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RESEARCH ARTICLE

Analysis of Postgraduate Theses on the Subject of Virtual Museum

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ABSTRACT

The aim of the research is to analyze postgraduate theses on the subject of virtual museums and to determine the general trends in theses. This study, which is a qualitative research, used descriptive content analysis. At the beginning of the data collection phase, a detailed search was conducted using the keyword "virtual museum" on the subject of the research using the "advanced search" tab in the National Thesis Search Center on the official website of the Council of Higher Education (CoHE). According to research findings, it was seen that postgraduate theses on the subject of virtual museums mostly consist of master's theses and students are mostly preferred as the research group. Despite the importance of virtual museums in education, academic studies on this subject are insufficient in number and existing studies offer a limited scope. It is important to increase the use of qualitative methods because postgraduate theses on virtual museums need to be diversified. It is possible to conduct more comprehensive and applied research on virtual museums.

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1. Introduction

The International Council of Museums has defined museums as permanent institutions that serve society and development, are open to society, and collect, research, preserve, share information and exhibit materials that bear witness to the environment in which they are located (Ulusoy, 2010). As museums prepare to welcome the 21st century, they have emphasized education and training, allowing people to spend their free time learning and having fun; museums have made their objects tangible and created an interactive social environment for everyone of all ages (Karadeniz, 2009). At the same time, museums can provide a space for individuals and groups to create meaning by interacting with narratives, artifacts and visuals (Falk & Dierking, 2000; Hein, 1999; Hooper-Greenhill, 1991). In addition, different types of museums have different purposes. For example, natural history museums aim to provide content related to cultures, environments, and science as well as to encourage students to develop personal interests in these topics (Abu-Shumays & Leinhardt, 2002; Marcus et al., 2012; Tal & Morag, 2007; Tran, 2007). One of the meaning-making strategies that support students' learning in museums is to provide students with options and opportunities to explore topics that interest them during museum visits (Falk & Dierking, 2000; Griffin & Symington, 1997; Kisiel, 2003). Similarly, many types of museums offer students the opportunity to learn from objects and artifacts. By using museums related to various subject areas, more effective learning can be achieved. (Buyurgan & Mercin, 2005, p.12)

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Researchers have shown that effective service learning supports students' civic tendencies and skills, including social responsibility and civic participation (Kahne & Middaugh, 2010; Wade, 2008). It is stated that museum trips increase participation in class and academic success, facilitate learning, contribute to creative and historical thinking skills, and provide students with an aesthetic perspective. However, in the implementation of museum trips, there are difficulties such as security concerns, financial support, difficulties of current legislation, distance, and transportation (Atayeter & Tozkoparan, 2016; Önder et al., 2009; Sağdıç & Demirkaya, 2015). In order to overcome this problem and provide access to different museums in a globalizing world, the concept of virtual museums has been developed.

Virtual museum can be defined as an interactive website that offers digital copies of works of art, historical artifacts and documents and information about these works to its visitors via the internet by using the possibilities of information technologies (Turan, 2015, p. 190). At the same time, the definition of virtual museum can be made as follows: "Museums that contain digital objects and information about them prepared by using different media opportunities, that go beyond the usual communication methods to provide uninterrupted communication with the visitor and to meet various access methods, and that do not require a physical space in order to enable worldwide access" (Schweibenz, 2004, p. 3).

The foundations of virtual museums were laid with the concept of "imaginary museums without walls" at a time when technology was not yet developed. According to Çolak, "It can be said that it was laid with the discussion between Walter Benjamin and Andre Malraux on the problem of the 'aura of the work of art' in the second half of the 20th century. In response to Benjamin's claim that the aura of the work of art was damaged in the age when it could be reproduced with the possibilities of technology, Malraux argued that new auras were added to the work of art. This discussion enabled Malraux to develop the concept of the 'imaginary museum without walls' that anyone could access from anywhere, at a time when computer and communication technologies were not yet developed" (Çolak, 2006).

Virtual museums create a more interactive and dynamic learning environment by going beyond the traditional museum approach. These platforms, which support learning processes covering different disciplines such as history, art, geography, and social studies in education, provide students with different perspectives. Social studies is a pivotal course formed by the combination of many disciplines. Cultural heritage topics that allow students to understand the past are taught through social studies and history courses (Mazman Budak, 2021). Museums can facilitate historical and civic understanding in social studies. For example, history museums can increase students' historical understanding and provide historical inquiry opportunities by offering multiple perspectives and providing the opportunity to analyze historical evidence (Barton & Levstik, 2004; Marcus, 2008; Marcus, et al., 2012; Trofanenko, 2010). For example, in social studies, students can visit virtual exhibitions belonging to the Ottoman Empire, examine these works in historical context, and evaluate their connections to today's world. Such experiences both provide cultural awareness and develop critical thinking skills. From this perspective, this issue is becoming increasingly important. Because one of the most important benefits of academic studies to the literature is that they reveal current developments, practices and deficiencies to researchers and offer solutions. In this respect, the determination of trends in theses prepared on the subject of virtual museums, which is associated with various fields, especially in the field of social studies, will contribute to the literature. In line with the aim of the research, answers to the following questions were sought:

In the theses prepared on the subject of virtual museum;

1. What is the distribution of researches according to fields?

2. What is the distribution of researches according to graduate level?

3. What is the distribution of the researches according to the year of publication?

4. What is the distribution of the methods used in the researches?

5. What is the distribution of the university in which the studies were published?

6. What is the distribution of the study group of the studies?

7. What is the distribution of data collection tools used in the studies?

8. What is the distribution of the studies according to the subject?

2. Method

2.1. Research Model

This research, in which the qualitative research method was used, is a descriptive content analysis study regarding the examination of postgraduate theses on virtual museums. Descriptive content analysis studies are systematic studies that include the evaluation of research results and trends by examining studies conducted on a determined subject (Lin et al., 2014; Suri & Clarke, 2009). In this study, independent qualitative, quantitative and mixed studies on virtual museums were examined and trends were tried to be determined.

2.2. Scope of the Research

The research includes master's and doctoral theses prepared on the subject of virtual museums in the Council of Higher

Education (CoHE) Thesis Center between the years 2004-2024. Three criteria were determined for postgraduate theses within the scope of the research. The first criterion was that the theses should be related to the virtual museum, should be included in the Higher Education Database and finally should be open to access. At the beginning of the data collection phase, a detailed search was conducted using the keyword "virtual museum" related to the subject of the research with the "advanced search" tab in the National Thesis Search Center on the official website of the Council of Higher Education (CoHE). Within this scope, 55 theses, 52 master's and three doctoral, published between the years 2004-2024 were reached.

2.3. Analysis of Data

In this study covering postgraduate theses on Virtual Museum, descriptive content analysis was used. The theses determined in the study were downloaded and a data set consisting of 55 theses was determined. Afterwards, after examining similar studies in the relevant literature, the researcher prepared the "Virtual Museum Theses Classification Form" as a data collection tool. The prepared form consists of seven parts. These parts include the field (branch of science) in which the thesis was prepared, year, university and the method, study group, subject and measurement tool of the thesis. This form was taken into consideration when the theses related to the research were coded by the researcher and comparisons were made to test the reliability of the form in the coded data. In order to ensure the reliability and validity of the research, the categorized data during the data analysis were also examined and compared by the field expert. It was determined that the codings made by the researcher and the field expert were significantly consistent. Reliability was calculated with the formula [Consensus / (Consensus + Disagreement) x 100] suggested by Miles and Huberman (1994). As a result of the reliability analysis, the compliance rate was determined as 92%. This study is limited to theses written on virtual museums between 2004-2024.

3. Findings

This section of the research includes findings on the subject of virtual museums.

3.1. Distribution of Theses on Virtual Museum According to the years of Publication

The highest rate of studies on virtual museums was made in 2023 with a rate of 24%. Nine theses were written in 2024 and it has a rate of 16% among the theses written. Seven theses were made in 2022 and six theses were made in 2021. Studies on virtual museums first started in 2004 and one thesis was written.

Table 1. Distribution of studies on virtual museum according to years.

Year	f	%
2024	9	16%
2023	13	24%
2022	7	13%
2021	6	11%
2020	2	4%
2019	1	2%
2017	2	4%
2016	2	4%
2015	2	4%
2014	2	4%
2013	1	2%
2012	2	4%
2011	1	2%
2010	2	4%
2008	2	4%
2004	1	2%
Total	**55**	**100%**

3.2. Distribution of Studies on the Subject of Virtual Museum According to Postgraduate Level

When the studies on virtual museums were examined according to their levels, it was seen that the most studies were done at the master's level. A total of 55 theses were written, 52 theses were written as master's theses, and three theses were written as doctoral theses.

Table 2. Distribution of studies on virtual museums by postgraduate level.

Postgraduate level	f	%
Master's Degree	52	95%
Doctorate	3	5%
Total	**55**	**100%**

3.3. Distribution of Studies on the Subject of Virtual Museum According to the Fields in Which They Are Published

When the studies on virtual museum were analysed according to their fields, 14 studies were conducted in the field of Social Studies Education with a rate of 25%. 11 studies were conducted in the field of Fine Arts Education with a rate of 20%. Studies on Virtual Museum have been carried out not only in the field of education but also in a wide range of fields such as Art History and Museology, Graphic Design, Radio and Television, Architecture, Tourism Management.

Table 3. Distribution of the studies on Virtual Museum according to the fields of publication.

According to the field of publication	f	%
Social Studies Education	14	25%
Fine Arts Education	11	20%
History Education	4	7%
Mathematics and Science Education	4	7%
Architecture Department	3	5%
Fashion Design	1	2%
Modeling and Simulation	1	2%
Tourism Management	2	4%
Interdisciplinary Museum Education	1	2%
Classroom Education	1	2%
Tourism Guidance Department	1	2%
Computer and Educational Technologies Education Department	2	4%
Art History and Museum Studies Department	1	2%
Radio Television and Cinema Department	1	2%
Educational Sciences Department	1	2%
Art and Design Department	1	2%
Applied Arts Education	1	2%
Art History Department	1	2%
Graphic Design Department	3	5%
Interior Architecture and Environmental Design	1	2%
Total	**55**	**100%**

3.4. Distribution of the Studies on Virtual Museum According to the Method Used

When the distribution of the methods used in the studies on the subject of Virtual Museum is examined, the studies were conducted within the framework of qualitative, quantitative and mixed methods. The most commonly used method consists of quantitative studies with 40%, qualitative studies with 31%, and mixed method studies with 16%.

Table 4. Distribution of the studies on Virtual Museum according to the method used.

Method	f	%
Quantitative	22	40%
Qualitative	17	31%
Mixed	16	29%
Total	**55**	**100%**

3.5. Distribution of the Studies on Virtual Museum According to the University

When the distribution of the theses on the subject of Virtual Museum according to the universities is examined, the highest number of studies was conducted at Gazi University with a rate of 16% and three studies were conducted at Marmara University with a rate of 5%.

Table 5. Distribution of studies on Virtual Museum according to universities.

Distribution According to Universities	f	%
Gazi University	9	16%
Hacı Bayram Veli University	2	4%
Sivas Cumhuriyet University	1	2%
Dokuz Eylul University	2	4%
Bartın University	1	2%
Giresun University	1	2%
Marmara University	3	5%
Gaziosmanpasa University	1	2%
Bahcesehir University	1	2%
Dumlupinar University	1	2%
Middle East Technical University	2	4%
Necmettin Erbakan University	3	5%
Istanbul University	1	2%
Celal Bayar University	1	2%
Onsekizmart University	1	2%
Trabzon University	1	2%
Hacı Bektaş Veli University	1	2%
Binali Yıldırım University	1	2%
Sinop University	1	2%
Erciyes University	2	4%
Ankara University	2	4%
Izzet Baysal University	1	2%
Mersin University	2	4%
Sakarya University	1	2%
Baskent University	1	2%
Ondokuz Mayıs University	1	2%
Afyon Kocatepe University	1	2%
Istanbul Gelisim University	1	2%
Pamukkale University	1	2%
Yasar University	1	2%
Adnan Menderes University	1	2%
Aksaray University	1	2%
Dumlupinar University	1	2%
Ihsan Dogra Bilkent University	1	2%
Hacettepe University	1	2%
Süleyman Demirel University	2	4%
Total	**55**	**100%**

3.6. Distribution of the Studies on Virtual Museum According to the Study Groups

When the distribution of the studies on Virtual Museum according to the study group is analysed, 21 studies with a rate of 38% were conducted with students, 12 studies with a rate of

22% were conducted with document analysis method, eight studies with a rate of 15% were conducted with prospective teachers, and seven studies with a rate of 13% were conducted with participants and teachers.

Table 6. Distribution of the studies on Virtual Museum according to the study group.

Working Group	f	%
Teacher Candidate	8	15%
Teacher	7	13%
Student	21	38%
Participant	7	13%
Document	12	22%
Total	**55**	**100%**

3.7. Distribution of the Data Collection Tools Used in the Studies on Virtual Museum

When the table is analysed, it is seen that questionnaire study was used the most with a rate of 25%, interview with a rate of 20%, pre-test and post-test data collection tools were used with a rate of 16% and attitude scale was used with a rate of 16%.

Table 7. Distribution of studies on Virtual Museum according to data collection tools.

Measurement Tools	f	%
Survey	14	25%
Audio recording	1	2%
Pre-posttest	9	16%
Interview	11	20%
Open-ended interview	1	2%
Semi-structured interview	4	7%
Attitude scale	9	16%
Camera recording	1	2%
Observation	5	9%
Total	**55**	**100%**

3.8. Distribution of the Studies on Virtual Museum According to the Subject

When the distribution of the studies on virtual museums according to their subjects was analysed, it was found that the most studies with a rate of 24% were in the field of social studies teaching. It was seen that there were 9% on the use of virtual museums, 9% on visual arts education, and 7% on attitudes towards science teaching.

Table 8. Distribution of the studies on Virtual Museum according to their subjects.

Subject	f	%
Virtual museum/Social studies education	13	24%
Virtual museum/Museum education	2	4%
Virtual museum/Out-of-school learning	2	4%
Virtual museum/Attitude towards science education	4	7%
Virtual museum/Virtual culture	1	2%
Virtual museum/Alternative approaches in museology	1	2%
Virtual museum/Space perception, analysis	2	4%
Virtual museum/Museology	2	4%
Virtual museum usage, application	5	9%
Virtual museum/Visual arts education	5	9%
Virtual museum/Cultural heritage education	3	5%
Virtual museum/Tourism	1	2%
Virtual museum/Media technologies attitude	1	2%
Virtual museum/Virtual reality	1	2%
Virtual museum/Fine arts education attitude	1	2%
Virtual museum/History teaching attitude	3	5%
Virtual museum/English education attitude	1	2%
Virtual museum/Architecture and documentation	1	2%
Virtual museum/Graphic analysis	1	2%
Virtual museum/Introduction to aviation education	1	2%
Virtual museum/Maritime archaeology	1	2%
Virtual museum/Panoramic image	1	2%
Virtual museum/Interface design	1	2%
Virtual museum/Virtual museum design	1	2%
Total	**55**	**100%**

4. Discussion and Conclusion

This study evaluated the current situation in this field by analyzing the trends of postgraduate theses on virtual museums between 2004 and 2024. The research findings reveal that the number of studies conducted is limited and more comprehensive research is needed.

