Trends in PhD Theses in Turkish Chemistry Education (1999-2019)*

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A R T I C L E   I N F O

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A B S T R A C T

Purpose: This study analyzes the content of doctoral theses completed in chemistry education within the last two decades (1999-2019) after the restructuring of education faculties in Turkey. This study examines the doctoral dissertations completed in chemistry education in 1999-2019 concerning their year of publication, university, objective, research design, sample properties, data collection tools and data analysis methods.

Research Methods: This study was conducted using the qualitative research method of document review. The documents analyzed as part of this study were PhD theses completed in chemistry education in Turkey in 1999-2019. The theses were subjected to descriptive content analysis.

Findings: The findings obtained in this study showed that the number of theses began to increase in 2001 and reached its peak in 2012, before beginning to taper off in the following years. The Middle East Technical University published the highest number of theses. It was observed that most theses concerned the development and implementation of a teaching method. Quasi-experimental designs featured prominently as a research method, with most samples comprising high-school-level study groups. Although examples of quantitative research were more on the whole, in recent years, there was a higher number of studies based on mixed and qualitative research. Interviews and concept testing/achievement tests were frequently observed as data collection tools, while inferential and descriptive statistics were predominantly brought to bear as data analysis methods.

Implications for Research and Practice: This findings obtained in this study suggest that more emphasis should be placed on graduate courses that teach research methods, incorporating more practice sessions because the research methods used in the theses were not specified appropriately by the researchers. There is also a need, in keeping with international trends, to focus more on mixed method research, and to increase the number of qualitative studies, which do a better job of exploring educational environments naturally.

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Introduction

Chemistry emerged in the 18th century as a field of science that explores matter, its internal structure and its interactions. Chemistry is an academic branch that makes discoveries and contributes to theoretical and applied sciences. Chemistry education, on the other hand, concerns itself with questions, such as what to teach and how to teach it, what the knowledge content should be and how successful teaching practices have become. The establishment of chemistry education as a scientific field is relatively new compared to the academic science of chemistry itself. The science of chemistry education, which is interested in how to teach chemistry effectively, is a hybrid field of research that requires the researcher to both be well-versed in the essentials of educational sciences and have expert knowledge of the subject matter in chemistry (Gilbert, 2006; Kempa, 2002; Sozbilir, Akilli, Yasar & Dede, 2016).

The rivalry between the United States and the Soviet Union after the Second World War, and the resulting emphasis on education, precipitated the birth of the fields of science education and chemistry education. Chemistry education focused on mistakes made in theoretical learning in the 1970s, and then shifted to fighting misconceptions until the 1990s. This was soon followed by an emphasis on the teaching of concepts and, more recently, on teaching methods and techniques. The field of chemistry education then focused on teacher education and the use of information technology in chemistry classes, eventually becoming the well-established area of expertise that it is today (Jorde & Dillon, 2012; Sozbilir et al. 2016; Sozbilir & Ayas, 2015). Until the 1990s, chemistry education research was relatively scarce in Turkey (Sozbilir, 2013). As part of a National Education Development project undertaken by Turkey’s Institution of Higher Education (HEI) and the World Bank, departments of education in universities across Turkey were restructured, with radically transformed functions and objectives. After that, there was a considerable rise in research in the field of chemistry education in Turkey. As academics working in departments of education began to focus on teacher education and applied chemistry education, the area of chemistry education expanded and gained tremendous momentum, reaching an all-time high in the mid-2000s (Sozbilir, Kutu & Yaşar, 2013; Sozbilir & Ayas, 2015).

As the number of publications grew, a host of diverse studies was conducted. Researchers who are working on a certain topic encounter difficulties in accessing research on that topic, wasting time and energy trying to locate what they are looking for among a large collection of studies. It is thus increasingly significant that we ascertain existing needs in the field and drive future research accordingly. Therefore, a study that monitors trends in the field by closely examining the body of research on chemistry education and its results will empower researchers working in the field of chemistry education (Cohen, Manion & Morrison, 2007). Content analysis is considered a synthesis of research, and it plays a pivotal role in making research topics widespread, shaping future work, policy, and practice, and raising public awareness (Suri & Clarke, 2009). In that regard, reviewing chemistry education research using content analysis will be beneficial for researchers in allowing them to follow trends in the field, spot problem areas, determine a course of action and avoid repetitions.
Literature Review

