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Meta-Synthesis Study on Socioscientific Issues in Science Education

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Abstract

The aim of this study is to examine the importance of socioscientific issues in science education at the graduate level. For this purpose, the data obtained as a result of the searches on the National Thesis Centre (YOKTEZ) database were analysed. The literature review was conducted with the keywords 'socioscientific', 'socioscientific issues' and 'socioscientific issues. In line with the inclusion criteria, 58 postgraduate studies (48 master's theses and 10 doctoral theses) were found. Although these three different keywords were searched by the researcher, it was noticed that there were common postgraduate thesis authors. The theses of these authors were included in the study only once. Following this situation, postgraduate theses whose field of study was not science education (science education, biology education, chemistry education, physics education) were not included in the study. After the inclusion and exclusion criteria, a total of 58 studies were reached. As a result of the examination in this field, a total of 48 master's and 10 doctoral theses were reached. Content analysis method was used in this meta-synthesis study which analysed the theses published in YOKTEZ database on socioscientific issues in science education. As a result of the analyses, a general framework was drawn about the theses published on socioscientific issues in Turkey and the findings were interpreted. At the end of the study, it is recommended that future SSI research contribute to the holistic development of the field by diversifying study groups and topic contexts, adopting longitudinal and in-depth methodological approaches, and focusing on effective pedagogical strategies and teachers' professional development.

INTRODUCTION

Science has affected and continues to affect society from the past to the present (Topçu, 2017). As scientific advancements began to rapidly impact social life, they gave rise to dilemmas, disagreements, and a desire among people to defend their own thoughts while rejecting others. For example, the recent pandemic (Covid-19) that affected the entire world led people to debate the issue of vaccines, experience disagreements, and sometimes fanatically defend the ideas they believed to be correct. With the increase in scientific research in this area, socioscientific issues (SSI) have taken their place on the agenda, partly due to media influence. Another example is villagers protesting against the felling of trees to shorten roads, or local people trying to prevent the construction of hydroelectric power plants due to concerns about ecological damage. Many such events are presented to the public through the media, which naturally leads everyone to view the situation from their own perspective, and these topics become the focus of debates (Aydın & Mocan, 2019). The media provides the easiest way for more people to learn about socioscientific issues and for people to mobilize collectively (Topçu,

2017). While a limited number of media channels, such as radio, newspapers, and magazines, might present biased news from a narrow perspective; today, news is reported from multiple perspectives and approached from various angles. With the proliferation of social media tools, even minority opinions can make their voices heard by the public (Kılıç, 2023). All these and similar events exemplify the reflections of science on society. Such examples are identified in the literature as socioscientific issues. According to Topçu (2008), socioscientific issues are topics related to problems people encounter in their daily lives, which they defend by presenting evidence. Socioscientific issues are intentionally designed to enable students to communicate with each other, engage in discussions, and develop arguments (Zeidler & Nichols, 2009). According to Topçu (2008), this engagement is necessary for students to become scientifically literate individuals.

Evren and Kaptan (2014) stated that teachers or prospective teachers aiming to cultivate scientifically literate individuals need to answer five questions to determine whether any encountered topic is a socioscientific issue. These are:

- Is the topic under examination scientific?
- Does the topic under examination create a dilemma in the mind?
- Does the topic under examination involve science-society-technology interactions?
- Is the topic under examination open-ended and does it accommodate more than one correct answer/perspective?
- Can the answers given within the scope of the topic vary depending on ethical, moral, or emotional values?

Socioscientific issues focus on listening to students' claims, developing arguments related to these claims (Zeidler et al., 2009), and acquiring skills on controversial topics. A correct understanding of socioscientific issues is important for individuals to acquire discussion skills and make sound decisions (Handan Hacıoğlu, 2022). In this context, Sadler and Zeidler (2005), similar to Evren and Kaptan (2014), divided the characteristics of SSI into five points. These are:

- SSI are open to discussion and bring together different perspectives.
- They lead to dilemmas within society.
- They are problematic and await understanding.
- They cannot be easily resolved.
- They generally involve ethical and moral issues.

