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This study is derived from the first author's master's thesis.

Received Date 26.08.2024
Accepted Date 15.01.2025
Publication Date 20.07.2025

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Cite this article: Kızmaç, N., & Yıldırım, H. E. (2025). Descriptive content analysis of research on cognitive structures in science education in Turkey. *Educational Academic Research*, 58, 153-168.



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Descriptive Content Analysis of Research on Cognitive Structures in Science Education in Turkey

ABSTRACT

In this study, the trends of cognitive structure researches published in the field of science education in Turkey were identified. A descriptive analysis of 156 studies (113 articles, 34 postgraduate theses and 9 proceeding papers) published between 2003 and 2023 was carried out using document analysis method. These studies were accessed from the National Thesis Centre of the Council of Higher Education, articles published by Turkish researchers searched in national and international databases, and proceedings of national congresses/conferences/symposiums held in Turkey. In order to evaluate the studies, the publication classification form prepared for the subject area by making use of the literature was used. With this form, the distribution of the studies according to year, language of publication, place of publication, type of publication, subject of the study, research model, sample, research method, data analysis, results and recommendations were determined. Descriptive statistics and descriptive content analysis were used to present the analysis's findings. In this study, it was seen that many studies were conducted on cognitive structures in science education and these studies were concentrated between 2017-2020. It was determined that the studies mostly aimed to determine the cognitive structures of individuals with a subject, mostly qualitative research method was used and mostly Word Association Test (WAT) was used as a data collection tool. The most common conclusions drawn from the investigations were that the sample's cognitive structures were lacking and that they had misconceptions regarding the topic.

Keywords: Cognitive structure, content analysis, science education, word association test.

Introduction

Cognitive structures are the frameworks that allow information to be organized meaningfully, to form connections with one another, and to be accessed when needed (Ceylan, 2015). As Ausubel (1963) points out, the most critical factor in making new information meaningful and connecting it with previous knowledge is current cognitive framework of an individual (Ausubel, 1963; as cited in Khurshid & Iqbal, 2009). According to Gilbert and Watts (1983), cognitive structure is an assumption-based framework that represents the connections between the ideas we commit to long-term memory (as cited in Kurt & Ekici, 2013).

There are some ways for identifying cognitive structures. Flow maps (Selvi & Yakışan, 2005), concept maps (Ekinçi & Şen, 2020), structured grid, V-diagram, concept cartoon (Bahar, 2003; Tsai & Huang, 2002), and word association test (WAT) (Baptista & Martins, 2023; Ercan et al., 2010; Yıldırım et al., 2020) are the most commonly used methods.

By identifying cognitive structures, teachers can better understand students' learning difficulties and improve their instruction (Snow, 1989; as cited in Temel & Özcan, 2016). For this reason, researchers have undertaken studies aimed at determining cognitive structures and misconceptions, while investigating the effects of different teaching methods on them.

A review of the research regarding cognitive structures indicates that many national and international studies have been carried out. "Science Education" has been the subject of most of these studies (Bahar et al., 1999; Önel et al., 2023; Özatlı, 2006; Yıldırım & Demirkol, 2018). Furthermore, research has been conducted in the following areas: "Social Studies Education" (Aksoy, 2022; Saleh, 2022; Yeni, 2023); "Mathematics Education" (Tanışlı & Köse, 2013); "Turkish Education" (Yıldız & Yaman, 2017); "English Education" (Aslan, 2019; Ersanlı, 2016); "Basic Education" (Gündoğan & Gültekin, 2018; Yurtbay, 2022); and "Music Education" (Gereken, 2018; Özaydın, 2022). These studies focused on determining the cognitive structure of a given subject (Aksoy, 2022; Bahar et al., 1999; Demirkaya et al., 2020; Ersanlı, 2016; Gündoğan & Gültekin, 2018; Önel et al.,

2023; Özatlı, 2006; Saleh, 2022; Tanışlı & Köse, 2013; Yeni, 2023; Yıldırım & Demirkol, 2018; Yıldız & Yaman, 2017; Yurtbay, 2022), identifying misconceptions (Ercan et al., 2010), examining the influence of teaching methods on cognitive structures (Doruk, 2015), and investigating the process of conceptual change (Ercan et al., 2010). In light of the studies conducted in line with these objectives; researchers found that alternative teaching methods caused positive changes in students' cognitive structures (Ercan et al., 2010), students' cognitive structures were not valid and they had alternative concepts (Ersanlı, 2016; Önel et al., 2023; Özyayın, 2022; Saleh, 2022; Yıldız & Yaman, 2017), that they lack knowledge about the subject (Ersanlı, 2016; Gündoğan & Gültekin, 2018; Özyayın, 2022; Yıldırım & Demirkol, 2018) and that they have sufficient level of knowledge about the subject but not many misconceptions (Aksoy, 2022; Gerekten, 2018; Tsai & Huang, 2002; Yeni, 2023; Yurtbay, 2022). Based on the research findings, studies on cognitive structures can be carried out across various subjects and with different participant groups (Aksoy, 2022; Ekinci, 2015; Ersanlı, 2016; Gündoğan & Gültekin, 2018; Yeni, 2023), new methods and techniques can be used in research (Özatlı, 2006; Özyayın, 2022; Tanışlı & Köse, 2013; Tsai & Huang, 2002; Yurtbay, 2022), qualified education can be given to prospective teachers (Gerekten, 2018; Yıldız & Yaman, 2017), lesson planning can be made by determining misconceptions (Yıldırım & Demirkol, 2018), interdisciplinary studies can be included (Kaya & Taşdere, 2016), and scientific knowledge should be included more in the curriculum (Önel et al., 2023; Saleh, 2022) has been proposed.