When looking at the content analysis work conducted in chemistry education, a few recent studies can be observed (Akkus, Sari & Uner, 2012; Sozbilir; 2013; Sozbilir et al. 2016; Sozbilir et al. 2013; Teo, Goh & Yeo, 2014; Towns & Kraft, 2013; Ulutaş et al., 2015; Yavuz, 2017). Teo et al. (2014) conducted a content analysis by reviewing 650 experimental chemistry education articles published in 2004-2013. They concluded that the most studied topic was a conceptual change, and 52% of the studies used the mixed research method. Furthermore, the most frequent sample group was university students, and the highest number of studies was carried out in the United States, with 48.6%. Sozbilir et al. (2013) examined 273 chemistry education articles published by Turkish academics in 67 national and international journals between 1999 and 2009. They reported that the most common topic concerned the impact of teaching methods on student achievement. The most frequent research method was the quasi-experimental design, and the most common data collection tool was achievement tests. Moreover, most samples comprised undergraduates with 31-100 being the most frequent sample size, and descriptive analytics was the most preferred data analysis method. Sozbilir et al. (2016) reviewed 1338 chemistry education articles published in 65 journals between 1997 and 2013, comparing articles published in Turkey and articles authored in English and published in international journals. They reported that although there has been a rise in the number of articles published in Turkey since 2000, Turkish academia has had difficulty producing studies of international quality. A study conducted by Sozbilir (2013) found that national articles in chemistry education were largely based on quantitative research, while international articles were predicated on qualitative research. Moreover, national articles mostly relied on a single data collection tool, while international articles featured multiple tools. In another study, Ulutaş et al. (2015) conducted a content analysis of 193 chemistry education articles published in ten Turkish journals between 2000 and 2013. They concluded that most studies focused on the effects of teaching methods on success and most of these studies were based on quantitative research. They mostly used multiple-choice tests as a data collection tool and did not use pilot studies ahead of implementation, and the most common topics were fundamental chemistry and the particulate nature of matter. In a recent content analysis, Yavuz (2017) focused on graduate and doctoral theses on misconceptions in chemistry education between 2005 and 2015 in Turkey. The analysis, which looked at 64 theses, showed that most theses used scanning as a quantitative research method. They worked with samples comprising 50-100 middle school students and gathered data using concept testing and analyzed existing data using percentages/frequencies. Unlike graduate studies, Ph.D. studies mostly used the qualitative interview method to gather data. Akkus et al. (2012) carried out a content analysis by reviewing 75 graduate dissertations completed on chemistry education in Turkey between 2000 and 2010. They reported that most theses were based on quantitative research, used experimental designs, featured samples of 50-100 people, employed multiple-choice tests and analyzed data using t-tests. It can be seen that content analysis studies in the literature on teaching chemistry generally concentrate the same time (2000-2010). To our knowledge, there is not any study surveying the last 5-6 years. It can be argued that content analysis is
generally on articles and they use the same sample groups and data collection instruments.

Doctoral dissertations are significant studies in that they contribute to the development of their area as a scientific field; at the same time, they are based on original research and are more comprehensive and longer-term than other studies. Therefore, doctoral theses are expected to offer something new to the field. Doctoral theses are a rich source of data that allow researchers to see the distribution of research topics and methods in chemistry education. Furthermore, they provide an up-to-date overview of the field and give information on how trends have changed over time. Calik et al. (2008) and Kuçukozer (2016) reviewed doctoral theses on science education; Gurel et al. (2017) reviewed doctoral theses on physics education; Karadag (2009) examined PhD theses on educational sciences, and Kozikoglu and Senemoglu (2015) analyzed doctoral theses on educational programs and teaching. However, to our knowledge, no such study on doctoral theses in the field of chemistry education. Therefore, there is a need to explore and report on the changes and existing trends in chemistry education. Thus, this study aims to conduct a content analysis of the doctoral theses completed in chemistry education in Turkey. The author aims that this study will offer guidance to researchers and graduate/Ph.D. students who plan to work in chemistry education. This study aims to conduct a content analysis of doctoral dissertations carried out in the field of chemistry education within the last twenty years (1999-2019) after the restructuring of departments of education in Turkey. The study reviews doctoral theses in chemistry education concerning their topics, methods, university, distribution over the years, the teaching approach used, which chemistry topics they focus on, sampling, data collection tools and data analysis methods. For this purpose, the study seeks answers to the following research questions.

- How are doctoral dissertations in chemistry education in Turkey distributed over the years?
- What are the main problem statements explored in doctoral theses in chemistry education in Turkey?
- What are the common learning/teaching approaches utilized in doctoral theses in chemistry education in Turkey?
- What are the oft-studied chemistry topics in doctoral dissertations in the field of chemistry education in Turkey?
- What are the research methods/designs frequently employed in doctoral theses in chemistry education in Turkey?
- What are the sample groups and sample sizes commonly observed in doctoral theses in the field of chemistry education in Turkey?
- What are the common data collection tools in doctoral theses in chemistry education in Turkey?
What are the common data analysis methods in doctoral theses in chemistry education in Turkey?

Method

Research Design

This study was conducted using the qualitative research method of document review. The main objective of document review is the study of written documents that contained information about the situation or problem that is being studied, and the analysis of the said documents with a view to inferring meaning from them (Merriam & Tisdell 2015; Yıldırım & Simşek, 2013).

Research Sample

This study relied on a comprehensive scan of the Turkish Higher Education Institution (HEI) database for studies conducted after the year 1999, as it was assumed that there was a strong rise in the number of thesis publications in the field of education following the restructuring of departments of education in Turkey (1998). Keywords, such as “chemistry education”, “chemistry, education and teaching” and “chemistry teaching” were used on the HEI database, with “Ph.D.” selected as the type of thesis. The search was repeated by selecting the department as “secondary education science and math”, “math and science”, and “primary school science education”, also adding keywords, such as “chemistry education”, “chemistry”, and “chemistry teaching”. Similar searches were conducted using English words. In total, 186 doctoral dissertations were found, and some of them were removed from the collection for being off-topic. Some theses could not be accessed due to restrictions. Some theses were accessed using the library of Artvin Çoruh University, as these dissertations were archived by the Turkey Document Management System (TÜBESS). As a result of these efforts, 168 doctoral theses were included in this research, with 162 of them reviewed in full and six reviewed on the basis of information provided on their abstracts (year, university, and objective) due to limitations on accessing the full texts. References contained a list of the theses accessed.

Research Instruments and Procedures

An analysis of these dissertations was conducted using the “Publication Classification Form” developed by Sozbilir, Kutu, and Yasar (2012). Many changes were made to this form, which was used extensively in a variety of studies. The form, which was revised for this particular study, consisted of nine categories that addressed the questions posed by this research (Appendix-1). The first two categories included the university at which the thesis was published and the year of publication; the third category featured the purpose or problem statement of the thesis (e.g., learning/teaching, teacher education, concept analysis, education/teaching problems, attitude/perception, curricula, test/criteria development and nature of science). The fourth category answered the question of which teaching/learning approach was used in the thesis (5E learning model, conceptual change approach, argumentation-based...
instruction, problem-based learning, computer-assisted instruction and active learning) The fifth category concerned the subject of the research, with research design explored in the sixth category, sampling properties in the seventh, data collection tools in the eighth, and data analysis methods in the ninth.