When the five points above are examined, it is seen that there is no difference among field researchers regarding the fact that socioscientific issues are directly related to the problems we encounter in our daily lives and the characteristics they entail.

The role of socioscientific issues has been a significant driving force in promoting scientific literacy in the science education community over the last two decades (Zeidler et al., 2019). The National Science Education Standards (NSES), put forth by the NRC (1996), aimed to create a scientifically literate society. These standards were addressed under six main headings: Science Teaching, Professional Development, Assessment in Science, Science Content, Science Education Programs, and Standards for Science Education Systems. The standards generally propose an educational approach where students develop scientific thinking and reasoning skills, take an active role in their learning processes, and learn through experience. While teachers play a guiding and decision-making role in this process, it is emphasized that educational programs should be supportive of learning and encourage success (Kardas, 2024).

Every day, the number of closely related issues at the intersection of science and social life (e.g., artificial intelligence, pandemic vaccines, euthanasia, nuclear power plants) is increasing (Kardas, 2024). Therefore, such issues need to be evaluated based on science and research (Topcu, 2017).

When the literature is reviewed, it is observed that studies related to socioscientific issues generally aim to measure skills such as argumentation, decision-making, higher-order reasoning, and scientific literacy. This situation is closely related to the nature of socioscientific issues. Studies show that socioscientific issues enhance students' skills such as higher-order reasoning (Kolstø, 2001), argumentation (Ozturna & Atasoy, 2024; Topcu & Atabey, 2017), and scientific literacy (Lomas & Ritchie, 2014; Yapıcıoglu & Kaptan, 2017).

The Purpose of Study

Since the study deals with postgraduate theses on socioscientific issues within the scope of science education, it plays a critical role in accessing accumulated knowledge in this field and guiding future studies. Therefore, the study is important in terms of its contribution to the literature. In light of all this information, the aim of this study is to conduct a meta-synthesis by examining postgraduate theses published in the YÖK National Thesis Center (YÖKTEZ) database on socioscientific issues in science education within the context of the formulated research questions. In line with this aim, the study sought to answer seven questions within the scope of the main problem: "What is the distribution of postgraduate theses written on SSI in Science Education in the context of the determined research questions?" The research questions of the study are as follows:

1. Which research designs were used in published theses on socioscientific issues in science education?
2. What is the distribution by year of published theses on socioscientific issues in science education?
3. What are the aims of published theses on socioscientific issues in science education?
4. On which study groups were studies conducted in published theses on socioscientific issues in science education?
5. In which science subject areas were studies conducted in published theses related to socioscientific issues in science education?
6. Which data collection tools were utilized in published theses on socioscientific issues in science education?
7. What were the research durations in published theses on socioscientific issues in science education?

Limitations

This study:

- Is limited to postgraduate theses published between 2020 and 2024.
- Is limited to postgraduate theses published in the YÖKTEZ database.
- Is limited to postgraduate theses published within the Science Education subject area.

METHOD

Study Design

In this study, a meta-synthesis, which is one of the qualitative research methods, was conducted to synthesize research written with qualitative, quantitative, and mixed research designs on socioscientific issues within the scope of science education, sourced from the YÖK TEZ database. Meta-synthesis is the re-combination, evaluation, comparison, and interpretation

of similar studies conducted on a topic, phenomenon, or theme identified by researchers, "under specific criteria" (Dincer, 2018). While quantitative data can be included in a meta-synthesis, meta-synthesis does not aim to reach a definitive conclusion; it aims to reveal what exists (Dincer, 2018).

Data Collection

In this study, data were obtained from the YOKTEZ database. First, a preliminary scan was conducted to access studies in the field of socioscientific issues. In the preliminary scan, searching with the keyword “sosyobilimsel konular” yielded 104 studies. Subsequently, searching with the keyword “sosyobilimsel” yielded 139 studies. Then, the English equivalent of this keyword, “socioscientific issues,” was searched, and 77 studies were found. Although these three different keywords were searched by the researcher, it was noticed that there were common postgraduate thesis authors. The theses of these authors were included in the study only once. Following this, postgraduate theses whose study area was not science education (Science teaching, biology education, chemistry education, physics education) were not included in the study. After applying the aforementioned inclusion and exclusion criteria, a total of 58 studies were identified. As a result of the review in this field, a total of 48 master's theses and 10 doctoral theses were identified.