When the descriptive analysis studies related to the field of science education are examined, technology supported science education (Arduç, 2024; Fındık et al., 2023; Ültay & Comardoğlu, 2021; Ünlü et al., 2024), adaptive learning environments in science education (Palta-Benek & Çirkinioğlu-Şekercioğlu, 2024), cooperative learning model in science education (Saygın, 2024), flipped learning model in Turkey (Karamete, 2024) and flipped learning model in science education (Ültay et al., 2023), learning cycle model (Oğuzman, 2023), student success in science education (Kara, 2023), brain-based learning in science education (Tosun & İlkörücü, 2023), computer-assisted instruction in science education (Şahin, 2021), science experiments conducted with pre-service teachers (Özkurt et al., 2023), scientific process skills in science education (Çevik & Kaya, 2021), affective variables for science course (Ültay & Sungur, 2019), associating science education with daily life (Ormancı & Çepni, 2018), qualitative studies in science education (Güven, 2014; Ültay & Aydın, 2017), trends in science education in Turkey (Kula-Wassink & Sadi, 2016), interdisciplinary studies in science education (Ültay et al.,

2019) and science education for visually impaired students (Sözbilir et al., 2015) have been studied. There are studies in which theses and articles are examined together (Arduç, 2024; Oğuzman, 2023; Ormancı & Çepni, 2018; Saygın, 2024; Tosun & İlkörücü, 2023) as well as studies in which only theses (Bayraklı, 2019; Çevik & Kaya, 2021; Kaplan et al., 2022; Kara, 2023; Şahin, 2021) and only articles (Güven, 2014; Kula-Wassink & Sadi, 2016; Sözbilir et al., 2015) are examined. As a result of these examinations, no study was found for the descriptive analysis of cognitive structure studies for the subjects in science education neither nationally nor internationally. This study is expected to serve as a valuable resource for researchers investigating cognitive structures.

This study employed descriptive content analysis to demonstrate the classification of research on cognitive structures in the field of science education in Turkey from 2003 to 2023 by year, within the framework of many dimensions. In the field of science education, there are many studies investigating students' cognitive structures at international level (Tsai, 1999). However, it is seen that these studies started to be conducted in our country at the beginning of 2000s (Kaptan & Korkmaz, 2001). For this reason, in this study, screening was started to be carried out from the year 2000. As a result of the scanning, since it was seen that there were cognitive structure studies on science subjects since 2003, the date range in this study was determined as 2003-2023. In the research, answers to the following questions were sought. For studies on cognitive structures in science education in Turkey;

1. How is the distribution according to the type of scientific publication?
2. How is the distribution by years?
3. How is the distribution according to the university, journal and congress in which it was published?
4. How is their distribution according to their objectives?
5. How is the distribution according to the research model?
6. How is the distribution of the sample and sample size?
7. How is the distribution according to the research topic?
8. How is the distribution according to the data collection method?
9. How is the distribution according to data analysis methods?
10. How is the distribution according to the most important results?
11. How is the distribution according to the suggestions?

Method

Research Model

This study is based on the document analysis method, which includes the analysis of written and printed materials (Yıldırım & Şimşek, 2016). Documents include documents and pictures that are recorded without the contribution of the researcher. The types of documents that can be used in research are books, journals, diaries, maps, newspapers, artworks, invitations, survey data, public records, etc., and provide information to researchers (Labuschagne, 2003; cited in Kiral, 2020).

Data Collection

Between 2003 and 2023, master's and doctoral theses related to cognitive structure in science education, proceedings of national-international congresses/conferences/symposiums held in Turkey, and studies identified through different search engines were collected as a result of literature research conducted within a period of approximately one year. Research data were obtained through the YOK National Thesis Center, the ERIC database, the Google Academic search engine, and TUBITAK ULAKBIM DergiPark.

The studies used in the research were required to be thesis, article or paper. The keywords "cognitive structure, cognition, cognitive perception, and cognitive structure" were searched in the databases. As a result of the search with key words, a total of 259 studies were reached. Of these studies, 14 were excluded from the scope of the review because they were conducted in the fields of mathematics education, 48 in history and geography education, six in Turkish education, two in English education, 12 in educational sciences, nine in tourism and finance, four in information technologies, and six in music education. The remaining 158 studies were included in the study since they were conducted in the field of science education. However, since the full text of two of these studies could not be accessed, the research was limited to 156 studies. Studies that were inaccessible or whose full texts were not available were excluded.

The ethical process in the study was as follows:

- Ethics Committee Approval: Since this study was a review study and did not involve any application on humans or animals, it did not require ethics committee approval. However, ethical guidelines were followed throughout the study.
- Informed Consent: Informed consent was not obtained as this was a review study.

Data Analysis

Data was created using a classification form. The study

classification form created by Sözbilir et al. (2012) was utilized in the production of this form, which was organized based on the issue under investigation. The forms were used to categorize the studies on cognitive structures based on variables such as year, research model, sample type, sample size, data collection tool, data analysis method, result, and recommendation. In the descriptive content analysis, especially in the analysis of the purpose, reasons, results, and recommendations of the studied studies, creating a code pool in accordance with the qualitative analysis approaches and using the appropriate thematizing/categorization method will ensure that the descriptive content analysis studies are enriched in terms of quality (Ültay et al., 2021). During the analyses, more than one marking was made for some variables. For example, it was seen that some of the studies investigated more than one purpose, and more than one marking was made in the frequency table related to the purpose. For this reason, the total frequency value is higher than the total number of studies, and the frequency values in the tables do not express the number of studies.

