Content Analysis of Graduate Theses Made in The Field of Education of The Concept of Atom in Turkey

Ali Kaya, Dr. Lecturer, Gümüşhane University, Faculty of Engineering and Natural Sciences, Department of Physical Engineering, Türkiye,

akaya290@gmail.com

Orcid: 0000-0003-2326-0705

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Ali Kaya

Abstract

This study aims to conduct a content analysis of the postgraduate theses on the education of the concept of atom in Turkey from 2000 to 2023. The document review method used within the qualitative research design was preferred. The theses were obtained by conducting a search in the "Thesis Center" of the Council of Higher Education (YÖK). "Thesis Classification Form" and "Thesis Screening Form" were used as data collection tools. Content analysis was performed on 51 theses that were conducted between 2000 and 2023 and whose full versions were accessed. It was observed that the theses were conducted in 25 different universities, using more than one data collection tool and analysis method. It has been determined that most of the theses were advised by professor-academicians. It was determined that almost all of the theses were conducted in the form of research-studies, qualitative research approach was mostly used as the research method, the quasi-experimental model was mostly used as the research model, and students were generally used as the sample group. The most widely used data collection tools were interviews and achievement tests, while t-tests and content analysis were used as analysis techniques. In selecting thesis topics, the studies in which teaching methods were tried the most were conducted. Students commonly faced challenges in understanding the atom concept, with prevalent misconceptions identified.
Keywords: Turkey, Atom, Graduate Theses, Content Analysis

134

Türkiye'de Atom Kavramının Eğitimi Alanında Yapılmış Lisansüstü Tezlerin İçerik Analizi
Öz

Bu araştırmanın amacı, 2000-2023 yılları arasında Türkiye'de atom kavramının eğitimi alanında yapılmış olan lisansüstü tezlerin içerik analizini yapmaktır. Araştırmada, nitel araştırma deseni içerisinde kullanılan doküman incelemesi yöntemi tercih edilmiştir. Tezlere, Yükseköğretim Kurulu'nun (YÖK) "Tez Merkezi" taranarak ulaşılmıştır. Veri toplama aracı olarak "Tez Sınıflama Formu" ve "Tez Tarama Formu" kullanılmıştır. 2000-2023 yılları arasında yapılan ve tam sürümüne ulaşılan 51 teze içerik analizi gerçekleştirilmiştir. Tezler 25 farklı üniversitede, birden

fazla veri toplama aracı ve analiz yöntemi kullanılarak yürütüldüğü gözlenmiştir. Tezlerde en fazla Prof. Dr. öğretim üyesi akademisyenlerin danışmanlık yaptığı belirlenmiştir. Tezlerin tamamına yakının araştırma-inceleme şeklinde yürütüldüğü, araştırma yöntemi olarak en fazla nitel araştırma yaklaşımının ve araştırma modeli olarak en çok yarı deneysel modelin kullanıldığı, genellikle öğrencilerin örneklem grubu olarak kullanıldığı tespit edilmiştir. Tezlerde en çok kullanılan veri toplama araçları mülakat ve başarı testleri iken, analiz tekniği olarak da t-testi ve içerik analizin kullanılmıştır. Tez konusu seçiminde en fazla öğretim yöntemlerinin denendiği çalışmalar yapılmıştır. Öğrencilerin atom kavramını anlamada zorluk çektiği ve yanlış anlamalara sahip olduğu belirlendi.