Inclusion and Exclusion Criteria for the Study

The inclusion criteria for the master's and doctoral theses considered in this study are as follows:

- Theses written on Socioscientific Issues in Science Education being published in the YÖK National Thesis Center database.
- Theses being published in the YÖK National Thesis Center between 2020 and 2024.
- Theses being written in the subject areas of science teaching, physics education, chemistry education, and biology education.

Data Anaysis

Descriptive content analysis was used in this meta-synthesis study, which examined theses published in the YOKTEZ database on socioscientific issues in science education. Descriptive content analysis is a research method that aims to define the presence and frequency of elements by systematically coding a specific content, usually according to predetermined categories or themes (Berelson, 1952; Creswell & Poth, 2018; Krippendorff, 2018). The primary purpose of this method is to describe the directly observable and countable elements of the examined material (Neuendorf, 2017). In this context, descriptive content analysis relies on analyzing data by segmenting it into meaningful units, coding them, and then forming broader patterns or themes from these codes (Creswell & Poth, 2018). The codes and themes were also developed with input from a field expert who has studies in the area of socioscientific issues. The master's theses examined in this study were coded as MT1, MT2...MT48, and the doctoral theses as DT1...DT10, and are presented in Table 1. In study, a Microsoft Word file (Table 2) was created for the postgraduate theses based on their year of study, aims, methods, sample groups, data collection tools, research durations, and obtained results; these were then analyzed through the determination and application of codes and themes.

Table 1. Codes of study according to thesis type

Level of Postgraduate Thesis	Codes of the Study According to Postgraduate Thesis Type	f
Master's	MT1, MT2, ……MT48	48
Doctoral	DT1, DT2 ……DT10	10

Table 2. Form used as a data collection tool

Thesis Details
Thesis title:
Type of Thesis:
Year:
Author:
University:
Department:
Topic:
Methodology: Qualitative: ..... Quantitative: ..... Mixed: .....
Sample: Student: ..... Pre-service Teacher: ..... Teacher: ..... Parent: .....
Sample Size :…….
Data Collection Tool(s):……
Data Analysis Technique(s):
Conclusion(s):
Recommendation(s):

Ethics, Validity, and Reliability

To ensure the validity and reliability of the study, during the process of generating codes and themes, tentative codes and potential themes were developed from the raw data obtained from a total of 58 postgraduate theses (10 doctoral, 48 master's), aligned with the research objectives. To assess the conceptual clarity, appropriateness, and comprehensiveness of this initially developed coding framework, expert opinion was sought from an academic with 11 years of experience in the field of socioscientific issues and qualitative research methods. Based on the expert's feedback, necessary revisions were made to the code list and theme definitions, thereby strengthening the content validity of the coding scheme (Creswell & Poth, 2018).

Furthermore, to ensure the reliability of the coding process and to minimize coder bias, an inter-coder reliability procedure was implemented. In this regard, following the initial coding by one of the researchers (the first coder), a randomly selected subset of the examined theses, representing approximately 20% of the total sample (12 theses), was recoded by a second, independent coder using the same coding scheme. The codings of the two coders were compared, points of disagreement were resolved through discussion, and consensus was reached. Inter-coder agreement was calculated using the formula proposed by Miles and Huberman (1994), [(Number of Agreements / (Number of Agreements + Number of Disagreements) x 100], and an agreement level of 86% was determined. A reliability percentage of 70 and above indicates that there is reliability between coders (Miles& Huberman,1994).

FINDINGS

This section presents and categorizes the tables and figures related to the data obtained to answer the research questions addressed in this study.