**Data Analysis**

The documents analyzed as part of this study were Ph.D. theses completed in chemistry education in Turkey between 1999 and 2019. The theses were subjected to descriptive content analysis. Descriptive content analysis is a study that is conducted with the purpose of determining trends and developments by reviewing research conducted in a specific field over a long time (Calik & Sozbilir, 2014). Content analysis is a method used to evaluate for a certain publication piles (Falkingham & Reeves, 1998). The study analysed doctoral theses in chemistry education concerning their topic, university, methods, the teaching approach used, sampling, data collection tools and data analysis methods.

Many theses were classified together with an expert academician who had conducted some content analysis studies before. Afterwards, the researcher and the domain expert coded ten theses one by one and the consistency of the coding has been compared to understand if the researcher learned the categorization appropriately. The consistency was over 90% between the two coders and uncertainties were cleared. Then, the 168 doctoral theses that were analyzed were categorized again by the researcher himself after a month-long interval to confirm the validity of the content analysis. There was a 94% compatibility between the researcher’s two reviews. Coding was highly aligned (Miles & Huberman, 1994). The coding differences between the two categorizations of the researcher were then reviewed again, and a field expert was consulted in cases where the researcher faced difficulty making categorization decisions. The data that were gathered as a result of the content analysis were saved in a Microsoft Excel file. The data were checked again to prevent double entries or loss of data and were exported to SPSS 18.0 for analysis. Subjected to a descriptive analysis, the results were presented in the form of frequency (f) - and percentage (%) - based graphics and tables.
Results

The distribution of the 168 theses examined in this study between 2001-2018 presented below in figure 1.

![Figure 1. Distribution of PhD Theses in Chemistry Education over the Years (1999-2019)](image)

As can be seen from the figure 1 during the 2000-2019 period, the first doctoral dissertations in the field of chemistry education began to be published in 2001-2002, and the number of theses published in a year reached a peak in 2012. There has been a downward trend in subsequent years. No doctoral thesis was published in the year 2019, the year of publication for this study.

The distribution of the theses by subject in Table 1 showed that most dissertations mainly dealt with improving teaching and learning, and they overwhelmingly concentrate on the effects of instructional methods on students’ achievement.
Table 1

<table>
<thead>
<tr>
<th>Subject</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction</td>
<td>137</td>
<td>81.5</td>
</tr>
<tr>
<td>Teaching as a profession</td>
<td>9</td>
<td>5.4</td>
</tr>
<tr>
<td>Curricula work</td>
<td>5</td>
<td>3.0</td>
</tr>
<tr>
<td>Teacher education</td>
<td>5</td>
<td>3.0</td>
</tr>
<tr>
<td>Material development</td>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td>Determining attitude/interest/motivation</td>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td>Others</td>
<td>6</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>168</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Table 1 demonstrated that the majority of PhD theses in the field of chemistry education focused on the effects of the instructional method on student success.

Figure 2 shows which instructional methods were used in Chemistry Education PhD theses.

![Figure 2. Instruction Approaches Applied in Doctoral Dissertations in the Field of Chemistry Education](image)

The most commonly used teaching methods were the 5E learning model (18) and the conceptual change approach (18). They were followed by argumentation-based instruction (13), context (life) based learning (11), active learning methods (10), cooperative learning (9), problem-based learning (9), computer-assisted instruction (9), inquiry-based learning (6), generative learning approach (5), project-based
learning (4), concept maps (4), case-based learning (4), self-regulated learning (3), and other instructional methods (22).

Table 2 shows on which chemistry topics the theses were based on. It can be seen from Table 2 that studies concentrated on high-school chemistry curriculum and the instruction is based on high-school chemistry curriculum subjects. The theses were mostly on topics, such as acids-bases, chemical equilibrium, solutions, electrochemistry, chemical bonds, gases and reaction rate, where misconceptions are frequent. Organic chemistry topics, which mainly require knowledge level were not included in the theses at all. Some dissertations dealt with multiple chemistry topics. In addition, the instruction in some of the dissertations was based on different chemistry experiments.

Table 2

<table>
<thead>
<tr>
<th>Chemistry Subject</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acids-Bases</td>
<td>16</td>
<td>10.5</td>
</tr>
<tr>
<td>The Structure of Matter</td>
<td>13</td>
<td>8.6</td>
</tr>
<tr>
<td>Multiple Chemistry Topics</td>
<td>13</td>
<td>8.6</td>
</tr>
<tr>
<td>Chemical Equilibrium</td>
<td>11</td>
<td>7.2</td>
</tr>
<tr>
<td>Solutions</td>
<td>10</td>
<td>6.6</td>
</tr>
<tr>
<td>Chemical Bonds</td>
<td>9</td>
<td>5.9</td>
</tr>
<tr>
<td>Electrochemistry</td>
<td>9</td>
<td>5.9</td>
</tr>
<tr>
<td>Gases</td>
<td>8</td>
<td>5.3</td>
</tr>
<tr>
<td>Using Experiments</td>
<td>7</td>
<td>4.6</td>
</tr>
<tr>
<td>Reaction Rate</td>
<td>7</td>
<td>4.6</td>
</tr>
<tr>
<td>Physical and Chemical Changes</td>
<td>6</td>
<td>3.9</td>
</tr>
<tr>
<td>Environmental Chemistry</td>
<td>5</td>
<td>3.3</td>
</tr>
<tr>
<td>Thermodynamics</td>
<td>5</td>
<td>3.3</td>
</tr>
<tr>
<td>Mixtures</td>
<td>4</td>
<td>2.6</td>
</tr>
<tr>
<td>Atoms and the Periodic System</td>
<td>4</td>
<td>2.6</td>
</tr>
<tr>
<td>Solubility Equilibrium</td>
<td>4</td>
<td>2.6</td>
</tr>
<tr>
<td>Chemical Reactions</td>
<td>3</td>
<td>2.0</td>
</tr>
<tr>
<td>Others</td>
<td>18</td>
<td>11.8</td>
</tr>
<tr>
<td>Total</td>
<td>152</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 3 below shows the research designs used in doctoral dissertations published in chemistry education in Turkey between 1999-2019. According to Table 3, the most frequently used method in the theses was a quasi-experimental design, which is generally used in instructional activities. However, there are also some studies on instructional activities using a mixed method design. Furthermore, it can be seen that studies on the teaching profession and curriculum were mainly carried out using qualitative design.
Table 3
Research Designs and Methods Used in PhD Theses

