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Article

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

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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 study utilized the document analysis method, a qualitative research design approach. 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 was determined that most of the theses were supervised by academicians having the title of Prof.Dr. 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, 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 in the theses were interviews and achievement tests, while t-tests and content analysis were used as analysis techniques. In the selection of thesis topics, the studies in which teaching methods were tried the most were conducted. It was determined that students had difficulty in understanding the concept of atom and had misconceptions.

Keywords: atom; graduate theses; education and training; content analysis; Türkiye

1. Introduction

Due to their creation, humans have always been interested in the events around them. This curiosity arose also about 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 knowledge on the atomic structure began to surface. Thomson's discovery of the electron in 1897 paved the way for the development of the study of fundamental particles. 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, atomic theory is widely regarded as a key notion in our scientific understanding. The particulate structure of matter is considered a fundamental topic in the field of science, particularly in scientific education [1]. Nevertheless, teaching the concept of 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 [2–5]. Furthermore, it should be highlighted that students' conceptions of particle models exhibit significant variations in terms of coherence levels [6]. In light of this reality, researchers have undertaken numerous studies to ascertain and address the challenges associated with teaching the idea of atom [2,4,7–21]. These studies reveal that students do not fully understand the concept of atom, confuse atomic models, and have many misconceptions. In these studies, it is clear that different teaching methods are mostly applied in order to achieve success in teaching this concept to students. Kaya

(2023) investigated the challenges encountered in teaching this topic by considering the perspectives of instructors and faculty members.

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 these researches is content analysis. Such studies aim to consolidate the research undertaken in the pertinent subject, elucidate their distinctive features, or facilitate comparisons. When the literature is examined, it is seen that content analysis studies have been conducted in many fields [22–29].

It is very important to examine and organize the researches conducted in the field of education at certain intervals and to determine in which direction they show a trend in order to provide information to scientists who want to conduct research in related fields [30]. Scientists intending to conduct research in related fields can follow the trends identified in these studies and determine and advance their own 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 [31].

Such studies have also been conducted in the field of science education [32–35]. The study carried out by Ilican and Gökçen (2019) revealed that a greater number of thesis studies focused on "Scientific Process Skills" with younger participants [33]. 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 [35]. 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 [35]. It is obvious that such studies have not been carried out on a concept basis. The concept of atom is very important 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 [36]. Hence, an extensive understanding of the atom concept by students starting from primary school will enhance their grasp of the aforementioned subjects pertaining 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. Several scholars have asserted that imparting the understanding of the atom is challenging [15,37,38]. A review of the literature reveals that there is no study examining the postgraduate theses on the concept of atom.

This study aimed to conduct a content analysis of the postgraduate theses on the education of the concept of atom 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. Research Methodology

2.1. Research Design

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 [31,39,40]. This study utilized postgraduate theses as the primary source of research material.

2.2. Sample

The sample of this study consists of postgraduate theses on the concept of atom, which were published in Turkey from 2000 to 2023 and whose full versions can be accessed. The theses that were recognized were downloaded in 'pdf' format from the website of YÖK Presidency Thesis Center. Due to the unavailability of the complete text for 9 of them, they were excluded from the assessment. Out of the theses assessed, 7 were classified as doctoral theses, while 44 were categorized as master's theses. The specified theses were saved to the computer in 'pdf' format from the website of YÖK Presidency Thesis Center.

2.3. 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 [31,41–43]. 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.

2.4. 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 [44]. It was then organized according to the emerging concepts, and themes explaining the data were identified 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, subject, results, research design, data collection tool, analysis method, sample group and number.

2.5. 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 to the Microsoft Excel program and selected 10 theses, 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 $[\text{Agreement} / (\text{Agreement} + \text{Disagreement}) \times 100]$ [44,45]. 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.

3. Findings

The results obtained in the study were analyzed based on the research questions and are presented below.

3.1. Distribution of Postgraduate Theses on the Concept of Atom According to Years

The distribution of postgraduate theses on the concept of 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	Doctorate	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

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 atom was 14 in 2019.

3.2. Findings Related to the Academic Titles of the Executors of Graduate Theses on the Concept of Atom

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

Table 2. Titles of thesis coordinators.