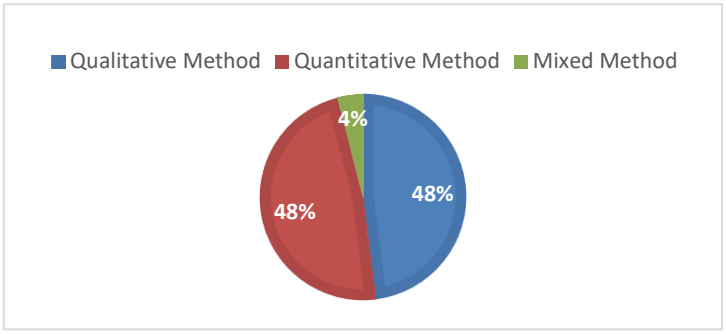

Figure 1. Methodological distributions of theses examined within the scope of the research

As seen in Figure 1, of the 58 studies obtained from the YÖK database, 48% were written using a mixed research design, 48% used a qualitative research design, and 4% used a quantitative research design. This indicates that qualitative and mixed methods are prominent in postgraduate theses. The higher prevalence of qualitative and mixed research designs may suggest that they were preferred due to the need for multi-dimensional data and in-depth analysis of the chosen topic.

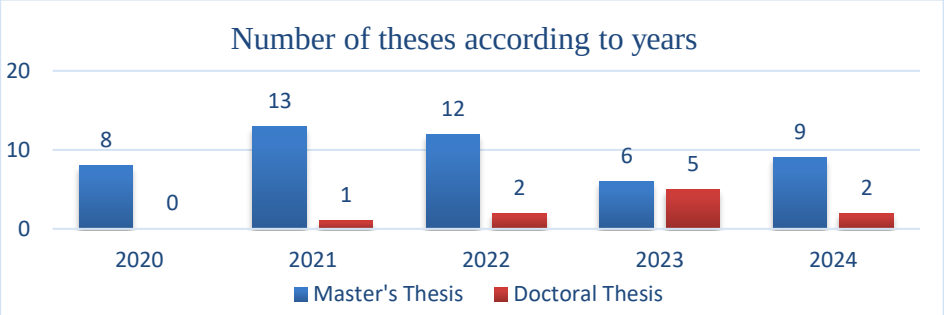

Figure 2. Distribution of theses examined within the scope of the research by year

This graph shows the number of master's and doctoral theses by year. Master's theses were written in greater numbers each year compared to doctoral theses. The trend, which began with 8 Master's (MT) theses in 2020, peaked in 2021 with 13 theses, then decreased to 12 in 2022 and 6 in 2023. In 2024, it rose again to 9.

These fluctuations may be influenced by factors such as an increase or decrease in the popularity of certain topics. The decrease in 2023 is particularly noteworthy.

Doctoral theses, on the other hand, gradually increased from 2021 onwards and peaked in 2023. In 2023, it is observed that the number of doctoral and master's theses was close to each other. This situation, while indicating a slowdown in master's theses, suggests that doctoral theses gained momentum in this subject context. While there were no doctoral theses in 2020, they made a slow start with 1 thesis in 2021 and 2 in 2022, showed a significant increase with 5 theses in 2023. In 2024, this number dropped to 2.

This increasing trend in the number of doctoral theses (especially until 2023) may indicate that the field of SSI (Socioscientific Issues) is beginning to be the subject of more in-depth and comprehensive academic research, and that the number of researchers specializing in the field has increased or has the potential to increase. The 5 doctoral theses in 2023 could be a positive sign in terms of the maturation of the field and the addressing of more sophisticated research questions. The decrease in 2024 can be interpreted as such fluctuations being normal on an annual basis due to the long duration of doctoral programs, or it may reflect a decrease in the number of theses completed that year.

Another point to note is that doctoral theses require a long preparation time. Despite there being no doctoral theses published in this subject context in 2020, the gradual increase in 2021, 2022, and 2023 indicates that studies at this level are slowly beginning to be completed.

