Trends of Postgraduate Theses Conducted in the Field of Science Education on Biotechnological Concepts in Turkey for the Last 20 Years: A Content Analysis

Gülşah GÜRKAN[a*], Sibel KAHRAMAN[b]

a* Dr. Lecturer, Malatya Turgut Ozal University, Malatya, Turkey,(https://orcid.org/0000-0003-0297-3060) *gulsah.gurkan@ozal.edu.tr

b Prof. Dr., Inonu University, Makatya, Turkey, (https://orcid.org/0000-0002-0720-4917), sibel.kahraman@inonu.edu.tr

ABSTRACT

This study presents a descriptive content analysis of the research trends of postgraduate theses conducted in the field of science education on biotechnological concepts in Turkey between 2000-2020. In line with the aim of the study, 65 postgraduate theses in total were examined by searching the database of the Council of Higher Education (CoHE) National Thesis Center. In this study using document analysis, one of the qualitative research designs, theses were analyzed according to years, universities, study subjects, concepts, methods, data collection tools, sampling, and sample size. The results showed that theses were predominantly master's theses, postgraduate theses conducted in the field of science education on biotechnological concepts were carried out in a total of 27 universities, and theses were mainly conducted at Gazi University, Inonu University, and Bolu Abant Izzet Baysal University. Regarding the subject distribution, it was seen that theses were mainly written on the attitudes, perceptions, and interests of middle school, high school, and university students and teachers concerning biotechnology and were teaching- and learning-oriented. Furthermore, it was concluded that quantitative approaches were mostly used in the examined theses, and experimental designs among quantitative research methods were preferred more than non-experimental designs. As data collection tools, mostly skill, attitude, perception, personality, etc. tests, achievement tests, Likert-type questionnaires, and semi-structured interviews were used, and it was observed that the most preferred sample group was university and high school students and the sample size was mostly between 101-300 and 31-100. Based on the study results, it can be suggested that researchers conduct more studies on biotechnology-related subjects using different samples and scales.

Keywords: Biotechnology education, content analysis, postgraduate theses, document analysis.

Türkiye'de Biyoteknolojik kavramlarla ilişkili Fen Bilimleri Eğitimi Alanında Lisansüstü Tezlerin son 20 yıllık eğilimleri: Bir İçerik Analizi

ÖZ

Bu çalışma, Türkiye'de 2000-2020 yılları arasında biyoteknoloji kavramına yönelik fen bilimleri eğitimi alanında yapılan lisansüstü tezlerin araştırma eğilimlerine yönelik, açıklayıcı içerik analizini sunmaktadır. Çalışma kapsamında Yükseköğretim Kurulu (YÖK) Ulusal Tez Merkezi veritabanı taranarak toplamda 65 lisansüstü tez incelenmiştir. Nitel araştırma desenlerinden doküman incelemesinin kullanıldığı bu çalışmada tezler yıllara, üniversitelere, çalışma konularına, kullanılan kavramlara, yönteme, very toplama araçlarına, örnekleme ve örneklem büyüklüğüne göre analiz edilmiştir. Bulgulardan elde edilen sonuçlara göre tezlerin ağırlıklı olarak yüksek lisans tezi olduğu, biyoteknolojik kavramlarla ilişkili fen eğitimi alanında yapılmış lisansüstü tezlerin toplam 27 üniversitede gerçekleştirildiği ve tezlerin ağırlıklı olarak Gazi Üniversitesi, İnönü Üniversitesi ve Bolu Abant İzzet Baysal Üniversite'nde yapıldığı görülmüştür. Konu dağılımına göre tezlerin ağırlıklı olarak, ortaokul, lise ve üniversite öğrencileri ile öğretmenlerin biyoteknolojiye yönelik tutum, algı ve ilgileri üzerine yapılarak öğretim ve öğrenme odaklı olduğu, görülmüştür. Ayrıca incelenen tezlerde çoğunlukla nicel yaklaşımların kullanıldığı, nicel araştırma yöntemlerinden deneysel desenlerin deneysel olmayan desenlere oranla daha çok tercihedildiği sonucuna ulaşılmıştır. Veri toplama araçları olarak çoğunlukla yetenek, tutum, algı, kişilik vb. testleri, başarı testleri, likert türü anketler ve yarıyapılandırılmış görüşmelerin kullanıldığı, en çok tercih edilen örneklem grubunun üniversite ve lise öğrencileri olduğu ve örneklem büyüklüğünün çoğunlukla 101-300 ve 31-100 aralığında olduğu görülmüştür. Çalışma sonuçlarından yola çıkarak araştırmacılara biyoteknoloji ile ilgili konularda farklı örneklemler ve ölçekler kullanarak daha çok çalışma yapmaları önerilebilir.

Anahtar kelimeler: Biyoteknoloji eğitimi, içerik analizi, lisansüstü tezler, doküman analizi .

1 | INTRODUCTION

Developments in the field of biotechnology are undoubtedly one of the most important scientific and technological developments of the 21st century. Nowadays, many biotechnological studies are carried out with applications such as the Human Genome Project, genetic replication, and gene therapy to find solutions to agricultural problems with genetically modified organisms ensuring the production of plant and animal breeds and products resistant to unfavorable conditions and having increased shelf life and nutritional value and to environmental problems using biological tools and systems, biological fuel and renewable energy sources.

Although archaeological evidence shows that biotechnological applications began with plant and animal breeding about 10 thousand years ago, the term biotechnology was first used by the Hungarian scientist Karl Ereky in 1919. However, it is known that developments affecting human life more in the field of biotechnology started with the discovery of restriction enzymes in the 1970s, following the discovery of the double helix structure of DNA in 1953. These discoveries initiated the modern age of biotechnology and resulted in the introduction of biotechnological developments in many fields, such as health, agriculture, food, and the environment, into human life. Therefore, biotechnology, together with information technology, is one of the scientific developments expected to make the most significant contribution to the welfare of humanity in the last quarter of the 20th century and the 21st century.

The multidisciplinary and complex nature of biotechnology poses difficulties for the society trying to learn this discipline and for science educators trying to teach it. Additionally, with the rapid development of this technology, different benefits and risks emerge every day, and the information and discussions on this subject gain more importance in our lives. In line with these developments and difficulties, the necessity and importance of providing biotechnology education in schools arise (Hanegan & Bigler, 2009; Steele & Aubusson, 2004).

The general objectives of science education include teaching science concepts that form the basis of advancements in science and technology and enabling individuals to be science literate at a level to follow these developments and understand their impact on social life (Albe, 2008; Kolsto, 2006; Nielsen, 2012; Walker & Zeidler, 2007). The science curriculum needs to adapt to change due to the constantly developing and updating structure of scientific and technological discoveries. In parallel with recent scientific developments, the science course curriculum in Turkey was also updated many times. Upon examining the related education programs for elementary school in Turkey, it was seen that the foundations of biotechnology and genetic engineering education were tried to be laid (Darcın, 2003). The studies conducted on biotechnology education have emphasized that programs at all levels of education should include a wide range of accurate information, especially for the use of biotechnology in daily life, and science teachers should be knowledgeable and equipped on these issues (France, 2000; Marchant & Marchant, 1999; Olsher & Dreyfus, 1999; Thomas, Keirle, & Griffith, 2002; as cited in Darcın, 2007).

According to some studies in the international literature, teachers do not devote much time to biotechnology in their lessons (Fonseca, Costa, Lencastre & Tavares, 2011; Steele & Aubusson, 2004), and students have preconceptions that biotechnology is difficult (Steele & Aubusson, 2004). It is also known that students are unwilling to learn biotechnology, possibly for this reason (Kidman, 2009). Likewise, it is stated that teachers have negative perceptions and beliefs about biotechnology (France, 2007). A study by Lamanauskas, Makarskaite-Petkevičienė (2008) revealed that pre-service teachers had low levels of knowledge about biotechnology, their attitudes toward the use of genetically modified foods were negative, and they believed that DNA manipulations were unethical. Researchers argue that one of the most important factors influencing attitude toward biotechnology applications is gender, and some studies have concluded that men have more positive attitudes toward biotechnology applications than women (Moerbeek & Casimir, 2005; Prokop et al., 2007; Qin & Brown, 2007).