According to the results of the study, 95% of the postgraduate studies on virtual museums consist of master's theses and 5% consists of doctoral theses. This situation shows that the studies on virtual museums at the doctoral level are insufficient and that more in-depth research is needed at this level. In addition, when examined from a methodological perspective, it is seen that 40% of the studies are quantitative, 31% are qualitative and 29% are mixed methods. The predominance of quantitative methods reveals that there is a need for further research on qualitative elements such as user experiences and interactive structure of virtual museums. When

examined in terms of data collection tools, it is seen that the most commonly used methods in the studies are surveys with 25%, followed by interviews with 20% and pre-test-post-test applications with 16%. In addition, Dilek et al. (2018) also found that the theses mostly consist of scale and survey-oriented research. This situation shows that more diverse tools should be used in data collection processes and that it is important to increase in-depth methods such as observation and structured interviews.

When examined by years, it has been seen that virtual museum studies have increased significantly since 2020. It can be said that the Covid-19 pandemic that emerged in 2019 was effective in this increase. It is thought that the fact that individuals were confined to their homes during the pandemic period increased the interest in virtual environments and this situation played an important role in the increase in research on virtual museums.

In the studies, it was seen that students were the most frequently preferred study group with 38%. In addition, it was determined that document reviews were selected as the study group with 22% and teacher candidates with 15%. These findings show that virtual museums are frequently discussed in educational environments and are especially focused on students. However, it is thought that research to be conducted on teachers, academics and other stakeholders can contribute to understanding how this technology can be evaluated in a broader context.

The findings reveal that a large portion of the research on virtual museums is concentrated in the field of educational sciences. 25% of the studies were conducted in the field of social studies education, and 16% in the field of fine arts education. Studies conducted in disciplines such as art history, architecture, tourism and technology remained below 10% in total. These results emphasize the importance of considering virtual museums with an interdisciplinary approach. In addition, Kaymakçı and Er (2009) also found in their study that more researchers from different fields conducted studies in the field of Social Studies compared to other fields.

In conclusion, this study has drawn attention to the deficiencies in the field by revealing the trends in virtual museum research. There is a greater need for qualitative method-based and interdisciplinary studies, especially at the doctoral level. In order to use the potential offered by virtual museums more effectively, applied research should be increased in both education and cultural heritage protection fields. Such studies will not only provide theoretical knowledge but also provide important clues on how virtual museums can be used more effectively in practice.

Compliance with Ethical Standards

This study does not require an ethics committee approval.

Conflict of Interest

The author has no conflict of interest to declare.

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RESEARCH ARTICLE

Views of Biology and Science Teachers on Biomimicry*

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ABSTRACT

The aim of this study is to determine the views of biology and science teachers regarding biomimicry. Phenomenology, one of the qualitative research methods, was used to obtain data for the purpose of the study. The study group consisted of 19 teachers who work as biology and science teachers in public institutions affiliated with the Ministry of National Education in Ankara. Criterion sampling was preferred in the selection of the study group since interviews were conducted with teachers who met certain criteria. A semi-structured interview form titled "Biology and Science Teachers' Views on Biomimicry Interview Form," prepared by the Researchers, was used as the data collection tool in the study. The interviews conducted during the implementation process of this research were carried out both face-to-face and online. The data in this study was evaluated using the content analysis method. The results obtained in the study showed that teachers were familiar with the concept of biomimicry, but some teachers experienced conceptual confusion. At the same time, this study revealed that when teachers used biomimicry for various purposes in their lessons, it made multifaceted contributions to the lessons and students. In addition, teachers made suggestions for biomimicry to be included more in textbooks, curriculum, printed and digital resources, teacher trainings and student workshops.

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1. Introduction

From the beginning of human history, it is known that humans have observed nature to protect themselves, sustain their lives, and make their existing lives more manageable (Say & Yıldırım, 2021). As a consequence of humans being inspired by nature, the concept of Biomimicry (Biomimetics) was introduced. The term "biomimicry" was first used by Janine Benyus in 1997. It is derived from the combination of two words: "bio," meaning life, nature, or living, and "mimicry," meaning imitation (Benyus, 2002; Yıldırım, 2019). When used together, these terms signify the imitation or emulation of nature (Mahgoub & Alawad, 2014). In her book *Biomimicry*, Benyus (2002) emphasizes the critical role of biomimicry in fostering innovative ideas by encouraging scientists to study the functional principles of plants, animals, and both living and non-living systems in nature (Avcı, 2019). Acting as a bridge that integrates various disciplines, particularly biology, biomimicry has become a widely utilized approach in the scientific community today (Avcı, 2019; Shimomura, 2010). With the changing times and advancing technology, there has also been a growing interest in innovative approaches in educational curricula, leading to the gradual incorporation of

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biomimicry applications, which blend nature and technology, into teaching practices.

In contemporary educational systems, it is recommended to provide a curriculum that emphasizes the development of inquiry and problem-solving skills, integrating innovative learning methods throughout the process. It is also emphasized that learning environments should be collaborative, enabling students to connect their learning with real-world contexts through projects and practical applications (Avcı, 2019).

Biomimicry is a powerful approach in science education, enhancing students' scientific and creative thinking skills, strengthening their connection to nature, and fostering a sense of environmental sustainability. In line with the goals of science education, biomimicry offers a learning framework that brings together multiple disciplines to cultivate environmentally conscious global citizens who understand their integral role in the natural world. Moreover, it plays a critical role in nurturing students as individuals who appreciate the natural environment around them and make positive contributions towards shaping a more sustainable planet (Çoban, 2019).

Projects inspired by nature increase students' engagement in active learning processes, reinforcing their interest in science and technology. Therefore, integrating biomimicry-based teaching approaches into educational curricula can provide students with a more comprehensive learning experience.

An examination of the specific objectives outlined in the Biology Curriculum prepared by the Ministry of National Education in 2018 reveals the following goals:

- Objective 2: Developing the ability to apply biological knowledge and practices in daily life.
- Objective 5: Encouraging students to generate new ideas and engage in original projects using the knowledge, skills, and competencies acquired in biology courses.
- Objective 7: Fostering awareness of technologies inspired by living organisms and motivating students to innovate in similar ways (MoNE, 2024).

Similarly, the curriculum includes the learning outcome, "9.3.2.2. Explains the contributions of living organisms to biological processes, the economy, and technology, and provides examples of technologies inspired by living organisms," which clearly aligns with biomimetic principles (MoNE, 2018).

Furthermore, the Science Curriculum aims to cultivate science and technology literate individuals who can use their scientific knowledge and skills to solve real-world problems, make informed decisions with scientific understanding, and take responsible, innovative actions (MoNE, 2018).

When the goals and outcomes within these curricula are considered, it becomes evident that linking the knowledge derived from nature and living organisms to real-life applications is highly valued. Given that the biomimicry process involves studying, examining, and drawing inspiration from the characteristics of living organisms to develop innovative solutions, incorporating this approach into lessons and projects is considered essential for meaningful science education (Ergül, 2023).

A review of the relevant literature reveals a number of studies on biomimicry conducted with preservice teachers enrolled in education faculties (Çakır, 2019; Fried et al., 2020; Gökgöz, 2022; Kandemir et al., 2022; Kaya, 2022; Mirici et al., 2021; Qureshi, 2020; Tavşan, 2022; Yıldırım, 2019). Similarly, research involving primary and secondary school students is also present in the literature (B. Aydın, 2023; D. Aydın, 2023; Çoban & Coştu, 2023; Çoban, 2019; Dilaver Türe, 2023; Özdemir & Mirici, 2022; Terzi, 2023; Ülbeği Ülker, 2023; Uluçınar Sağır et al., 2022; Yakışan & Velioğlu, 2019; Yıldız, 2023). However, there appears to be a gap in the literature regarding studies conducted with in-service biology and science teachers. This research, therefore, aims to address this gap by focusing on biology and science teachers, contributing to the existing body of literature in this emerging field.

In order to cultivate scientifically literate and entrepreneurial individuals, which are among the 21st century skills emphasized in educational curricula, it is essential for teachers to have a deep understanding of nature, recognizing its complex systems and vast interconnections (MoNE, 2018). As the primary facilitators of learning, teachers play a critical role in integrating biomimicry concepts into their teaching practices, guiding students to draw inspiration from the natural world. Given that biology and science are disciplines inherently focused on the study of nature, it is vital for teachers, as well as society as a whole, to be aware of biomimicry as a scientific field that draws inspiration from nature to develop innovative designs and solutions.

Therefore, this study aims to explore the perspectives of biology and science teachers regarding biomimicry. Within this framework, the following sub-questions have been formulated for the study:

1. What is the teachers' prior knowledge about the concept of biomimicry?
2. How do teachers incorporate biomimicry into their lessons?
3. Why do teachers choose to use biomimicry in their teaching?
4. What contributions does biomimicry make to their teaching practices?
5. What challenges do teachers encounter when using biomimicry in their lessons?

6. What are teachers' recommendations for integrating biomimicry into their lessons?

2. Method

The study protocol was approved by Gazi University Ethics Committee with the decision number E898063 on 06.03.2024.

2.1. Research Design

In this study, which aims to investigate the perspectives of biology and science teachers on biomimicry, phenomenological design, one of the qualitative research methods, was employed. Phenomenological research focuses on how individuals experience a given phenomenon through methodical, in-depth, and carefully constructed descriptions (Patton, 2014). In this context, the phenomenon to be thoroughly examined in this study is defined as the perspectives of biology and science teachers regarding the concept of biomimicry.

2.2. Study Group

The study group for this research consists of 19 teachers currently employed as biology and science teachers in public schools affiliated with the Ministry of National Education in Ankara. Given that the study involved interviews with teachers meeting specific criteria, criterion sampling was chosen as the sampling method. Due to the compatibility of biology and science curricula with the use of biomimicry, teachers of biology and science who will teach these subjects were selected through criterion sampling. This approach involves selecting participants based on predefined criteria. In this study, the criteria required that participants be either biology or science teachers actively engaged in the teaching profession. Detailed information regarding the participants in the study group is presented in Table 1.

Table 1. Demographic information of the participants.

Participant Code	Gender	Age	Professional Seniority	Education Status	Branch	Teaching Level	School Type
T1	Women	38	14 Year	Master's Degree	Science	Middle School	Middle School
T2	Women	36	10 Year	Master's Degree	Biology	High School	Science High School
T3	Women	40	18 Year	Master's Degree	Science	Middle School	Middle School
T4	Men	44	24 Year	License	Biology	High School	Anatolian Imam Hatip High School
T5	Women	46	24 Year	License	Science	Middle School	Imam-Hatip Middle School
T6	Women	39	18 Year	License	Science	Middle School	Imam-Hatip Middle School
T7	Women	39	16 Year	Master's Degree (Continue Doctorate)	Science	Middle School	1.Evening Art School
T8	Men	37	12 Year	Master's Degree (Continue Doctorate)	Science	Middle School	Science and Art Center
T9	Men	47	25 Year	Master's Degree	Biology	High School	Science High School
T10	Women	39	16 Year	Master's Degree with Thesis/ Master's Degree without Thesis	Biology	High School	Vocational and Technical Anatolian High School
T11	Women	52	29 Year	Master's Degree	Biology	High School	Science and Art Center
T12	Men	39	12 Year	License	Science	Middle School	Middle School
T13	Women	45	25 Year	License	Biology	High School	Science High School
T14	Women	36	11 Year	License	Biology	High School	Science High School
T15	Women	39	11 Year	License	Science	Middle School	Middle School
T16	Women	51	28 Year	License	Science	Middle School	Middle School
T17	Women	52	20 Year	License	Science	Middle School	Middle School
T18	Women	52	28 Year	License	Biology	High School	Science High School
T19	Women	53	30 Year	License	Biology	High School	Science High School

As shown in Table 1, the study group consists of 15 female and 4 male participants. To ensure the confidentiality of the participants' identities, each teacher was assigned a code ranging from T1 to T19. Of these, nine teachers are biology teachers at the high school level, while ten are science teachers at the middle school level.

Among the high school teachers, one works at a Science and Art Center (BILSEM), six at science high schools, one at a vocational and technical Anatolian high school, and one at an Anatolian Imam-Hatip high school. At the middle school level, one teacher is employed at a BILSEM, two at Imam-Hatip middle schools, one at a first evening arts school, and six at regular middle schools.

The ages of the participating teachers range from 36 to 53 years, with professional experience spanning 10 to 30 years. Regarding their educational backgrounds, 11 teachers hold bachelor's degrees, five have completed master's degrees, one has both thesis-based and non-thesis master's degrees, and two are currently pursuing doctoral studies.

2.3. Data Collection Tools

In this study, data were collected using a semi-structured interview form titled "Biology and Science Teachers' Perspectives on Biomimicry," which was developed by the researcher.

2.3.1. Interview Form on the Perspectives of Biology and Science Teachers on Biomimicry

The interview form was designed in accordance with the main objectives and sub-objectives of the study, informed by an extensive review of the relevant literature. To assess the appropriateness and clarity of the questions, expert opinions were obtained from six independent scholars: three specializing in biology education, two in science education, and one with expertise in qualitative research methodologies. The feedback received from these experts was jointly evaluated by the researcher and the academic advisor. As a result of this evaluation, certain questions were reformulated as sub-questions, and revisions were made to the sentence structures of some items to enhance clarity and coherence. Following these modifications, the final version of the form included a total of 15 open-ended questions, comprising 9 main questions and 6 sub-questions.

2.3.2. Validity and Reliability

In order to ensure the validity and reliability of the research data, the criteria of credibility, dependability, transferability, and confirmability, as proposed by Lincoln and Guba (cited in Creswell, 2016), were addressed. One of the strategies employed to enhance credibility was expert review, which involves the evaluation of the study by experts from various perspectives (Merriam, 2013; Yıldırım & Şimşek, 2013). In this context, expert opinions were obtained regarding the open-ended interview form developed by the researcher. The draft of the interview form was submitted to six experts, and their suggestions were evaluated jointly by the researcher and the academic advisor, after which the final version of the interview form was established.