Anahtar Kelimeler: Türkiye, Atom, Lisansüstü Tezler, Eğitim-Öğretim, İçerik Analizi
JEL Classification: J24

1. Introduction

Due to their creation, humans have always been interested in the events around them. This curiosity extended to understanding the structure of matter. The first views on the structure of matter date back to the 5th century BC. The Greek philosopher Democritus proposed that all matter was composed of very small, indivisible particles called atoms. Although this view of Democritus gave a basic idea about the structure of matter, it did not fully explain the situation. No contribution was made to this view for many years. Due to its small size, the structure of the atom has posed challenges in terms of explanation. In the late 19th century, Scientific facts about the structure of the atom emerged. The discovery of the electron by Thomson (1897) led to the establishment of the elementary particle field. The identification of the initial subatomic particle fundamentally altered our understanding of the physical realm, and subsequent advancements in the domain of particle physics have consistently enhanced atomic models. The best known of these are the Dalton (1805), Thomson (1904), Rutherford (1912) and Bohr (1913) atomic models. Currently, it is not wrong to say that atomic theory is one of the key concepts of our current scientific knowledge. The particulate structure of matter is considered a basic topic in the field of science, particularly in scientific education (Park & Light, 2009). Nevertheless, teaching the concept of the atom, envisioned by Richard Feynman as "a bit of imagination and thinking", posed a great challenge for teachers and students. This has been confirmed by researchers (Adbo & Taber, 2009; Griffiths & Preston, 1992; Harrison & Treagust, 1996; Samarapungavan et al., 2017) Furthermore, it should be highlighted that students' conceptions of particle models exhibit significant variations in terms of coherence levels (Wiser & Smith, 2008). In light of this reality,

135

researchers have undertaken numerous studies to ascertain and address the challenges associated with teaching the idea of the atom (Feher and Meyer 1992; Harrison and Treagust 1996; Ünlü, 2000; Taylan-Yıldız, 2006; Ünal, 2007; Adbo and Taber, 2009; Tağ, 2012; Netzell, 2014; Polat, 2014; Kiray, 2016; Erdamar, 2017; Kaya, 2018; Kardeş, 2018; Özkan, 2019; Alkan, 2022; Savaşan, 2023; Kaya, 2010; Kaya, 2018; Kaya, 2023; Suanda & Wahyudiati, 2023). These studies reveal that students do not fully understand the concept of atom, are confused about atomic models, and have many misconceptions. Additionally, studies have generally examined how successful different teaching methods are in teaching this concept to students.

Similar to the structure of an atom, the collective analysis of research undertaken in an area enhances the evaluation of the subject. The term used to refer to thes research is content analysis. Such studies aim to consolidate the research undertaken in the pertinent subject, elucidate their distinctive features, or facilitate comparisons. It is crucial to examine and organize the research conducted in the field of education at certain intervals and to determine in which direction they show a trend to provide information to scientists who want to conduct research in related fields (Cohen, Manion, & Morrison, 2007). Scientists intending to conduct research in related fields can follow the trends identified in these studies and determine and advance their studies accordingly. As in this study, detailed evaluation studies on topics such as the topics covered by the researchers in the studies conducted in the field and what kind of methods they use will contribute to the development of the literature. In accordance with Bağcı's (2012) research, this approach involves a thorough examination of studies completed from the past to the present, allowing for the identification of flaws in the area. Such studies have also been conducted in the field of science education (Evrekli et al., 2011; Ilıcan and Gökçen, 2019; Polat, 2013; Sönmez and Hastürk, 2020). The study carried out by Ilıcan and Gökçen (2019) revealed that a greater number of thesis studies focused on "Scientific Process Skills" with younger participants. In Sönmez and Hastürk's (2020) study, it was determined that mixed methods were mostly used as the research method in theses, and the research group consisted mostly of pre-service science teachers (Sönmez and Hastürk, 2020). Research indicates that the number of doctoral dissertations in the field of science education that focus on the nature of science as their research topic is greater than those focusing on other themes (Sönmez ve Hastürk, 2020). It is observed that such studies are

136

not carried out on a conceptual basis and regarding the concept of atom in the research conducted in the field of science education.

The concept of the atom is essential in terms of science teaching. The fundamental notion of an atom serves as the foundation for comprehending several subjects in chemistry, including chemical bonds and molecular structure. Additionally, it plays a crucial role in understanding key components of living organisms in biology, as well as phenomena like electricity, magnetism, and metallic conductivity in physics (Aygen, 2019). Hence, an extensive understanding of the atom concept by students starting from primary school will enhance their grasp of the aforementioned subjects about to the domains of physics, chemistry, and biology. This will have a beneficial impact on their future academic pursuits and enhance their enthusiasm for the field of science. A review of the literature reveals that there is no study examining the postgraduate theses on the concept of the atom.