THE PURPOSE AND SIGNIFICANCE OF THE STUDY

While it is a known fact that the correct way to teach developments in biotechnology and genetic engineering is through educational institutions and formal education, there are few studies conducted with teachers currently working in Turkey. In these studies, it has been observed that teachers have sufficient knowledge about the definitions of concepts such as biotechnology applications and genetically modified organisms (GMOs). However, it has been determined that they do not have sufficient and consistent knowledge and equipment about such

applications in daily life (Aksoy, 2006; Ciçekci, 2008; Demirci, 2008; Gurkan & Kahraman, 2018; Senler, Kozcu Cakır, Gorecek & Gocmen Taskın, 2006). A study conducted by Ocal (2012) with science teachers revealed that they generally learned biotechnological developments from the media and the internet, not from educational institutions. Considering that the information obtained through the internet is mostly not valid and correct, this situation may cause the adoption of false ideas and prejudice against such a socioscientific issue due to the misinformation in the media (Aydin & Cetin, 2020). Studies conducted with students on biotechnological concepts in Turkey have examined the attitudes and knowledge levels of primary and middle school students and university students studying in various departments. According to the results obtained from these studies, conducting biotechnology lessons with laboratory support leads to a positive change in success and attitude (Darcın, 2007). Students' attitudes toward biotechnology may differ depending on variables such as knowledge level, gender, and class level (Balemen, 2009; Darçın, 2011; Turkmen & Darcın, 2007). The fact that pre-service teachers have taken a course on biotechnology before coming to the university and during their undergraduate education positively affects their knowledge and attitudes (Yuce & Yalcın, 2012).

The education that societies receive in the field of biotechnology and genetic engineering, their knowledge and their academic studies will determine whether they will have a say in shaping this area of the future world. Therefore, it is very important to determine whether the education provided in this field and whether the status of the field are sufficient and reveal the problems in education (Sıcaker & Ozaydin, 2015). The wide range of studies on biotechnology education in terms of subject context and the continuous increase in the number of studies make it difficult to follow the literature. When the relevant literature is reviewed, no study has been found analyzing research conducted in the field of science education in Turkey on biotechnology education to determine the trends in terms of various factors.

However, to look at the subject holistically, provide explanatory information about the position of biotechnology education in our country, and thus direct future research, it is necessary to determine what kind of studies are carried out in the literature and what deficiencies this field has.

RESEARCH QUESTIONS

This study investigated the status and trends of nationally conducted postgraduate thesis studies on the use of biotechnology and related concepts in science education. To this end, the postgraduate theses in the field of science education, including biotechnological concepts, which were registered to the CoHE National Thesis Center between 2000 and 2020, were analyzed descriptively to answer the following questions:

1. What is the distribution of theses by years and types?

2. What is the distribution of theses by the universities where they were conducted?

3. What is the distribution of theses by study subjects?

4. Which research methods were used in theses?

5. What is the distribution of the sample group used in theses?

6. What is the size of the sample groups used in theses?

7. Which data collection tools were used in theses?

8. Which data analysis methods were used in theses?

The current study aims to provide researchers working in the field of biotechnology education with the opportunity to view postgraduate theses in a single resource and provide researchers with information about study trends in the field. It is thought that revealing the trends in the literature will also be useful in determining the path that researchers will follow in their studies by shedding light on what deficiencies are and generating ideas to fill gaps in the literature. The fact that this study was limited to postgraduate thesis studies in science education and its implementation in a more specific area helped to conduct a detailed study.

2 | METHOD

RESEARCH MODEL

A qualitative research model was used in this study. Qualitative research is a research method in which "the qualitative process is followed to reveal perceptions and events in a realistic and holistic manner in the natural environment" (Yıldırım & Simsek, 2008). In this study, the research trends of postgraduate theses conducted in our country in the field of science between 2000-2020 on the concept of biotechnology were revealed by a content analysis method based on document analysis. Content analysis, a qualitative method, is defined as the process of examining the contents and information of previously published written and other materials within the framework of objective and certain systematic criteria (Cohen, Manion & Morrison, 2007; Tavsancıl & Aslan, 2001).

DATA COLLECTION

In addition to science education, biology education, and chemistry education, which include concepts related to biotechnology in their curricula, this study also focused on postgraduate thesis studies in the fields of classroom and preschool education due to the biotechnological concepts in their curricula. Furthermore, while the research was conducted in the fields mentioned above, the study was limited to theses conducted in the field of education and teaching biotechnology-related concepts. The related postgraduate thesis studies were reached by searching in the CoHE National Thesis Center. The keywords "biotechnology," "genetic engineering," "cloning/copying," "genetically modified organisms (GMO)," "genome project," and "recombinant DNA" were used in the search. The search was repeated in a way to cover the title, abstract, keywords, and text parts of graduate theses. Thus, it was tried to reach not only the title but also all postgraduate thesis studies that include biotechnology and concepts related to its content. Within the scope of the study, 65 postgraduate theses (Appendix 1), registered in the CoHE National Thesis Center, published between 2000-2020 and whose full texts could be accessed, were analyzed. Since studies on biotechnology, especially in the field of education, started in the 2000s, this study examined theses published since 2000.

DATA ANALYSIS

A thesis classification form was created using similar thesis survey forms in the literature for 65 postgraduate theses that were reached according to the search results and met the study's criteria. First, the information on postgraduate theses (author names, year, language), then the purpose and method information (study design, sample, data collection, and analysis methods) and the results obtained from the findings were recorded in this file.

The full texts of the postgraduate theses included in the study were repeatedly examined, and codes and themes were created in accordance with the research questions. During the coding process, the relevant parts of each thesis were read in detail, and similar studies in the literature were reviewed and identified. The codes that were categorized afterward were gathered under similar themes. To avoid data confusion, each thesis examined in the study was coded as 1, 2, ……., 65. It was reviewed whether the categories and codes created were compatible with each other, and it was seen that the researchers agreed on the majority of them.

Reliability in this study was tried to be ensured with transferability, consistency, and verifiability criteria. To ensure transferability, a detailed description method was used by explaining the criteria for determining the studies included in the study, the processes of collecting data, coding and creating themes. For consistency, the data were used as contained in the theses, without adding comments. To avoid bias in the data analysis, codes and themes were created using similar studies in the literature. The list of the reviewed studies was presented for verifiability, and the analyses were archived to be presented when requested. The values obtained from the analysis were digitized for each category as frequency values. Digitizing the data is important in terms of the reliability of the research and providing the opportunity to compare the findings if the research is repeated (Yıldırım & Şimşek, 2008).

3 | FINDINGS

The study was carried out in the field of science education by reaching the full versions of postgraduate theses in the CoHE National Thesis Center. Table 1 shows the distribution of the postgraduate theses on biotechnological concepts by years and types in terms of frequency and %. As seen in Table 1, there was no thesis study conducted on the subject in 2000 in Turkey, and the first thesis was written in 2001 as a master's thesis. There was a gradual increase in theses in the following years, and a more significant increase was experienced after 2010. Moreover, it was determined that the first doctoral dissertation on biotechnological concepts was written in 2005. It is remarkable that the majority of the 65 theses reached and analyzed (f = 55) were master's theses and only a very small part (f = 10) were doctoral dissertations. The highest number of thesis studies was conducted in 2019 when a total of 9 theses (8 master's + 1 Ph.D.) were done.

Table 1. Distribution of the theses examined by years and types

Years	Master Thesis		PhD Thesis		Total	
	f	%	f	%	f	%
2000	-	-	-	-	-	-
2001	1	1.8	-	-	1	1.5
2002	1	1.8	-	-	1	1.5
2003	2	3.6	-	-	2	3.1
2004	1	1.8	-	-	1	1.5
2005	2	3.6	1	10	3	4.6
2006	2	3.6	-	-	2	3.1
2007	1	1.8	1	10	2	3.1
2008	1	1.8	1	10	2	3.1
2009	5	9.1	-	-	5	7.7
2010	2	3.6	-	-	2	3.1
2011	2	3.6	1	10	3	4.6
2012	4	7.3	1	10	5	7.7
2013	6	10.9	-	-	6	9.2
2014	1	1.8	1	10	2	3.1
2015	3	5.5	1	10	4	6.2
2016	2	3.6	1	10	3	4.6
2017	4	7.3	-	-	4	6.2
2018	3	5.5	-	-	3	4.6
2019	8	14.6	1	10	9	13.8
2020	4	7.3	1	10	5	7.7
Total	55	100	10	100	65	100

Table 2 shows the data regarding the distribution of the universities where the theses were conducted. Upon examining the data in Table 2, it is noteworthy that postgraduate theses conducted on biotechnological concepts and in the field of science education in Turkey were carried out in 27 universities, and approximately one-third of these theses were conducted at Gazi University. In the last two decades, 19 postgraduate theses on biotechnological concepts in the field of science education were written at Gazi University. Following Gazi University, the universities with the highest number of theses on this subject were Bolu Abant Izzet Baysal University and Inonu University, with four theses each.