To facilitate readers' judgments regarding transferability, rich and thick descriptions were provided, including direct quotations from participants. Additionally, detailed explanations of the participants' characteristics were included to support transferability (Merriam, 2013).

Confirmability, which corresponds to the criterion of objectivity, refers to the extent to which the findings and interpretations are grounded in the data and derived through a reliable and transparent inquiry process (Lincoln & Guba, 2013). To ensure dependability, the research data were analyzed independently by two separate researchers. Each researcher conducted an independent analysis of the qualitative data, and the results were then compared collaboratively.

To test the reliability of the coding process, the formula proposed by Miles and Huberman (1994) was used:

Reliability Percentage (P) = (Agreement (Na) / (Agreement (Na) + Disagreement (Nd) x 100

In qualitative research, a reliability percentage of 70% or above is considered acceptable (Miles & Huberman, 1994). In this study, the data were analyzed independently by two researchers, and the inter-rater agreement was calculated. The agreement percentage was found to be 85% with the first researcher and 87% with the second. To minimize discrepancies between the researchers' interpretations, these results were discussed, and consensus was achieved through negotiation.

2.4. Data Collection

The interviews conducted for data collection were scheduled by arranging appointments with the participating teachers on mutually agreed dates and times. Eleven of the interviews were conducted face-to-face, while eight were conducted online due to the teachers' demanding work schedules. Prior to each interview, the purpose of the study was explained to the participants, and their consent was obtained regarding audio and video recording. All teachers consented to audio recording, and some participants also agreed to video recording.

The duration of the interviews varied between 8 and 40 minutes, depending on the depth of the teachers' responses. The teachers responded to the questions verbally, and the collected data were transcribed verbatim into a digital document, resulting in a total of 39 pages of text.

2.5. Data Analysis

In this study, the collected data were analyzed using the content analysis method. Content analysis is an analytical approach that aims to examine the data in depth and generate concepts and categories (Yıldırım & Şimşek, 2013). Since no prior study was found on this specific topic, the codes and categories were derived directly from the data, and an inductive content analysis approach was adopted (Hsieh & Shannon, 2005). Categories were created by grouping multiple codes or subcategories that reflected a common pattern or idea (Creswell, 2017).

The data were gathered through a semi-structured interview form administered to 19 teachers. During the analysis, the teachers' statements were coded in line with the research objectives, and these codes were then organized into categories and subsequently into overarching themes. While identifying subcategories, the researchers remained as faithful as possible to the original expressions of the participants. In some cases, teachers' responses addressed more than one theme and/or category, which resulted in frequency values exceeding 19. The findings were presented through frequency tables along with the researcher's interpretations. Direct quotations from the participants were also included in the findings. To maintain anonymity while preserving authenticity, the teachers were coded as T1, T2, and so forth.

In the next stage, codes were created to determine under which categories and themes the data should be classified. These codes were grouped under preliminary categories based on the frequency of specific expressions used by the teachers. This coding process was independently conducted by two subject-matter experts. At the end of this process, similar codes were used to define categories, and the corresponding themes for these categories were identified. The categories and themes developed by the two experts were then compared, and adjustments were made based on the observed similarities and differences. Finally, the resulting categories and themes were reviewed by a third researcher. The inter-coder reliability among the experts was assessed to be high.

3. Findings

In this study, which aimed to gather teachers' perspectives on the concept of biomimicry, a semi-structured interview form was administered to 19 teachers included in the research.

3.1. Teachers' Prior Knowledge of the Biomimicry Concept

When analyzing the responses to the questions related to the first sub-problem, which aimed to explore teachers' prior knowledge of the concept of biomimicry, it was found that all participating teachers reported having previously encountered the term.

An additional question was posed to participants to identify the sources from which they had acquired their knowledge of biomimicry. The responses, categorized under the theme of "sources of biomimicry knowledge," were grouped into five main categories: formal education, books/articles, curriculum, personal interest, and other. The majority of teachers indicated that they first encountered the concept of biomimicry during their formal education, particularly at the university level. Similarly, the second most common category (f=7), books/articles, revealed that many teachers became familiar with biomimicry through exposure to the concept in textbooks, academic books, and scientific articles during their professional careers.

Another prominent category (f=6) was the curriculum. Several teachers noted that the concept had been included in previous high school curricula, leading them to address it in their lessons. For instance, one participant (Teacher 6) shared, "There was a reading passage titled 'Nature-Inspired Imitations' in the 7th grade ecosystems unit," indicating that biomimicry is sometimes introduced as supporting content within science textbooks. This observation suggests that the concept, though brief, is occasionally incorporated into science curricula as a supplementary idea.

Overall, the interviews highlighted that science teachers, in particular, encounter the concept of biomimicry more frequently within the context of their teaching topics.

For the second question, teachers were asked to define the term "biomimicry." The responses were grouped into two main categories: "imitation" and "designing new products/designing." The term "imitation" emerged as the most commonly used descriptor (f=16), with many teachers defining biomimicry as the process of creating new products or designs inspired by the imitation of nature, living organisms, and animal behaviors.

However, a noteworthy finding from the interviews was the conceptual confusion between "biomimicry" and "mimicry," as some teachers appeared to use these terms interchangeably. For example, Teacher 18 defined it as "Imitation. It can be described as one species imitating the similar features of a closely related species," while Teacher 9 stated, "There are various definitions related to biomimicry. For instance, imitating an animal's behavior," reflecting this misunderstanding.

As a follow-up to the second question, teachers were also asked about the disciplines that might be involved in biomimicry. Their responses indicated a wide range of fields, including "engineering (f=15)," "biology (f=11)," "multiple disciplines (f=9)," "physics (f=8)," "architecture (f=6)," "medicine/pharmacy (f=6)," "mathematics (f=6)," "science (f=4)," "design (f=4)," "aerospace (f=4)," "chemistry (f=2),"

"art (f=2)," "fashion (f=2)," "technology (f=2)," "STEM (f=2)," and other related fields (f=6).

Notably, Teacher 8 commented, "It has started to be used in education," indicating a relatively recent expansion of biomimicry into the educational field, though this perspective was only mentioned by one participant.

3.2. The Use of Biomimicry in Classroom Instruction

For the second sub-problem, teachers were asked a main question regarding whether they incorporate biomimicry into their lessons, and if so, how they implement this concept through activities, projects, or exercises. Upon analyzing the responses, it was found that 10 teachers answered "Yes," while 9 teachers responded "No." Among those who responded affirmatively, four teachers specifically noted that they integrate biomimicry into their project work.

A closer examination of the responses from the teachers who answered "Yes" revealed that some educators engage their students in hands-on, practical activities related to biomimicry, while others, despite not conducting dedicated classroom activities due to the lack of explicit curriculum content, use the concept as supportive examples to aid understanding.

Conversely, the responses from teachers who answered "No" indicated that their lack of use of biomimicry in lessons is primarily due to the absence of this concept in the curriculum. This issue was particularly noted by biology teachers, who expressed that the pressure to prepare students for university entrance exams often leaves little time for incorporating biomimicry-related activities.

Those who indicated using biomimicry in their projects explained that they primarily incorporate it within the context of national and international competitions, such as TÜBİTAK (The Scientific and Technological Research Council of Turkey) and TEKNOFEST, where they encourage students to develop innovative designs and propose practical solutions inspired by biomimicry.

From this analysis, it can be inferred that science teachers tend to incorporate biomimicry more frequently than biology teachers, likely due to a broader thematic overlap in their curricula.

As a follow-up, teachers who responded "Yes" were asked to provide specific examples of the activities they use in their lessons. These responses were categorized into two main groups: "animals" and "plants." It was observed that teachers use biomimicry examples not only to illustrate scientific concepts but also to inspire project work, offer problem-solving strategies, and guide students toward developing sustainable designs for long-term human needs.

3.3. Reasons for Using the Biomimicry Concept

For the third sub-problem, teachers who reported using the biomimicry concept in their lessons were asked to explain why they choose to incorporate it. The responses were categorized into four main themes: reinforcing course content, project development, fostering environmental awareness, and supporting workshop activities.

Teachers indicated that they use biomimicry in various contexts, such as during topic transitions, when responding to student questions, providing real-life examples, or as part of direct instruction. Several responses highlighted project development and encouraging environmental awareness as particularly prominent reasons for using biomimicry in their teaching.

For example, Teacher 1 shared, "We used biomimicry within the scope of a project for mathematical modeling. In the STEM projects created by students, biomimicry was utilized not just for visual inspiration but also for functional design. For instance, we designed a house inspired by the way a sunflower orients itself, creating a structure that follows the sun for optimal solar energy capture."

Similarly, Teacher 19 noted, "I try to include it when discussing current topics so that students can become biologically literate, environmentally conscious individuals with a broadened perspective on their surroundings," emphasizing the role of biomimicry in promoting environmental awareness and shaping students into more environmentally responsible citizens.

3.4. The Contribution of Biomimicry to Classroom Instruction

To address the fourth sub-problem, teachers were asked several questions to identify the potential benefits of using biomimicry in their lessons. The first question was, "Do you believe biomimicry contributes to biology education?" In response, 16 teachers answered "Yes," while 3 teachers responded "No."

For instance, Teacher 6 expressed a more reserved stance, stating, "When I consider the areas where biomimicry is applied, it doesn't seem to provide a significant contribution to biology education specifically, though it might benefit other fields." Similarly, Teacher 3 noted, "Rather than directly contributing to biology, I believe it supports other fields through the foundational principles of biology," suggesting that the influence of biomimicry extends beyond the boundaries of biological sciences.

Teachers who agreed that biomimicry contributes to biology education were then asked, "If so, how?" The responses were grouped into four main categories: contributions to science and technology, contributions to material and project

design, contributions to understanding nature and living organisms, and contributions as a teaching tool.

For example, Teacher 9 emphasized the role of biomimicry in scientific innovation, stating, "I believe it is important for designing, developing, and perhaps finding solutions to problems by observing living things on Earth." Meanwhile, Teacher 1 highlighted the importance of biomimicry in educational material design, noting, "In biology education, it can be a source of inspiration for designing materials and integrating technology into education through functional, technology-based models."

In the category of contributions to understanding nature and living organisms, teachers noted that biomimicry encourages students to better grasp the complexities of the natural world, including both living and non-living components, through their design projects and class discussions.

Under the contributions as a teaching tool category, teachers mentioned that biomimicry can play a motivational role in directing students toward biology as a field of study and supporting their learning across multiple disciplines. They also highlighted the interdisciplinary potential of biomimicry, noting that it allows for connections to be made between biology and other subjects like mathematics, ultimately enhancing students' overall scientific literacy.

To further explore the benefits of using biomimicry in the classroom, teachers were asked three additional questions: "What are the advantages of using biomimicry in your lessons?", "What cognitive, affective, and psychomotor gains do you observe from using biomimicry in your lessons?" and "Have you observed any changes in your students before and after incorporating biomimicry? Could you explain?"

Given that not all teachers use biomimicry in their lessons, the number of responses to these questions was limited. The responses were categorized into three main types of student gains: cognitive gains, affective gains, and psychomotor gains.

Cognitive Gains: This category included insights like shifting perspectives, raising awareness, enhancing lesson effectiveness, building foundational knowledge, connecting lessons to real life, and contributing to teacher development.

Affective Gains: Responses in this category emphasized increased student interest and enthusiasm, inspiration, and heightened curiosity and excitement.

Psychomotor Gains: This category included improvements in fine motor skills and observational abilities.

Overall, the interviews suggested that the use of biomimicry in lessons provides a range of cognitive, emotional, and practical benefits, reinforcing the value of interdisciplinary learning and hands-on educational approaches.

3.5. Challenges in Using Biomimicry in Classroom Instruction

To address the fifth sub-problem, teachers were asked, "What challenges do you encounter when using biomimicry in your lessons?" to identify the difficulties faced in integrating biomimicry into classroom teaching. The findings related to the challenges of using biomimicry in lessons are presented in the table below (Table 2).

Table 2. Findings regarding the difficulties encountered during the use of biomimicry in lessons.

Theme	Category	Reviews	*f*
Challenges in Using Biomimicry in the Classroom	Insufficient Material/Technological Facilities	Depending on the region where the institutions we work in are located, sometimes children at the socioeconomic level have insufficient technological infrastructure (T1). We had a financial difficulty (T10). Material costs are required for the projects to be carried out. Ergonomic materials are required. It is very difficult for children to access these materials. There are financial difficulties (T15).	4
	Children's Low Level of Readiness	I see that children in middle school have some difficulty in structure and function due to their age. They may have difficulties in comprehending (T8). I think that this subject may not be suitable for the age of children. It may be more appropriate for use in high school (T15).	3
	Inadequate Course Materials	Examples for biomimicry are insufficient and very limited in the books (T1). Not encountering too many examples (T6).	2
	Other	Since they are the last subjects, students do not take the subject seriously (T2).	2

The responses gathered from the teachers revealed three main categories of challenges related to the use of biomimicry in lessons: low student readiness levels, insufficient financial/technological resources, and inadequate teaching materials.

In this category, teachers highlighted that younger students or those with gaps in their prior knowledge often struggle to grasp the concept, definition, and purpose of biomimicry. As a result, students may produce designs or projects that deviate from the intended learning objectives. For example, Teacher 8 noted, "…They can struggle to grasp the concept. Some even try to create exact replicas of living organisms, which can be a disadvantage," emphasizing the challenge of aligning student understanding with the broader principles of biomimicry.

Similarly, Teacher 16 explained, "…Sometimes children aren't aware of the living organisms in nature because they haven't seen them before. We often have to individually show these to students before starting activities," indicating the need for preliminary instruction to bridge these knowledge gaps.

Many teachers expressed that financial and technological limitations pose significant obstacles to implementing biomimicry projects. For instance, Teacher 1 shared, "…When I mention a sunflower, a child might picture it, but if I had a smart board in the classroom, I could show a real-time video of its movement, helping them observe and understand the concept better. Unfortunately, the lack of technology in schools is a major barrier," highlighting the importance of visual aids and technological support in enhancing student understanding.

Teachers also noted that increased funding for such projects could lead to both a higher quantity and quality of student outputs. This category included challenges related to the absence of biomimicry content in textbooks and curricula. Teachers pointed out that the limited and often scattered nature of biomimicry examples in educational materials makes it difficult to fully integrate the concept into regular lessons.

3.6. Recommendations for the Use of Biomimicry in Education

In the final sub-problem of this study, teachers were asked to share their recommendations for incorporating biomimicry into their lessons. The responses were categorized into several main themes: integration into the curriculum, inclusion in lessons and topics, increasing teacher awareness and knowledge, project-based learning, interdisciplinary applications, and laboratory work.

