and reconstruction of the relevant literature was done by the consultant second author.

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