Thesis type	Prof. Dr.	Assoc. Prof. Dr.	Lecturer
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.

3.3. Distribution of Postgraduate Theses on the Concept of Atom According to Universities

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

Table 3. Universities where the theses were prepared.

University	Master's Degree	Doctorate	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

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

3.4. Results on the Type of Research Conducted in the Postgraduate Theses on the Concept of Atom

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

3.5. Results on Which Research Methods Were Used in Postgraduate Theses on the Concept of 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 survey, 14 (27%) were case studies, and 28 (55%) were quasi-experimental.

3.6. Results Regarding the Data Collection Tools Used in the Postgraduate Theses on the Concept of 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.

3.7. Results of the Data Analysis Methods Used in the Postgraduate Theses on the Concept of Atom

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

Table 4. Data analysis techniques used in theses.

Data Analysis Technique	Number	Percentage
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

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

3.8. Sample Group in Postgraduate Theses on the Concept of 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.

The majority of the analyzed theses comprised 39 students, accounting for 76% of the sample. The remaining participants included pre-service teachers, accounting for 12% of the total, while student-teachers and teachers each made up 4% and 2%, respectively. Two studies utilized books, whereas one study relied on academic publications.

3.9. Topics Researched in 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	Number	Percentage
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 were categorized into eight distinct 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.

3.10. Findings Obtained from the Examination of 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 atom [8,11,46–61]. The methods used in the theses include conceptual change texts, active learning, interactive teaching, 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 [62]. 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 of the atom [9,17,36,63].

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 [9]. It is also stated that the atomic theories presented in chemistry textbooks do not adequately reflect the desired historical and philosophical dimensions [64]. Kardeş (2018) argued in his thesis that the representation of the atom notion in textbooks is insufficient [16]. 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 [19].

Primary, secondary and university students were selected as the sample, and it was stated that they had misconceptions about the concept of atom [65,66].

4. 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 studies were conducted on the concept of atom in the field of education in Turkey. This situation is important in terms of showing that the concept of 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 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 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 teaching the idea of atom (Table 5). It has been determined by many researchers in Turkey and other countries that the concept of atom is not well understood by students and that they have misconceptions in this field [2,4,6–20,67]. 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.

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 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 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 [68]. Erdoğan and Çağiltay (2009) [23] and Dilek et al. (2018) [69] 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, Kalkaçı-Gürel et al. (2017) stated that the achievement test was mostly used as a data collection tool [70]. 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 was determined that primary, secondary and university students were mostly used as samples in theses on the concept of atom. 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 [2,4,67,71–76]. 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 atom in general and it is difficult for students to comprehend this subject. Recently, it has been determined that augmented reality application has started to be used in teaching the concept of atom and positive results have been obtained [56]. 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[21]. Şenkal, & Dincer, (2016) in their research on the tendency of the studies on physics education in Turkey, determined that most of the researches were conducted on learning approaches as in our study [77]. It is acknowledged that these researches are unable to offer efficient and enduring answers to the field. Engaging in further research in domains such as curricula, textbooks, and laboratory applications can have a beneficial impact on physics education.

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 [78]. From this point of view, we can state that the studies to determine the method to be used in teaching the concept of atom are ongoing.

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 atom. In Özkan's (2019) [17] 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. There are many studies with similar results [2,4,7–10,20,65,69–76]. In order to solve this problem, it is evident that there is a need for a wide-ranging regulation in the education system in

the teaching of the concept of atom, starting from planning, 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 [9,16,19,64]. Again, according to the results of the thesis, it was determined that students have misconceptions about the concept of atom [64,65]. 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. The textbook is an essential and readily accessible source of information for students on the subject matter. The presence of presentation errors in the textbook might impede the student's comprehension of the subject matter and potentially lead to misconceptions.