A significant portion of the teachers recommended that biomimicry be included in the curriculum and textbooks. Many teachers mentioned that the lack of explicit biomimicry content in current textbooks and curricula makes it challenging to teach this concept effectively. For example, Teacher 6 stated, "It is not a well-known or widely included concept. It could be added to textbooks," emphasizing the need for dedicated biomimicry sections in educational materials.

Additionally, teachers noted that the limited presence of biomimicry in Ministry of National Education (MoNE) textbooks restricts students' opportunities to engage with this concept as a primary source, potentially limiting their understanding and application of biomimicry in real-world contexts. Teacher 8 highlighted this gap, stating, "Students outside BILSEM should also have the opportunity to learn about these concepts, incorporate them into their lives, and develop their awareness," reflecting the need for broader curriculum reform.

Inclusion in Lessons and Topics

Several teachers suggested incorporating biomimicry into existing lesson plans, either as standalone units or integrated into related topics like environmental science, technology, and design. For instance, Teacher 12 proposed, "It can be adapted to life-related topics. Experiments can be conducted, models can be made for practical application, and visual comparisons can be included in lessons," emphasizing the importance of hands-on learning and visual aids in teaching complex concepts like biomimicry.

Increasing Teacher Awareness and Knowledge

Teachers also recommended professional development programs to enhance their understanding of biomimicry, enabling them to serve as more effective guides for their students. This includes workshops, seminars, and training sessions aimed at improving teachers' knowledge and confidence in teaching this interdisciplinary concept.

Project-Based Learning

Many responses highlighted the importance of incorporating project-based learning (PBL) to engage students in real-world problem-solving. Teachers suggested that biomimicry-themed projects, like those included in STEM and engineering sections of science textbooks, could foster critical thinking and creativity. This approach would also align with the broader goals of developing 21st-century skills, such as collaboration, innovation, and environmental awareness.

Interdisciplinary Applications

Given the interdisciplinary nature of biomimicry, several teachers emphasized its potential for integration into subjects beyond the natural sciences, including mathematics, art, and technology. They noted that encouraging students to explore connections between different fields can lead to more innovative and holistic learning experiences.

Laboratory Work

Finally, teachers suggested the inclusion of biomimicry in laboratory work, providing students with hands-on opportunities to experiment with biomimetic designs and applications. This approach, they argued, would make lessons more engaging and meaningful, helping students better understand the principles of biomimicry through direct observation and practice.

Overall, the responses indicate that teachers view biomimicry as a valuable educational tool with the potential to enhance student learning across multiple disciplines, provided that appropriate curriculum adjustments, teacher training, and resource support are implemented.

4. Discussion and Conclusion

In this study, biology and science teachers' views on biomimicry were investigated. The results obtained are listed as; "teachers have a good command of the concept of biomimicry, but some teachers have concept confusion, they use biomimicry for various purposes in their lessons, biomimicry provides multifaceted contributions to lessons and students, teachers encounter various difficulties during the studies, and suggestions that biomimicry should be included in textbooks, course curriculum, printed and digital resources, teacher trainings, and student workshops".

In the interviews conducted within the scope of this study, it was observed that science teachers included the concept of biomimicry in their lessons more than biology teachers. Based on the teachers' opinions, the reason for this situation is that the subjects in the science curriculum include subjects that allow the use of the concept of biomimicry. In the biology curriculum, on the other hand, this concept is included in only one reading passage. In addition, teachers working at the secondary education level, especially science high school teachers, stated that they prepare their students for central exams and plan their lesson hours to include these studies. For this reason, it was seen that they had difficulties in including current issues such as the concept of biomimicry in their lessons. It was concluded that teachers working in primary and secondary BİLSEMs were able to carry out more studies on the concept of biomimicry due to the curriculum compared to teachers working in other school types.

It was determined that all of the teachers with whom interviews were conducted knew the concept of biomimicry, but teachers who had a master's or doctorate degree, participated in seminars and various trainings had a higher command of the subject. This situation was also reflected in the analysis of the study and caused the opinions of some teachers to come to the fore.

During the interviews, it was realized that some teachers used the concepts of "biomimicry" and "mimicry" in the same sense and that they had a concept confusion in this regard. In the national 11th Grade Science High School Biology coursebook, mimicry is defined as "Mimicry is the phenomenon in which a species imitates the appearance, smell or sound of another species. Mimicry allows the species to protect itself from predators. Mimicry can be seen in both prey and predator species" (p. 261). However, biomimicry is defined as "people taking nature as an example to solve the problems they face" (TÜBİTAK Bilimgenç, 2023). As can be seen from the definitions, the concepts of mimicry and biomimicry are two different concepts in the literature. While mimicry is the imitation of another living creature by a living creature, biomimicry is the design of designs in a wide variety of fields that can solve existing problems by taking inspiration from living and non-living beings. During the interviews, it was observed that especially the teachers working in the biology branch used these two concepts as the same concepts. For this reason, they included explanations about mimicry in their definitions. T18 said, "Mimicry. We can define it as a species imitating similar characteristics of a close species." and T9 said There are different definitions about biomimicry. For example, imitating the behavior of an animal." are among the answers that support this situation.

In the results obtained in the study, it was seen that the teachers used the expressions "imitating ecosystems, living and non-living things to create new products or to offer solutions to problems" when defining the concept of biomimicry. Oguntona and Aigbavboa (2023) stated that by studying and imitating natural forms, strategies, processes and ecosystems, students can develop a deeper understanding of the world around them and apply this knowledge to create sustainable designs and solutions. Similarly, Yıldız (2023) observed that regarding the concept of biomimicry, students generally adopted the definitions of being inspired by nature or living things, imitating living things and being inspired by nature. It is seen that the data obtained in this study overlap with the studies on the definition of biomimicry.

In the data of the study, it was seen that science teachers (f=8) included the concept of biomimicry in their lessons or studies more than biology teachers (f=2). Biology teachers stated that they could not include this and similar studies due to the inadequacy of the curriculum and course programs both in terms of having studies on the subject and in terms of course hours, and the demands of the students to conduct studies for the university exam. Science teachers, on the other hand, stated that they used the concept to support the subject with examples within the scope of "engineering skills" studies and "Force and Motion, Sound Properties" units within the scope of the course curriculum. Similarly, Çakır (2019) found that pre-service biology teachers were often inspired by natural events to demonstrate curriculum outcomes, but their understanding of the concept of biomimicry was relatively weak. In the study, it was observed that teachers who included biomimicry in their lessons stated that they guided their students to make designs inspired by insects, plants and bats and gave examples to their students. In the study conducted by Yakışan and Velioğlu (2019) with 4th grade students, it was observed that students were inspired by animals such as turtles, frogs, whales, fish, insects, giraffes, snakes, sea turtles, rabbits, owls, bats, birds, and cheetahs to create designs and drawings related to these designs. Savran Gencer et al. (2020) planned an engineering design process that allows students to imitate the structure,

function and tasks of living and non-living things. In the study, students made designs inspired by pelicans, geckos, flycatcher plants, bats, hawks and chickens and explained which problem their designs would solve. Ergül (2023) included organisms such as the flexible arms of octopus, potter's bird, spider web, sunflower, chrysanthemum, etc. to exemplify biomimicry in his study and mentioned both the structural and functional dimensions of the organisms presented as examples.

Stating that they introduced biomimicry to their students through workshops and offered them the opportunity to make designs, teachers stated that they carried out studies at the point of integrating biomimicry and education. In addition, teachers stated that they use biomimicry in their lessons, projects and in raising students' awareness of nature. Similarly, Oguntona and Aigbavboa (2023) stated that biomimicry concepts can be integrated into education through courses and workshops. In this context, the study is similar in terms of the implementation of the theoretical suggestion. Yıldırım (2019) stated that pre-service teachers wanted to include biomimicry practices in their courses and that they thought to use biomimicry practices in their courses under the titles of teaching-learning processes, teaching principles and scientific process skills. The pre-service teachers stated that they would use biomimicry applications for teaching from concrete to abstract within the scope of teaching principles; for observation and data recording within the scope of scientific process skills; and for active learning and learning through play within the scope of teaching-learning processes. In this context, although pre-service teachers expressed the reasons why they wanted to include biomimicry in their lessons as gaining 21st century skills, facilitating the understanding of the course by integrating it into teaching principles that respond to the needs of students, and using methods in which students will take an active role in learning-teaching processes, the teachers in the study stated where they used biomimicry. In the light of the findings obtained in the study, it was seen that the results differed from the data in the literature in terms of the reasons for the use of biomimicry.

In the study, it was observed that teachers who included biomimicry applications and activities in their lessons or projects expressed the positive contribution of biomimicry in supporting the cognitive, affective and psycho-motor multidimensional development of their students after the activities. When the literature was examined, studies conducted with pre-service teachers and secondary school students who continue their education at the faculty of education were found. In these studies, it was stated that within the framework of the concept of biomimicry, significant contributions were made to students in terms of cognitive, metacognitive, affective and psychomotor aspects. Yıldırım (2019) stated that including biomimicry applications in STEM education benefits the cognitive and psychomotor development of prospective teachers. Adıgüzel et al. (2024) emphasized that the contribution of the biomimicry approach is important in supporting the development of metacognitive and affective features among the curriculum objectives. They emphasized that developing the biomimicry approach and integrating it with education through different disciplines supports students' metacognitive skills and affective characteristics. In this context, the study coincides with the results emphasized in the literature.

In this study, teachers stated that when they included biomimicry applications or examples in their lessons, their students' motivation, enthusiasm, interest and curiosity increased; it made the lessons more enjoyable and guided them to gain new perspectives by sensitizing them. In the interviews with the teachers, it was stated that the teachers who used biomimicry in their lessons observed cognitive, affective and psychomotor developments in their students, and that they were supported to become more conscious, respectful to nature, able to look at their environment with different eyes, enthusiastic, curious and knowledgeable individuals in daily life. When the information in the literature and the results obtained from the analysis are examined, it is seen that our study is similar to previous studies. Similarly, Hu (2023) emphasizes that biomimicry aims to develop students' creative skills, enhance their curiosity and motivation, increase their achievement and self-confidence through hands-on learning experiences, promote peer interaction through collaborative teamwork, and encourage them to explore their own interests and expertise through various hands-on tasks.

Oguntona and Aigbavboa (2023) stated that biomimicry often begins with a sense of curiosity. They stated that educators can encourage a sense of awe and curiosity in their students by organizing activities such as outdoor learning experiences, nature walks and observation exercises. Mirici et al. (2021) stated in their study that practices in which biomimicry is integrated into education have a positive effect on students' motivation as they enrich the educational environment. In particular, he stated that the activities included in the classroom facilitate students' learning in different areas, increase their interest and contribute greatly to making the lessons fun. In addition, Oguntona and Aigbavboa (2023) stated that biomimicry is an effective field in gaining skills such as respect for nature, developing a different perspective on the natural environment, associating learned knowledge with real life, critical thinking and problem solving, and developing students in a multifaceted way. Yıldırım (2019) stated that pre-service teachers stated that biomimicry applications contributed to awareness, hand-eye coordination and gaining a different perspective. B. Aydın (2023) stated that biomimicry activities made science lessons more fun and exciting and increased their interest in lessons and school, a topic frequently emphasized by students in their interviews. In addition, D. Aydın (2023) stated in the observations made within the scope of the study that these activities improved students' awareness of nature, environment and sustainability. Similarly, studies conducted with

prospective biology and science teachers on nature, environment, and sustainability have also been found to contribute to the development of their awareness (Köklükaya & Yıldırım, 2016; Selvi et al., 2018; Uzel, 2019; Yiğit et al., 2022; Yildirim et al., 2022). In his study, Stevens (2021) stated that making nature-inspired designs arouses a sense of happiness in students, increases their curiosity and encourages their desire for continuous learning. He also emphasized that it increased students' interest in sustainable solutions.

Textbooks and the internet are the primary sources of information. Therefore, it is important for students and educators that resources are rich in information and examples. In this study, the lack of sufficient information and examples on biomimicry in the sources and the limited written resources were among the difficulties encountered. When the literature is examined, Oguntona and Aigbavboa (2023) reached similar conclusions by stating that there are insufficient resources and difficulties in accessing relevant information, so it will be difficult to integrate biomimicry into the curriculum. Dilaver Türe (2023) stated that the integration of STEM studies involving biomimicry activities into the teaching process is incompatible with the curriculum and syllabi, concerns arising from the preparation process for the university entrance exam and the time factor are among the difficulties experienced. The difficulties in the literature and the findings in this study are similar.

In the interviews with the teachers, it was seen that students had difficulty in understanding the philosophy of biomimicry due to the differences in their level of readiness while making biomimicry designs and projects on this subject, and for this reason, students stated that they tried to make a living model directly instead of being inspired by the characteristics of living things. Stevens (2021) stated that during biomimicry applications, students had difficulty in translating biological mechanisms into biomimicry designs. Similarly, Alperen (2020), during his study with 5th grade students, found that although he showed many examples of biomimicry to the students, they could not gain an understanding of biomimicry due to their age group. In this context, it is seen that the difficulties encountered in the studies in the literature are similar.

As a result of the analyses, it was seen that teachers' views on the inclusion of biomimicry in the curriculum and textbooks came to the fore. When the national and international literature was examined, it was seen that there are many suggestions for including biomimicry in the curriculum. Similarly, Staples (2005) emphasized that integrating the concept of biomimicry into the environmental education curriculum is important for two main reasons. The first one is to convey that there is hope in solving environmental problems. The second is to understand the importance of education for a sustainable future. In particular, the integration of biomimicry into the environmental education program in the high school curriculum is seen by Staples (2005) as an important material for the learning environment and a good example for the problem-based learning approach. In addition, Arslan Selçuk and Mutlu Avinç (2022) stated in their study that it would be useful to develop a course on "bio-informed design in architecture" in the architectural education curriculum beyond the elective course of bio-inspired design approach and emphasized the importance of including the subject in the curriculum. Barnes (2007) stated that education is the key to the spread of biomimicry and that biomimicry should be included in the curricula so that individuals can become aware of this concept. Çoban and Coştu (2023) stated that the more organisms students meet, the more creative ideas they can produce. The richer we keep the books, which are one of the main ways for students to obtain information, in terms of examples and information, the easier it will be for individuals to meet and work with such concepts. For this reason, curricula, books and computer-aided technological applications should be enriched and include current issues. Again, Savran Gencer et al. (2020) emphasized that it is important to include biomimicry in the science curriculum because it allows the integration of the STEM concept with the classroom environment. According to the researchers, introducing the concept of biomimicry to children during STEM education will provide an opportunity to connect nature with engineering, technology, mathematics, and science.