Table 3. Distribution of theses examined within the scope of the research according to aims

Aim of Study	Study Codes	f
Argumentation	MT3, MT10, MT24, MT44, MT46, MT47, DT1, DT5, DT8, DT10	10
Decision-Making Skill	MT1, MT18, MT23, MT28, MT33, DT1, DT4, DT8, DT9	9
Attitude	MT3, MT8, MT17, MT19, MT34, MT42, MT48, DT9	8
Opinion	MT9, MT13, MT22, MT27, MT35, MT38, DT5, DT7	8
Judgment	MT10, MT14, MT23, MT25, MT31, MT32, MT37, MT45	8
Critical Thinking	MT1, MT29, DT4, DT9	4
Academic Achievement	MT1, MT47, DT8	3
Understanding of the Nature of Science (NOS)	MT36, MT44, DT5	3
Pedagogical Content Knowledge (PCK)	MT15, DT3	2
Communicative approach / discourse patterns	MT26, MT39	2
Problem-Solving Skill	MT29, MT36	2
Metacognition	MT41, DT1	2
Epistemological Beliefs	MT47, DT5	2
Reasoning	MT34, DT10	2
SSI (Socioscientific Issues) Awareness	DT4	1
Misconceptions	DT5	1
Scientific Process Skills	DT5	1
Relating to Daily Life	DT2	1
Entrepreneurial Skills	DT2	1
Gender	MT47	1
Content Knowledge	MT44	1
Teaching of SSI	MT43	1
Thinking Skills	MT38	1
Design Development and Evaluation (STEM)	MT40	1
Learning StMTes	MT41	1
Teaching Method Preferences	MT41	1
Impact on the Nature of Scientific Inquiry/Research	MT30	1
Critical Thinking Skills	MT36	1
Examination of Mental Structures	MT19	1
Examination of Textbooks	MT20	1
Scale Development	MT21	1
Effect on Discussion Tendencies	MT8	1
Science Learning Motivations	MT7	1
Moral Reasoning	MT8	1
Awareness Levels	MT11	1
Metaphorical Perception	MT12	1
Mental Modeling	MT12	1
Perception Levels	MT11	1
Effect on its Use as a Pedagogical Tool	MT2	1

Table 3 shows the aims addressed in the postgraduate theses and the frequency with which these aims appear in the studies. Since the postgraduate theses included in the study often had multiple aims, a single thesis could be coded under several aims. Among the examined studies, the research aim with the highest frequency is the examination and development of argumentation (f=10) skills. This finding is directly related to the nature of SSIs (Socioscientific Issues), which are inherently controversial, multidimensional, and involve diverse perspectives.

The development of evidence-based claims about SSIs by individuals, their evaluation of counter-arguments, and their effective participation in discussions are considered fundamental goals of education in this field. Following argumentation, decision-making skills (f=9), examination of attitude (f=8), opinion/view (f=8), and reasoning (f=8) abilities are also topics frequently addressed by researchers. This situation indicates that SSIs have not only cognitive but also affective and ethical dimensions, and that research tends to reflect this holistic structure. How individuals' attitudes towards SSIs and their opinions on these topics are shaped and changed, and how they interact with reasoning processes, are among the important research questions in the field. Decision-making skills (f=9) processes and skills can also be included in this dominant group, as interaction with SSIs ultimately directs individuals to take a stance and make decisions on a subject. Other frequently addressed topics include critical thinking (f=4), impact on academic achievement (f=3), decision-making skill (f=3), and especially understanding of the nature of science (NOS) (f=3). Addressing the understanding of the nature of science in conjunction with SSI studies emphasizes the critical importance of understanding the characteristics, validity, limitations, and societal context of the scientific knowledge that forms the basis of these issues. This frequency suggests that while the nature of science is accepted as an intertwined structure with SSIs, it is not as central a research focus as argumentation or attitude. Aims appearing at lower frequencies (f=1 or f=2), while demonstrating the breadth and diversity of the SSI field, also indicate that more research is needed in some areas. For example, pedagogical content knowledge (PCK) (f=2), despite being vitally important for teachers to effectively teach SSIs, has been relatively less studied. Similarly, structures such as metacognition (f=2), epistemological beliefs (f=2), and problem-solving skills (f=2), which profoundly affect an individual's learning and thinking processes, also deserve more attention.