Table 2. Distribution of the examined theses on biotechnological concepts by universities

Rank	Universities	f	%
1	Adiyaman University	1	1.5
2	Ahi Evran University	1	1.5
3	Aksaray University	2	3.1
4	Ankara University	1	1.5
5	Aydın Adnan Menderes University	1	1.5
6	Balıkesir University	3	4.6
7	Bolu Abant Izzet Baysal University	4	6.2
8	Canakkale Onsekiz Mart University	1	1.5
9	Cukurova University	2	3.1
10	Dicle University	1	1.5
11	Dokuz Eylul University	2	3.1
12	Eskisehir Teknik University	1	1.5
13	Fatih University	2	3.1
14	Gazi University	19	29.2
15	Giresun University	1	1.5
16	Hacettepe University	2	3.1
17	Inonu University	4	6.2
18	Kafkas University	1	1.5
19	Karadeniz Teknik University	2	3.1
20	Kastamonu University	2	3.1
21	Marmara University	2	3.1
22	Mugla Sıtkı Kocman University	3	4.6
23	Necmettin Erbakan University	2	3.1
24	Ondokuz Mayıs University	1	1.5
25	Pamukkale University	1	1.5
26	Selcuk University	2	3.1
27	Suleyman Demirel University	1	1.5
	Total	65	100

Table 3 shows the distribution of postgraduate theses on biotechnological concepts by study subjects, which were conducted in the field of science education between 2000 and 2020 in Turkey. As seen in Table 3, thesis studies were frequently conducted in the field of learning (f = 44; 30.2%). It was observed that the theses conducted in the field of learning include the sub-study subjects of determining the level of knowledge/achievement (f=33; 22.6%), conceptual understanding/learning (f=7; 4.8%), meaningful and permanent learning (f=2; 1.4%), and the need for information/ways of obtaining information (f=2; 1.4%). While attitude/perception/interest (f=37; 25.3%) study subjects take the second place among the study subjects of postgraduate theses on biotechnological concepts, the subject of teaching (f=28; 19.1%) study is in the third place. The least studied subject was determined to be purchase intention (f = 1; 0.7%).

Table 3. Distribution of the examined theses on biotechnological concepts by study subjects

Subject	Sub Study Subject	*f*	%
Learning Teory/Approach	Knowledge/Achievement	33	22.6
	Conceptual Understanding/Learning	7	4.8
	Meaningful and Permanent Learning	2	1.4
	Need for Information Ways of Gaining Information	2	1.4
	Total	44	30.2
Attitude/Perception/ Interest	Attitude	27	18.5
	Perception/Perception of Risk	6	4.1
	Interest	4	2.7
	Total	37	25.3
Teaching	Methods and Techniques	24	16.4
	Program/Material Design/ Investigation	4	2.7
	Total	28	19.1
Skill	Argumentation	5	3.4
	Critical Thinking	1	0.7
	Empathy Skill	1	0.7
	Informal Reasoning	1	0.7
	Total	8	5.5
Belief	Self-efficacy	4	2.7
	Epistemological Belief	1	0.7
	Total	5	3.4
Opinion/Thought		10	6.9
Bioethics/Values		5	3.4
Relationship		4	2.7
Scale Development		2	1.4
Scientific Literacy/The Nature of Science		2	1.4
Purchase Intention		1	0.7
Total		146	100

In addition to the data in Table 3 regarding the study subjects of the theses, the content analysis findings regarding which biotechnological concepts were studied in the examined theses are presented in Table 4. As seen in Table 4, the concepts of biotechnology (f = 34, 45.4%) and/or biotechnology applications were mostly preferred when choosing the study subject in theses. Following the concept of biotechnology, thesis studies were conducted mostly on the concepts of GMO (f = 21, 28%) and genetic engineering (f = 10, 13.4%).

**Table 4.** Distribution of biotechnology-related concepts used in postgraduate theses

Biotechnological Concept	*f*	%
Biotechnology / Biotechnological Applications	34	45.4
Genetically Modified Organisms (GMO)	21	28
Genetic Engineering	10	13.4
Cloning	6	8
Human Genome Project	1	1.3
Biosecurity	1	1.3
Nanobiotechnology	1	1.3
Recombinant DNA Technology	1	1.3
Total	75	100

Table 5. Distribution of research methods used in postgraduate theses

Research methods	F	%
Quantitative	41	63.1
Qualitative	6	9.2
Mixed	18	27.7
Total	65	100

According to Table 5, the quantitative research method was used in 41 (63.11%) postgraduate theses. In the theses examined within the scope of the study, the quantitative research method, one of the most used research methods, was followed by the mixed method (f = 18, 27.7%) and the qualitative research method (f = 6, 9.2%).
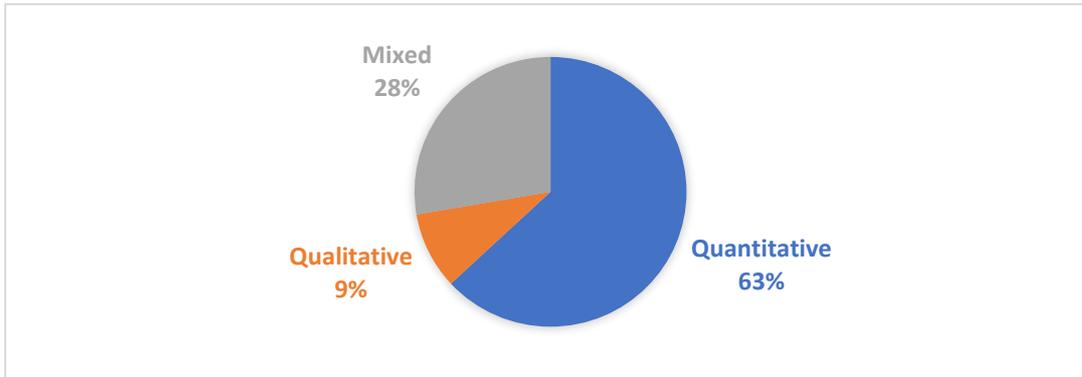
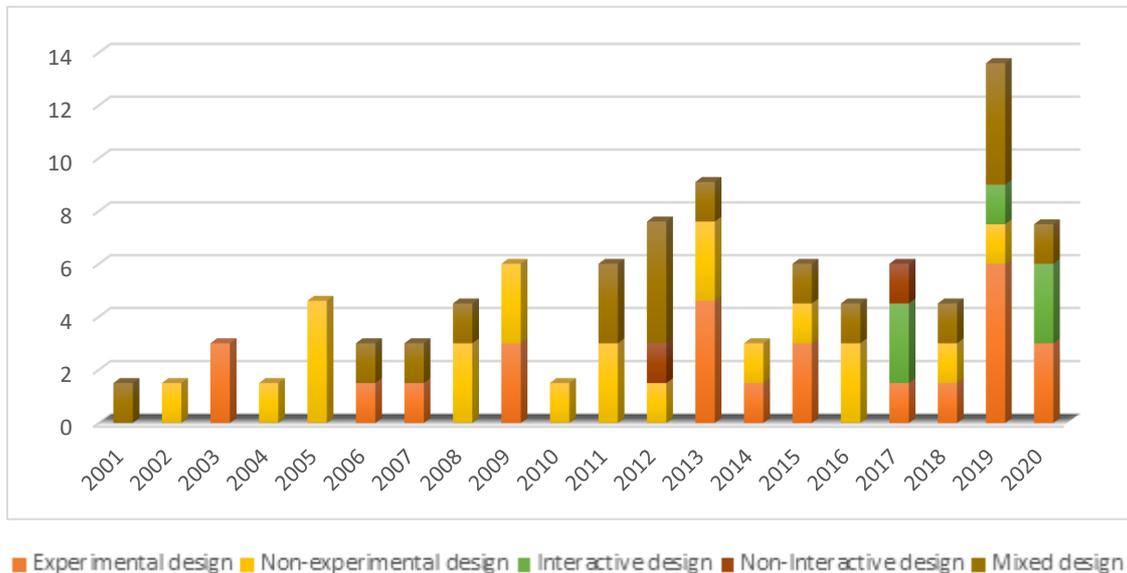**Figure 1.** *Percentage values of methods used in postgraduate theses*

When Figure 1 was examined, it was seen that quantitative, mixed and qualitative methods were used the most, respectively, in the examined graduate theses.

Table 6. Distribution of research designs and methods used in postgraduate theses

	Research design	Research method	f	%
Quantitative	Experimental	Quasi experimental	6	9.2
		Pre-experimental	22	33.8
		Sub-total	28	43.0
	Non-experimental	Survey	10	15.3
		Comperative	2	3.1
		Correlational	1	1.6
		Sub-total	13	20.0
Qualitative	Interactive	Case study	2	3.1
		Phenomenographic study	2	3.1
		Sub-total	4	6.2
	Non-interactive	Content analysis	2	3.1
		Sub-total	2	3.1
Mixed	Basic designs	Explanatory (Quan to Qual)	10	15.3
		Explaratory (Qual to Quan)	2	3.1
		Triangulation (Quan+Quan)	4	6.2
		Sub-total	16	24.6
	Advanced designs	Multistage evaluation	2	3.1
		Sub-total	2	3.1
		Total	65	100

The distribution of quantitative, qualitative, and mixed-method studies and designs was analyzed using the table developed by Gul and Sozbilir (2016). According to Table 6, the quantitative research method was the dominant research method (~ 63%) in the theses on the concept of biotechnology, and the number of studies conducted using the qualitative research method (~ 9%) was less than the quantitative and mixed methods (~ 28%). When Table 6 was examined in detail, it was seen that experimental designs (~ 43%) were preferred more than non-experimental designs (20%) in quantitative research. Furthermore, the weak experimental method (~ 34%) was used the most among the experimental design types in the theses, and the quasi-experimental methods (~ 9%) were used less. Among the non-experimental research designs, the most preferred method was the basic descriptive method (~ 15%), followed by causal comparison methods (~ 9%) and relational methods (~ 2%), respectively. When the interactive designs based on qualitative research methodology were examined in detail in Table 6, it was seen that phenomenology (~ 6%) and case studies (~ 3%) were used, whereas action research, ethnographic study, grounded theory, critical studies, and hermeneutic methods were not used.