It is important that teachers, who act as a bridge between knowledge and students, become well-equipped, researcher individuals who follow current scientific knowledge and transfer it to their students. The results obtained in this study emphasize the suggestions for organizing workshops and laboratories in cooperation with universities and encouraging teachers to participate in these activities. Teachers stated that such trainings would be beneficial for their personal development. When the literature was examined, it was seen that there were studies that drew attention to this issue. Ergül (2023) stated that in order for the biomimicry approach to be adopted and used in schools, teachers should be supported with undergraduate education or in-service training such as skill-oriented training workshops. Dilaver Türe (2023) stated that extra in-service trainings should be organized for teachers for reverse engineering and biomimicry applications. He also emphasized the need for students to get to know living things, especially in order to be able to make biomimicry applications. Similarly, Ergül (2023) stated that interactive workshops held in science centers can be turned into more comprehensive studies with the support of universities and non-governmental organizations. D. Aydın (2023), on the other hand, found that students' inability to design products inspired by nature was due to the deficiencies of teachers who would guide them in this regard.

In the interviews, teachers suggested that biomimicry-based applications can be made to students in lessons, out-of-school learning environments, projects, laboratory environment and engineering skills. They also thought that its use in education would inspire students to make designs inspired by nature. When the literature was analyzed, similar results were found. Oguntona and Aigbavboa (2023) stated that students can develop innovative solutions to engineering and design challenges by examining and imitating biomimetic materials; biomimicry can inspire students to create more sustainable and efficient solutions or technologies by integrating biomimicry into STEM education. Mirici et al. (2021) stated that it is extremely important to enrich the teaching environment by including studies that encourage students to research, produce and invent, and reveal their abilities and interests in these subjects. Similarly, Çoban and Coştu (2023) stated that biomimicry can be effective in field observations in nature, exploring organisms with educational materials such as microscopes and magnifying glasses, and creating more different design ideas. Ergül (2023) stated that due to the nature of biomimicry, it would be useful to observe the creature to be inspired in its natural environment and emphasized the necessity for children to make observations, discoveries and activities in open spaces, in nature.

In the interviews, teachers emphasized the need to include biomimicry not only in biology or science but also in different disciplines. In addition, teachers stated that studies should be carried out to increase awareness and knowledge levels. When the literature on these suggestions is examined, B. Aydın (2023) stated that biomimicry can be applied not only in science courses but also in other courses such as mathematics and Turkish. Similarly, Staples (2005) stated in his study that biomimicry has a high potential to be integrated into many disciplines and many levels of education. The researcher also drew attention to the interdisciplinary nature of biomimicry by stating that projects can be developed in elementary school years on a basic exploration of nature, in high school in environmental science, biology and art courses, and in fields such as architecture and design. In addition, Oguntona and Aigbavboa (2023) stated that it would be difficult to realize an effective adaptation of biomimicry to the curriculum without educators having sufficient knowledge and skills in biomimicry. Similarly, Arslan Selçuk and Mutlu Avinç (2022) emphasized the importance of the personal development of people interested in architectural education by stating that it is extremely important for them to follow the technological and scientific developments of the age, to adopt sustainable methods and strategies integrated with nature, and to be aware of the potential that nature can offer them.

4.1. Recommendations

It is recommended that biomimicry applications and similar topics be included in the curriculum and textbooks. For this purpose, curricula, textbooks and course hours should be organized accordingly. Teacher training programs should include more information about biomimicry. Teacher trainings, seminars and workshops can be encouraged. In future studies, teachers can be informed about the subject and participate in application studies. Interviews before and after the training can be conducted to contribute to the literature on the subject. The scope of the study can be expanded to include different provinces or even the whole of Turkey, and quantitative studies can be conducted with a large sample of biology and science teachers. Future research could include interviews with teachers from different branches and school types to make comparisons.

Compliance with Ethical Standards

The study protocol was approved by Gazi University Ethics Committee with the decision number E898063 on 06.03.2024.

Conflict of Interest

The authors have no conflict of interest to declare.

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Systematic Analysis of Studies on Professional Competencies, 21st Century Skills and Literacy Skills by Social Studies Teachers and Prospective Teachers

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ABSTRACT

Teacher competencies are defined as the knowledge, skills and attitudes required to fulfil the teaching profession effectively and efficiently. Teachers' possession of these basic competencies is seen as one of the key factors for increasing students' achievement and ensuring their personal development. In addition, to adapt to the changing conditions of the 21st century, several significant businesspeople, politicians and educational experts of the period have gathered and put forward studies on the skills that individuals should gain. In order to effectively implement these skills, it is of great importance that teachers have the appropriate competencies. The alignment of teacher competencies with the skills set forth in the P21 framework is necessary to increase the level of success in education. In recent years, literacy skills have gained importance and literacy fields have diversified. Due to this importance, many literacy skills have been included in curricula. In the acquisition of these skills by students, it is emphasized that teachers should have these skills first. From this point of view, this study aims to determine how the researches on social studies teacher competencies are distributed according to research approach, method, sample/study group, research year and type and in which competency area they are concentrated. In line with this purpose, it is thought that this study will provide a road map for future research on social studies teacher competencies, 21st century skills partnership framework and field literacy skills. In accordance with the purpose of the study, 190 studies that were reviewed in "YÖK Thesis" and "TR Index" databases, using 36 key concepts, and met the inclusion criteria were included in the review. According to the results of this research using the systematic literature review method, it was determined that the studies were mostly conducted by prospective social studies teachers, most of which were master's theses, that there was an increase in the number of studies after 2019, and that they were concentrated in the fields of content knowledge, field education knowledge, information and communication technologies literacy, and digital literacy.

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1. Introduction

Qualification means a document issued when an individual's learning outcomes are recognized by the relevant institution at the end of an evaluation and validation process (T.C. Mesleki Yeterlilik Kurumu, 2015). Bandura (1977) defines self-efficacy as "one's belief in one's own abilities to plan and carry out the courses of action needed to manage future situations". He analysed the components of self-efficacy under three headings: cognitive processes, emotional processes and control process. Self-efficacy theory is based on the idea that people's belief in themselves about how successful they can

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be shapes a part of their performance and motivation (Bandura, 1989). The institutions and organizations that carry out the legal regulations, procedures and coordination related to the definition and presentation of qualifications are the Ministry of National Education, higher education institutions under the coordination of the Council of Higher Education and the Vocational Qualifications Authority (T.C. Mesleki Yeterlilik Kurumu, 2015).

The teaching profession, which has responsibilities beyond transferring and measuring knowledge, has existed in all stages of human history (MoNE, 2017). In this context, a research has been conducted by the Ministry of National Education, Educational Research and Development Directorate at the beginning of the 21st century in Turkey, on the skills that teachers should have. In this research, it was emphasized that there should be teachers who can adapt to the information age, renew themselves and have the skills to utilize alternative paths to access information (MoNE, 2006). For this purpose, the competencies that teachers should have were determined.

Teacher competencies are defined as "the knowledge, skills and attitudes that teachers should possess in order to fulfil the teaching profession effectively and efficiently". Teachers' possession of basic competencies is one of the key factors for increasing students' achievement and ensuring their personal development. General competencies required for the teaching profession can be expressed as follows:

1. Professional Knowledge: field knowledge, field education knowledge, legislation knowledge

2. Professional Skills: planning education and training, creating learning environments, managing the teaching-learning process, measurement and evaluation

3. Attitude and Values: National, spiritual and universal values, approach to students, communication and cooperation, personal and professional development (MoNE, 2017).

To adapt to the changing conditions of the 21st century, several significant businesspeople, politicians and educational experts of the period have gathered and put forward studies on the skills that individuals should gain (Rotherham & Willingham, 2009). Among these studies, the "21st Century Learning Partnership" project, which has an important place in the world, was realized. The aim of the project, which was created with the partnership of thirty-three different institutions and organizations, is to carry out studies to gain the skills anticipated for the 21st century (P21, 2009). Under the 21st century learning partnership, the P21 framework was determined. This framework consists of three main headings and sub-headings. These are:

1. Learning and Innovation Skills: creativity, flexibility, collaboration, problem solving and communication.

2. Information, Media and Technology Skills: information literacy, information and communication technologies literacy, media literacy.

3. Life and Career Skills: flexibility and adaptability, self-management, social skills, productivity and accountability, leadership (P21, 2009).

To effectively implement these skills, it is crucial that teachers have the appropriate competencies. The alignment of teacher competencies with the skills in the P21 framework is necessary to increase the level of success in education. In particular, the P21 framework is centred on critical thinking and problem-solving components. These components are important for teachers to plan their lessons creatively and flexibly and to create classroom environments that are conducive to students' development (Saavedra & Opfer, 2012)

In this direction, social studies teacher competencies include the characteristics that teachers should have to provide their students with knowledge, skills and values in the field of social sciences effectively. The field-specific competencies for social studies teaching are grouped under the following main headings. Planning and Organizing the Teaching Process; Learning-Teaching Process; Monitoring and Evaluation; Collaboration with School, Family and Community; and Providing Professional Development (MoNE, 2008).

According to the Turkish Century Education Model, knowledge and skills are in an interactive structure that feed each other in the learning process. According to this model, knowledge is the basis for acquiring skills, while skills are used to access knowledge and produce new knowledge. Moreover, relevant content is considered as the context for the maturation of social-emotional learning skills, values, literacy skills and dispositions. The process components of literacy skills in the Turkish Century Education Model are designed to be acquired by students at three levels. These three levels are the level of awareness for defining, understanding, being aware of and showing sensitivity to the basic knowledge, terms, concepts and facts in the literacy type; the level of functionality for students to realize the holistic relationship between these knowledge, terms, concepts and facts; and the level of agency for students to act on the acquired knowledge (MoNE, 2024).

A systematic literature review (SLR) is a detailed and replicable strategy that seeks answers to a specific research question. It includes published and unpublished studies relevant to the research question. It is evaluated according to the results of inclusion and exclusion. It is a comprehensive literature review that provides an objective and coherent summary of the results of this assessment. A systematic literature review is usually conducted by a research team. This literature review can identify gaps and trends in the available evidence. It also helps to support future research in the relevant field of study (Munn et al. 2018). In this context, the purpose of this study is to reveal

the focus of the studies examining the competencies of social studies teachers and pre-service teachers within the framework of teacher competencies and to analyse the trends in the related field. This study can provide a roadmap for future studies by using a systematic literature review.

This study aims to provide information about the general characteristics, research methodologies and research trends of the research on social studies teacher competencies and to provide a road map for future research in the related field of study. For this purpose, answers to the following questions were sought:

1. What are the general characteristics of the studies conducted on "teaching profession competencies", "21st century skills" and "literacy" skills of social studies teachers and candidates?

1.1. What are the general characteristics?

1.2. How is the distribution according to research approach/method and publication type?

1.3. How is the distribution according to sample/study group and data collection tools?

1.4. How is the distribution according to the sub-qualification areas specified in the "General Qualifications for the Teaching Profession" of MoNE (2017)?

1.5. How is the distribution according to the sub-dimensions of 21st century skills?

1.6. How is the distribution according to literacy types?

2. Method

A systematic literature review was used in this study, which aimed to analyse the studies on current and prospective social studies teachers' general competencies for teaching profession, 21st century skills and literacy skills. The purpose of a systematic literature review is to conduct a comprehensive search for existing studies on a topic. This search ultimately results in a systematic, transparent and reproducible presentation of results and findings (Siddaway et al., 2019). A systematic literature review requires a systematic process to be followed, which depends on standardized guidelines. When conducting a progressive literature review, the results of the review are filtered. The broadest literature related to the research topic is tried to be obtained (Snyder, 2019). The research was conducted by adhering to the procedure in Figure 1.

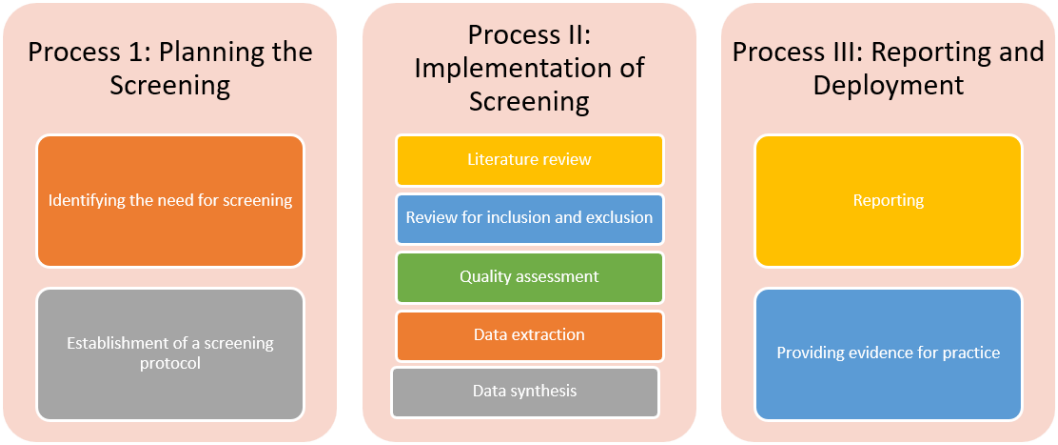

Figure 1. Steps of systematic literature review (Tranfield et al., 2003).

The review protocol was created by interviewing three experts in the field. "General Qualifications for the Teaching Profession" (MoNE, 2017), "The Partnership for 21st Century Learning" (P21, 2009), "Multiple Literacies for Social Studies I, II" (Gençtürk & Karatekin, 2013; Gençtürk Güven & Karatekin, 2021) and "2024 Education Model Social Studies Curriculum" (MoNE, 2024) were determined as the protocols that were the source for determining the key concepts. Considering the relevant literature and basic texts, 36 key concepts related to "Teacher Competencies" were identified. These key concepts were searched for related studies by using "YÖK Thesis" and "TR Index" databases.

Within the framework of the protocols that were the source of the scanning process, the concepts of "Social Studies Teacher", "Prospective Social Studies Teacher" and the sub-concepts of "Competence/21st century skills/literacy" were reviewed separately and related studies were reached. The sub-key concepts included in the review were "Field knowledge", "Field education knowledge", "Legislation knowledge", "Education and training planning", "Creating learning environments", "Managing teaching and learning process", "Assessment and evaluation", "Communication and collaboration", "Personal and professional development", "Critical thinking and problem solving skills", "Creative thinking and innovation implementation skills",

"Communication skills", "Collaboration skills", Information literacy", "Information communication technologies literacy", "Flexibility and adaptability", "Entrepreneurship and self-orientation", "Social and intercultural skills", "Productivity and accountability", "Cultural literacy", "Visual literacy", "Digital literacy", "Water literacy", "Spatial literacy", "Financial literacy", "Moral literacy", "Natural disaster literacy", "Civic literacy", "History literacy", "Geography literacy", "Political literacy", "Environmental literacy" and "Forest literacy" were determined as "self-efficacy". Studies whose full texts could not be accessed and studies outside the identified competency areas were excluded.