In the theses, it was observed that the curriculum and course materials were not sufficiently researched. Determining the positive and negative aspects of curricula and materials in understanding the subject in theses can provide important contributions to the solution of problems related to the teaching of the concept of atom. The suitability of the curriculum and materials for student age groups, their presentation, and whether the teaching materials are prepared appropriately in education should be discussed. Kaya (2023) reported in his research in this field that the inclusion of atomic models in the primary education curriculum makes the teaching of the concept of atom difficult and causes misconceptions [21]. More research should be done on curricula and textbooks, which are the product 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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Conflicts of Interest:

References

1. Park E. J. & Light G. (2009) Identifying atomic structure as a threshold concept: Student mental models and troublesomeness. *International Journal of Science Education*, 31(2), 233-258. <https://doi.org/10.1080/09500690701675880>
2. Adbo, K., ve Taber, K. Learners' mental models of the particulate nature of matter: A study of 16-year-old Swedish science students. *International Journal of Science Education*, 31(6), 757- 786.
3. Griffiths, A. K., & Preston, A. K. (1992). Grade-12 students' misconceptions relating to fundamental characteristics of atoms and molecules, journal of research in science teaching. *Journal of Research in Science Education*, 29(6), 611-628. <https://doi.org/10.1002/tea.3660290609>
4. Harrison A. G., & Treagust, D.F. (1996). Secondary students' mental models of atoms and molecules: implications for teaching chemistry. *Science Education*, 80(5), 509-534. [https://doi.org/10.1002/\(SICI\)1098-237X\(199609\)80:5%3C509::AID-SCE2%3E3.0.CO;2-F](https://doi.org/10.1002/(SICI)1098-237X(199609)80:5%3C509::AID-SCE2%3E3.0.CO;2-F)
5. Samarapungavan A., Bryan L. & Wills J. (2017). Second graders' emerging particle models of matter in the context of learning through model-based inquiry. *Journal of Research in Science Teaching*, 54(8), 988-1023.
6. Wisner, M. & Smith, C. L. (2008). Learning and teaching about matter in grades k -8: When should the atomic molecular theory be introduced? In S. Vosniadou (Ed.), *International handbook of research on conceptual changes* (pp. 205 -239). New York, NY: Routledge.
7. Feher, E. ve Meyer, K. R., (1992). Children's Conceptions of Color, *Journal of Research in Science Teaching*, V. 29 N. 5 pp. 505-520.
8. Ünlü S., 2000. Kavramsal değişim yöntemlerinin çocukların atom, molekül ve madde kavramlarını anlamadaki başarılarına etkisi, Yüksek Lisans Tezi, Orta Doğu Teknik Üniversitesi, Ankara.
9. Taylan-Yıldız H., (2006) İlköğretim ve ortaöğretim öğrencilerinin atomun yapısı ile ilgili zihinsel modelleri, Yüksek Lisans Tezi, Balıkesir Üniversitesi, Fen Bilimleri Enstitüsü, Balıkesir.
10. Ünal S., 2007. Atom ve molekülleri bir arada tutan kuvvetler konularının öğretiminde yeni bir yaklaşım: BDÖ ve KDM'nin birlikte kullanımının kavramsal değişime etkisi, Doktora tezi, Karadeniz Teknik Üniversitesi, Fen Bilimleri Enstitüsü, Trabzon