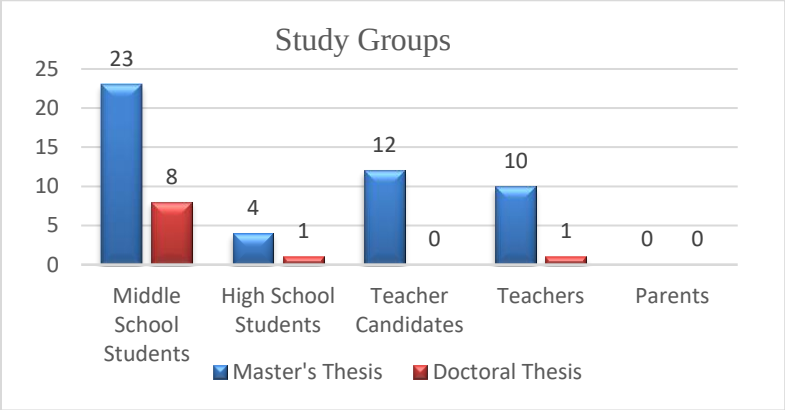

Figure 3. Distribution of theses examined within the scope of the research according to study groups

This figure compares the number of participants used in master's and doctoral theses according to study groups. Consequently, it is observed that studies were most frequently conducted with middle school students in both master's and doctoral theses. This can be explained by SSIs (Socioscientific Issues) generally being more prominent in science curricula for this age group, students being in a period where their abstract thinking skills are developing yet they are still receptive to guidance, and the relative ease of access to this age group. It is understood that there is an educational expectation and research interest towards fostering skills such as argumentation, critical thinking, and decision-making, which form the basis of SSIs, during this critical developmental period. Preservice teachers and teacher groups were also seen as important sample groups for master's theses. The graph shows that postgraduate thesis

researchers generally prefer to work with middle school students and preservice teachers, who are easily accessible and observable groups in the educational environment. The fact that no studies were conducted with parents indicates the difficulty of accessing this group. Another noteworthy situation is that doctoral thesis authors have worked with less diverse groups. The lack of research on topics such as parents' perspectives on SSIs and how these issues are discussed or supported at home can be considered a significant deficiency in addressing SSI education with a holistic approach.

Table 4. Implementation durations of socioscientific issues in theses within the scope of the research

Duration of Implementation	Code	f
1 class hour (40 min)	MT6, MT7, MT11, MT13, MT16, MT19, MT24, MT31	8
10 weeks	MT1, MT40, DT3, DT4, DT5, DT6	6
8 weeks	MT5, MT23, MT29, MT38, MT44	5
6 weeks	MT2, MT17, MT30, DT9, DT10	5
5 weeks	MT8, MT39, DT1, DT2	4
2 terms	MT37, MT46, MT47	3
9 weeks	MT4, MT10	2
1 terms	MT48	2
24 weeks	DT7	1
15 weeks	MT14	1
12 weeks	DT8	1
7 weeks	MT18	1
3 weeks	MT12,	1
30-minute interview	MT15	1

When the table is examined, there are differences in terms of implementation durations. The most striking finding is that implementations lasting "1 lesson period (40 min)" have the highest frequency with 8 studies. This situation suggests that many studies in the SSI (Socioscientific Issues) field focus on measuring immediate states (e.g., opinions on a topic, argumentation level after a specific activity) through cross-sectional or short-term interventions within existing course curricula. Such studies may be advantageous in terms of practical applicability but may be insufficient for monitoring long-term changes or skill development.

Implementation durations of several weeks, such as "10 weeks" (f=6), "8 weeks" (f=5), and "6 weeks" (f=5), also hold a significant place. These durations may generally indicate research examining SSI integration throughout a unit or theme, more comprehensive interventions aimed at supporting the development of specific skills (e.g., argumentation, decision-making), and the effects of these interventions. These durations offer a more suitable time frame for students to process topics more deeply and reinforce their skills.