<table>
<thead>
<tr>
<th>Research Design</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantitative</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quasi-experimental</td>
<td>86</td>
<td>52.8</td>
</tr>
<tr>
<td>Pre-experimental</td>
<td>8</td>
<td>4.9</td>
</tr>
<tr>
<td>Descriptive survey</td>
<td>4</td>
<td>2.5</td>
</tr>
<tr>
<td>Correlational survey</td>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>101</td>
<td>62.0</td>
</tr>
<tr>
<td><strong>Qualitative</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Case study</td>
<td>29</td>
<td>17.8</td>
</tr>
<tr>
<td>Action research</td>
<td>4</td>
<td>2.5</td>
</tr>
<tr>
<td>Document review</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>34</td>
<td>20.9</td>
</tr>
<tr>
<td><strong>Mixed</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explanatory mixed design</td>
<td>3</td>
<td>1.8</td>
</tr>
<tr>
<td>Triangulation mixed design</td>
<td>15</td>
<td>9.2</td>
</tr>
<tr>
<td>Embedded mixed design</td>
<td>10</td>
<td>6.1</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>28</td>
<td>17.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>160</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Figure 3 contains a graph that shows the distribution of various research methods over the years.

The graph demonstrates that experimental designs have not been used as frequently in recent years, while there has been a growing interest in qualitative and mixed designs. The fact that studies on chemistry teaching initially concentrated on finding misconceptions and correcting them led to the frequent use of experimental
designs in the early years. It can be seen that educational studies have recently headed for qualitative and mixed research designs because education is a social science. Using mixed research design, educational studies can be carried out both quantitatively and qualitatively in a more holistic way. It can be argued that the new trend is a mixed approach.

Figure 4 shows the distribution of sample groups that were commonly studied in dissertations.

![Figure 4. Sample Groups Studied in PhD Theses on Chemistry Education](image)

As can be seen from figure 4, researchers gravitate towards a high school level because the topics they chose were mostly formed the high-school chemistry curriculum. University students formed the second-largest sampling group because of convenience sampling for instructional activities. Chemistry teachers were not preferred much as a sample group due to teacher education and curriculum being studied less frequently in dissertations.

The Figure 5 shows the sample sizes commonly chosen in PhD theses in the field of chemistry education in Turkey.
Figure 5. Sample Sizes Commonly Preferred in PhD Theses in Chemistry Education

The graph demonstrates that the most common sample size was 31-100 in line with instructional activities carried out in experimental designs. This may be a result of the size of the two classes, namely the experimental and control groups, because the average classroom size was between 30-40. That some experimental studies were conducted with 3-4 classes, and some of them were conducted with more crowded university samples might be responsible for the use of sample sizes of 100-300 to a relatively large extent. That the number of qualitative studies using interviews was limited might account for the limited number of small sample sizes (1-10). Similarly, that survey studies with large sample sizes were preferred less in the theses might be the reason why sample sizes over 300 were used so infrequently.

Figure 6 exhibits the number of data collection tools used in the PhD theses, that have been published in chemistry education over the last two decades and that were subjected to the content analysis as part of this study.
It is to be expected for PhD dissertations, which are normally comprehensive and long-term studies, to use different measurement tools. As can be seen from Figure 6, most of the theses covered in this study used four or more data collection tools. In addition to achievement tests, instruments, such as attitude scale, scientific process skill scale and interview forms, were used together.

Table 4 displays the types of data collection tools utilized in doctoral dissertations completed in chemistry education within the last twenty years (1999-2019) in Turkey. The 162 theses that were subjected to the content analysis used 635 data collection tools. It can be understood from Table 4 that, on average, four different scales were used for each thesis. The most commonly used data gathering instrument was the interview. The depth of learning can be assessed qualitatively using interviews. The dissertations dealt with the effects of instructional activities on achievement to a large extent as well as their effects on student’s attitudes about the course. The level of how much learning took place was measured using concept tests and achievement tests. It can also be understood that in a considerable number of studies, the effect of instruction on scientific process skill was investigated besides its effects on achievement and attitudes. It was seen that interviews for different purposes were used in PhD dissertations as well as in many other studies.
Table 4
Data Collection Tools Commonly Used in PhD Theses