The review process was completed between October 7-21, 2024. As a result of the review, 7 of the 197 studies were excluded from the study in accordance with the exclusion criteria. It was determined that 72 of the studies were related to the self-efficacy beliefs of social studies teachers/prospective teachers and 33 of them were conducted with mixed subject groups including social studies teachers/prospective teachers. Since the aim of this study was to reveal a holistic view of the studies covering competency areas, studies with self-efficacy and sampling variation were included in the review.

3. Findings

In this section, the general characteristics of the studies obtained from the literature review, research approaches/methods and types of publications, teaching profession general competencies, 21st century skills and literacy skills are presented.

Table 1. General characteristics of the studies included in the study.

Year	f	%	f	%	f	%	f	%
1999	-	-	1	1	-	-	1	0.5
2003	-	-	-	-	1	4.8	1	0.5
2006	2	2.9	1	1	-	-	3	1.6
2008	1	1.4	2	2	1	4.8	4	2.1
2009	1	1.4	-	-	1	4.8	2	1.1
2010	3	4.3	2	2	-	-	5	2.6
2011	1	1.4	2	2	4	19.0	7	3.7
2012	2	2.9	2	2	-	-	4	2.1
2013	5	7.2	4	4	-	-	9	4.7
2014	3	4.3	1	1	1	4.8	5	2.6
2015	3	4.3	4	4	-	-	7	3.7
2016	4	5.8	2	2	1	4.8	7	3.7
2017	6	8.7	8	8	1	4.8	15	7.9
2018	2	2.9	5	5	2	9.5	9	4.7
2019	8	11.6	16	16	3	14.3	27	14.2
2020	5	7.2	6	6	-	-	11	5.8
2021	5	7.2	5	5	2	9.5	12	6.3
2022	6	8.7	16	16	2	9.5	24	12.6
2023	8	11.6	15	15	1	4.8	24	12.6
2024	4	5.8	8	8	1	4.8	13	6.8
Total	**69**	**100**	**100**	**100**	**21**	**100**	**190**	**100**

According to Table 1, 100 of the 190 studies involving social studies teachers and pre-service teachers were master's theses, 69 were articles and 21 were doctoral dissertations. When we look at the distribution of the studies by years, it is seen that the first article was published in 2006, the first master's thesis in 1999, and the first doctoral study in 2003. It was determined that the most scientific publications in this field were made in 2019 and the least in 1999 and 2003. In 2019 and later, it was determined that there was an increase in the number of studies conducted. While the highest number of publications in master's studies was in 2019, the least studies were conducted in 1999 and 2014. In addition, no study on the subject was found in 2003 and 2009. In doctoral studies, it was determined that the highest number of publications were made in 2011, and no studies were conducted in 1999, 2006, 2010, 2012, 2013, 2015 and 2020. In 2019 and afterwards, it was determined that doctoral studies on the subject increased, albeit partially. In article studies, the highest number of publications were made

in 2019 and 2023. Since 2006, articles have been published every year.

Table 2. Distribution of studies by research approach/method and type.

Approach	Method	Article	f	Master's	f	PhD	f
Quantitative	Screening/Descriptive Screening	S4, S5, S9, S14, S15, S23, S26, S27, S29, S31, S32, S39, S40, S41, S46, S47, S48, S52, S65, S66, S70, S99, S101, S102, S103, S113, S114, S117, S118, S119, S121, S153, S152, S156, S160	35	S1, S3, S8, S13, S19, S20, S24, S33, S34, S36, S56, S58, S59, S74, S76, S80, S82, S87, S90, S92, S94, S97, S107, S108, S109, S112, S123, S136, S139, S141, S143, S144, S146, S147, S162, S165, S166, S167, S170, S171, S173, S174, S175, S176, S177, S178, S182, S184, S185	49	S7, S10, S17, S21, S85, S127, S129	7
	Relational Screening	S11, S16, S28, S49, S68, S71, S106, S115, S148, S189	10	S6, S12, S25, S42, S43, S45, S62, S63, S75, S79, S81, S89, S96, S98, S110, S125, S128, S130, S133, S137, S142, S163, S164, S179, S180, S181, S186	27	S53, S64, S78, S93, S2	5
	Scale Development	S30, S50, S105, S157	4				
	Cross-Sectional Survey	S72, S150, S158	3	S126	1		
	Experimental	S187	1	S38, S140	2		
	Causal Comparison			S55	1		
Total			**53**		**80**		**12**
Qualitative	Case Study	S104, S120, S154, S155, S159, S169, S188, S190	8				
	Document Analysis	S122	1			S145	1
	Phenomenology	S161	1	S134	1		
Total			**10**		**1**		**1**
Mixed	Unspecified	S51	1	S44, S124	2	S22	1
	Exploratory Sequential Pattern	S67, S69, S151	3	S57, S77, S83, S86, S88, S111, S131, S135, S138	9	S18, S84, S132, S183	4
	Variation Design			S95	1	S37	1
	Screening-Case Study			S54	1		
	Simultaneous Nested Design			S35, S61, S168	3		
	Explanatory Sequential Pattern			S91	1		
	Quasi-Experimental Design + Case Study	S100	1				
	Proximal Parallel Pattern	S116	1	S60	1	S73, S172	2
	Embedded Pattern	S149	1				
Total		**7**			**18**		**8**

The findings regarding the research approach of the analysed scientific studies are presented in Table 2. When the distribution of the studies according to research approach/method and type is examined, it was determined that most of the studies were master's theses (f=99), followed by articles (f=70) and doctoral studies (f=21). Considering the approaches of the studies on teacher competencies, it was understood that quantitative studies (f=144) were the most prominent, followed by mixed (f=34) and qualitative studies (f=12). It was determined that qualitative studies on the subject were insufficient. In the qualitative research approach, the most case study (f=8), in the quantitative research approach, the most

survey/descriptive survey (f=91) and relational survey (f=41) studies were conducted, while in the mixed approach, the most studies were conducted with exploratory sequential design (f=16). It was determined that scale development studies were conducted only in articles (f=4) and there was no scale development studies in master's and doctoral programs.

Table 3. Distribution of studies according to sample/study group and data collection tools.

Sample/ Study Group	Data Collection Tool	Article		Master's Degree		Doctoral Thesis	
		Code	f	Code	f	Code	F
Social Studies Teacher Candidate	Personal Information Form - Scale	S40, S41	2	S3, S56, S76, S79, S89, S92, S108, S110, S123, S124, S162, S163, S174, S179, S182	15	S53	1
	Self-Efficacy Scale			S5	1		
	Scale	S14, S32, S52, S68, S72, S103, S106, S114, S115, S160	10	S13, S38, S55, S62, S75, S82, S96, S97, S98, S109, S125, S133, S144, S171, S176, S184	16	S7, S10, S64, S127	4
	Scale/Daily	S116	1				
	Scale/Semi-structured Interview Form	S149	1				
	Interview Form - Daily Forms					S145	1
	Demographic Information Form - Scale			S126	1		
	Scale - Achievement Test			S147	1		
	Observation Form / Evaluation Form	S9	1				
	Survey					S21	1
	Scale/Information Form/Interview Form	S51	1	S60, S111	2	S183	1
	Scale-Interview Form	S67	1	S35, S77, S83, S135, S95	5	S132, S172	2
	Semi-structured Interview Form	S120	1	S134	1		
	Measurement and Evaluation Literacy Inventory			S59	1		
	Literacy Inventory Perception Scale	S102	1				
	Scale-Literacy Test-Measurement Questions			S90	1		
	Literacy Test, Assessment Form, Observation Form, Interview Form	S100	1				
	Self-Assessment Form	S122	1				
	Literacy Inventory	S101	1				
	Scale Development	S105, S157	2			S129	1
	Scale-Interview Form-Personal Information Form			S54	1		
	Scale-Digital Proficiency Test			S140	1		
	Knowledge Test-Scale			S12, S43	2		
	Scale - Interview Form - Document Analysis					S18	1
Total			**24**		**48**		**12**

Table 3. (continued).

Sample/ Study Group	Data Collection Tool	Article		Master's Degree		Doctoral Thesis	
		Code	**f**	**Code**	**f**	**Code**	**F**
Social Studies Teacher	Questionnaire/Observation Form			S1	1		
	Observation Form			S4	1		
	Survey	S26, S49, S117, S119	4				
	Scale/Survey			S142	1		
	Personal Information Form-Scale	S152	1	S19, S42, S45, S87, S136, S137, S141, S148, S177	9	S17	1
	Scale	S29, S31, S47, S66, S113, S150, S153, S156, S158, S187, S189	11	S20, S63, S80, S94, S107, S128, S139, S146, S164, S165, S166, S167, S170, S178, S185, S186	16		
	Scale - Interview Form	S151	1	S57, S61, S88, S91, S138, S168	6	S22, S37	2
	Demographic Information Form-Scale			S130, S143, S173, S180	4		
	Demographic Information Form-Interview Form-Event Texts Form			S169	1		
	Interview	S154, S161, S188	3				
	Observation / Interview	S104, S190	2				
	Semi-structured Interview Form	S155, S159	2				
	Scale-Concept Test			S33	1		
	Scale Development	S50	1			S93	1
	Personal Information Form-Scale-Interview Form			S131	1	S84	1
	Survey-Interview Form			S34, S86	2		
Total			25		43		5
General Total			**49**		**91**		**17**

The findings regarding the distribution of the analysed scientific studies according to the sample/study group and data collection tools are presented in Table 3. When the distribution of the studies according to the data collection tools was analysed, it was determined that the data collection tools varied. Among these tools, “Likert-type scale” tools for different competence/literacy areas were found to be prominent. It was observed that this data collection tool was primarily preferred in master's theses (f=16). It was followed by article studies (f=10) and doctoral studies (f=4). Secondly, “scale/personal information form” was the most frequently used data collection tool. It was noteworthy that there were mostly master's studies (f=15), while articles and doctoral studies were very few.

In the studies conducted with social studies teachers, it was determined that scales were mostly used as data collection tools. It was determined that these scales, which were developed for different competency areas, were mostly used in master's theses (f=38), followed by articles (f=14) and doctoral studies (5). Among the data collection tools collected with this study group, the second most common data collection tool was a combination of personal information form/scale. It was determined that master's studies (f=9) ranked first, while the number of articles and doctoral studies using these data collection tools together was limited.

Table 4. Distribution of studies according to the sub competency areas specified in MoNE (2017) "General Qualifications for the Teaching Profession".

Teacher Competency Area	Article		Master's		PhD	
	Code	f	Code	f	Code	f
Field Knowledge	S52, S5, S14	3	S34, S38, S43, S54, S57, S61, S62, S77, S83, S91, S94, S96, S126, S135, S144, S166, S170, S179	18	S37, S53	2
Field Education Knowledge	S4, S41, S49, S103, S104, S119, S160, S188	8	S75, S86, S107, S128, S141, S168	6	S17, S64, S84, S132	4
Legislation Knowledge			S169, S174	2		
Education and Training Planning			S177	1		
Creating Learning Environments					S172	1
Managing the Teaching and Learning Process	S9, S29, S47, S113, S117, S122, S150	7	S1, S13, S167	3		
Measurement and Evaluation	S26, S32, S100	3	S33, S59, S80	3		
National, Spiritual and Universal Values			S35, S89, S176	3		
Approach to the Student	S189	1				
Communication and Cooperation	S102	1				
Personal and Professional Development	S31, S67, S114, S120, S148, S149, S152, S187, S190	9	S42, S45	2		
Total		**32**		**38**		**7**

The findings regarding the distribution of the analysed scientific studies according to the teaching proficiency areas are presented in Table 4. A total of (f=77) studies related to the key concepts of MoNE (2017) "General Competencies for Teaching Profession" were reached. According to these findings, it was determined that the most studies related to teaching competency areas were conducted in the field of field knowledge (f=23) and field education knowledge (f=18). Among the studies conducted in this field, it was seen that one study was conducted on the key concepts of "education and training planning", "creating learning environments", "approach to students" and "communication and cooperation". At the same time, it was determined that S47 and S189 were also included in the "communication and cooperation" category in Table 5. There were no articles on the key concepts of legislative knowledge, educational planning, creating learning environments, national, spiritual and universal values. There were no master's studies on the key concepts of creating learning environments, approach to students and communication and cooperation. Doctoral studies are related to the key concepts of field knowledge, field education knowledge and creating learning environments.

Table 5. Distribution of studies according to 21st century skills sub-dimensions.

21st century skills	Article		Master's Degree		PhD	
	Code	f	Code	f	Code	f
Critical Thinking, Problem Solving Skills	S153	1	S20	1	S7	1
Creative thinking and Innovation Implementation Skills						
Communication Skills	S189	1				
Collaboration Skills	S47	1				
Information Literacy			S56, S110	2		
Media Literacy	S115	1	S76, S98, S124, S125, S136	5		
Information and Communication Technologies Literacy	S40, S155	2	S3, S55, S63, S88, S97, S133, S137, S142, S143, S162, S184, S185, S186	13	S18, S129	2
Flexibility and Adaptability						
Entrepreneurship and Self-Direction						
Social and Intercultural Skills	S159	1	S82, S163	2		
Productivity and Accountability					S172	1
Leadership and Responsibility						
Total		**7**		**23**		**4**

The findings regarding the distribution of the analysed scientific studies according to 21st century skills are presented in Table 5. It was determined that most of these studies were master's theses (f=23), followed by articles (f=7) and doctoral studies. When the distribution according to 21st century skills sub-dimensions was examined, it was determined that most of the studies conducted were related to "information and communication technologies literacy" (f=17) and "media literacy" (f=6) skills. Considering the type of these studies, it was determined that most of them were master's theses (f=18), articles (f=3) and doctoral studies (f=2). In contrast to these skills, there were no studies on "creative thinking and innovation implementation skills", "flexibility and adaptability", "entrepreneurship and self-direction" and "leadership and responsibility" skill areas.

Table 6. Distribution of studies according to literacy types.