Within the scope of qualitative methodology, it was seen that the content analysis method among non-interacting designs was used in only two studies (~ 3%). Among the theses examined, the number of mixed-method studies (~ 28%) was higher than those conducted with qualitative study methods (~ 9%). It was seen that basic designs were used more (~ 25%), while advanced designs (~ 3%) were not preferred more than the mixed method. It was revealed that explanatory (~ 15%), triangulation (~ 6%), and exploratory (~ 3%) basic designs were used in mixed-method studies, respectively.

Figure 2. *Percentage values of designs used in postgraduate theses by years*

Figure 2 shows the trends of the theses on the concept of biotechnology in terms of research designs by years. As seen in the figure, interactive research designs were used in 2017, 2019, and 2020. While there were studies using a single type of research design until 2005, 2019 was the year with the highest number of studies and the most diversity in terms of research design. There was a decrease in the number of studies conducted in 2010, and a rising trend has been observed in the number of theses written in the field of biotechnology and the variety of research designs as of 2011. Especially in 2019 and 2020, there was an increase in experimental research designs, while a decrease in non-experimental research designs was observed.

**Table 7.** Distribution of data collection tools used in postgraduate theses

Type of data collection tools	F	%
Questionnaires*		
Open-ended	3	4.6
Likert type	10	15.3
Multiple choice	-	-
Others	4	6.2
Achievement tests*		
Multiple choice	26	40
Open-ended	8	12.3
Others	10	15.3
Aptitude, attitude, perception, personality etc. tests	47	72.3
Interviews*		
Semi-structured	12	18.4
Structured	1	1.5
Unstructured	-	-
Focus group interviews	-	-
Observations		
Non-participant observation		-
Participant observation	1	1.5
Alternative assessment tools	10	15.3
Documents	1	1.5
Others	1	1.5

The distribution of data collection tools was analyzed using the table developed by Gul and Sozbilir (2016). Among the data collection tools, mostly skills, attitudes, perceptions, personality, etc. tests (~ 72%), achievement tests (~ 67%), questionnaires (~ 26%), interviews (~ 20%), and alternative assessment tools (~ 15%) were used (Table 7). The least preferred data collection tools were documents (~ 2%) and others (~ 2%). Among the types of questionnaires in the studies, Likert type (~ 15%), others (~ 6%), and open-ended questionnaire (~ 5%) types were used, respectively. It was seen that multiple-choice (~ 40%), other (~ 15%), and open-ended (~ 12%) tests were used, respectively, among the achievement tests. The most preferred interviews in the studies were semi-structured interviews (~ 18%) and structured interviews (~ 2%), respectively.

Table 8. Distribution of samples studied in postgraduate theses
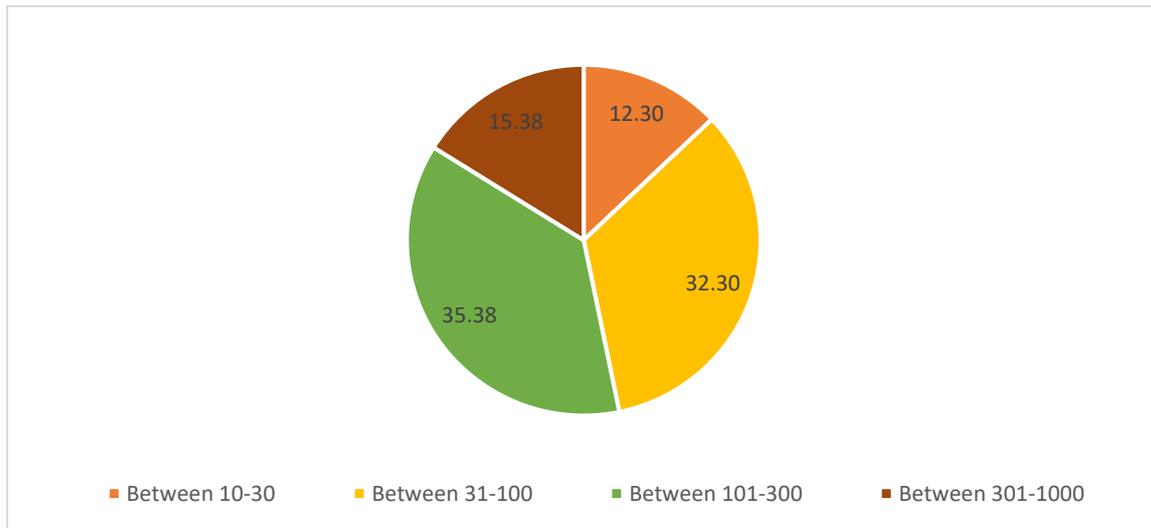
Sample	F	%
Middle School students (5-8)		
5th-grade	47	3
6th-grade	-	-
7th-grade	202	13
8th-grade	1154	74
Total	1553	100
High School students (9-12)		
9th-grade	538	25.67
10th-grade	510	24.33
11th-grade	682	32.53
12th-grade	366	17.47
Total	2096	100
University students		
Science teacher candidates	3777	73.20
Biology department teacher candidates	432	8.40
Class teacher candidates	296	5.70
Other departments	655	12.70
Total	5160	100
Teachers		
Science teachers	571	44.16
Biology teachers	179	13.84
Other branches	543	42.00
Total	1293	100

The sample groups used in theses were mostly undergraduate students (f = 5160), high school students (f = 2096), middle school students (f = 1553), and teachers (f = 1293), respectively. When the distribution of the sample populations was examined in detail, it was observed that the most studied sample groups included pre-service science teachers (f = 3777) from university students, 11th-grade students (f = 682) from high school students, and 8th-grade students from middle school students and science teachers (f= 571) from teachers (Table 8).
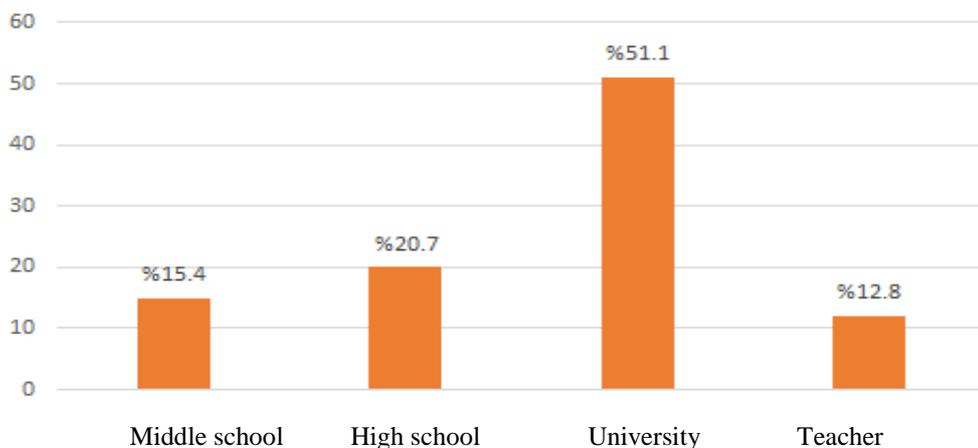
Figure 3. *Distribution of sample groups used in theses*

According to Figure 3, the samples studied in the theses in the field of biotechnology were mostly university students (~ 51%), high school students (~ 21%), middle school students (~ 15%), and teachers (~ 13%), respectively.

Figure 4. *Distribution of the sample size used in theses*

According to Figure 4, the main sampling range used in theses was 101-300 (35.38%). This sample range was followed by the sampling intervals of 31-100 (32.30%), 301-1000 (15.38%), and 10-30 (12.30%), respectively.