This study aimed to conduct a content analysis of the postgraduate theses on the education of the concept of atoms in the field of education from 2000 to 2023 in Turkey. For this purpose, answers to the following questions were sought:

Graduate theses on the concept of atom in Turkey:

a. How is their distribution according to years?
b. What are the academic titles of thesis coordinators?
c. How is the distribution according to universities?
d. Which research types were used?
e. Which research methods were used?
f. Which data collection tools were used?
g. Which data analysis methods were used?
h. How is the sample determined, and who or what are the samples?
i. What are the topic selection and the results obtained?

2. Method

In accordance with the purpose of the study, the document analysis method, one of the qualitative research methods, was used. Document analysis is a research method used to make valid and reliable inferences from texts (Krippendorff, 2004).

Documents are important sources of information used effectively in qualitative research. Through the utilization of the document analysis method, researchers can acquire the necessary data without the necessity for

direct observation or interviews (Cardno, 2018; Sallabaş & Polat, 2022). This study utilized postgraduate theses as the primary source of research material.

Sample

The sample of this study consists of postgraduate theses on the concept of atoms published in Turkey between 2000-2023 and whose full versions can be accessed. In the YÖK thesis database, 60 theses were reached by selecting the years "Atom,", "Education and Training," and "2000-2023.". 9 of these were not included in the evaluation because their full texts could not be accessed. 7 of the evaluated theses were doctoral and 44 were master's theses. The determined theses were saved to the computer environment in 'pdf' format from the website of the YÖK Presidency Thesis Center.

3. Data Collection Tools

In this study, basic data on the theses studied in Turkey were collected with the "Thesis Classification Form". While preparing the thesis classification form, the screening forms used in some studies were taken into consideration (Sözbilir & Kutu, 2008; Bahar & Kiras, 2017; Kiras & Bahar, 2021). By using the thesis classification form, the type, year, university, and advisor title of the theses were categorized. These categories consisted of thesis year, thesis type (master's or doctoral), university where the thesis was conducted, author, advisor, and second advisor (if any). The subject and methodological data of the theses were obtained with the "Thesis Screening Form" as the coding list in this study. With the thesis screening form, descriptive features of the theses were categorized and classified. These categories are thesis topic, sample, research method, research model, data collection tools, and data analysis methods. Due to the fact that there may be more than one thesis topic, sample, research method and model, data collection tools, and data analysis methods in theses, the frequency of data belonging to these categories may be higher than the number of theses. Data such as the type of thesis (master's or doctoral), date of publication (year), thesis topic, author of the thesis, thesis advisor, and in which university the thesis was published were determined by examining the cover pages of the thesis. The thesis topic was first determined by looking at the title. In cases where it was not specified in the title, the thesis topic was determined by looking at the content of the thesis. In order to determine the methodological features of the theses, the abstracts of the theses were examined first. If the author provided the necessary information in the abstract, the data in the

abstract were used. However, in cases where the necessary information was not provided in the abstract, data were collected by examining the method section in the content of the thesis. The data obtained through the Thesis Classification Form and Thesis Screening Form were transferred to the findings in tables and text and analyzed, and the results were obtained.

4. Data Analysis

The data obtained from the theses were analyzed based on the content analysis method. Content analysis is a research technique that consists of organizing, classifying, comparing, and drawing theoretical conclusions from texts (Cohen, Manion, & Morrison, 2007). The data were organized according to concepts, and themes explaining the data were determined accordingly. The collected data were subjected to content analysis based on document analysis, and the meaningful parts of the data were named. The concepts obtained were classified with each other under a specific theme. These theses were grouped according to the date of their publication, the academic titles of their executives, the universities where they were conducted, the subject, the results, the research design, the data collection tool, the analysis method, the sample group and the number.