Validity and Reliability

Sources were randomly selected as 20% from each data group. Accordingly, 32 studies (23 articles, seven postgraduate theses, and two papers) were evaluated and classified by two researchers who have research in this field. Cohen's Kappa (Cohen's Kappa Coefficient) value was calculated to ensure the reliability between the two assessors. The calculated Cohen's Kappa (κ) was found to be .94. This value indicates a high level of agreement (Landis & Koch, 1977).

Results

In the study, 156 studies were analysed to answer the sub-problems. The analysed data were coded following the themes, and their percentages, frequencies, total percentages, and total frequencies according to years are given in the tables below.

Results Concerning the First Sub-Problem

In light of the analyses related to the research's first sub-problem, 113 (72.4%) studies in article format, 30 (19.2%) in master's degree format, 4 (2.6%) in doctoral thesis format and nine (5.8%) in proceedings format were published in Turkey between 2003 and 2023. 48 articles were published in national journals and 65 articles were published in international journals.

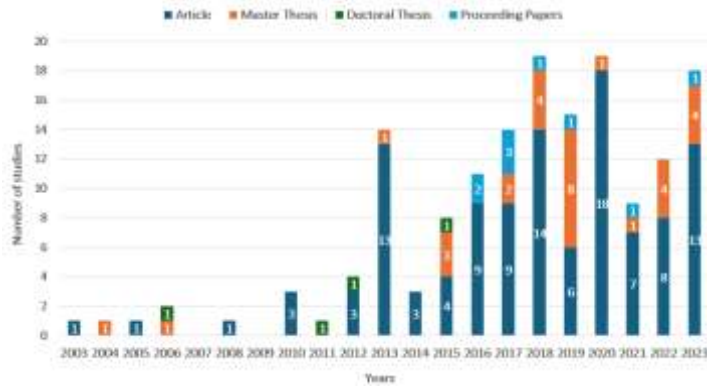
Results Related to the Second Sub-Problem

The findings related to the second sub-problem of the research are displayed in Figure 1. When Figure 1 is examined, it is seen that the most studies on cognitive

structures were conducted in 2020, while no studies were conducted in 2007 and 2009. Looking at the type of studies, it is understood that articles were conducted in 2020, master's theses in 2019, and papers in 2017 with the highest rate.

Figure 1.

Classification of Studies by Year



Results Concerning the Third Sub-Problem

The findings related to the third sub-problem of the research are presented below.

When Table 1 and Table 2 are analysed, it is seen that 65 articles were published in international journals and 48 articles were published in Turkish journals. The journal with the highest number of articles published in Turkey was "Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education" with six articles. The journal with the highest number of articles published internationally was 'Educational Research and Reviews' with five articles.

It is seen that the theses examined within the scope of the study were carried out in various universities in Turkey. When the distribution of these according to universities is analysed, it is determined that Necmettin Erbakan University is the institution that contributes the most, with nine theses. This is followed by Balıkesir University (five theses), Niğde Ömer Halis Demir University (four theses), and Hacettepe University (three theses). While Uludağ University is represented with two theses, Gazi University, Abant İzzet Baysal University, Uşak University, 19 Mayıs University, Kırıkkale University, Mersin University, Aydın Adnan Menderes University, Erzincan Binali Yıldırım University, Alaaddin Keykubat University, Süleyman Demirel University, and Sakarya University have one thesis each.

Table 1.

Classification of Journals in Which Articles Were Published in Turkey

Journals	(f)
Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education	6
Journal of Inonu University Faculty of Education	3
Turkish Journal of Science Education	2
Journal of Dicle University Ziya Gökalp Faculty of Education	2
Turkish Studies (Electronic)	2
Kastamonu Education Journal	2
Yüzüncü Yıl University Journal of Faculty of Education	2
Abant İzzet Baysal University Journal	1
Journal of Ahi Evran University Kırşehir Faculty of Education	1
Hacettepe University Journal of Faculty of Education	1
Gazi University Journal of Faculty of Education	1
Journal of Science Teaching	1
Turkish Journal of Social Research	1
Journal of Amasya University Faculty of Education	1
Ekev Academy Journal	1
E-International Journal of Educational Research	1
Mustafa Kemal University Journal of Institute of Social Sciences	1
Electronic Journal of Social Sciences	1
Estüdam Education Journal	1
Journal of Education and Training Research	1
Anemon Mus Alparslan University Journal of Social Sciences	1
Baskent University Journal of Education	1
Pamukkale University Journal of Faculty of Education	1
Journal of Ağrı Chechen University Graduate School of Social Sciences	1
Third Sector Journal of Social Economy	1
Manas Journal of Social Research	1
Journal of Scientific Research in Turkey	1
Osmangazi Journal of Education Research	1
Gumushane University Institute of Social Sciences Electronic Journal	1
Çukurova University Journal of Faculty of Education	1
Adıyaman University Journal of Educational Sciences	1
Western Anatolian Journal of Educational Sciences	1
Uşak University Journal of Educational Research	1
Erzincan University Journal of Faculty of Education	1
Mevzu Journal of Social Sciences	1
Trakya Education Journal	1
Total	48