4 | DISCUSSION & CONCLUSION

This study conducted the content analysis of postgraduate thesis studies done nationally between 2000-2020 on the use of biotechnology and other concepts related to this concept in the field of science education. Upon examining the findings obtained from the research in line with the research questions, it is noteworthy that the first thesis study conducted in Turkey in the field of biotechnology education was prepared in 2001 as a master's thesis, and the first doctoral dissertation was conducted in 2005. Considering that the effects of biotechnological developments on human life started in the last quarter of the 20th century and continued increasingly in the 21st century, it is a very positive finding that the first thesis study in Turkey was conducted in the early 2000s and continued to increase depending on the years. This finding shows that in parallel with biotechnological developments, biotechnology education studies have also started in the field of science education, and the subject has attracted increasing attention. However, another factor that caused this increase is that although the history of scientific research in the field of science education in Turkey dates back to the 1990s (Sozbilir & Canpolat, 2006), there are very few scientific studies in the literature before these years. Moreover, it can be said that research in science education gained speed in our country with the restructuring of education faculties in 1997 (Kaltakcı-Gurel et al., 2017). Likewise, according to the results of the research conducted by Dogru et al. (2012) to analyze the content of master's and doctoral theses on science education in Turkey between 1990 and 2009, a significant increase has been observed in the number of theses in all fields since 2005-2006.

Another remarkable finding is that approximately 85% of the postgraduate theses included in the content analysis were master's theses, and very few doctoral dissertations were written. According to the study results, most of the thesis studies on the aforementioned concepts were master's theses because the number of graduate students in our country was higher than the number of doctoral students. However, it was thought that it would be positive for researchers to focus on biotechnology-related topics in their doctoral studies, even in a small number, in terms of responding to the need and contributing to the field when the speed of developments in this field was taken into account.

Considering the distribution of theses in the CoHE National Thesis Center by universities, it was determined that postgraduate theses on biotechnological concepts and written in the field of science education were carried

out in a total of 27 universities in Turkey, and most of these theses (about one-third) were prepared at Gazi University. After Gazi University, Inonu University and Bolu Abant Izzet Baysal University stand out.

When the subject distribution of the postgraduate theses on biotechnological concepts in our country was examined, it was observed that learning (~ 30%)-based thesis studies were dominant, attitude/perception/interest (~ 25%) studies were in the second place, followed by teaching (~ 19%) studies. In line with these results, it can be said that the topics of learning and teaching stand out among the subjects studied in relation to biotechnological concepts. Considering the field of biotechnology, there are many studies in the literature in which there are difficulties in learning the concept, misconceptions, and students have inadequate and incorrect information (Dawson, 2007; Prokop, Lešková, Kubiatko and Diran, 2007; Surmeli & Sahin, 2009; Semenderoğlu & Aydın, 2014; Usak, Erdogan, Prokop & Özel, 2009; Yuce & Yalcın, 2012). The fact that postgraduate thesis studies carried out in the field of learning include subjects such as determining the level of knowledge/achievement, conceptual understanding, and meaningful learning was very positive at the point of determining and solving the problems encountered in learning biotechnological concepts. It is remarkable that teaching studies are mostly based on method and technique comparisons. In this sense, postgraduate thesis studies conducted to determine different teaching methods and techniques that were thought to be effective in learning contributed significantly to the literature.

Another interesting result is that nearly a quarter of the graduate thesis studies were subject-oriented attitude/interest/perception studies. There are many studies in the international literature, stating that biotechnological applications bring cultural, social, political, and economic discussions together and individuals who make up society usually have a negative attitude due to insufficient information (Dawson, 2007; Eaton, 2004; Gray & Bryce, 2006; Haynie & Greenberg, 2001; Leslie & Schibeci, 2006; Saez, Nino & Carretero, 2008). In this sense, it is an expected result that attitude/interest/perception subjects are among the most studied subjects in postgraduate thesis studies conducted in Turkey. It is also a striking finding that there are thesis studies on the issues of determining opinion, determining skills and beliefs, apart from the first three study topics mentioned above. However, the bioethics discipline, which has been emphasized to be very important in the literature, and the context of values education are among the topics of only seven dissertations (Altıparmak, 2005; Gor, 2019; Sürmeli, 2008; Yaman, 2011; Yazıcı, 2009; Yuce, 2011; Turgut, 2018). Considering that individuals exhibit an ethical attitude in the actions they face according to the belief and value system shaped by the cultural values of the society they live in (Ilgaz & Bilgili, 2006; Keskin, Samancı & Kurt, 2013), revealing the situation in our country will contribute significantly to the science education literature.

Considering the examined theses in terms of method, it was seen that mostly quantitative studies (f = 41) were performed and most of the remaining studies were conducted with the mixed method (f = 18). It was concluded that studies using qualitative research methodology (f = 6) were limited. The research questions in theses were mostly related to the knowledge, attitude, perception, risk-taking, etc. of the participants, and this may be the reason for the predominant use of the quantitative method. Theses using the mixed method also attract attention. The mixed method, in which qualitative and quantitative methods are blended together, is more effective than using these methods separately in terms of a better understanding of research problems (Creswell, 2008). It was seen that studies in which the qualitative research method was used alone were very limited. At every step of the qualitative research process, researchers are given the opportunity to develop new methods and approaches and make new arrangements to increase the impact of the research (Guba & Lincoln, 1994; Merriam, 1998). The difficulty in interpreting qualitative results for new researchers (Sozbilir, Kutu & Yasar, 2012) may be the reason for the limited use of qualitative methods in studies. In the theses, studies were carried out mostly with quantitative, mixed, and qualitative methods, respectively. Similar to the results of the current study, there were studies conducted mainly with mixed and quantitative methods in the literature (Inam & Guven, 2019; Kiras, 2019; Memis, 2017).

Among the quantitative research methods used in theses, experimental designs were preferred more than non-experimental designs. It was seen that weak experimental designs (f = 22) among the experimental designs were used more than quasi-experimental designs (f = 6).

Among the non-experimental quantitative methods, the most frequently used research model was the descriptive (screening) (f = 10) model. The reason for the frequent use of survey models can be shown as research

problems in dissertations that focus on identifying the knowledge, attitude, and perception of the participants regarding biotechnology.

In theses, talent, attitude, perception, personality, etc. tests (f = 47), achievement tests, Likert-type questionnaires, and semi-structured interviews were mostly used as the data collection tools (Table 7). The widespread use of quantitative research methods in the theses examined can be shown as the reason for the predominant use of tests such as skills, attitudes, perception, personality, etc. as data collection tools. In particular, multiple-choice achievement tests are preferred over alternative assessment tools due to the easier preparation, implementation, and scoring of multiple-choice tests. The results we obtained regarding the data collection tools in the theses are similar to the results of the study by Gul and Sozbilir (2015). Likert-type questionnaires are among the most widely used data collection tools (Sozbilir et al., 2012), and as data collection tools, surveys generally enable the quick and easy collection of data (De Joung, 2007). Questionnaires are frequently used in theses because they provide fast and easy data collection.

It was seen that participant observation was used as a data collection tool in only one study. Among the theses examined, qualitative studies were fewer in number than studies conducted with quantitative and mixed methods. The lower preference of qualitative research methods in theses can be shown as the reason why observation was used very little as a data collection tool (Ciltas, Guler & Sozbilir, 2012). Considering the sample populations, the most preferred sample group was university students, followed by high school students, middle school students, and teachers, respectively. The most preferred sample group was at the undergraduate level, and working especially with pre-service teachers emphasizes the importance of teacher education and raising individuals who are familiar with subjects, concepts, and processes related to biotechnology as future teachers. Moreover, research is conducted with students at the undergraduate and high school levels because these samples are the most suitable populations for research problems and are easily accessible. In the theses examined, the sample size used was between 101-300, 31-100, 301-1000, and 11-30, respectively, from high to low. In qualitative studies, sample sizes of less than 50 people are preferred, while quantitative studies are carried out with samples of 500 or more (Yagan & Cubukcu, 2021). It can be said that the sample size was generally large since the quantitative research method was mainly used in the theses examined in the present study (f = 41). A study examining international trends in biology education research through content analysis revealed that qualitative research methods were used predominantly and sample sizes were mostly between 31 and 100 (Gul & Sozbilir, 2015), which is consistent with the results of our study.

REFERENCES

Aksoy, F. (2006). *Lise öğretmenlerinin genetiği değiştirilmiş gıdalara ilişkin bilgi düzeyleri, görüşleri ve bilgilendirilme ihtiyaçlarının belirlenmesi: Adana Örneği [The determination of knowledge levels, opinions and informational needs toward genetically modified foods of highschool teachers: A sample of Adana]* (Publication No. 233814) [Master's thesis, Ankara *University*]. https://tez.yok.gov.tr/UlusalTezMerkezi/

Albe, V. (2008). When scientific knowledge, daily life experience, epistemological and social considerations ıntersect: students' argumentation in group discussions on a socioscientific ıssue. *Research in Science Education, 38,* 67-90. https://doi.org/10.1007/s11165-007-9040-2

Altıparmak, M. (2005). *Rekombinant DNA Teknolojisinin Öğretiminde İnteraktif Uygulamalar ve Biyoetik [Teaching recombinant DNA technology with interactive applications and bioethics]* (Publication No. 162143) [Doctoral dissertation, Dokuz Eylul *University*]. https://tez.yok.gov.tr/UlusalTezMerkezi/

Aydin, S. & Cetin, K. (2020). Science and Classroom Teacher Candidates' Knowledge and Attitudes About Biotechnology. *International Journal of Education Technology and Scientific Researches*, *5*(11), 631-656. https://doi.org/10.35826/ijetsar.82

Cicekci, O. (2008). İlköğretim okullarında görevli öğretmenlerin transgenik (gdo) konusundaki bilgilerinin ve görüşlerinin belirlenmesi [Determining the knowledge and the opinions abaut the transgenic products (GMO) of the teacers in primary school] (Publication No. 219677) [Master's thesis, Gazi University]. https://tez.yok.gov.tr/UlusalTezMerkezi/

Ciltas, A., Guler, G., & Sozbilir, M. (2012). Türkiye'de matematik eğitimi araştırmaları: İçerik analizi çalışması [Mathematics education research in Turkey: A content analysis study]. *Educational Sciences: Theory and Practice , 12*(1), 515-580.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed.). Routledge.