Validity and Reliability

The processes of accessing, evaluating and analyzing data were meticulously completed to ensure research validity and reliability. Code and theme checks were repeated, particularly during the analysis phase, to guarantee consistency. Upon completion of the data analysis, the names of the theses were imported into the Microsoft Excel program, and 10 theses were selected, with a random 20% number, and submitted to a second review, and the correspondence with the first data was examined. In order to achieve this purpose, the whole texts of the chosen theses were provided to an education specialist. Following a detailed explanation of the unit of analysis and the goal of the study to the researcher, the theses were requested to be recoded. The formula utilized for comparison between the derived data and the original data was [Agreement / (Agreement + Disagreement) x 100] (Hubberman & Miles 2002; Başkan Takaoğlu, 2023). The level of agreement for the outcomes in this calculation was assessed to be 87%. Given that a result of 70% or more is considered to indicate complete agreement, it was determined that the data were credible. As the study was not conducted on humans, it does not require ethics committee permission.

5. Findings

139

The results obtained in the study were analyzed based on the research questions and are presented below. Distribution of postgraduate theses on the concept of the atom according to years:

The distribution of postgraduate theses on the concept of the atom according to years is given in Table 1.

Table 1. Distribution of Theses on the Concept of Atom in Turkey by Years

Years	Masters (f)	Doctorate (f)	Total	%
2000	1		1	2
2001	1		1	2
2002	2		2	4
2003	3		3	6
2004	2		2	4
2005	3		3	6
2006	1		1	2
2007	1	1	2	4
2009	2		2	4
2010	1	1	2	4
2011	3	2	5	10
2012	1		1	2
2013	2	1	3	6
2014	1		1	2
2015	4		4	8
2017	3		3	6
2018	2	1	3	6
2019	7		7	14
2022	2	1	3	6
2023	2		2	4
Total	**44**	**7**	**51**	**100**

140

As seen in Table 1, it is seen that between the years 2000-2023, except for four

years, between two and fourteen theses were conducted. The highest number of theses on the concept of the atom was 14 in 2019.

Findings related to the academic titles of the executors of graduate theses on the concept of the atom:

The titles of the faculty members involved in the execution of the theses on the concept of the atom are given in Table 2.

Table 2. Titles of thesis coordinators

Thesis type	Prof. Dr. (f)	Assoc. Prof. Dr. (f)	Assistant Proffesor (f)
PhD	4	3	-
Master's Degree	17	14	13
Total	21	17	13

It is seen that the faculty members who have theses are Professor Dr. and Associate Professor Dr. in doctoral theses and Professor Dr., Associate Professor and Assistant Professor Dr. in master's theses. It is seen that the faculty members who have the most thesis studies are professors.

Distribution of postgraduate theses on the concept of the atom according to universities:

141

Distribution of postgraduate theses on the concept of the atom according to universities Table 3.

Table 3. Universities with the highest number of theses on the concept of the atom

University	Master's Degree (f)	Doctorate (f)	Total
Gazi	10	1	11
Dokuz Eylül	4	-	4
Aksaray	3	-	3
Atatürk	1	2	3
Marmara	2	1	3
ODTÜ	3	-	3
Karadeniz Teknik	2	1	3

Muğla Sıtkı Koçman	2	-	2
Ağrı İbrahim Çeçen	1	-	1
Balıkesir	1	-	1
Celal Bayar	1	-	1
Erciyes	-	1	1
Fırat	1	-	1
Hacettepe	1	-	1
İnönü	1	-	1
İstanbul	1	-	1
Kastamonu	-	1	1
Kilis 7 Aralık	1	-	1
Necmettin Erbakan	3	-	3
On Dokuz Mayıs	1	-	1
Recep Tayyip Erdoğan	1	-	1
Trabzon	1	-	1
Selçuk	1	-	1
Van Yüzüncü Yıl	1	-	1
Yıldız Teknik	1	-	1
Total	**44**	**7**	**51**

142

Table 3 displays the results of postgraduate theses completed on the idea of the atom in 25 different universities. Gazi University has the most number of theses, with a total of 11.