Table 2.*Classification of Journals in Which Articles were Published Abroad*

Journal	(f)
Educational Research and Reviews	5
Chemistry Education Research and Practice	4
International Education Studies	3
Journal of Turkish Science Education	3
European Journal of Physics Education	2
Universal Journal of Educational Research	2
The Eurasia Proceedings of Educational and Social Sciences	2
Journal of Education and Training Studies	2
Journal of Qualitative Research in Education	2
Journal of Science Learning	2
International Council of Association for Science E.	2
Journal of Baltic Science Education	2
Educational Sciences: Theory and Practice	1
Eurasian Journal of Physics and Chemistry Edu.	1
American-Eurasian Journal of Agricultural & Environmental Sciences	1
Global Journal of Education Research	1
Creative Education	1
International Online Journal of Educational Sci.	1
International Journal of Research in Teacher Edu.	1
International Electronic Journal of Environmental	1
Journals of Education Sciences Research	1
Elementary Education Online	1
Journal of Education and Practice	1
International Journal of Human Sciences	1
European Journal of Education Studies	1
Journal of Education and Future	1
International Journal of Education Science and Technology	1
Higher Education Studies	1
World Journal of Education	1
Asian Journal of Education and Training	1
International Journal of Society Researches	1
The Journal of International Social Research	1
International Journal of Research in Education and Science	1
Online Journal of Mathematics, Science and Technology Education	1
Jurnal Penelitian Dan Pembelajaran Ipa	1
International Journal of Curriculum and Instruction	1
International Journal of Progressive Education	1
Acta Didactica Napocensia	1
Ibad Journal of Social Sciences	1
Shanlax International Journal of Education	1
Journal of Biological Sciences and Health	1
International Journal of Science Education	1
Jurnal Ilmiah Peuradeun	1
Science Education International	1
International Journal of Social, Humanities and Administrative Sciences	1
Journal of Individual Differences in Education	1
Total	65

Within the scope of this study, it was seen that the proceedings analyzed related to cognitive structures were presented in six different congresses. When the distribution of the proceedings according to the congresses is studied, it is seen that the highest participation rate is IV. International Eurasian Educational Research Congress (34%). This was followed by the III. International Eurasian Educational Research Congress (22%) and the 12th National Science and Mathematics Education Congress (11%). XVI. International Congress of Educational Research, AIP Conference Proceedings, and International Congresses on Education are equally represented (11%). This distribution shows that research on cognitive structures is particularly concentrated in Eurasian Congresses on Educational Research.

Results Concerning the Fourth Sub-Problem

Table 3 presents the findings pertaining to the fourth sub-problem of the study.

A review of Table 3 reveals that the researches was carried out for seven reasons: "to determine cognitive structure about a subject, to examine the impact of teaching strategies on cognitive structure, to determine misconceptions, to identify the cognitive structure and examine its permanence, to compare cognitive structure at different grade levels, to observe concept change, to investigate the structural and descriptive properties of cognitive structures, and to compare cognitive structures according to gender.". It was determined that 91 of the articles, 23 of the theses, and seven of the papers conducted research to "determine the cognitive structures of the participants about a subject.". This purpose was the most common purpose in the studies. In the second place in the articles, cognitive structure studies were carried out for the aim of "determining misconceptions" ($f=13$) and "examining the impact of instructional methods on cognitive structure" ($f=13$). Secondly, the researchers' goal in the theses was to examine how teaching methods affect cognitive structure. The aim of "investigating the structural and descriptive properties of cognitive structures" in articles, the aim of "comparing cognitive structures at different grade levels" in theses, and the aim of "determining misconceptions in papers" in dissertations emerged at the lowest rate.

Table 3.*Classification of Studies According to Their Purposes*

Objective	Article (<i>f</i>)	Thesis (<i>f</i>)	Proceedings (<i>f</i>)	Total (<i>f</i>)
To determine cognitive structure about a subject.	91	23	7	121
To examine the impact of teaching strategies on cognitive structure.	13	6	-	19
To identify misconceptions.	13	5	2	20
To identify the cognitive structure and examine its permanence.	4	-	-	4
To compare cognitive structure at different grade levels.	3	1	-	4
To observe concept change.	-	2	-	2
To investigate the structural and descriptive properties of cognitive structures.	1	-	-	1
To compare cognitive structures according to gender.	-	1	-	1
Total	125	38	9	172

Results Concerning the Fifth Sub-Problem

Table 4 presents the findings pertaining to the fifth sub-problem of the study.

Table 4.*Classification of Studies According to Research Method*

Method-Pattern	Article (<i>f</i>)	Thesis (<i>f</i>)	Proceedings (<i>f</i>)	Total (<i>f</i>)	
Quantitative	Survey	10	4	-	14
	Experimental	8	6	-	14
	Descriptive	3	5	-	8
	Correlational	1	-	-	1
	Total	22	15	-	37
Qualitative	Unspecified	29	4	-	33
	Case study	23	4	2	29
	Survey	11	-	-	11
	Phenomenology	10	1	1	12
	Action Research	1	-	-	1
Mixed	Descriptive Research	-	3	6	9
	Total	74	12	9	95
	Unspecified	15	6	-	21
General Total	Explanatory	2	1	-	3
	Total	17	7	-	24
General Total	113	34	9	156	

Analysis of Table 4 reveals that the qualitative research approach is most frequently used in articles and proceedings ($f=74$ and $f=9$, respectively), whereas the quantitative approach is most frequently used in theses ($f=15$). It was revealed that the number of quantitative ($f=22$) and mixed ($f=17$) research articles was close to each other, while the number of qualitative research ($f=12$) was higher than mixed research ($f=7$) in theses. Among the studies carried out with the quantitative research method, most of the studies in article-type publications were conducted in survey design ($f=10$) and most of the studies in thesis-type publications were conducted in experimental design ($f=6$). It was observed that the research design was not mentioned in 29 of the article-type publications with the highest rate among the studies conducted with the qualitative research methods. It was revealed that four of the thesis-type

publications in which qualitative research was conducted were case studies, and four other studies did not specify the research design. In proceedings, it was determined that six studies were carried out with a descriptive design, two studies were carried out with a case study, and one study was carried out with a phenomenological design. When all studies are evaluated, it is seen that most studies were conducted with qualitative research methods ($f=95$). When all studies are evaluated, it is seen that most studies were conducted with qualitative research methods ($f=95$).

Results Concerning the Sixth Sub-Problem

The sixth sub-problem of the study is 'How are studies conducted on cognitive structures in science education in Turkey distributed according to sample group and sample size?'