Creswell, J. W. (2008). *Educational research planning, conducting and evaluating quantitative and qualitative research*. International Pearson Merril Prentice Hall.

Darcın, E. S. (2003). Biyoteknoloji Dünyasındaki Yerimiz [Our place in the world in biotechnology]. *Sakarya University Journal of Education Faculty, 6,* 305-315.

Darcın, E. S. (2007). *Fen-teknoloji ve biyoloji öğretmen adayları için biyoteknoloji eğitiminin deneysel planlanması [Experimental planning of biotechnology training for trainee science-technology and trainee biology teachers]* (Publication No. 206943) [Doctoral dissertation, Gazi University]. https://tez.yok.gov.tr/UlusalTezMerkezi/

Darcın, E. S. (2011). Turkish pre-service science teachers' knowledge and attitude towards application areas of biotechnology. *Scientific Research and Essays, 6*(5). 1013-1019.

De Jong, O. (2007). Trends in western science curricula and science education research: A bird's eye view. *Journal of Baltic Science Education*, *6*(1), 15-22.

Demirci, A. (2008). Perceptions and attitudes of geography teachers to biotechnology: A study focusing on genetically modified (gm) foods. *African Journal of Biotechnology, 7*(23), 4321-4327. https://www.ajol.info/index.php/ajb/article/view/59580

Dogru, M., Gencosman, T., Ataalkın, A. N., & Seker, F. (2012). Fen bilimleri eğitiminde çalışılan yüksek lisans ve doktora tezlerinin analizi [Analysis of master's and doctoral theses in science education]. *Türk Fen Eğitimi Dergisi, 9*(1), 49-64.

Eaton, M. (2004). *Ethics and the Business of Bioscience*. Stanford University Press.

Fonseca, M. J., Costa, P., Lencastre, L., & Tavares, F. (2011). Disclosing biologyteachers' beliefs about biotechnology and biotechnology education. *Teacher and Teaching Education, 28*, 368-381. https://doi.org/10.1016/j.tate.2011.11.007

France, B. (2000). *The Role of Models in Biotechnology Education: An Analysis Teaching Models. In Gilbertt, John and Boulter*, Carolyn (Eds.), Developing models in science education. (pp. 271-288). Kluwer Academic Publishers.

France, B. (2007). Location, location, location: Positioning biotechnology education for the 21st century. *Studies in Science Education, 43*(1), 88-122. https://doi.org/10.1080/03057260708560228

Gor, S. (2019). *Fen Bilgisi Öğretmen Adaylarının Genetiği Değiştirilmiş Organizmalara (GDO) İlişkin Karakter ve Değer Eğilimlerinin Belirlenmesi [Determination of character and value trends of science teacher candidates related to genetically modified organisms* (GMO)] (Publication No. 594084) [Master's thesis, Aksaray University]. https://tez.yok.gov.tr/UlusalTezMerkezi/

Gray, D. G., & Bryce, T. (2006). Socio-scientific issues in science education: Implications for the professional development of teachers. *Cambridge Journal of Education, 36*(2), 171-192. https://doi.org/10.1080/03057640600718489

Guba, E. G. & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research, 2*(105), 163-194.

Gul, Ş., & Sozbilir, M. (2015). Biology education research trends in Turkey: 1997-2012. *Eurasia Journal of Mathematics, Science & Technology Education*, *11*(1), 93-109. https://doi.org/10.12973/eurasia.2015.1309a

Gul, Ş., & Sozbilir, M. (2016). International Trends in Biology Education Research from 1997 to 2014: A Content Analysis of Papers in Selected Journals. *Eurasia Journal of Mathematics, Science and Technology Education, 12*(6), 1631-1651. https://doi.org/10.12973/eurasia.2015.1363a

Gurkan, G. & Kahraman, S. (2018). Fen Bilgisi Öğretmen Adaylarının Biyoteknoloji ve Genetik Mühendisliği Bilgi Düzeyleri [Knowledge Levels of Preservice Science Teachers about Biotechnology and Genetic Engineering]. *Karaelmas Journal of Educational Sciences*, 6(1), 25-39.

Hanegan, N. L., & Bigler, A. (2009). Infusing authentic inquiry into biotechnology. *Journal of Science Education and Technology, 18*(5), 393-401.

Haynie, W. J., & Greenberg, D. (2001). Genetic disorders: An integrated curriculum project. *The Technology Teacher, 60*(6), 10-13.

Ilgaz, S., & Bilgili, T. (2006). Eğitim ve Öğretimde Etik [Ethics in Education and Training]. Journal of *Kazim Karabekir Education Faculty, 14*, 199-210.

Inam, A., & Guven, S. (2019). Argümantasyon Yönteminin Kullanıldığı Deneysel Çalışmaların Analizi: Bir Meta-Sentez Çalışması [Analysıs of Experımental Studıes Usıng Argumentatıon Method: A Meta-Synthesıs Study]. *The Journal of International Lingual Social and Educational Sciences, 5*(1), 155-173. https://doi.org/10.34137/jilses.584642

Kaltakcı-Gurel, D., Olmezturk, A., Durmaz, B., Abul, E., Ozun, H., Irak, M., Subası, Ö., & Baydar, Z. (2017a). 1990-2016 yılları arasında Türkiye'de fizik eğitimi alanında yapılmış lisansüstü tezlerin içerik analizi [The content analysis of the graduate theses in physics education in Turkey between the years 1990 and 2016]. *Gazi Journal of Education Sciences, 37*(3), 1141-1172. https://doi.org/10.17152/gefad.335238

Keskin, Ö. M., Samancı, K. N., & Kurt, İ. (2013). Öğretmen adaylarının güncel etik konular hakkındaki görüşlerinin bazı değişkenler açısından incelenmesi [The Investigation of the Opinions of Teacher Candidates about Current Ethical Issues in Terms of Various Variables]. *Journal of Higher Education and Science, 3*(2), 142-152.

Kidman, G. (2009). Attitudes and interests towards biotechnology: the mismatch between students and teachers. *Eurasia Journal of Mathematics, Science & Technology Education, 5*(2), 135-143. https://doi.org/10.12973/ejmste/75265

Kiras, B. (2019). *Türkiye'deki fen eğitimi konulu tezlerin konu yönelimi ve yöntemsel analizi [Trend in topics and methodological analysis of theses on science education in Turkey].* (Publication No. 602313) [Doctoral dissertation, Abant Izzet Baysal University]. https://tez.yok.gov.tr/UlusalTezMerkezi/

Kolsto, S. O. (2006). Patterns in students' argumentation confronted with a risk focused socio-scientific ıssue. *International Journal of Science Education, 28*(14), 1689-1716. https://doi.org/10.1080/09500690600560878

Lamanauskas, V., & Makarskaitė-Petkevičienė, R. (2008). Lithuanian university students 'knowledge of biotechnology and their attitudes to the taught subject. *Eurasia Journal of Mathematics, Science & Technology Education, 4*(3), 269-277. https://doi.org/10.12973/ejmste/75349

Leslie, G., & Schibeci, R. (2006). Teaching about designer babies & genetically modified foods: Encouraging the teaching of biotechnology in secondary schools. *American Biology Teacher, 68*(7), 98-103.

Marchant, R., & Marchant, E. M. (1999). GM plants: concepts and issues. *Journal of Biological Education, 34*(1), 5-12.

Memis, E. K. (2017). Türkiye'de argümantasyon konusunda gerçekleştirilen tezlerin analizi: bir meta-sentez çalışması [Analysis of theses on argumentation in Turkey: a meta-synthesis study]. *Cumhuriyet International Journal of Education*, *6(1)*, 47-65. https://doi.org/10.30703/cije.321436

Merriam, S. B. (1998). *Qualitative Research and Case Study Applications in Education. Revised and Expanded from" Case Study Research in Education".* Jossey-Bass Publishers.