11. Tağ M. S., (2012). Atomun Yapısı Konusunu öğrenmede Klasik Yöntemler ile Bilgisayar Destekli öğretimin öğrenci Başarısına Etkileri, Yüksek Lisans Tezi Fırat Üniversitesi Eğitim Bilimleri Enstitüsü.
12. Netzell E., 2014, Using models and representations in learning and teaching about the atom- A systematic literature review, Linköpings universitet, Institutionen för fysik, kemi och biologi 581 83 Linköping.
13. Polat H., 2014. Atomun yapısı konusunda argümantasyon yönteminin ilköğretim 7. sınıf öğrencilerinin başarıları üzerine etkisi, Yüksek Lisans Tezi, İnönü Üniversitesi, Eğitim Bilimleri Enstitüsü
14. Erdamar N., 2017. İşbirlikli öğrenme yönteminin 11. sınıf öğrencilerinin atomun yapısı ve atom modelleri konusundaki kavramsal başarılarına etkisi, Yüksek Lisans Tezi, Gazi Üniversitesi / Eğitim Bilimleri Enstitüsü
15. Kaya A., (2018). Ortaöğretim Öğrencilerinin Atom Kavramını Anlama Seviyelerinin Tespiti, MSKU Eğitim Fakültesi Dergisi, ISSN 2148-6999 Cilt-Volume 5, Sayı- Number 1, Mayıs, s. 1-9.
16. Kardeş H., 2018. Ortaokul 7. sınıf fen ders kitaplarındaki atom modellerinin incelenmesi, Yüksek Lisans Tezi, Necmettin Erbakan Üniversitesi, Eğitim Bilimleri Enstitüsü, Konya
17. Özkan E. B. (2019). Fen Bilgisi öğretmen adaylarının “Atom Ve Atomun Yapısı” Konuları İle İlgili Algılarının Belirlenmesi, Yüksek Lisans Tezi, Aksaray Üniversitesi, Fen Bilimleri Enstitüsü, Aksaray
18. Alkan M., (2022) Ortaokul 7. sınıf öğrencilerinin atom kavramına ilişkin algılarının metafor aracılığıyla belirlenmesi, Yüksek Lisans Tezi, Aksaray Üniversitesi, Fen Bilimleri Enstitüsü.
19. Savaşan E., 2023. Türkiye’de son on yılda yayınlanmış kimya ve fizik ders kitaplarındaki atom modelleri konusunun belirlenen kriterler doğrultusunda bilim tarihi ve felsefesi çerçevesinde incelenmesi, Yüksek Lisans Tezi, Van Yüzüncü Yıl Üniversitesi, Eğitim Bilimleri Enstitüsü
20. Kaya A., (2010). Fen bilgisi öğretmen adaylarının ışık ve atom kavramlarını anlama seviyelerinin tespiti, Erzincan Eğitim Fakültesi Dergisi, 10(1), 15–37.
21. Kaya, A. (2023). Addressing student misconceptions about atoms and examining instructor strategies for overcoming them. *Journal of Pedagogical Research*, 7(4), 251-262. <https://doi.org/10.33902/JPR.202323077>
22. Oruç Ş. ve Ulusoy K. (2008). Sosyal Bilgiler Alanında Yapılan Tez Çalışmaları. *Ahmet Keleşoğlu Eğitim Fakültesi Dergisi*, 26: 121-132.
23. Erdoğan, F. U., & Çağiltay, K. (2009). Türkiye’de eğitim teknolojileri alanında yapılan master ve doktora tezlerinde genel eğilimler. *Akademik Bilişim*, 9, 11-13.