Areas of literacy	Article		Master's		PhD	
	Code	f	Code	f	Code	f
Health Literacy	S151	1				
Program Literacy	S99	1				
Legal Literacy	S154	1	S60, S138	2	S145	1
History Literacy	S161	1				
Assessment and Evaluation Literacy	S101, S102	2				
Digital Literacy	S156	1	S92, S95, S123, S131, S140, S146, S164, S165, S171, S178, S180, S182	12		
Media Literacy	S115	1				
Pedagogical Literacy			S139	1		
Technology Literacy			S111	1		
Geography Literacy			S90	1	S10	1
Ecological Literacy			S147	1	S21, S78, S183	3
Financial Literacy			S87	1		
GeoSpatial Literacy			S134	1		
Political Literacy			S173	1		
Total		**8**		**21**		**5**

The distribution of the analysed scientific studies according to literacy types is given in Table 6. It was determined that 14 different literacy types were examined in a total of 34 studies conducted according to literacy areas. When the distribution of these studies according to the type of publication was examined, it was determined that there were mostly master's theses (f=21), followed by articles (f=8) and doctoral studies (f=5). According to these findings, it was determined that most studies were conducted on the concept of "digital literacy" (f=13). There were no articles on pedagogical, technology, geography, ecology, financial, spatial, political literacy; no master's thesis on health, curriculum, history, assessment and evaluation, media literacy; and no doctoral study on health, curriculum, history, assessment and evaluation, digital, media, pedagogical, technology, financial, spatial, political literacy.

4. Discussion and Conclusion

Within the scope of this research, a total of 190 national scientific studies that met the inclusion criteria were analysed based on a search of databases using keywords related to 21st century skills/literacy/self-efficacy skills and teacher competencies identified by social studies teachers and candidates. Of these studies, 100 were master's theses, 69 were articles, and 21 were doctoral theses. The analysis revealed that the first study related to teacher competencies was conducted in 1999. The current study was found to be a quantitative study using a descriptive survey method conducted with social studies teachers. It was determined that the year with the most scientific studies was 2019, while the years with the fewest were 1999 and 2003. In particular, it was determined that there was an increase in the number of studies conducted on teacher competencies in 2019 and thereafter. This situation may be related to the publication of the MoNE's "General Competencies of the Teaching Profession" and "Education Vision Document" (MoNE, 2017, 2023). It can be said that the publication of these frameworks has increased the research trend on teacher competencies.

When the studies included in the research on teacher competencies were examined according to the research approach, it was seen that quantitative (144) studies stood out. In addition, mixed (34) and qualitative (12) studies were also found. In quantitative research approaches, survey/descriptive survey and correlational survey studies were encountered as research methods, while scale development, cross-sectional survey, experimental, and causal comparison methods were also preferred. When looking at other systematic review studies on teacher competencies, it is seen that quantitative studies are also predominant. Saykal and Uluçınar Sağır (2021) examined 525 studies published between 2000 and 2020 on teacher competencies and TPACK and found that quantitative methods were predominant, while mixed and qualitative approaches were limited in number. Other studies examining master's and doctoral theses in the field of teacher competencies have also determined that descriptive and correlational survey methods are predominantly used (Gündoğdu et al., 2015; Kazu & Çam 2019). It can be said that quantitative studies are conducted with larger sample groups and produce generalizable results for the problem situation, which is effective in this preference. However, the availability of quantitative measurement tools for teacher competencies and the ability to complete the data collection and analysis processes of the study in a shorter time are also considered to be effective in determining the research approach. In studies where a mixed research approach was preferred, it was observed that the explanatory sequential design was used most frequently. This design allows for a more in-depth analysis by supporting quantitative findings with qualitative data (Creswell, 2017). In qualitative research methods, it has been determined that case studies are given the most weight. Such studies aim to reach more comprehensive interpretations regarding teachers' competencies (Yıldırım & Şimşek, 2016), but the small number of qualitative studies limits the depth of analysis in the field (Kazu & Çam, 2019). Kaşkaya (2012), on the other hand, emphasizes the need to use both qualitative and quantitative studies together, particularly emphasizing the adoption of qualitative approaches.

When examining the distribution of studies according to sample/study group, it was determined that the largest number of studies were conducted with social studies teacher candidates (84). This situation shows that there is a strong tendency to seek the opinions of teacher candidates, especially in the areas of teacher competencies, self-efficacy, 21st century skills, and literacy. The majority of postgraduate theses on teacher competencies have stated that the sample group consists of teacher candidates (Gündoğdu et al., 2015). Focusing on teacher candidates in research is important in terms of providing feedback on the education system and taking preventive measures against possible problems at an early stage (Kaşkaya, 2012). However, it is also thought that the ease of access to teacher candidates as a sample group is a contributing factor. In studies conducted with social studies teacher candidates and social studies teachers, scales and personal information forms/scales were more commonly used as data collection tools. These tools mostly consist of scales adapted to areas such as teacher competence perception, digital literacy, and communication skills (Gündoğdu et al., 2015; Saykal & Uluçınar Sağır, 2021).

When the studies were examined according to the sub-competence areas specified in the general competences of the teaching profession, it was determined that most of the studies were conducted in the competence area of subject knowledge and subject education knowledge. This situation can be attributed to the traditional tendency in Turkey to train subject-specific technical teachers (Tingil et al., 2023). In the studies examined, it was found that there were no articles in the areas of legislation knowledge, educational planning, creating learning environments, and national, spiritual, and universal

values, and no master's theses in the areas of approach to students, communication and cooperation, and creating learning environments. In the areas of managing the teaching and learning process, measurement and evaluation, national, spiritual, and universal values, approach to students, communication and collaboration, personal and professional development, legal knowledge, and educational planning. This result indicates that these competency areas are still open to development in terms of academic research.

When examining the types of studies according to the sub-dimensions of 21st century skills, it was determined that master's degree studies (23) were predominant (Ayaz et al., 2015). At the same time, it was found that these studies focused on the competence area of "information and communication technology literacy." Within the scope of digital transformation in education, initiatives such as strengthening the technological infrastructure in schools in line with the requirements of the 21st century and the era, preparing digital teaching materials and making them available to teachers, and developing and implementing systems such as e-learning, e-school, EBA, etc. can be said to have been effective in this result (Karoğlu et al., 2020). However, it is noteworthy that no studies have been conducted in the areas of creative thinking and innovation application skills, flexibility and adaptability, entrepreneurship, and self-direction.

When looking at the distribution of studies according to literacy types, it is seen that master's studies (21) are predominant. Most of these master's studies are related to the field of digital literacy. This situation can be explained by the fact that digital transformation is being promoted in all areas in Turkey. No articles were found related to pedagogical literacy, geographical literacy, ecological literacy, financial literacy, spatial literacy, or political literacy, and only one study was found for each of the other literacy areas. It is thought that researchers' tendency to focus on popular and widespread research areas may have contributed to this result.

Considering the results of teacher competency studies conducted with social studies teachers/social studies teacher candidates, the following recommendations can be made:

• It is considered important that future studies on 21st century skills focus on sub-skills such as creative thinking and innovation, flexibility and adaptability, entrepreneurship, leadership, and self-direction to reflect a holistic perspective on social studies teacher competencies.

• No studies related to moral literacy, forest literacy, visual literacy, cultural literacy, and sustainability literacy, etc. were found in the literature on social studies teacher competencies. Studies can be conducted to contribute to the literature on these areas of literacy.

• It has been observed that studies related to the sub-competency areas of general teacher competencies, particularly the subject knowledge and subject education knowledge competency area, have been given more attention. However, all sub-competencies are equally important. Different studies can be conducted on these teacher competency areas.

Compliance with Ethical Standards

This type of study does not require ethical committee approval.

Conflict of Interest

The authors have no conflict of interest to declare.

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REVIEW ARTICLE

Project Method in Social Studies: Pen Pal Project

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ABSTRACT

Today, teachers can go beyond being passive recipients or transferrs of information to students in the learning process. Teachers can apply project-based learning in their classes to increase students' participation, question, discover and learn effectively throughout the teaching-learning process. As a result of using project-based learning in classes, students can develop research, participation, collaboration, rethinking, critical thinking and decision-making skills. Projects can increase students' motivation, be exciting and interesting. At the same time, deep learning can occur. Therefore, teachers can develop original projects for their students in classes. A pen-pal project can be one of these methods. Students' knowledge and skills in subjects such as recognizing different cultures, establishing intercultural interaction and communication can be expanded with the pen-pal project. This study was designed to examine the positive gains that social studies teachers can provide to students as a result of implementing project-based learning in their classes. This study was conducted using the document review method, one of the qualitative research methods. In this study, data were collected primarily through document analysis and document decoding. In the document review, project studies used in social studies education and articles on penpal projects were examined. In the document review, international studies, primarily the NCSS publications Social Education, Social Studies and Young Learner journals, were used. The document review was conducted between the years 2024-2025. In social studies education, project-based learning can provide students with opportunities such as solving real-world problems, questioning, sharing experiences, looking at events from different perspectives, creating meaningful learning opportunities, understanding different perspectives, using technology, establishing connections, deepening knowledge, discovering and doing interdisciplinary studies. Project-based learning can be one of the ways that motivates students, educates them with factual information, provides awareness and develops skills. A pen-pal project from primary sources can be exciting, interesting and intriguing for students. Teachers can apply project-based learning in social studies classes. Teachers can implement a pen-pal project to ensure that students interact with different cultures.

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1. Introduction

Project-based learning can be an active method that ensures the highest level of student participation in the learning process. In project-based learning, students can learn effectively and show more interest in the lesson. Social skills such as cooperation and communication develop among students and a real problem can be addressed in a structured process (Walberg & Paik, 2002). Research results on project-based learning have determined that it includes a process far from practical and traditional learning activities aimed at increasing student participation and preventing rote learning (Bell, 2010). Project-based learning supports questioning, authentic, meaningful and creative learning in students. The project approach emphasizes the importance of listening to students, following their leadership, seeing them as talented researchers, and providing

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real-life experiences for questioning and exploring (Katz et al., 2014). This learning method can play a role in encouraging students to be aware, rethink, think critically, as well as providing deep learning and facilitating learning (De la Torre-Neches et al., 2020).

Teachers can implement pen-pal projects as projects by working collaboratively with students to conduct research, make decisions, answer questions and provide real-life experiences during the project process. In pen-pal projects carried out to create original project-based learning, my students can establish connections beyond the classroom, increase their self-confidence and develop relationships with positive role models (Bram, 2023). As a result of the pen-pal project, there can be developments in students' attitudes, increase motivation, learn about different cultures and develop communication skills (Hendrickson & Peterson-Hernandez, 2020). In this context, the need for change in social studies education, transformation into innovative and constructive learning, and changing the understanding while teaching the subject content to students (Halvorsen et al., 2019). Using project-based learning in classes is very effective for achieving specific learning outcomes. It also increases students' academic achievement and provides a deep learning experience (Larmer, 2018). Therefore, schools should encourage students to participate in simulations of democratic processes and procedures. Simulations of voting, hearings, legislative debates, and diplomacy in schools can lead to increased political knowledge and interest. Students learn skills that are clearly applicable to both civilian and non-civilian contexts, such as public speaking, teamwork, close reading, analytical thinking, and the ability to argue both sides of an issue. All of these are skills that prepare students for active citizenship as well as future academic and career success (NCSS, 2013). These individuals are also more likely to vote, debate politics, speak publicly and communicate with their elected representatives, volunteer, and work on community issues in the future. Schools with civic education programs are more likely to be safe, inclusive, and respectful (Jamieson et al., 2011). The purpose of this research is to provide information to textbook writers, curriculum developers, field experts, and teachers by evaluating the positive outcomes that social studies teachers can provide to their students as a result of implementing project-based learning in their classes.

2. Method

This study was conducted using the document review method, which is one of the qualitative research methods. The document review method can be defined as obtaining, examining, questioning and analyzing various documents that are considered as primary or secondary sources that constitute the data set of the research (Özkan, 2019). In this study, data were collected primarily through document analysis and document decoding. In the document review, articles related to the project method used in social studies education and the pen pal project were used. The document review was conducted between the years 2024-2025.

3. Social Studies Education with Project Based Learning Method

Through project-based learning, students can take part in the planning, discussion and implementation of projects that are important to their nation, local community or themselves (Blank, 1997). Thus, students can learn content and skills by addressing real problems through project-based learning. In this context, project-based learning manifests itself in three stages that reflect the scientific research process. These stages;

Stage 1. Students can talk about their personal information as well as the experiences shared by their friends to create research questions. The aim of this stage is to find out what students already know about a topic and what they want to know more about. Students can bring works related to the topic from home and display their existing knowledge on a web site. In this way, teachers can detect students' misconceptions about the topic.

Stage 2. Students try to find answers to their questions by researching new information, drawing what they have learned, body movements or other expressions. Teachers plan learning experiences for children to answer research questions and provide in-depth information. During this stage, students can research on the internet, in books and review published lesson plans. Students can go on field visits or have an expert come and visit them in the classroom. Students can share their new knowledge through various means of representation, such as writing, drawing, graphics, paint, clay, dramatization, and construction.

Stage 3. Students disseminate what they have learned by sharing what they know with others. Finally, students have the opportunity to share what they have learned. There can be many different ways to finalize a project to prove knowledge, such as organizing an event (game, celebration, grand opening) or creating a product (book, poster, or digital video) and sharing it with others (Damjanovic et al., 2021). In addition, project-based learning can be carried out in the form of interdisciplinary learning. Students can learn about the functioning of government, the structure of politics, and politically controversial issues (Larmer, 2018). In this context, project-based learning was used to teach citizenship skills to students at a school in the USA. The stages of the project are as follows:

• In the first project, students took on the role of delegates to the 1787 Constitutional Convention, where they had to debate the merits of the Constitution, understand the principles of federalism, and decide whether the federal government or state governments should make important decisions.

• The second project was a simulation of a U.S. presidential election in which students were assigned the roles of candidates, campaign managers, the media, political parties, and interest groups. Through the project, students learned about the complexities of the election process as they tried to elect the candidate most suited to their interests.

• In the third project, students took on the role of Supreme Court justices and attorneys as they conducted mock court trials (mock appellate court hearings) in important Supreme Court cases.

• In the fourth project, students took on the role of a legislative body in which they worked together as members of Congress to enact legislation.

• In the fifth project, students served as political consultants to interest groups. In this final project, students used all the knowledge they learned throughout the course to provide comprehensive political action plans for the interest group (Piper & Neufeld-Kaiser, 2018). These topics are vital to laying the foundation for civic learning in students. Project-based learning can directly teach students about government, history, economics, law, and democracy in ways that foster critical thinking skills and can contribute to students' long-term civic and political engagement (NCSS, 2013).

3.1. Elements of the Project Method

The Buck Institute for Education also outlines seven key design elements for a project. These elements are:

• A compelling problem: The project is framed by a meaningful problem to be solved or a question to be answered at an appropriate level of difficulty.