Moerbeek, H. H. S., & Casimir, G. J. (2005) Gender differences in consumers' acceptance of genetically modified foods, *International Journal of Consumer Studies, 29*(4), 308-318. https://doi.org/10.1111/j.1470-6431.2005.00441.x

Nielsen, J. A. (2012). Science in Discussions: An analysis of the use of science content in socio-scientific discussions. *Science Education, 96*(3), 428-456. https://doi.org/10.1002/sce.21001

Ocal, E. (2012). *İlköğretim Fen bilgisi öğretmenlerinin biyoteknoloji (genetik mühendisliği) farkındalık düzeyleri [The level of biotechnology (genetic engineering) awareness of elementary science teachers]*. (Publication No. 300586) [Master's thesis, Inonu University]. https://tez.yok.gov.tr/UlusalTezMerkezi/

Olsher, G., & Dreyfus, A. (1999). The "ostension-teaching" approach as means to develop junior high school studens attitudes towards biotechnologies, *Journal of Biological Education, 34*(1), 25-31.

Prokop, P., Lešková, A., Kubiatko, M., & Diran, C. (2007). Slovakian students' knowledge of and attitudes toward biotechnology. *International Journal of Science Education, 29*(7), 895-907. https://doi.org/10.1080/09500690600969830

Qin, W. & Brown, J. L. (2007). Public reactions to information about genetically engineered foods: Effects of information formats and male/female differences. *Public Understanding of Science 16*(4), 471-488. https://doi.org/10.1177/0963662506065336

Saez, M. J., Nino, A. G., & Carretero, A. (2008). Matching society values: Students' views of biotechnology. *International Journal of Science Education, 30*(2), 167-183. https://doi.org/10.1080/09500690601152386

Semenderoğlu, F. & Aydın, H. (2014). Effect of constructivist approach on students' conceptual understanding of biotechnology and genetic engineering topics. *Electronic Turkish Studies, 9*(8), 751- 773. http://dx.doi.org/10.7827/TurkishStudies.6634

Senler, B., Kozcu Çakır, N., Gorecek, M. & Gocmen-Taskın B. (2006). Determınıng the knowledge level of scıence teachers on bıotechnology (Mugla sample). *Hacettepe University Journal of Education, 31,* 126-132. http://hunefd/article/view/5000048622.

Sıcaker, A. & Ozaydın, S. (2015). Ortaöğretim biyoteknoloji ve gen mühendisliği kavramlarının öğrenciler tarafından değerlendirilmesi [Evaluation of Biotechnology and Genetic Engineering Concepts by Secondary Students]. *Ondokuz Mayis University Journal of Faculty of Education*, *34*(2), 51-67.

Sozbilir, M., & Canpolat, N. (2006). Fen eğitiminde son otuz yıldaki uluslar arası değişmeler: Dünyada çalışmalar nereye gidiyor? Türkiye bu çalışmaların neresinde? [Developments in science education in the last thirty years: Where the researches go in the world? Where Tur- key is about in these researches?] (417–432). In M. Bahar. (Ed). *Teaching science and technology*. PegemA Publishers.

Sozbilir, M., Kutu, H., & Yasar, M.D. (2012). Science education research in Turkey: A content analysis of selected features of papers published. In J. Dillon & D. Jorde (eds.), *The World of Science Education: Handbook of Research in Europe* (pp. 1-35). Sense publishers.

Steele, F., & Aubusson, P. (2004). The challenge in teaching biotechnology. *Research in Science Education, 34*(4), 365-387.

Surmeli, H. (2008*). Üniversite öğrencilerinin biyoteknoloji ve genetik mühendisliği çalışmaları ile ilgili tutum, bilgi ve biyoetik görüşlerinin değerlendirilmesi [Evaluation of university students' attitudes, knowledge and bioethical perceptions about biotechnological and genetic engineering studies].* (Publication No. 226375) [Master's thesis, Marmara University]. https://tez.yok.gov.tr/UlusalTezMerkezi/

Surmeli, H., & Sahin, F. (2009). Üniversite öğrencilerinin biyoteknoloji çalışmalarına yönelik bilgi ve görüşleri [Information and opinions of university students on biotechnology studies]. *Cukurova University Faculty of Education Journal, 3*(37), 33-45.

Tavsancıl, E., & Aslan, E. (2001). *İçerik analizi ve uygulama örnekleri* [Content analysis and application examples]. Epsilon Yayınları.

Thomas, M., Keirle, K. & Griffith, G. (2002). The biotechnology summer school: a novel teaching initiative. *Innovations in Education and Teaching International, 39*(2). Retrieved 20 April 2021 from Internet: http://www.tandf.co.uk/journals/

Turgut, D. (2018). *Öğretmen adaylarının biyoetik değerleri, bilimsel okuryazarlık ve empati beceri düzeylerinin sınıflar bazında incelenmesi [Investigation of class-based to science teacher candidates' bioethical values, scientific literacy levels and empathy skills]* (Publication No. 524085) [Master's thesis, Pamukkale University]. https://tez.yok.gov.tr/UlusalTezMerkezi/

Turkmen, L., & Darcın, E. S. (2007). A Comparative study of Turkish elementary and science education major students' knowledge levels at the popular biotechnological ıssues. *Internatiol Journal of Environmental and Science Education. 2*(4), 125-131. https://eric.ed.gov/?id=EJ901276

Usak, M., Erdogan, M., Prokop, P. & Ozel, M. (2009). High school and university students' knowledge and attitudes regarding biotechnology. *Biochemistry and Molecular Biology Education, 37*(2), 123-130.

Walker, K., & Zeidler, D.L. (2007). Promoting discourse about socioscientific issues through scaffolded inquiry. *International Journal of Science Education, 29*(11), 1387-1410. https://doi.org/10.1080/09500690601068095

Yagan, S. A., & Cubukçu, Z. (2021). The content analysis of doctoral dissertations completed in the field of curriculum and instruction (2006-2017). *Hacettepe University Journal of Education, 36*(1), 157-176. http://dx.doi.org/10.15390/EB.2015.4784

Yaman, H. H. (2011). *Argümantasyon tabanlı biyoetik eğitiminde örnek bir uygulama: Genetiği değiştirilmiş organizma ve genetik tarama testi [Argumentation based bioethics education: Genetically modified organisms and genetic screening tests]* (Publication No. 317172) [Master's thesis, Gazi University]. https://tez.yok.gov.tr/UlusalTezMerkezi/

Yazıcı, N. N. (2009). *Bilim kurgu ile biyoetik grup tartışmalarının biyoteknolojiye yönelik tutumlar ve akademik başarı üzerine etkileri [The effects of science fiction and bioethics group discussions on academic achievement and attitudes towards biotechnologies]* (Publication No. 258856) [Master's thesis, Mugla University]. https://tez.yok.gov.tr/UlusalTezMerkezi/

Yıldırım, A., & Simşek, H. (2008). *Sosyal Bilimlerde Nitel Araştırma Yöntemleri* [Qualitative research methods in the social sciences]. Seckin Publishing.

Yuce, Z. (2011). *Fen bilgisi öğretmenliği öğrencilerinin biyoteknoloji konusundaki bilgileri ve biyoteknoloji uygulamalarına yönelik biyoetik yaklaşımları: Tutum, görüş ve değer yargıları [Preservice science teachers? knowledges about biotechnology and their bioethic approaches towards biotechnology practices: Attitudes, views and values]* (Publication No. 298435) [Doctoral dissertation, Gazi University]. https://tez.yok.gov.tr/UlusalTezMerkezi/

Yuce, Z., & Yalcın, N. (2012). Fen bilgisi öğretmen adaylarının biyoteknoloji konusundaki bilgi düzeyleri [The knowledge level of preservice science teachers about biotechnology]. X. National Science and Mathematics Education Congress. http://kongre.nigde.edu.tr/xufbmek/dosyalar/tam_metin/pdf/2261-16_05_2012 10_53_15. pdf

Appendix 1. The postgraduate theses examined in the study (f=65)