24. Akça-Üstündağ, D. (2009). Türkiye’de bilgisayar ve öğretim teknolojileri alanında yapılan yüksek lisans tezlerinin içerik ve yöntem açısından değerlendirilmesi. Yüksek lisans tezi, Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara.
25. Alper, A., & Gülbahar, Y. (2009). Trends and issues in educational technologies: A review of recent research in TOJET. *Turkish Online Journal of Educational Technology*, 8(2), 124-135.
26. Karadağ, E. (2009). Eğitim Bilimleri Alanında Yapılmış Doktora Tezlerinin İncelenmesi. *Ahi Evran Üniversitesi Eğitim Fakültesi Dergisi*, 10(3), 75-87.
27. Lee M.H., Wu Y.T. & Tsai C.C. (2009). Research Trends in Science Education From 2003 To 2007: A Content Analysis Of Publications İn Selected Journals. *International Journal of Science Education*, 31(15), 1999-2020.
28. Tarman B., Güven C., & Aktaşlı İ. (2011). Türkiye’de sosyal bilgiler eğitimi alanında yapılan doktora tezlerinin değerlendirilmesi ve alana katkıları. *Selçuk Üniversitesi Ahmet Keleşoğlu Eğitim Fakültesi Dergisi*, 32, 391-410.
29. Yüksel, S., Gündoğdu, K., Akyol, B., & Akar-Vural, R. (2016). Content analysis of thesis and articles related to lifelong learning: 2000-2015. *Erzincan University Journal of Education Faculty*, 18(2), 1491-1513.
30. Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed.). New York: Routledge.
31. Bağcı, Ş. (2012). Sınıf öğretmenliği lisansüstü tezlerinin karakteristik özellikleri: Tematik, metodolojik ve istatistiksel yönelimler (Yüksek Lisans tezi). <https://tez.yok.gov.tr/UlusalTezMerkezi> adresinden edinilmiştir.
32. Evrekli, E., Didem, İ. N. E. L., Deniz, H., & Balım, A. G. (2011). Fen Eğitimi Alanındaki Lisansüstü Tezlerdeki Yöntemsel ve İstatistiksel Sorunlar. *İlköğretim Online*, 10(1), 206-218.
33. Ilıcan, S., & Gökçen, A. V. A. R. (2019). Okul Öncesi Fen Eğitimi Alanında Türkiye’de Yapılan Lisansüstü Tezlerin İncelenmesi (2013-2017). *The Journal Of Academic Social Science*, 71(71), 1-16.
34. Polat M. (2013). Fen Bilimleri Eğitimi Alanında Tamamlanmış Yüksek Lisans Tezleri Üzerine Bir Araştırma: Celal Bayar Üniversitesi Örneği. *Dokuz Eylül Üniversitesi Buca Eğitim Fakültesi Dergisi*(35), 46-58.
35. Sönmez D. & Hastürk G. (2020). Türkiye’de Fen Eğitimi Alanında Doktora Düzeyinde Yapılan Tez Çalışmalarının Bibliyografik Analizi. *İnsan ve Toplum Bilimleri Araştırmaları Dergisi*, 9(5), 3174-3194.
36. Aygen A., (2019) Kimya Öğretmen ve Öğretmen Adaylarının Atom Modelleri İle İlgili Kavramsal Anlamaları, Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü, Yüksek Lisans Tezi.
37. Kiray S. A. (2016). The pre-service science teachers’ mental models for concept of atoms and learning difficulties. *International Journal of Education in Mathematics, Science and Technology*, 4(2), 147-162.