When the sample groups of the studies are examined, it is seen that 64 of the publications in the article type studied with undergraduate students, 13 of the publications in the thesis type, and 4 of the publications in the paper type studied with secondary school students as the sample group. In thesis-type publications, high school students ($f=9$) ranked second. While high school ($f=2$) and undergraduate students ($f=2$) were the second most studied group in proceedings, secondary school students were the second most studied group in articles with 26 studies. There are also studies in which several sample groups are used together. In four articles, three theses, and one proceeding, different sample groups were used together.

When the studies were analysed, while all of the articles and theses gave information about the sample size, three out of nine proceedings did not give information about the sample size. The data of the studies giving information about sample size are given in Figure 2. It is evident from Figure 2, which lists sample sizes, that the majority of the research are conducted using sample sizes ranging from 0 to 50 to 51 to 100.

Results Concerning the Seventh Sub-Problem

Table 5 presents the findings pertaining to the seventh sub-problem of the study. When Table 5 is analysed, it is seen that cognitive structure studies in articles ($f=63$), theses ($f=19$) and proceedings ($f=4$) are mostly related to biology subject area. In articles, chemistry ($f=19$), physics ($f=14$), other subject areas ($f=9$) and science education and training ($f=8$) followed. In theses, chemistry ($f=8$), physics ($f=5$) and science education and training ($f=2$) are the subject areas respectively. In the proceedings, while two studies were related to physics and other subject areas, only one study was found to be related to chemistry subject area.

Figure 2.

Classification of the Size of the Samples in the Studies

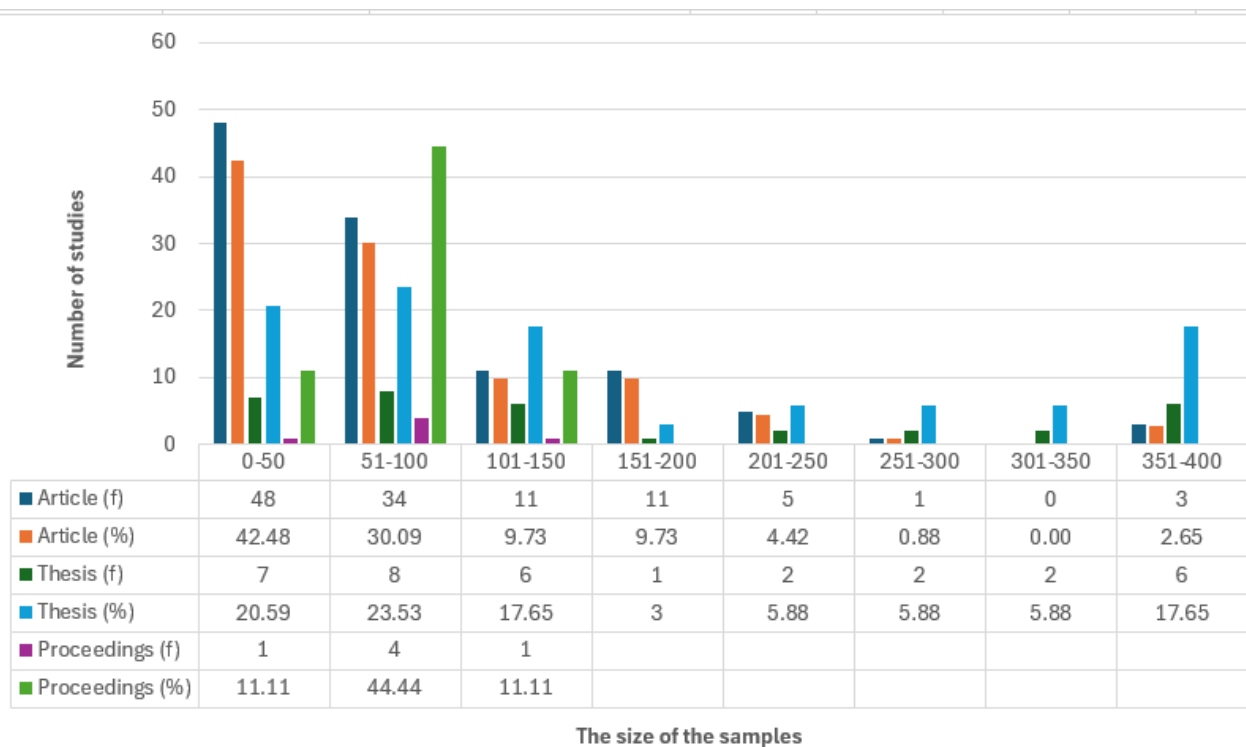


Table 5.*Classification of Studies According to Their Subjects*

	Subject area	Article (<i>f</i>)	Thesis (<i>f</i>)	Proceedings (<i>f</i>)	Total (<i>f</i>)
Physics	Physical phenomena	8	-	-	8
	Energy	4	2	1	7
	Astronomy	2	-	1	4
	Light and sound	-	2	-	2
	Friction force	-	1	-	1
	Total	14	5	2	22
Biology	Life science	12	-	-	12
	Cycles of matter	4	-	-	4
	Blood	4	-	-	4
	Systems	4	4	-	8
	Plants	4	-	1	5
	Cell	16	1	-	17
	Genetics	6	3	1	10
	Ecology	13	10	2	16
	Our food	-	1	-	1
	Total	63	19	4	86
Chemistry	Matter and change	15	6	-	21
	Stereochemistry	1	-	-	1
	Kinetic-equilibrium	1	-	-	1
	Periodic table	1	-	-	1
	Quantum numbers	1	-	-	1
	Acid-Base	-	1	-	1
	Gases	-	1	-	1
	Heat and temperature	-	-	1	1
	Total	19	8	1	28
Science education and teaching	Science self-efficacy/ attitude	-	1	-	1
	Basic physics, chemistry, biology concepts	1	-	-	1
	STEM	4	1	-	5
	Argumentation	1	-	-	1
	Micro teaching	1	-	-	1
	Classroom management	1	-	-	1
Total	8	2	-	10	
Other	Technology	2	-	-	2
	The nature of science	1	-	-	1
	Self-regulation	1	-	-	1
	Science	1	-	-	1
	Innovation	1	-	-	1
	Life skills	1	-	-	1
	Educational game	1	-	-	1
	School	1	-	-	1
	Physics teacher concept	-	-	1	1
	Science centre concept	-	-	1	1
	Total	9	-	2	11
General Total		113	34	9	156