Results on the type of research conducted in the postgraduate theses on the concept of the atom:

48 (94%) of the analyzed theses were in the research-study type, while only 3 (6%) were in the theoretical (review) type.

Results on which research methods were used in postgraduate theses on the concept of the atom:

An analysis of the studies shows that 5 (10%) were quantitative, 19 (37%) were mixed and 27 (53%) were qualitative.

Examining the studies in terms of model, it was seen that 9 (18%) were

surveys, 14 (27%) were case studies, and 28 (55%) were quasi-experimental.

Data analysis technique	f	%
t-test + Anova	4	7.84
Content analysis + Simple percentage calculation	4	7.84
Content + Descriptive analysis	4	7.84
t-test + variance analysis	3	5.88
t-test + mancova	3	5.88
Anova	3	5.88
t-test + content and descriptive analysis	2	3.92
Simple percentage calculation (percentage, mean, Standard deviation)	2	3.92
Percentage calculation	2	3.92
t-test	2	3.92
Anova+ Post-Hoc	1	1.96
Anova + Content analysis	1	1.96
Manova	1	1.96
Ancova	1	1.96
t-test + content analysis	1	1.96
t-test + Descriptive analysis	1	1.96
t-test + Wilcoxon signed rank test	1	1.96
Statistics + comparison tests + Variance analysis	1	1.96
Inductive analysis + Qualitative data analysis	1	1.96
Mann-Whitney Test analysis + Quantitative analysis	1	1.96
Analogy and Historical + Classical and Semi-classical Model	1	1.96
Chi-square test + Qualitative and Quantitative data analysis	1	1.96
Not specified	10	19.6

Results regarding the data collection tools used in the postgraduate theses on the concept of the atom:

It was seen that more than one data collection tool was used in the theses. These are: interview and achievement test 21 (41%); questionnaire and achievement test 11 (22%); questionnaire, interview form, observation and open-ended question 10 (20%); attitude questionnaire, interview, concept

map, and evaluation form 6 (12%) and documents were used in three of them.

Results of the data analysis methods used in the postgraduate theses on the concept of the atom:

More than one analysis technique was used in the analyzed theses. These are given in Table 4 below together with their corresponding numbers.

Table 4. Data analysis techniques used in theses

As can be seen in Table 4, more than one data analysis technique was used in most of the theses.

Sample group in postgraduate theses on the concept of the atom:

Upon examining the sample methodology employed in the research, it is evident that 49 (96%) of them utilized random selection, whereas 3 (4%) studies relied on document-based sampling.

In most of the examined theses, the sample consisted of students, 39 (76%). In the others, 6 (12%) were prospective teachers, 2 (4%) were student-teachers, and in one, 2 (2%) were teachers. Two studies utilized books, whereas one study relied on academic publications.
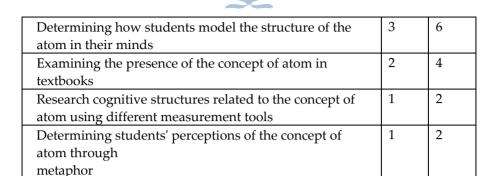
144

Discoveries pertaining to the topic of postgraduate theses on the concept of atom:

The thesis themes are presented in Table 5, together with their corresponding frequency and percentage values.

Table 5. Frequency and percentage values of thesis subjects

Thesis topic	f	%
Studies testing teaching approaches, methods, models, strategies, and techniques	29	57
Determining students' level of understanding of the concept of atom	7	13
Determining misconceptions	4	8
Model development studies	4	8

Determining how students model the structure of the atom in their minds	3	6
Examining the presence of the concept of atom in textbooks	2	4
Research cognitive structures related to the concept of atom using different measurement tools	1	2
Determining students' perceptions of the concept of atom through metaphor	1	2

The thesis subjects are categorized into eight titles. It is clear that the teaching approaches, methods, models, strategies, and techniques that are thought to be successful for teaching the concept of atom were studied the most.