<table>
<thead>
<tr>
<th>Data Collection Tools</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interview</td>
<td>113</td>
<td>17.8</td>
</tr>
<tr>
<td>Course-Based Attitude Scale</td>
<td>81</td>
<td>12.8</td>
</tr>
<tr>
<td>Concept Testing</td>
<td>70</td>
<td>11.0</td>
</tr>
<tr>
<td>Achievement Tests</td>
<td>69</td>
<td>10.9</td>
</tr>
<tr>
<td>Observation</td>
<td>66</td>
<td>10.4</td>
</tr>
<tr>
<td>Scientific Process Skill Scale</td>
<td>56</td>
<td>8.8</td>
</tr>
<tr>
<td>Surveys</td>
<td>46</td>
<td>7.2</td>
</tr>
<tr>
<td>Method-based Attitude Scale</td>
<td>16</td>
<td>2.5</td>
</tr>
<tr>
<td>Logical Reasoning Test</td>
<td>13</td>
<td>2.0</td>
</tr>
<tr>
<td>Written Opinions</td>
<td>13</td>
<td>2.0</td>
</tr>
<tr>
<td>Attitude Scale on Nature of Science</td>
<td>10</td>
<td>1.6</td>
</tr>
<tr>
<td>Others</td>
<td>82</td>
<td>12.9</td>
</tr>
<tr>
<td>Total</td>
<td>635</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Figure 7 shows the number of data analysis methods used in the PhD theses reviewed by this study. It can be seen from Figure 7 that different data analysis methods were used in the studies as a result of using different data collection instruments.

Figure 7. Number of Data Analysis Methods Commonly Used in PhD Theses
Table 5 shows the data analysis methods frequently used in the doctoral dissertations reviewed as part of this study. The most commonly utilized method was predictive analysis as a result of the dominance of quantitative studies. Qualitative data analysis instruments were also used considerably. Descriptive statistics, which can be used in all kinds of studies, were also utilized to a large extent. Among predictive analytics methods, t-tests were the most commonly used method, followed by the ANOVA/ANCOVA method. The most frequently used qualitative analysis method was content analysis.

<table>
<thead>
<tr>
<th>Data analysis method</th>
<th>f</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descriptive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t-tests</td>
<td>72</td>
<td>16.2</td>
</tr>
<tr>
<td>ANOVA/ANCOVA</td>
<td>70</td>
<td>15.7</td>
</tr>
<tr>
<td>Mann-Whitney U/Wilcoxon Signed-Rank Test</td>
<td>33</td>
<td>7.4</td>
</tr>
<tr>
<td>Predictive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MANOVA/MANCOVA</td>
<td>31</td>
<td>7.0</td>
</tr>
<tr>
<td>Correlation</td>
<td>14</td>
<td>3.1</td>
</tr>
<tr>
<td>Regression</td>
<td>8</td>
<td>1.8</td>
</tr>
<tr>
<td>Subtotal</td>
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<td>51.2</td>
</tr>
<tr>
<td>Qualitative</td>
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<td></td>
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<tr>
<td>Content analysis</td>
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<td>15.7</td>
</tr>
<tr>
<td>Descriptive analysis</td>
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<tr>
<td>Subtotal</td>
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<tr>
<td>Others</td>
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<tr>
<td>Total</td>
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Discussion and Conclusion

Doctoral dissertations are original, comprehensive and long-term studies that contribute to the development of their area as a scientific field. With a view to understanding the state of affairs in the field of chemistry education and offering guidance to researchers by highlighting trends, 168 PhD theses published in the last twenty years (1999-2019) have been subjected to content analysis concerning their year of publication, subject and purpose, research method, data collection tools, sample groups and data analysis methods.

This study has found that doctoral dissertations in the field of chemistry education in Turkey emerged in the years 2001-2002 and peaked in number in 2012 with 20 theses published. However, a decline has been observed in subsequent years. In 2018, this number fell to four dissertations in total; moreover, as of March 2019 -- the date of completion for this study--no new dissertations have been published this year. This study has observed the phenomenon, already established in several studies (Sozbilir; 2013; Sozbilir et al., 2013; Ulutas et al., 2015; Yavuz, 2017), that interest in the field of chemistry education research rose after the 1998 restructuring of departments of
education by HEI concerning their framework and functioning. Given that PhD theses are long-term academic works that take at least 3-4 years to complete, it is meaningful that the first theses over the last twenty-year period emerged in 2001 and 2002, or 3-4 years after the 1998 restructuring policy. It is believed that most academics working in departments of education focused on pure chemistry and did not deal with chemistry education and teaching. It can be asserted that the decline in the number of theses published in recent years stems from the oversaturation of this area of research, as well as the difficulty of attracting students to chemistry education departments, the closures of some departments, and a fall in employment opportunities in the field. Although there is a sufficiently large group of academics and researchers at universities, that fewer students are now applying to and enrolling in PhD studies means that the number of theses has inevitably decreased due to reasons, such as the termination of ÖYP (Teaching Staff Training Program), which was supported by YÖK (The Council of Higher Education).