Among the most studied topics by biology subject area, 'cell' ($f=16$) is the focus in articles, while 'ecology' is prominent in theses ($f=10$) and proceedings ($f=2$). In the subject area of chemistry, "matter and change" was mostly studied in articles ($f=15$) and theses ($f=6$), and "heat and temperature" was studied in only one proceeding. In the

subject area of physics, "physical events" ($f=8$) in articles, "energy" ($f=2$) and "light and sound" ($f=2$) in theses, "energy" ($f=1$) and "astronomy" ($f=1$) in proceedings were studied. It was observed that articles and theses were conducted on "science education and training" and cognitive structure research was mostly conducted on the subject of STEM. When the subjects collected under the title of "other" were analysed, it was determined that

"technology" subject was studied more and the frequency of other subjects was the same.

Results Concerning the Eighth Sub-Problem

Table 6 presents the findings pertaining to the eighth sub-problem of the study.

Table 6.
Classification of Studies According to Data Collection Tool

Data Collection Tool	Article (<i>f</i>)	Thesis (<i>f</i>)	Proceedings (<i>f</i>)
WAT	100	26	9
DWT	31	6	3
Concept map	6	5	-
Written expression	6	-	-
Interview	5	4	-
Metaphor	4	4	-
Survey	3	1	-
Knowledge/ Achievement test	3	8	-
Flow map	2	1	-
Thinking aloud	1	1	-
V diagram	1	1	-
Structured grid	1	1	-
Concept cartoon	1	3	-
Concept inventory	1	-	-
Attitude scale	1	4	-
Mind maps	1	-	-
Open-ended question	-	6	-
Free writing	-	2	-
Concept test	-	1	-
Reflective diaries	-	1	-
Model	-	1	-
Total	167	76	12

Table 6 shows that WAT was the most frequently used data collection tool across all study categories, followed by DWT ($f=31$, $f=6$, $f=3$), concept map ($f=6$, $f=5$) and written expression ($f=6$).

Results Concerning the Ninth Sub-Problem

Table 7 presents the findings pertaining to the ninth sub-problem of the study.

When Table 7, which is the distribution table of the data analysis methods used in the studies, it is seen that descriptive analysis ($f=83$), descriptive statistics ($f=19$) and content analysis ($f=8$) are mostly used in articles, theses and proceedings, respectively. This is followed by content analysis in articles and theses ($f=58$; $f=13$) and descriptive analysis in proceedings ($f=1$), respectively.

Table 7.
Classification of Studies According to Data Analysis Method

Data Analysis Method	Article (<i>f</i>)	Thesis (<i>f</i>)	Proceedings (<i>f</i>)	
Quantitative	Descriptive statistics	4	19	-
	Predictive statistics	-	1	-
Qualitative	Descriptive analysis	83	5	1
	Content analysis	58	13	8
Quantitative + Qualitative	4	3	-	
Total	149	41	9	

Results Concerning the Tenth Sub-Problem

Table 8 presents the findings pertaining to the tenth sub-problem of the study. When Table 8 is examined, 12 result statements were determined in the studies related to cognitive structure. In all of the studies, the result that the participants' cognitive structures related to the subject studied were weak was the highest. This result was reached in 71 article-type studies, 24 thesis type studies and seven proceedings. Secondly, in 21 articles, and 12 thesis-type studies, it was concluded that alternative teaching methods for the subject positively affected the cognitive structures of the students. Apart from this, it was observed that there were three different results in proceedings-type studies.

These results are that teaching methods affect the cognitive structures of students; WAT is the most effective tool in determining cognitive structures, and the cognitive levels of high school students in the studies about the concept of physics teacher are sufficient.

Results Concerning the Eleventh Sub-Problem

The eleventh sub-problem of the research was expressed as "How is the distribution of the studies on cognitive structures in the field of science education in Turkey according to their suggestions?"

Table 8.*Classification of Studies According to the Most Important Results*

Results	Article (<i>f</i>)	Thesis (<i>f</i>)	Proceedings (<i>f</i>)	Total (<i>f</i>)
Participants' cognitive structures related to the subject are weak.	71	24	7	102
Alternative teaching methods for the subject positively affect students' cognitive structures.	21	12	1	34
The participants' prior knowledge caused differences in their cognitive structures.	10	8	-	18
Participants' cognitive structures towards technology are at low level.	4	-	-	4
Compared to other data collection tools, WAT is an effective method in determining cognitive structure.	3	3	1	7
Lessons in the laboratory positively affected the development of cognitive structure.	2	1	-	3
Students have more developed cognitive structures about the word "BİLSEM" and parents have more developed cognitive structures about the word "school".	1	-	-	1
Students at various levels—secondary, high school, and undergraduate—had comparable cognitive processes.	1	1	-	2
It was determined that the participants could not establish a relationship between science and engineering.	-	1	-	1
Participants' cognitive structures related to the subject are at a sufficient level.	-	12	1	13
Total	113	62	10	185