38. Suanda N. & Wahyudiati D. (2023). Ethnochemistry: Analysis of the Relevance of Material Atomic Structure with the Ngejot Tradition as a Source for Learning Chemistry. *Hydrogen: Jurnal Kependidikan Kimia*, 11(3), 267-274.
39. Cardno, C. (2018). Policy document analysis: A practical educational leadership tool and a qualitative research method. *Educational Administration: Theory and Practice*, 24(4), 623-640.
40. Sallabaş F. & Polat T. (2022). Yabancı dil olarak Türkçe öğretiminde teknoloji tabanlı konular üzerine yapılan lisansüstü tezlerin incelenmesi. *Aydın Tömer Dil Dergisi*, 7(2), 183-212.
41. Sözbilir M. & Kutu H. (2008). Development and current status of science education research in Turkey. *Essays in Education [Special issue]*, 1-22.
42. Bahar, M., & Kiras, B. (2017). Türkiye’de yayımlanan çevre eğitimi konulu makale ve tezlerin genel analizi. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, 17(4), 1702-1720. <https://doi.org/10.17240/aibuefd.2017.17.32772-363962>
43. Kiras, B., & Bahar, M. (2021). Türkiye’de 1990-2017 yılları arasında fen eğitimi alanında yapılan tezlerin konu yönelimi ve yöntemsel analizi. *Kocaeli Üniversitesi Eğitim Dergisi*, 4(2), 333-354. <http://doi.org/10.33400/kuje.951253>
44. Hubberman, M. ve Miles, M. B. (2002). *The qualitative researcher's companion*. Sage.
45. Başkan Takaoğlu, Z. (2023). Sosyobilimsel Konulara Yönelik Yürütülen Lisansüstü Tezlerin İncelenmesi: Sistemik Bir Analiz. *Milli Eğitim Dergisi*, 52(237), 547-576. <https://doi.org/10.37669/milliegitim.1075185>
46. Salmaz Ç., (2002). Lise 1. Sınıftaki öğrencilerin atom ve yapısı konusundaki yanlış kavramlarının belirlenmesi ve giderilmesi üzerine yapılandırıcı yaklaşımın etkisi, Yüksek Lisans Tezi, Gazi .Ü. Eğitim Bilimleri Enstitüsü, Ankara.
47. Zavrak, M., 2003. Lise Kimya programında atomun yapısı ünitesinde aktif öğrenme yöntemlerinin uygulanması, Yüksek Lisans Tezi, Dokuz Eylül Üniversitesi, İzmir.
48. Oğuz B., 2003. İnteraktif öğretimin öğrenci başarısına etkisine bir örnek: atom teorisi ve yapısı, Dokuz Eylül Üniversitesi, Eğitim Bilimleri Enstitüsü Yüksek Lisans, İzmir.
49. Aydın-Altuntaş, M., 2011. Model ve Kavramsal Değişim Metinlerinin Birlikte Kullanılmasının İlköğretim 7. Sınıf öğrencilerinin ‘Atomun Yapısı’ Konusunu Anlamaları Üzerine Etkisi, Yüksek Lisans Tezi, Karadeniz Teknik Üniversitesi, Eğitim Bilimleri Enstitüsü, Trabzon
50. Akıllı M., 2011. Fen bilgisi eğitimi 2. sınıf öğrencilerine “atomun yapısı” konusunun 3d bilgisayar modelleri yardımıyla öğretimi, Doktora tezi, Atatürk Üniversitesi, Eğitim Bilimleri Enstitüsü. Erzurum.
51. Golgır S., 2011. Genel kimyada atom ve kuantum sayıları konusunda işbirlikçi öğrenmenin öğrencilerin akademik başarılarına etkisi, Yüksek Lisans Tezi, Dokuz Eylül Ün., Fen Bilimleri Enstitüsü, İzmir.
52. Ergün A., 2013. Atom ve molekül konusunda kavram yanlışları ve bunları iyileştirmek için örnek etkinlikler, Doktora tezi, Gazi Üniversitesi / Eğitim Bilimleri Enstitüsü
53. Meydan A. M, (2015), Atomun Yapısı Konusunda Uygulanan 7e Öğrenme Modelinin Öğrencilerin Akademik Başarısı ve Tutumlarına Etkisi, Yüksek Lisans Tezi, Ağrı İbrahim Çeçen Üniversitesi, Fen Bilimleri Enstitüsü, Ağrı.
54. Ayık Z., 2017. Understanding Progressive Nature of Science Based on History And Philosophy of Science Perspective: Thomson, Rutherford and Bohr Atom Theories, Yüksek Lisans, Yıldız Technical University Graduate School of Natural And Applied Sciences, İstanbul.
55. Üçer S., (2019). Fen öğretiminde popüler bilim makalelerinin rolü: atom kavramı örneği, Yüksek Lisans Tezi, Aksaray Üniversitesi, Fen Bilimleri Enstitüsü, Aksaray.
56. Güngördü D., (2018). Artırılmış gerçeklik uygulamalarının ortaokul öğrencilerinin atom modelleri konusuna yönelik başarı ve tutumlarına etkisi, Yüksek Lisans Tezi, Kilis 7 Aralık Üniversitesi / Fen Bilimleri Enstitüsü
57. Mert V., (2019). Kavram haritası yönteminin modern atom teorisi ünitesinin öğretiminde akademik başarıya etkisi, Yüksek Lisans, Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara.
58. Kılıçoğlu F., 2019. "Maddenin tanecikli yapısı" konusunun model ve modellemelerle öğretiminin öğrencilerin başarıları ve atomla ilgili zihinsel modelleri üzerine etkisi, Trabzon Üniversitesi, Lisansüstü Eğitim Enstitüsü
59. Topçuoğlu N., (2022). Kimya eğitiminde atom ve molekül yapılarının öğretiminde üç boyutlu tasarım uygulamaları, Doktora, Kastamonu Üniversitesi, Fen Bilimleri Enstitüsü, Kastamonu.
60. Çolak E., 2022. Atomla ilgili kavram karikatürleri ile desteklenmiş çevrim içi fen bilimleri derslerinin tasarlanması ve değerlendirilmesi, Yüksek Lisans, Recep Tayyip Erdoğan Üniversitesi, Fen Bilimleri Enstitüsü, Rize.
61. Gümüş Ö., 2023. Yapılandırmacı öğrenme tabanlı etkileşimli doğrudan öğretim yaklaşımıyla "Atom modelleri" konusunun öğretimi, Yüksek Lisans Tezi, Atatürk Üniversitesi, Eğitim Bilimleri Enstitüsü
62. Elmacı E., (2013) Fen bilgisi öğretmen adaylarının güdüsel inançları ve öğrenme stillerinin kavramsal anlamalarına etkisi: atom ve bağlar konusu, Yüksek Lisans Tezi, Marmara Üniversitesi Eğitim Bilimleri Enstitüsü, İstanbul.