• Sustained inquiry: Students engage in a rigorous and long-term process of asking questions, finding sources, and applying knowledge.

• Originality: The project includes a real-world context, tasks, tools, quality standards, or impact. It addresses students' personal concerns, interests, and issues in their lives. Because originality is a key project design element, simulations can occasionally be used in historical contexts rather than requiring all projects to be completely "real world." For example, simulations can be used in a topic on ancient Egypt. Students are more likely to find originality in a project about recent history, where students can interview people who lived it or find evidence of its lasting impact on their society. However, a project about more distant history is often more engaging if it can be connected to themes or issues that students find relevant today.

• Student decisions: Students make some decisions about the project, including how they will work and what they will create.

• Reflex: Students and teachers reflect on learning, questioning, and the effectiveness of project activities, the quality of student work, obstacles, and how to overcome them.

• Critique and revision. Students give, receive, and use feedback to improve their processes and products.

• Social product: Students make their projects public by explaining, exhibiting, or presenting them to people beyond the classroom (Piper & Neufeld-Kaiser, 2018).

3.2. Topics in Project Methodology

Since globalization and rapid technological developments in the 21st century have deeply affected the conceptualization of what it means to be a productive member of democracy and society, any subject such as society, history, government, and economy can be included in the project within the framework of the design elements determined for the project (NCSS, 2013). Project topics should focus on students' areas of interest and concrete elements. They can contribute to the development of students' knowledge and skills by working on the following topics with their students as project topics. These topics;

• A debate, speech, social media campaign, or multimedia presentation about a current event or controversial issue,

• A museum exhibition about a historical time, place, person, event, or development,

• A monument proposal that describes a historical event or development,

• A simulation of a situation in which the student has to solve a problem, make a decision, or give advice to a leader,

• A sign, podcast, guided tour, field guide, or annotated online map about local history,

• An action or service learning project that will benefit society.

3.3. Skills Developed in Students as a Result of the Project Method

The project-based learning topics mentioned can be used at all grade levels. All students can be included in the project. Nations ask students to think critically, solve real-world problems, communicate with different people, collaborate, use technology, and develop speaking and listening skills. Such competencies are also called 21st century skills. Project-based learning can be one of the most effective ways to develop these skills. This method is also motivating, engaging, factual, and suitable for making connections between disciplines (Larmer, 2018).

In an example of a study conducted in the form of interdisciplinary learning, the teacher decided to ask the students the research question "How do we get the ingredients we need to cook?" She asked the students to visit the market to

expand their understanding of places that sell food and explore it more deeply. During the first field visits, the students observed, interacted, and recorded their experiences while sampling the available items. During the second visit, students were exposed to real-life economic, math, science, literacy, and social interaction competencies. Students had the chance to see, smell, touch, and even taste products, and learn what they were made of. They voted for what they liked the most, then purchased items from the market by exchanging money, interacting with others in the community, and applying their math knowledge. Meanwhile, some students were responsible for drawing, photographing, and documenting their experiences. The experience of participating in the fieldwork led the children to explore the market. It gave them the opportunity to work as part of a group, with each student taking on specific roles that supported a broader vision of creating their own market. Students voted to select products to purchase, embracing the civic idea that everyone's voice matters when making product choices. Through their interactions with vendors, students observed the ways products are sold, customer interactions, and the buying and selling process. As a result of this study, it was determined that students developed collaborative, problem-solving, basic democratic principles, and civic skills (Damjanovic et al., 2021).

In social studies education, project work creates real learning opportunities in developing students' citizenship skills. It stands out in supporting and deepening interaction with various content areas by adding purpose and meaning to students' experiences. Projects are important in terms of recognizing the role they play in students' development of meaningful connections, creating fun learning, and creating spaces for sharing and exploring culture. The project approach focuses on connections with students' lived experiences, ideas, and skill levels. Project work allows for highly differentiated education by inviting children to question at their own individual level. Teachers can provide highly differentiated integrated learning opportunities based on identifying connections between content areas and developing children's skills and mental levels. The ongoing inquiry process throughout the project can create opportunities for students to engage in more than one content area at the same time while exploring the real world around them and deepening their knowledge about the world (Damjanovic et al., 2021).

3.4. Pen Pal Project in Social Studies Education

In societies where citizens have historically been divided and diverse, it is essential for citizens to develop a rational commitment to the founding principles and values that bind them together. Commitment to democratic principles, a desire to participate in the democratic process, and high-quality civic education policies and programs that will ensure the blessings of freedom for future generations should be encouraged. In order to create policies that provide high-quality social studies education for all students at all grade levels (NCSS, 2013), the teacher read to students an 1818 letter from the Archbishop of Mexico about the Spanish colonial period. The letter included information about history, geography, and the local people of the period. The teacher asked the students to make presentations about this letter, provide information about the Spanish colonial period, and use drawings and models. The students presented the assigned tasks in the next lesson. As a result, it was determined that students developed skills such as participation, critical thinking, collaboration, communication, and creativity (Larmer, 2018).

Carrying out such activities in the classroom can develop students' understanding of the basic processes of democracy, understanding and awareness of public and social issues, the ability to acquire information, critical thinking, the ability to look at events from different perspectives and the ability to understand different perspectives (NCSS, 2013). In this context, two teachers working in Indiana and Hawaii decided to carry out a pen-pal project for their students. The project aimed to make the students' learning experiences about society as concrete and relevant to real life as possible, to provide them with intercultural experiences, to introduce them to the citizens of a culturally different nation and to enable them to establish relationships with the world. The pen-pal project brought about unforgettable learning experiences with the use of children's literature, society and technology resources. In order to use pen-pal correspondence as an important student activity, the teacher developed a plan for a standards-based, integrated unit of study about society. During the seven-week duration of the theme, students in the two states compared the geographic, economic and cultural aspects of their countries. The teachers encouraged the students to find answers to some questions in their letters. These questions were as follows; (1) How do people living in Michigan City differ from people living in other regions? (2) How far is the distance between Indiana and Hawai'i? (3) What are the social problems experienced in Indiana and Hawai'i? (4) What are the common characteristics and differences between the two cultures? (5) Are household items more expensive in Hawaii or Indiana? Three letters were exchanged between the students. The students brought objects that they thought represented their culture or society to the classroom. These items included photographs, toy jewelry they made themselves, and sculpy clay figures. Each student selected one of these items and introduced it to their pen pal in Hawaii and wrote a short letter explaining the importance of the selected item. The students from Hawaii also introduced their own cultural items to their pen pals. In addition, the students were advised to use children's books, explanatory texts, and internet resources to explore the similarities and differences between Hawai'i and Indiana. After approximately two weeks, the students brought different types of sand, seashells in various shapes, pictures of the students' families, origami, and colorful neck ties to the classroom. Students introduced each other by selecting an item.

In this way, students discovered similarities and differences between the two countries. Students compared the prices of products in their countries using information collected from the latest Indiana and Hawaii newspapers. As a result of the study; students saw the differences and similarities between the two societies through the pen-pal project. Students exchanged information about homes, family members, traditions, languages, foods, geographical locations, physical systems, community resources and economic factors. Students found the pen-pal project interesting, intriguing and exciting. It was determined that students developed skills such as questioning, connecting with people who are different from them in various aspects and intercultural interaction (Callahan & Chan, 2007). Through penpals, students can consider the impact of economic status, gender, and religion in different societies. Students can confront issues such as poverty or child labor. They can build bridges to other social studies topics, such as the history of European rule in colonial America, the women's suffrage movement, and the struggle for twentieth-century civil rights (Sider, 2008).

Projects such as pen pals from primary sources can facilitate students' learning about history and civics (Duncan, 2011). Teachers can provide first-hand information to help students learn about topics better and discover new ways to participate. In one study, students in a world history class expressed a desire to learn about dance traditions from around the world. The teacher decided to find pen pals in South Africa to fulfill her students' desire. The teachers who helped the teacher manage the pen pal project indicated that the project would be an interesting way to explore the topic of dance. The students asked their pen pals about dance traditions. So, I arranged for a day when we would write letters to our pen pals about dance traditions in the United States and asked about their dance traditions. After about two months, the pen pals listed a number of dance traditions in their letters. The teacher and her students decided to choose one of the dance traditions listed in the letters. Working in groups, the students began to critically question the dance tradition they had chosen. This research included an understanding of what the dance tradition looks like now, as well as the historical foundations of the dance tradition. Through this research, students were able to make connections between a number of modern and historical dance traditions around the world. After completing their research, students compiled a compilation of historical dance traditions that replaced the modern dance tradition they researched. In addition to the performance, they made a presentation that included a historical analysis of the dance tradition (Allen, 2023).

Through visual imagery and thinking strategies, students were able to see the lifestyle of another region or nation, the diversity of climates, landforms, diversity in socio-economic levels, economic activities, and differences between rural and urban areas. In this context, students in two schools between Dundlod and Rajasthan cities established pen-pal friendships. Excerpts from the student letters are as follows; "I have a cow at home that gives us milk. How many students are in your class?" "I have a goat at home. It gives us milk. Our village is covered in sand. I like peacocks, but there are too many peacocks in my village!" "The best animal that can help us here is camels," "My favorite food is pepper rice." "I want to be an engineer, what is your goal?" "Our national flower is lotus." "My family went for a picnic to Mount Abu." The students found Mount Abu on the map out of curiosity. This study in social sciences is based on interaction, hands-on experiences with Indian culture, and fostering intellectual curiosity (Sider, 2008).

Students in schools that embrace civic ideals can take active roles in local and global events. Opportunities can be created for students to understand the world and develop their long-term propensity, skills, and desire to take action. In this context, pen pals were formed between students in Colorado and Belize. The students in Colorado learned about the inequality of resources at the school their pen pals in Belize attended. Therefore, they decided to collect school supplies for their peers. The students were excited as they brainstormed a list of things to do for a successful project. What began as a process of encouraging students to take action became a long-term service-learning initiative that continued with the children and families helping to collect materials. In this way, students learned about global issues in age-appropriate ways and developed the skills and dispositions that are the hallmarks of active citizenship. Students became curious global citizens. Instead of making broad cultural generalizations, they dug deeper and learned more (Fry et al., 2012).

3.5. Benefits of Pen Pals

Real-life experiences can be a driving force for the social studies curriculum. Teachers can incorporate primary sources and real images into their lesson plans. For example, a Nigerian author's book from an African perspective can be read to students by the teacher, or an e-mail message sent by a child from Zomba can be responded to. This can make the daily lives of Africans at home, in the community, and at school vivid and real for students. Often, students make generalizations about Africa as if it were a country rather than a continent of more than 50 nations with different histories, societies, and landscapes. Africans are often viewed as mere recipients of American aid rather than creators of their own lives. Hearing from people from across the continent helps students understand other cultures. For example, Wangari Maathai, a Kenyan woman who won the Nobel Peace Prize in 2004 for her contributions to sustainable development and peace, can be used to broaden students' images of Africa (Brown & Carroll, 2008).

Teachers can develop strategies that enhance students' knowledge and provide experiences. At this point, University

of Texas Elementary School, which believes that cultural celebrations are beneficial by increasing students' respect for cultural diversity, provides information to students about Red/White/Blue Day, Rosh Hashanah, Ramadan, Thanksgiving, Circle of Light (Fitr, Hannukah, Christmas, Kwanzaa), Las Posadas, Martin Luther King Day, Black History Month, Lincoln's Birthday, Passover, and Easter. School-wide events for each celebration attract the attention of students and families (Field & Bauml, 2012).

4. Discussion and Conclusion

In social studies education, project-based learning can provide students with opportunities such as solving real-world problems, questioning, sharing experiences, looking at events from different perspectives, creating meaningful learning opportunities, understanding different perspectives, using technology, establishing connections, deepening knowledge, discovering and doing interdisciplinary studies. Levin (2016) stated in his study that project activities can increase students' citizenship competencies. It was stated that the project allows students to gain multiple perspectives by comparing their own perspectives on events or phenomena with different perspectives. At the same time, students get to know the values of the society they live in through projects. They develop their skills. It was stated that individuals can apply these values and skills they have learned in issues related to citizenship. In the study conducted by Tonbuloğlu et al. (2013), it was found that the project-based learning method created a significant difference in the students' metacognitive skills and self-efficacy perceptions, and it was concluded that the behaviors in the groups generally changed positively over the weeks. In the research conducted by Ulukaya Öteleş and Ezer (2020), it was determined that the academic success scores of the control group, where traditional learning activities were used, and the experimental group, where the project-based learning method was used, increased. In the research conducted by Gömleksiz and Fidan (2013), it was concluded that the views of the students regarding the positive effects of the project-based learning method in terms of cognitive aspects were permanence, application opportunity, effective learning, web design, active participation, reinforcement, feedback-correction and higher-order thinking. It was obtained that the student views were mostly focused on permanence in terms of cognitive positive effects.

Project-based learning can be one of the ways that motivates students, educates them with factual information, provides awareness and develops skills. Pope et al. (2011) stated in their study that citizenship projects are student-centered and action-oriented. It was stated that projects support both students' academic success and civic participation. It has been determined that students expand their skills such as collaboration, problem solving, communication, critical thinking and rethinking through project-based learning. In a study conducted by Print (1999), it was concluded that citizenship education provides students with skills such as problem solving, critical thinking, decision making, participation, voting and social service.

A pen-pal project from primary sources can be exciting, interesting and intriguing for students. In a study conducted by Coquillon and Wei (2011), it was stated that pen-pal projects provide students with the opportunity to examine, understand, evaluate, communicate, reason and create and express ideas on all aspects of critical thinking. With pen-pals, students can interact with different cultures by getting to know them. In addition, students can expand their skills such as communication, empathy and participation. In a study conducted by Larrotta and Chung (2020), it was determined that a pen-pal project helps individuals develop civic skills. It has been determined that penpals increase intercultural interaction, and individuals develop participation, communication and socialization skills necessary for citizenship by getting to know different cultures and eliminating prejudices and stereotypes. In the research conducted by Özsoy and Baş (2024), regarding the difference between the pre-test and post-test writing success scores of the students with the pen-pal application, it was concluded that the writing success scores of the students increased in the post-test application compared to the pre-test application, and the pen-pal application improved the students' writing skills positively and with a great effect.

5. Recommendations

Teachers can implement project-based learning in social studies classes. Teachers can carry out interdisciplinary learning through project-based learning. Teachers can implement a penpal project to ensure that students interact with different cultures. Teachers can develop different strategies and methods that can provide skill development in students.

Compliance with Ethical Standards

This study does not require an ethics committee decision.

Conflict of Interest

The author has no conflict of interest to declare.

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