Conclusions derived from the examination of the thesis results:

In most of the theses, it was concluded that different teaching approaches, methods, strategies, and techniques compared with the traditional method were more successful in teaching the concept of the atom (Ünlü, 2000; Tağ, 2012; Salmaz, 2002; Zavrak, 2003; Oğuz, 2003; Aydın-Altuntaş, 2011; Akıllı, 2011; Golgır, 2011; Ergün, 2013; Meydan, 2015; Ayık, 2017; Üçer, 2019; Güngördü, 2018; Mert, 2019; Kılıçoğlu, 2019; Topçuoğlu, 2022; Çolak, 2022; Gümüş, 2023). The methods used in the theses include conceptual change texts, active learning, interactive teaching, the team game tournament technique, three-dimensional computer-aided instructional materials, model and conceptual change texts, 3D computer models, cooperative learning, sequential activities based on observation and experiment, computer-aided three-dimensional visuals, interactive education, and animations. One of such studies, Elmacı (2013) investigated the contribution of preservice science teachers' learning styles to their conceptual understanding of atoms and bonds and found that it was not successful. In some of the theses, it is stated that primary, secondary, and university students do not sufficiently acquire the objectives and behaviors specified in the curricula in the fields of atomic structure, atomic models, shape of the atom, mental models related to the structure of the atom, and mental models related to the energy levels

145

of the atom (Hanoğlu, 2004; Taylan-Yıldız, 2006; Aygen, 2019; Özkan, 2019). The textbooks offer numerous atomic models and simulation models, but, they do not include the Modern Atomic Theory which is the valid and latest atomic model, and appropriate figures related to it are not included (9Taylan-Yıldız, 2006). It is also stated that the atomic theories presented in chemistry textbooks do not adequately reflect the desired historical and philosophical dimensions (Kılıç, 2010). Kardeş (2018) argued in his thesis that the representation of the atom notion in textbooks is insufficient. Savaşan (2023) stated that some textbooks do not sufficiently examine the subject of atomic models in terms of history and philosophy of science, and in this context, there are inaccurate presentations in the textbooks. It is seen that more deficiencies are identified in the research conducted on book reviews.

Primary, secondary, and university students were selected as the sample, and it was stated that they had misconceptions about the concept of atom (Gündüz, 2001; Kılıcı, 2019).

6. Results and Discussion

The results obtained depending on the research problem are given below. Except for the four years between 2000 and 2023, the number of theses ranging from one to nine was determined. The maximum number of theses was 9 in 2019 (Table 1). It was determined that a large number of theses were conducted on the concept of the atom in the field of education in Turkey. This situation is important in terms of showing that the concept of the atom has a complex structure and there are problems in its teaching.

It was determined that the academicians involved in the conduct of the theses related to the concept of the atom had the titles of Professor, and Associate Professor in doctoral theses and were conducted by Professor, Associate Professor and Doctor faculty members in master's theses. The number of theses conducted by faculty members decreases from higher to lower titles. This situation shows that in Turkey, experts with higher qualifications in their fields are mostly involved in conducting thesis studies in this field.

The studies were conducted in 25 distinct universities. The highest number

146

of theses produced by universities are Gazi (11), Dokuz Eylül (4), Aksaray (3), Atatürk (3), Marmara (3), METU (3), and Karadeniz Technical (3) universities, respectively (Table 3). These universities are institutions that have completed their faculty and physical development and have been in operation for many years. Possible factors contributing to the preference of graduate students for well-established universities over others include the presence of highly qualified academic staff, the university's long-standing history and positive reputation, and the perception of receiving a superior education.