Looking at the distribution of chemistry subjects that the theses dealt with, most studies focused on the teaching of various chemistry topics These studies mostly developed or adapted a teaching method and explored its effects on the success of students in a given chemistry subject. Since PhD theses are comprehensive in nature, these studies focused on the effects of instruction on success as the main problem, while examining other criteria, such as attitude, scientific attitude, and opinion on the nature of science. The content analysis conducted as part of this study conducted the problem statements when categorizing Ph.D. theses by research topic. Apart from instruction, other topics included teaching as a profession (5 percent), curricula study (3 percent), teacher education (3 percent), material development (2 percent), attitude/interest/motivation tests (2 percent) and content analysis (1 percent). The results of this study slightly differ from those obtained by Teo et al. (2014) and Sozbilir et al. (2013) concerning umbrella research subjects. These studies similarly featured instruction as a prominent research topic among chemistry education articles, but the frequency of this topic was much smaller (20-30%) compared to the findings of this study; in addition, these previous studies found that learning was as common as instruction among the research topics of articles published in chemistry education. The PhD theses reviewed by this study were concerned with both learning and instruction. The majority of the theses set out to determine the level of learning in sample groups before focusing on ways to develop teaching methods that would enhance learning. As instruction research takes a long time to design, implement and analyze, field researchers might have viewed them as more appropriate for PhD-level work. This study has found that PhD studies in Turkey have tended to be confined in a narrow thematic area. Most studies, therefore, are duplicates of one another or adaptations of a given concept to a different subject matter. This study finds that it is necessary for researchers to shift their focus to original themes and define new problem statements. Teachers are a crucial element of chemistry teaching as they are the actual practitioners of teaching chemistry at schools. Teacher training will enhance chemistry teaching, as well. For high-quality education, high-quality teachers are essential. Therefore, more studies should be conducted on teacher training. Another significant component of chemistry education is the chemistry teaching curriculum. Curricula determine what will be taught, how it will be taught and how the teaching will be assessed. To improve the quality of chemistry teaching, the quality of the chemistry curriculum should be
improved. There should be more PhD dissertations on chemistry curriculums, which are supposed to contribute to chemistry teaching a lot. Furthermore, there is a pressing need for studies on the assessment and evaluation approach in chemistry teaching.

Looking at the instructional approaches/strategies studied in the 137 theses coded as instruction research and others focusing on teacher education and material development (145 theses in total), the most common approaches were conceptual change instruction and the 5E learning model. These were followed by argumentation-based instruction, cooperative learning, problem-based learning, context-based instruction, and various active learning approaches. Ulutas et al. (2015) and Teo et al. (2014), report the conceptual change instruction method as the most common teaching approach studied in graduate programs. As on international scale, studies in Turkey on chemistry teaching initially concentrated on concept analysis. In the first few years of the two-decade timeframe designated by this study, the PhD theses that were subjected to content analysis focused mostly on the 5E learning model, while more recently, the argumentation-based teaching approach and the context-based instruction strategy began to attract more academic interest. Thanks to the influence of constructivist teaching methods, activities in which students do and experience things have grown in importance. Similarly, academic studies have developed teaching methods that would nurture this approach. To grasp the attention of new generations, there is a need for further studies on the use of technology in chemistry teaching. With the increasing use of smart boards and tablet computers, more studies should be conducted on the use of such electronic devices in chemistry teaching. In parallel with the widespread use of YouTube and other social media platforms, new studies can contribute to the development of chemistry education by focusing on the applicability of chemistry teaching using these platforms.

Looking at the distribution of topics explored by 150 theses subjected to content analysis (Table 2), acids & bases featured as the most common chemistry subject. This was followed by the structure of matter, chemical equilibrium, miscellaneous general chemistry subjects, solutions, chemical bonds and electrochemistry. This finding is in line with that of Ulutas et al. (2015) and Sozbilir et al. (2016), who found that chemistry education articles frequently focused on the particulate nature of matter, basic chemistry, reaction rate, chemical bonds, acids & bases, and solutions. These topics tend to be associated with misconceptions that are frequently mentioned in the literature. Therefore, it is meaningful that these topics have been featured in studies that aim to enhance conceptual learning. The number of studies on the concept of mol, which is one of the topics that students have the most difficulty understanding, is inadequate and more studies should be conducted on this topic. It can be argued that topics, such as a periodic table, carbon chemistry and organic chemistry, which require knowledge level, are not preferred much. There is a need for further studies to develop teaching materials and put these materials at teachers’ and students’ service for these topics, which constitute an important part of the chemistry curriculum. Moreover, it is significant to note that there is no PhD dissertation on nanotechnology in Turkey, which is a very important concept in the science world, yet, it has not been covered adequately in the chemistry curriculum yet. Still, there are some master’s theses on the subject, and to have a place in the international science and technology world, PhD dissertations in the field of nanotechnology should be supported. Furthermore, to our
knowledge, environmental chemistry, sustainability, fossil fuels, renewable energy and health and safety in chemistry topics, which have recently been included in the chemistry curriculum, have not been studied yet. Studies on these topics will also benefit chemistry teaching.

Many of the theses that were reviewed by this study were conducted using qualitative designs and more than half were found to have utilized a quasi-experimental design (53 percent). Among qualitative designs, case studies were frequently employed, while the use of mixed designs -- despite being in the minority -- was observed in nearly one-fifth of the studies. Among mixed designs, triangulation was the most commonly used method. The pre-experimental design, survey designs, action research, document review, and the explanatory mixed design were rarely preferred as research methods. On the other hand, methods, such as the strong experimental design, single-subject design, ex post facto design, comparative design, cultural analysis, and theory building, were not utilized in any of the theses. These results are similar to those of the existing body of research in that quantitative studies are quite frequent (Sözbilir et al. 2013; Ulutas et al., 2015; Yavuz, 2017), although there are diverging aspects. Several studies (see Sözbilir et al. 2013; Ulutas et al., 2015; Yavuz, 2017) have shown non-experimental quantitative methods to be the most common, while this study has found that experimental designs are more often preferred as the research method. Since PhD theses are more comprehensive and are required to present more reliable results, it is expected that they would feature experimental designs more frequently. Interventional studies provide students with a novel opportunity for better learning. Experimental designs allow the researcher to statistically compare the new method with the old method (McMillian & Schumacher, 2010). Thus, since most of the PhD theses reviewed in this study focused on instruction, they frequently used experimental designs. Looking at the distribution of research designs over the years (Figure 4), we observe that experimental designs were used more often in the first years, while qualitative designs and mixed designs emerged more recently. Mixed method research has apparently been the most common design since 2010, as reported by Kuzuokzer (2016) on PhD theses on science education, and by Kozikoglu & Senemoglu (2015) on educational programs and instruction. These results are consistent with the findings of this study. According to the study conducted by Teo et al. (2014), mixed designs were the most common research method. To obtain more reliable results, various data collection tools need to be used in coordination with each other. Combining quantitative and qualitative approaches ensures a better understanding of the research problem and more reliable results (Creswell, 2014). The rise of mixed designs in research in Turkey might have been influenced by international studies. Qualitative research requires more effort and serves to interpret facts in their natural environment and with a holistic approach (Creswell, 2014). In fact, more qualitative studies are needed in the social science field, such as chemistry education.