The low frequency (generally f=1 or f=3) of longer-term implementations such as "24 weeks," "15 weeks," and "2 semesters" is noteworthy. Although such longitudinal or long-term studies are ideal for observing lasting changes over time in attitudes, understanding, and skills related to SSIs, they might be less preferred due to challenges in their implementation (time, resources, participant tracking, etc.).

The table shows a wide range, from very short durations for specific data collection purposes, such as "30 min interview," to periods covering an academic year, such as "2 semesters." This diversity demonstrates that SSI research can serve various purposes (e.g., obtaining immediate

opinions, skill development, tracking attitude changes) and accommodate different methodologies (e.g., experimental, case study, action research).
Consequently, the inclusion of longer-term studies (e.g., DT7 - 24 weeks, DT8 - 12 weeks) in doctoral theses is consistent with the fact that doctoral research allows for more in-depth and extended investigations.

Table 5. Distribution of socioscientific issues covered in theses examined within the scope of the research

Socioscientific Issues	**Code**	**f**
Genetically Modified Organisms (GMOs)	MT4, MT8, MT10, MT12, MT13, MT17, MT19, MT24, MT31, MT38, MT39, MT42, MT44, DT1	14
Global Warming	MT6, MT7, MT19, MT29, MT38, MT39, MT40, MT42, MT44, DT5, DT10	11
Nuclear Energy	MT4, MT10, MT12, MT24, MT39, MT42, MT44, MT45, MT48, DT2	10
Organ Donation/Transplantation	MT4, MT12, MT13, MT19, MT46, DT9, DT10	7
Pandemic Vaccine/Vaccination	MT4, MT13, MT29, MT45, MT46, MT47	6
Space Pollution	MT4, MT10, DT9, DT10	4
Cloning	MT4, MT13, MT44, DT5	4
Recycling	MT6, MT30, DT9, DT10	4
CurrentEnvironmental Issues/Environmental Pollution	MT2, MT48, DT9	3
Global Climate Change	MT4, MT31, DT3	3
Transplantation	MT4, MT13, MT44	3
Plastic Use	MT5, MT16, MT23	3
Blood Donation	MT6, MT11, MT13	3
Biotechnology	MT13, MT19, DT4	3
Hydroelectric Power Plants	MT19, MT28, DT2	3
Genetic Engineering	MT48, DT4, DT5	3
Energy Sources	MT1, DT5	2
Pesticides / Agricultural Pesticides	MT11, MT38	2
Organic Farming	MT14, DT10	2
Hydraulic Fracturing	MT25, MT45	2
Animal Testing	MT29, MT47	2
Endangered Species	MT38, MT39	2
ArtificialIntelligence Technologies	MT47, DT1	2
Solar Energy	DT9, DT10	2
Ecosystem Ecology	MT2	1
Euthanasia	MT4	1
Medicine and Alternative Medicine	MT4	1
Consanguineous Marriage	MT6	1
Substance Addiction / Substance Abuse	MT6	1
Thermal Power Plant	MT11	1
Chemical Industry	MT11	1
Antibiotic Use	MT13	1
Water Wells	MT14	1
Fishing Activities in Protected Areas (SIT Areas)	MT14	1
Dam Activities / Dam Projects	MT14	1
Tourism Activities	MT14	1
Delta UNESCO World Heritage	MT14	1
Genetic Improvement / Genetic Breeding	MT15	1
Artificial Organs	MT15	1
Fishing in the Black Sea	MT23	1

Cryobiology	MT23	1
Nanotechnology	MT28	1
Processed Foods	MT29	1
/Domestic Waste	MT30	1
Acid Rain	MT31	1
Care of Stray Animals / Street Animal Care	MT32	1
Genetically Designed Babies / Designer Babies	MT34	1
Causes of Forest Fires	MT37	1
Diet Pills / Weight Loss Drugs	MT38	1
Geothermal Energy	MT38	1
Base Station	MT38	1
Air Pollution	MT40	1
Plastic Bag Usage	MT41	1
Inappropriate Medication Use	MT41	1
Excessive Salt Consumption	MT41	1
Boiling Point	MT41	1
Colligative Properties	MT41	1
Nanoparticles	MT41	1
Human Genome Project	DT1	1
Biodiversity	DT2	1
Noise Pollution	DT6	1
Healthy Nutrition and Diet	MT46	1
Light Pollution	DT9	1