Nearly all of the theses on the concept of atom are in the form of research examination (95%). The majority of these researches are conducted in the field with the purpose of enhancing the instruction of the atom concept. The difficulty in comprehending the concept of atoms among students has prompted numerous research studies aimed at identifying innovative teaching approaches. Our review reveals that the majority of research focuses on identifying more efficient approaches to teaching the idea of the atom (Table 5). It has been determined by many researchers in Turkey and other countries that the concept of the atom is not well understood by students and that they have misconceptions in this field (Anderson & Karrquist 1983; Feher & Meyer 1992; Harrison & Treagust 1996; Ünlü, 2000; Taylan-Yıldız, 2006; Ünal, 2007; Adbo & Taber, 2009; Kaya, 2010; Tağ, 2012; Netzell, 2014; Polat, 2014; Erdamar, 2017; Kaya, 2018; Kardeş, 2018; Özkan, 2019; Alkan, 2022; Savaşan, 2023). This situation may cause more field studies to be conducted in research on the subject. It is seen that there are very few studies examining the curriculum and documents that constitute the first step of education.

A qualitative approach and a quasi-experimental method were determined to be used in more than half of the theses on the teaching of the concept of the atom. This may be due to the fact that two different teaching methods are compared in most of the theses. Determining the most effective and applicable teaching method that can be used in teaching this concept in the education system is important. However, it is important that this method is applicable in the whole education system. This is because uneconomical

147

applications that require very special and technological equipment may cause problems in terms of cost and applicability.

The data collection tools used in the theses were interview and achievement test 21 (41%); questionnaire and achievement test 11 (22%); questionnaire, interview form, observation, and open-ended question 10 (20%); attitude questionnaire, interview, concept map, and evaluation form 6 (12%) and document 3 (5%). It was determined that more than one data collection tool was used in the theses. It is also recommended by researchers to use qualitative data collection techniques such as unstructured observation, unstructured interview, and document analysis in data collection in studies using such a qualitative approach and to follow a qualitative process by presenting the facts and events in their natural environment in a realistic and holistic way (Baltacı, 2019). Erdoğmuş and Çağıltay (2009) and Dilek et al., (2018) reported that similar data collection tools were used in theses. In their study on the content analysis of articles published in the field of physics education, Kaltakçı-Gürel et al., (2017) stated that the achievement test was mostly used as a data collection tool. This study also states that most of the studies conducted in Turkey in the field of physics education are studies aimed at finding more successful methods in teaching the selected subjects. Similar results were obtained in our study. We can conclude from this situation that students have difficulty in understanding physics topics.

It was determined that content analysis, t-test, analysis of variance, ANOVA, MANOVA, percentage, descriptive analysis, mean, and standard deviation values were mostly used in the analysis of thesis data. Upon analyzing the thesis subjects, it was seen that researchers predominantly utilized the t-test to assess shortcomings in concept teaching and to compare the effectiveness of two distinct techniques employed for their resolution. Furthermore, it was ascertained that the interview approach was employed as a means of gathering data to directly assess the students' expertise in the field and elicit their perspectives on the subject matter. As the data obtained from the interviews were qualitative, they were evaluated by content and descriptive analysis methods.

It has been determined that students are mostly used as samples in theses

related to the concept of atoms. The reason for this phenomenon may stem from the belief that the challenges encountered in teaching this idea and potential solutions can be addressed through research undertaken in a different discipline.

The theses mostly utilized studies that examined the impact of teaching theories, models, approaches, methods, and strategies on academic performance while selecting subjects. Other thesis topics focused on assessing the students' comprehension of the notion of atoms, including their structure, models, and the visual aids utilized to teach this subject. Similar topics have been investigated by many researchers in countries other than Turkey (**Anderson & Karrquist 1983; Harrison & Treagust 1996; Adbo & Taber, 2009; Aguiar & Correia, 2016; Delvia et al., 2021; Nkadimeng & Ankiewicz, 2022; Sa'diyah & Lutfi, 2023; Susanti et al., 2023; Yauna et al., 2023**). This may be because the atom is abstract, smaller than microscopic size, and it takes a very long time to determine its structure, and in this process, many theories (models) have emerged by scientists. From this, it can be concluded that there are problems in teaching the concept of the atom in general and it is difficult for students to comprehend this subject. Recently, it has been determined that augmented reality applications have started to be used in teaching the concept of the atom and positive results have been obtained (Güngördü, 2018). When deciding on thesis subjects, it is evident that the examination and incorporation of the atom concept in curricula and textbooks have not been thoroughly investigated. Nevertheless, the initial and most important stage of teaching is the process of planning. Mistakes made in this context can lead to significant complications in practical application. In his research on the subject, Kaya (2023) argued that the deficiencies in the inclusion of the concept of atom in the primary education curriculum make it difficult to comprehend the subject and cause misunderstandings. Şenkal & Dinçer (2016), in their research on the tendency of the studies on physics education in Turkey, determined that most of the research was conducted on learning approaches as in our study. It is acknowledged that these researchers are unable to offer efficient and enduring answers to the field. Engaging in further research in domains such