Concerning sample groups, high school students were the most common, followed by undergraduates. Other sample groups included chemistry teachers, middle school students and students with special needs. This result is compatible with the results of other studies in the field (Sözbilir et al. 2016; Sözbilir et al. 2013; Teo et al. 2014; Ulutas et al., 2015; Yavuz, 2017). Since chemistry subjects are taught at the high school level, academic studies should focus on this context. The reason why undergraduates were
a common sample group is the ease with which researchers, who are often resident lecturers at universities, can find students to interview or invite to an experiment. Due to the lack of activity in the field in recent years, special needs schools were also included in the theses as sample groups. In line with the other results of the study, the most common sample group size was 31-100 people, followed by 101-300. This result is anticipated as the quasi-experimental design, the most common research method used in the PhD theses that were reviewed by this study makes use of control groups and experimental groups that are compared with each other. The sample size is significant for the reliability and external validity of qualitative studies (Creswell, 2014). This study has found that some dissertations utilized smaller sample groups than required.

Concerning the number of data collection tools used, the most common scenario was the use of five of more data collection tools. This was followed by four and three tools, respectively. There were also a small number of cases in which two different tools and a single tool were utilized. Studies in which different types of data support each other are considered to have higher validity (Fraenkel et al., 2012). Doctoral dissertations are required to be comprehensive and valid studies. Thus, raising the number of data collection tools to ensure the validity and reliability of the results and to expand the scope of the study is expected and appropriate. This study has found that theses that made use of a single data collection tool were content analysis studies that were conducted using document review. Similarly, studies on curricula and teaching as a profession were carried out using fewer data collection tools. Looking at which data collection tools were preferred more often (Table 4), we see that concept testing and achievement tests to measure academic performance were the most common, in accordance with the problem statements of the studies. Some studies focusing on instruction employed measured learning using achievement tests, while other studies used concept testing for the same purpose. Thus, the use of concept testing and achievement tests is proportionate to the number of studies on instruction and teaching. Interviews were also used frequently to collect data. Approximately 70 percent of the dissertations made use of interviews for data collection purposes. Most of them were in the form of semi-structured interviews, while some studies preferred a structured interview format. Interviews can be leveraged both to collect qualitative data and as a means of supporting quantitative research. This explains why they are one of the most popular data collection tools. Similarly, tests to measure attitude towards chemistry courses and scientific attitude tests also feature prominently as data collection tools. Although used infrequently, surveys developed for a variety of reasons were also employed in some studies. These findings are compatible with studies in chemistry education, which report that the most common data collection tools are achievement tests and interviews (Sozbilir et al. 2016; Sozbilir et al. 2013; Ulutas et al., 2015; Yavuz, 2017). Data collection and analysis can also be effectively conducted using multiple-choice achievement tests and Likert-type attitude scale. Interviews can also provide a rich source of data (De Jong, 2007). When the first PhD dissertations appeared in chemistry education, the studies concentrated on concept analysis, and as a result, the most commonly used assessment tools were concept tests and achievement test. Later, qualitative data collection instruments became more prominent because education is a field of social science. With the interview method, rich data can be obtained (De Jong, 2007). Interviews can be applied in both qualitative
and mixed method studies and even in experimental studies. Accordingly, interviews have become an integral data collection tool for PhD dissertations. When the data collection instruments in dissertations are analyzed, it can be seen that psychological scales, which are inherent in the field of education, are not developed in the field of chemist education. In chemistry education, there is a growing need to develop new scales specifically designed for chemistry education and long term observations in the natural environment of the chemistry lessons. New data collection tools can be developed for laboratory experiments rather than achievement in chemistry courses, for which laboratories are essential.

Methods used in the PhD studies for data analysis were compatible with the research design, and the most common method for data analysis was predictive analytics. Predictive analyses are useful for exploring relationships between variables (McMillian & Schumacher, 2010). In studies based on experimental designs, it is more appropriate to analyze quantitative results using predictive analytics. Approximately half of the PhD theses made use of predictive data analysis. The most common predictive analytics methods were t-tests and variance analysis. Non-parametric tests and multivariate analyses of variance were also among the frequently utilized predictive analytics methods. The reason for the use of these analyses may be the aim of explaining the relationship between variables investigated a study in a more explicable way and the easier interpretation of the results. It was seen that researchers rarely used such advanced statistical methods as correlation, factor analysis and regression analysis, which may be a result of their not having a good knowledge of statistics. For high-quality dissertations, different statistical techniques should be used in combination.

Quantitative analysis methods were followed by qualitative data analysis methods. Content analysis was the most common qualitative analysis method. Aside from qualitative and predictive analyses, frequency and percentage-based tables are also commonly used as data analysis methods. Similar results were also reported in other studies (Akkus et al. 2012; Sozbilir et al. 2016; Sozbilir et al. 2013). This study found that nearly 90 percent of the PhD theses that were reviewed employed more than one data analysis method. To improve the validity and reliability of studies, different data collection instruments and data analysis methods should be used to enrich the theses. This is crucial for the quality, validity and reliability of research.