63. Hanoğlu S., 2004. Öğrencilerin atom ve atomun enerji seviyeleri ile ilgili görüşleri, Yüksek Lisans Tezi, Marmara Üniversitesi, Eğitim Bilimleri Enstitüsü, İstanbul.
64. Kılıç F., 2010. Ortaöğretim kimya ders kitaplarında atom teorilerinin sunumunun bilim tarihi ve felsefesi açısından incelenmesi ve öğretmen görüşleri, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü Ortaöğretim Fen ve Matematik öğretmenliği Anabilim Dalı, Yüksek Lisans Tezi. Ankara.
65. Gündüz A., 2001. İlköğretim ve ortaöğretim öğrencilerinde atom ve molekül kavramı, Yüksek Lisans Tezi, Gazi.Ü. Eğitim Bilimleri Enstitüsü, Ankara.
66. Kılıcı A. T., (2019), Ortaokul 7. Sınıf öğrencilerinin Atom Kavramı Hakkındaki Kavram Yanılgıları, Necmettin Erbakan Üniversitesi Eğitim Bilimleri Enstitüsü, Yüksek Lisans Tezi, Konya.
67. Anderson, B. ve Karrquist, C., (1983). How Swedish Pupils, Aged 12-15 Years, Understand Light and Its Properties. *Journal of Science Education*, 5(4), pp. 316-322.
68. Baltacı, A. (2019). Nitel Araştırma Süreci: Nitel Bir Araştırma Nasıl Yapılır?. Ahi Evran Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 5(2), 368-388. <https://doi.org/10.31592/aeusbed.598299>
69. Dilek A., Baysan S., Öztürk A. A., (2018). Türkiye’de Sosyal Bilgiler Eğitimi Üzerine Yayımlanan Tezlerin Araştırılması: Bir İçerik Analizi Çalışması. *Türkiye Sosyal Araştırmalar Dergisi*, 22(2), 581-602.
70. Kaltakçı-Gürel D., Sak M., Ünal Z. Ş., Özbek V., Candaş Z., Şen S., (2017). 1995-2015 Yılları Arasında Türkiye’de Fizik Eğitimine Yönelik Yayımlanan Makalelerin İçerik Analizi, Mehmet Akif Ersoy Üniversitesi Eğitim Fakültesi Dergisi ISSN:1302-8944 Sayı: 42 Sayfa: 143-167
71. Aguiar, J. G., & Correia, P. R. (2016). Using concept maps as instructional materials to foster the understanding of the atomic model and matter–energy interaction. *Chemistry Education Research and Practice*, 17(4), 756-765.
72. Delvia, T. F., Mufit, F., & Bustari, M. (2021). Design and validity of physics teaching materials based on cognitive conflict integrated virtual laboratory in atomic nucleus. *Pillar of Physics Education*, 14(1), 05-14.
73. Nkadimeng M. & Ankiewicz P. (2022). The affordances of Minecraft education as a game-based learning tool for atomic structure in junior high school science education. *Journal of Science Education and Technology*, 31(5), 605-620.
74. Sa'diyah A., & Lutfi, A. (2023). Atomic Structure Teaching Module with PhET Simulation to Increase Student Motivation and Learning Outcomes. *Hydrogen: Jurnal Kependidikan Kimia*, 11(4), 459-468.
75. Susant A., Mawardi, M. & Suryani O. (2023). Development of TextBook to Support Merdeka Curriculum on the Atomic Structure of Phase E. *Edunesia: Jurnal Ilmiah Pendidikan*, 5(1), 101-125.
76. Yauna, F., Sopandi, W., & Wahyu, W. (2023). Profile of Student's Actual Competencies on Atomic Structure Topic using E-Module based on RADEC Model. *Journal of World Science*, 2(10), 1591-1598.
77. Şenkal, O., & Dinçer, S. (2016). Türkiye’de fizik eğitimi-öğretimi ile ilgili yapılan çalışmaların eğilimi. Çukurova Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 25(2), 57-70.
78. Margel H., Eylon B. S., & Scherz Z. (2008). A longitudinal study of junior high school students' conceptions of the structure of materials. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 45(1), 132-152.

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