149

as curricula, textbooks, and laboratory applications can have a beneficial impact on physics education. In addition, it should not be forgotten that using innovative and effective current techniques such as virtual reality, augmented reality, and artificial intelligence in physics teaching will be effective in teaching the course.

The theses revealed that numerous methods, strategies, and models were explored in relation to the instruction of the atom concept. However, the impact level of this success is relative, and as a result, their usability within the education system in order to be used in teaching is a matter of discussion. It is important to remember that there are issues regarding the availability of essential tools and technological equipment in schools, as well as the competence of teachers to effectively implement these approaches. It would not be wrong to say that the majority of teaching approaches (such as popular scientific articles, sequential activities based on observation and experimentation, 3D computer models, etc.) chosen as alternatives in the thesis investigations are not appropriate for widespread application. It is suggested that the long-term spiral approach is the most appropriate model for teaching about the particle nature of matter (Margel et al., 2008). From this point of view, we can state that the studies to determine the method to be used in teaching the concept of the atom are ongoing.

150

In the results obtained in the theses, it was determined that primary, secondary and university students obtained incomplete acquisitions related to the concept and structure of the atom. In Özkan's (2019) study, an analysis was conducted on the drawings and explanations provided by pre-service science teachers about the notions of "atom" and "structure of atom." This study found that only a small number of pre-service teachers provided scientifically accurate responses for both concepts (Özkan,2019). There are many studies with similar results (Anderson & Karrquist 1983; Feher & Meyer 1992; Harrison & Treagust 1996; Ünlü, 2000; Taylan-Yıldız, 2006; Ünal, 2007; Adbo & Taber, 2009; Kaya, 2010; Delvia et al., 2021; Nkadimeng & Ankiewicz, 2022; Sa'diyah & Lutfi, 2023; Susanti et al, 2023; Yauna et al, 2023). To solve this problem, education planners can be helped by conducting extensive thesis studies, starting with planning in the education

system for teaching the concept of atoms, textbooks, teaching methods and techniques, and how teachers will make presentations.

It has been determined that there are some deficiencies and errors related to the presentation of the concept of atom in textbooks (Taylan-Yıldız, 2006; Kılıç, 2010; Kardeş, 2018; Savaşan, 2023). Again, according to the results of the thesis, it was determined that students have misconceptions about the concept of atom (Gündüz, 2001; Kılıcı, 2019). One of the main sources for teaching a concept is the textbooks published in that field. Maximum attention should be paid to the preparation of books. Conducting such research can make positive contributions to the teaching of the concept of the atom.

It has been observed in the theses that the curriculum and course materials have not been sufficiently researched. Determining the positive and negative aspects of the curriculum and materials in the understanding of the subject in the theses can make significant contributions to solving the problems related to teaching the concept of the atom. The suitability of the curriculum and materials for the student age groups, their presentation, and whether the teaching materials are prepared appropriately in education should be discussed. In his research in this field, Kaya (2023) states that including atomic models in the primary school curriculum makes teaching the concept of atoms difficult and causes misconceptions. More research should be done on the curriculum and textbooks, which are the products of planning, which is the first step of education.

This study is expected to serve as a reference for researchers doing future graduate studies and for anyone involved in the instruction of the atom concept.

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152

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158