In conclusion, a content analysis of the doctoral dissertation conducted in Turkey in the field of education within the last two decades (1999-2019) is here with presented to researchers and decision-makers who will chart the future course of scientific policies. Taken as a whole, the results show that the authors of the PhD theses failed to adequately define the research methods that they employed. Thus, this study recommends that more emphasis be placed on graduate courses that teach research methods, incorporating more practice sessions. There is also a need, in keeping with international trends, to focus more on mixed method research, and to increase the number of qualitative studies, which do a better job of exploring educational environments in a natural manner. As stressed by Towns (2013) and Towns and Kraft (2011), lab-based instructional approaches, which are crucial in chemistry teaching, should be developed and researched; in addition, long-term qualitative studies (e.g., action and longitudinal) in teaching environments should be conducted more
frequently. This study has observed that researchers tend to settle for easily accessible sample groups. It would therefore be more appropriate to conduct studies using various sampling methods. It can be said that the number of data collection tools and data analysis methods used in the PhD theses are adequate concerning ensuring validity and reliability. However, qualitative findings were often quantized using frequencies/percentages. Additional care should be taken to develop new ways of analyzing qualitative data and integrating various data types. The author aims that this study, which explores trends in the field of chemistry education, will help guide researchers and higher education planners in their efforts to improve and enhance instruction.

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* Doctoral thesis examined.

Türkiye Kimya Eğitimi Doktora Tezlerinde Eğilimler

Atıf:


Özet

Problem Durumu: YÖK (Yüksek Öğretim Kurulu)/Dünya Bankası Milli Eğitimleri Geliştirme projesi kapsamında 1998 yılında eğitim fakülteleri yeniden yapılandırılmış ve işlevlerinde köklü değişikliklere gidilmiştir. Bu tarihten sonra Türkiye’de kimya eğitim araştırmalarında önemli artış gözlenmiştir. Eğitim fakültelerinde görev yapan akademisyenlerin eğitim bilimleri, öğretmen eğitimi ve alan eğitimi gibi alanlara...


da bulunmaktadır. En sık uygulanan öğretim yöntemleri 5E öğrenme modeli (18) ve kavrumsal değişim yaklaşımı (18) olmuştur. Tez çalışmalari sırasında yapılan uygulamaların hangi kimya konusu üzerinde olduğunu bakıldığında; en çok çalışmalar kimya konusu asitler-Bazlar (16) olmuştur. Maddenin yapısı (13), farklı genel kimya konularının harmanlandığı çalışmalar (13), kıyısal denge (11), çözelti konusu (10), elektrokimya konusu (9), kıyısal bağlar (9), gazlar (8), reaksiyon hızı (7), Kimya deneyleri (7) üzerine yapılan tezler, fiziksel ve kıyısal değişimler (6), çevre kıyıması (5) konuları sık sık tercih edilen kimya konuları olmuştur. En çok kullanılan araştırma yöntemlerinin nicel yöntemler (%62) olduğu, nitel (%21) ve karma yöntemlerin (%17) daha az kullanıldığını görülmektedir. Yan deneySEL desenin (%53) barı bir şekilde en çok kullanıldıği, daha sonra nitel durum çalışmalarının (%18) tercih edildiği ve karma desenlerden de çeşitlileme desen (%9) ile araştırmaların sık sık kullanıldığı görülmüştür. Araştırmacıların en çok tercih ettikleri örneklem grubu sıklıkta (%49) myśli olmuştur. İkinci olarak önemli oranda üniversite (%35) düzeyi örneklem grubu sıklıkta çalışılmıştır. En sık çalışılan örneklem büyüklüğü 31-100 (83) arası grup olmuştur. Bunu 101-300 arasında (46), 11-30 aralığı (21) gruplar takip etmektedir. İçerk analizi yapılan 162 tezde toplama 635 veri toplama aracı kullanıldığı tespit edilmiştir. En çok kullanılan veri toplama aracı mülakat (%17,8) olmuştur. Derse yönelik tutum ölçeği (%12,8), gözlem (%10,4) ve ders başarısını ölçmek için kullanılan kavram testi (%11) ile başarı testi (%10,4) sık kullanılan örneklemler olmuştur. Çalışmalarda en çok 3 çeşit veri analizi yöntemi (%43) tercih edilmiştir. İkinci olarak 2 çeşit veri analizi yöntemi (%27), üçüncü olarak ise 4 ve üzeri veri analizi yöntemi (%19) kullanılmıştır. Araştırma kapsamında incelenen doktora tezlerinde sık sık kullanılan veri analizi yöntemleri açısından en çok kestirimsel (%51) istatistikten yararlanmıştır. Nitel veri analizi yöntemlerinden %25, betimsel istatistikten ise %21 oranında faydalanılmaktır. Kestirimsel istatistik yöntemlerden en çok t testi (%72) kullanılmış hemen sonra anova/ancova (%70) yöntemi tercih edilmiştir. Mann-Whitney U/U/Wilcoxon işaretler Testi (33) ve manova\mancova (31) da sık sık kullanılan kestirimsel istatistik yöntemler arasındadır.


Anahtar Sözcükler: Kimya eğitimi, içerik analizi, doktora tezi, eğilim
Appendix 1. Thesis Classification Form

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<tr>
<td><strong>Title:</strong></td>
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<td><strong>Date:</strong></td>
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Subject of The Thesis

Applied Instruction Approaches

Chemistry Subject

Research Methods/Designs

Data Collection Tool

Sample

Sample Size

Data Analysis