When the suggestions from the studies were analysed to address the sub-problem, it was found that these suggestions are categorised under four headings (Suggestions for future research, suggestions for teacher education, suggestions for classroom teaching and suggestions for measurement and evaluation). In article ($f=52$) and thesis-type studies ($f=58$), most of the suggestions were made for future researches, while in proceedings-type publications, most of the suggestions were made for classroom teaching ($f=5$). Researchers suggested that cognitive structure studies can be repeated using different methods and different sample groups for future research. Moreover, it was suggested that conceptual teaching of pre-service teachers should be given importance and courses on cognitive structure should be added to education programs. It was mentioned in the recommendations for in-class instruction that by selecting various subject-related teaching strategies, the alteration in cognitive structures may be examined. Lastly, the need to employ various measuring instruments to improve the dependability of the research was emphasized in the recommendations for measurement and evaluation.

Discussion

This study conducted a descriptive analysis of theses, proceedings, and articles on cognitive structures in science education in Turkey from 2003 to 2023. Research on cognitive structure in science education was conducted mostly between 2016 and 2023, with the greatest number of studies ($f=19$) occurring in 2018 and 2020 and the fewest (one each) in 2003, 2004, 2005, 2008, and 2011. The study's findings showed that no research was conducted in 2007 or 2009. Therefore, the rise in research over the past seven years can be interpreted as a sign that the topic of cognitive structure is becoming increasingly significant. Simultaneously, it is anticipated that research in the area of scientific education will become more significant over time and that there will be more studies in the upcoming years.

When the types of studies were analysed, it was seen that there were more studies in article type. In thesis type studies, it was determined that doctoral theses were less. Özkul (2023) reached the same result in his study with mental model applications. There are fewer studies on thesis and paper kinds, which could be because graduate school involvement in science education is low nationwide (Tosuntaş et al., 2019). Moreover, the reason for this situation may be that, as Dağ and Horzum (2022) state, although the number of universities offering master's

programmes in Turkey is quite high, the number of universities offering doctoral education is more limited.

Analysis of the papers' distribution by the periodicals in which they were published revealed, it was seen that more studies were sent to journals publishing abroad ($f=65$) than to journals publishing in our country ($f=48$). For this reason, in the examination of the publication language of the studies, it was determined that the most studies were in English (41.67%). Among these journals, "Educational Research of Reviews" has the highest number of publications with five studies. The journal with the highest number of publications in Turkey was Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education with six studies. This shows that researchers in Turkey prefer international journals. In terms of the distribution of thesis studies by the universities where they were published, Balıkesir University came in second with five studies and Necmettin Erbakan University first with six. In the type of paper, the congress where the most studies were presented was Pamukkale University IV. International Eurasian Education Studies Congress with three studies.

Most of the studies (55.13%) were in the biological discipline, according to an analysis of the research subjects. The other topics were "Physics", "Chemistry", "Biology", "Science education and teaching" and "Other". According to subject areas, 'Physical Events' (36.36%) in Physics, 'Cell' (22.08%) in Biology, 'Matter and Change' (75%) in Chemistry, 'STEM' (50%) in Science Education, and 'Technology' (18.18%) in the 'Other' category are the prominent topics.

It was found that the majority of research on cognitive structures in science education focused on identifying misconceptions (11.63%), assessing the impact of teaching methods on cognitive structure (11.05%), or determining cognitive structure about a subject (70.35%). It is crucial to try to ascertain the learner's cognitive structure in educational research, particularly in scientific education (Tsai, 1999), and to create instructional strategies that take this into consideration (Tsai & Huang, 2002). Learners' misconceptions and learning challenges can be identified by analysing their cognitive structures (Jonassen, 1987; Varoğlu et al, 2020). Educators will then be able to plan what has to be done to enhance students' learning experiences.

It was observed that case studies, one of the qualitative research methodologies, were primarily favoured in the publications on cognitive structure in science education. In theses, quantitative and qualitative methods were used together, but experimental design from quantitative

methods was given more weight. The reason why experimental studies are more preferred is that researchers have the opportunity to conduct comprehensive and long-term research in thesis type studies. Such studies are widely preferred because they focus on determining the effect of a particular teaching approach on the change in students' cognitive structures, especially by using experimental methods in one or two semesters. All of the proceedings were carried out according to qualitative method. While there are more quantitative studies in other educational researches (Göktaş et al., 2012; Selçuk et al., 2014), qualitative method is at the forefront in cognitive structure studies. In qualitative studies, detailed information is obtained by using many data collection tools. In cognitive structure studies, data collection tools such as WAT, concept map, flow map, paired interviews and DWT are used to reveal students' cognitive structures. With these tools, mis associated concepts in students' minds and the misconceptions they have accordingly are revealed. The data obtained from these tools can be evaluated together in accordance with the nature of qualitative research. The detection of misconceptions requires a detailed and in-depth analysis process. Data collection tools used in qualitative research methods provide rich and detailed data to understand students' misconceptions (Jamaludin & Maat, 2020). Therefore, it can be thought that the more frequent preference of qualitative research methods in articles and papers is related to this situation. It is recommended in the literature that more qualitative research be done in studies that use descriptive analysis (Kula-Wassink & Sadi, 2016). It is stated that different research methods should be used in educational research due to the nature of teaching systems (Driscoll, 1995; Göktaş et al., 2012).

When sampling types were analysed in the studies, it was determined that convenience sampling was mostly preferred. Similarly, it is seen that the most preferred sampling types in the literature are purposive and convenience sampling (Şimşek et al., 2008). The reason for this situation may be that the analysed studies were mostly conducted with qualitative research method and case study. Convenience sampling favours smaller sample sizes.