Thesis No	Thesis Author/ University	Thesis Name	Thesis Year
1	Yunus Ozyurt/Bolu Abant Izzet Baysal University	Diagnosis of key science concepts and examination of science teaching programs and national textbooks within the context of these concepts	2020
2	Fatma Nur Turan/Hacettepe University	Student conceptions about cloning	2020
3	Ebru Yilmazcelik/Suleyman Demirel University	The effect of argumentation method on the academic achievement and attitude of science teacher candidates in 'Genetic copying' unit	2020
4	Merve Tabak/Eskisehir Teknik University	High school students 'attitudes, opinions and purchase intention on genetically modified organisms: An examination in Eskisehir TOKİ Şehit İkram Cirit Anatolian High School	2020
5	Derya Kara/Gazi University	Opinions of primary school teacher candidates' about genetically modified organisms one of the socio-scientific topic	2020
6	Veysel Arslankara/ Necmettin Erbakan University	Opinions of prospective science teachers on the importance of biotechnology in science education: The case of Konya	2019
7	Tugce Yagmur Orhan/ Mugla Sıtkı Kocman University	The impact of innovative teaching approaches on the biotechnology related laboratory experiences of science teachers	2019
8	Ramazan Sogukpinar/Aydin Adnan Menderes University	Investigation of preservice science teachers' attitudes towards genetic and biotechnology	2019
9	Fatma Eda Vuran/Gazi University	The effect of genetic engineering and biotechnology activities on students 'success, attitude and self evaluations	2019
10	Hilal Agac/Canakkale Onsekiz Mart University	The effect of science teacher candidates on knowledge and attitudes of structured experimental applications on 'agricultural biotechnology'	2019
11	Selin Akdoner/Cukurova University	Investigation of the effect of the application of the development of argumentation - supported cooperative learning methods on the genetics of a modified organization (GMO) on the academic achievements of the ten years students	2019
12	Kaan Inaltekin/Gazi University	Knowledge levels and attitudes of secondary school 7th and 8th year students about genetically modified organisms	2019
13	Selvi Gor/Aksaray University	Determination of character and value trends of science teacher candidates related to genetically modified organisms (GMO)	2019
14	Ayten Yildirgan/ Aksaray University	Science 3. graduate teacher candidates determination of the opinions of genetically modified organisms	2019
15	Emine Guney/Necmettin Erbakan University	Development of attitude scale about genetically modified organisms and evaluation of biology student teachers' attitude about genetically modified organisms in terms of different variable	2018
16	Muzeyyen Akyuz/Karadeniz Teknik University	The effect of argumentation-based learning environment on pre-service elementary teachers' conceptual understanding a case of genetically modified organism	2018
17	Duygu Turgut/Pamukkale University	Investigation of class-based to science teacher candidates' bioethical values, scientific literacy levels and empathy skills	2018
18	Meryem Demirci/Kafkas University	Experimental planning on teaching of biotechnology and genetic engineering for 8th grade students	2017

19	Fatma Bilgican/Balıkesir University	Designing instructional material for teaching the biotechnology topic with usage of active learning at secondary schools	2017
20	Zeynep Ertas Karaaslan/Dicle University	Preservice science teachers' metaphors and visual images on genetically modified organisms (GMO)	2017
21	Eyuphan Bahadir/Giresun University	The determination of prospective classroom teachers views on genetically modified organisms	2017
22	Asiye Kilinccioglu/Gazi University	Investigating the level of ability of 8th level science and technology syllabus to raise interest of students towards biotechnology	2016
23	Emine Camur/Gazi University	The relationship of pre-service biology teachers' attitudes towards biotechnology practices and their scientific epistemological beliefs	2016
24	Gulay Urhan/Gazi University	An examination of students' quality of arguments and informal reasoning skills in argumentation based learning environments	2016
25	Esra Acikgul Firat/ Inonu University	Effects of instruction supported by web 2.0 tools on prospective teachers' biotechnology literacy	2015
26	Sevde Yasar Cimen/Fatih University	Uygulamalı biyoteknoloji eğitiminin öğretmen ve öğretmen adaylarının biyoteknolojik algıları üzerine etkileri	2015
27	Asli Kocyigit/Ondokuz Mayıs University	Determination of level of knowledge, self-efficacy confidence, attitudes and risk perceptions of science teachers about GMOs and their products	2015
28	Halil Kaya/Cukurova University	Biotechnology education from the teachers' perspective	2015
29	Elif Sonmez/Kastamonu University	The effects of extra-curricular activities of biotechnology on students' biotechnology knowledge and their nature of science perceptions	2014
30	Umit Demiral/Karadeniz Teknik University	Investigating argumentation skills of pre-service science teachers in a socio-scientific issue in terms of critical thinking and knowledge level: GM foods case	2014
31	Besime Ergin/Adıyaman University	Researching the effect of discussion-based teaching activities to the teacher candidates about their ideas at risk taking sensation and critical thoughts related to genetically modified (GM) food	2013
32	Onur Aydogmus/Gazi University	The effect of laboratory aided teaching in biotechnology to the students? academic achievement	2013
33	Aysun Sicaker/Balıkesir University	The development study of a secondary school biotechnology and genetic engineering knowledge scale with rasch measurament model	2013
34	Gulsah Gurkan/Inonu University	The comparison for several variables of knowledge levels of science teachers and prospective science teachers about biotechnology and genetic engineering	2013
35	Ahmet Guccuk/Inonu University	Effect of case teaching on learning genetics engineering subject meaninifully and retention of the learning	2013
36	Seda Baltaci/Abant Izzet Baysal University	Preservice science teachers teaching efficacy beliefs about a socioscientific issue (GM foods) and the relationships between efficacy beliefs and epistemological beliefs	2013
37	Evrim Ocal/ Inonu University	The level of biotechnology (genetic engineering) awareness of elementary science teachers	2012
38	Umran Atabas/Fatih University	A study for training and raising awareness of elementary school students about nanotechnology and biotechnology subjects	2012
39	Yilmaz Soysal/Abant Izzet Baysal University	Influence of content knowledge level to socioscientific argumentation quality: Genetically modified organisms	

			2012
40	Funda Semenderoglu/Dokuz Eylul University	The effect of a constructivist education program designed on high school students' perceptions about "human genetic structure and the genome project", misconceptions and attitudes towards biology course	2012
41	Ali Yigit Kutluca/Abant Izzet Baysal University	Investigating of pre-service science teachers? socio-scientific and scientific argumentation quality in terms of content knowledge level	2012
42	Zeynep Yuce/Gazi University	Pre-service science teachers? knowledges about biotechnology and their bioethic approaches towards biotechnology practices: Attitudes, views and values	2011
43	Muhammed Said Dogru/Kastamonu University	Primary 8 grade students' about biotechnology approaches and measure the levels of knowledge	2011
44	Hafize Hale Yaman/Gazi University	Argumentation based bioethics education: Genetically modified organisms and genetic screening tests	2011
45	Arzu Sonmez/Ahi Evran University	Science and technology student teachers' knowledges, risk perceptions, attitudes about GMO foods and self-efficacy about teaching GMO foods	2011
46	İpek Bici/Gazi University	The evaluation of the students' knowledge levels and attitudes related to genetically modified organisms and biosafety concepts	2010
47	Gokben Kilic/Gazi University	Nanobiotechnology education of biology teaching programme students studying at educational sciences at universities	2008
48	Osman Celik/Selcuk University	The evaluation of the effectiveness of biotechnology education at secondary levels	2009
49	Pinar Sentürk/Selcuk University	The investigation of basic knowledge and concepts about biotecnology of biology teachers and biology teacher candidates	2009
50	Nejla Kaya/Mugla University	Birlikte öğrenme gruplarında pratik deney ve materyal tasarımları ile biyoteknoloji öğretiminin başarı ve tutum üzerine etkileri	2009
51	Nigda Nermin Yazici/Mugla University	The effects of science fiction and bioethics group discussions on academic achievement and attitudes towards biotechnologies	2009
52	Hikmet Surmeli/Marmara University	Evaluation of university students' attitudes, knowledge and bioethical perceptions about biotechnological and genetic engineering studies	2008
53	Osman Cicekci/Gazi University	Determining the knowledge and the opinions abaut the transgenic products (GMO) of the teacers in primary school	2008
54	Emine Selcen Darcin/Gazi University	Experimental planning of biotechnology training for trainee science-technology and trainee biology teachers	2007
55	Rukiye Ozcan/Gazi University	The effect of project based learning approach in algal biotechnology to the students' academic achievement, attitude and opinions	2007
56	Fatma Aksoy/ Ankara University	The determination of knowledge levels, opinions and informational needs toward genetically modified foods of highschool teachers: A sample of Adana	2006
57	Sevgi Eroglu/ Gazi University	The effect of audio visual-material usage of third grade high school students' learning biotechnological conception and their attitude	2006
58	Aylin Sevimli/Gazi University	The effects of laboratory based learning on Gazi University, Gazi Faculty of Education, science education 3rd grade student's learning Agrobacterium mediated gene transfer	2005

59	Sezin Tanir/Gazi University	Çukurova University first year science field students knowledge level about 'biotechnology and genetical engineering'	2005
60	Melek Altiparmak/Dokuz Eylul University	Teaching recombinant DNA technology with interactive applications and bioethics	2005
61	Teslime Esra Kaytanci/Gazi University	The interest of secondary eduction students towards the genetic engineering	2004
62	Nilay Keskin/Gazi University	The Effect of poster presentation activity on science education 3rd grade students' learning gene cloning	2003
63	Burcu Saglamer/Marmara University	The Improvement and the conceptualization of biotechnology in the students of primary education	2003
64	Gokhan Goktan/Hacettepe University	The Importance and the place of biotechnology which has interdisciplinary implentation field at chemistry education	2002
65	Havva Meltem Kurtuldu/Balıkesir University	The Curriculum design of the units science for the years of 2000, biology for high school first grade and biotechnology and genetics engineering for high school third grade	2001