Secondary school students are the most favoured sample group in theses and dissertations, but undergraduate students (64 pre-service teachers) are the most favoured sample group in articles. The preference for pre-service teachers as the primary sample group in the articles may stem from the researchers' goal to explore the cognitive structures of future teachers and to design instruction to

address any misconceptions. The reason why secondary school students were mostly selected in theses and proceedings can be considered as the fact that the science curriculum includes the teaching of concepts that form the basis for the following levels. Groups of fewer than fifty people were the most frequently explored in the examined papers when it came to sample size, however groups of up to 300 persons were more preferred in theses. Comparing the papers by sample size revealed that groups of fewer than 100 people were studied. This is believed to be because the articles and papers under review have fewer than 50 and 100 samples, the WAT and DWT are primarily employed as data collection instruments, and the research is primarily conducted using the qualitative research approach.

It was found that practically all of the research on cognitive structure in scientific education used WAT as a data gathering technique. We can conclude that WAT is an effective data collection tool in determining cognitive structure (Önal, 2017). The DWT was seen to be the most popular instrument in the investigations, following the WAT. With this technique, participants can express what they cannot express with words by drawing (Nergiz, 2022). It was noted that the research lacked details regarding the reliability and validity of the instruments used to collect the data. Akdemir and Kılıç (2021), who analysed 187 articles prepared with a qualitative approach, similarly determined that there were no findings on validity and reliability in some of the articles they examined. The ability of researchers to prove the validity and dependability of their findings is one factor that determines the worth of a scientific study (Arslan, 2022, p. 396). Because of this, researchers will improve the quality of their work if they describe how they guarantee validity and reliability in their studies, whether they are quantitative or qualitative. In addition, incomplete information in the method section of the studies poses a threat to validity and reliability. In order to avoid inadequate methods and lack of information, it is extremely important for graduate students to carry out data collection, data analysis and research report writing processes by researching a certain problem in the "scientific research methods and ethics" course. In order to increase the quality of research, faculty members should manage the process well by guiding graduate students.

Examining the data analysis techniques revealed that while most research used multiple analysis techniques, descriptive analysis was the most often employed. This may be due to the fact that qualitative research methods are mostly used in the studies on cognitive structures. It was found that the majority of quantitative research was analysed using descriptive and predictive analysis, whilst

qualitative studies were analysed using descriptive and content analysis.

In general, it was determined that the results of articles, theses and proceedings were similar to each other. The participants' cognitive structures were found to be weak once the study's results were analysed. In addition, it was found that alternative teaching methods positively affected the cognitive structures of the participants. In the light of these results, it is recommended that researchers conduct further research to develop teaching strategies that enable students to have a stronger cognitive structure.

Conclusion and Recommendations

This study identified the trends of cognitive structure research published in the science education field in Turkey. A descriptive analysis of 156 studies published between 2003 and 2023 was carried out using document analysis method. This study determined that the number of studies on cognitive structure in science education increased between 2016 and 2023 in Turkey and that most studies were conducted in 2018 and 2020. The majority of these studies are in the article type and the number of doctoral theses was found to be less. It was determined that researchers in Turkey prefer international journals more; the most published international journal was Educational Research of Reviews, and in Turkey, Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education. Within the scope of the analysed studies, it was determined that cognitive structure research was mostly conducted in the field of biology. It was observed that most of the studies focused on determining the cognitive structures of the participants about a subject. It was determined that the most commonly used method in the analysed studies was case study and WAT was used as a data collection tool. In the light of the findings obtained, it was revealed that secondary school students were mostly selected as the sample in the theses and undergraduate students (teacher candidates) were selected as the sample in the articles. In addition, it was determined that descriptive analysis method was used in most studies on cognitive structure. According to the results of the analysed studies, it was determined that the cognitive structure of the participants was weak and alternative teaching methods positively affected the cognitive structure. In the cognitive structure studies, it was seen that most of the suggestions for future research were made in the form of "cognitive structure studies can be repeated using different methods and different sample groups".

Educators can have information about students' prior knowledge and metacognition when they investigate their cognitive structures (Tsai & Huang, 2002). The studies

reviewed show that students can develop a meaningful and accurate cognitive structure related to the subject in inquiry-based, research-based, and collaborative learning environments. Therefore, to support and develop students' cognitive structures, it is crucial to organize and develop learning environments, curricula, instructional materials and activities, and textbook contents (Yıldırım & Kızmaz, 2024). Learning will be more successful if the weaknesses in students' subject-related cognitive structures are recognized, and a teaching strategy is implemented accordingly.

In this study, the trends of cognitive structure studies published in the field of science education in Turkey were identified. However, cognitive structure studies are not limited to Turkey. A descriptive content analysis of the studies investigating the cognitive structures of participants in Physics, Chemistry, Biology and Science subjects in the international arena will provide a broader perspective on cognitive structure studies. Thus, in the future, comparative analyses can be carried out by focusing on studies conducted in different countries. Examining similar studies conducted at the international level will contribute to a better understanding of the general approaches in education by revealing the global trends of cognitive structure studies.

Ethics Committee Approval: Ethics committee permission was not obtained as it was a review study.

Informed Consent: Informed consent was not obtained as this was a review study.

Peer Review: Externally peer-reviewed.

Author Contributions: Concept-H.E.Y.; Design-H.E.Y., N.K.; Supervision-H.E.Y.; Sources-H.E.Y., N.K.; Data Collection and/or Processing-H.E.Y.-N.K.; Analysis and/or Interpretation-H.E.Y., N.K.; Literature Review-N.K.; Manuscript Writing-H.E.Y.,N.K.; Critical Review-H.E.Y.-N.K.

Conflict of Interest: The authors have no conflict of interest to declare.

Financial Support: The authors declared that this study has received no financial support.

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