This table presents a frequency distribution of socioscientific issues and their coverage in postgraduate theses. The most frequently addressed topic is "Genetically Modified Organisms (GMOs)" with a frequency of 14, while the second most common topic is global warming with a frequency of 11, and the third is nuclear energy with a frequency of 10. Some of the less studied topics in postgraduate theses, with a frequency of 1, include consanguineous marriage, euthanasia, antibiotic use, and thermal power plants.

Looking at the distribution of topics in the studies, it is seen that they span a wide spectrum, covering multifaceted areas such as environmental pollution, genetics, energy sources, plastic use, and endangered species.

The fact that topics such as GMOs, nuclear energy, and global warming are addressed and examined in many studies suggests that these issues create dilemmas in people's minds from both scientific and societal perspectives and lead to debate. Additionally, the topic of Vaccines/Pandemic vaccines, a current issue studied with a frequency of 6 in postgraduate theses, shows that this subject is not confined to health sciences or medicine but is also related to fields such as education and ethics.

Table 6. Data collection tools used in theses examined within the scope of the research

Data Collection Tools	**Code**	**f**
Interview	MT1, MT2, MT3, MT5, MT6, MT9, MT10, MT11, MT15, MT17, MT18, MT26, MT28, MT29, MT30, MT33, MT35, MT38, MT42, MT43 DT2, DT3, DT9, DT10	27
Attitude Scale	MT7, MT8, MT9, MT10, MT12, MT17 MT19 MT34, MT35, MT38, MT42, MT48, DT7, DT9	15

Scenario	MT5, MT10, MT11, MT13, MT15 MT23, MT34, MT37, MT44, MT46, MT47, DT10	12
Argument Texts/Forms	MT4, MT5, MT10, MT16, MT24, MT28, DT1, DT2 DT5	8
Observation Records	MT2, MT4, MT10, MT23, MT39 MT40, DT1	7
Critical Thinking Scale	MT1, MT29, Y38, DT4, DT4, DT9	6
Decision-Making Scale	MT1, MT18, MT23, DT1, DT7, DT8	6
Classroom Observation	MT2, MT38, MT43, DT2, DT3, DT9	6
Academic Achievement Test	MT1, MT18, MT37, DT7, DT8	5
Moral Thoughts/Reasoning Scale	MT8, MT14, MT25, MT32, MT45	5
Epistemological Belief Scale	MT46, MT47, MT48, DT10	4
Dilemma Cards	MT4, MT10, MT27	3
Diary	MT29, MT40, DT7	3
Conceptual Understanding Questionnaire	MT1, DT6	2
Motivation Scale	MT7, MT10	2
Word Association Test	MT11, MT19	2
Textbooks	MT20, MT33	2
Nature of Science Questionnaire	MT31, DT5	2
Student Written Documents	MT38, MT40	2
Awareness Scale	DT2, DT4	2
Audio Recordings	MT39, DT1	2
Developed Material(s)	MT2	1
Critical Thinking Disposition Scale	MT5	1
Reasoning Scale	MT7	1
Discussion Skills Scale	MT8	1
Metaphor Forms	MT12	1
Drawing Analyses	MT12	1
Self-Efficacy Belief Scale	MT15	1
Affective Disposition Scale	MT21	1
Informal Reasoning Scale	MT25	1
Problem-Solving Skills Questionnaire	MT29	1
Open Reflective Classroom Discussions	MT30	1
Reflective Thinking Scale	MT38	1
Discourse Pattern Models	MT39	1
STEM Attitude Scale	MT40	1
Parent Opinion Form	MT40	1
Rubric	MT40	1
Learning Skilles Scale	MT41	1
Teaching Method and Preferences Questionnaire	MT41	1
Metacognition Scale	MT41	1
Logical Thinking Ability Test	MT47	1
Science Learning Skill Scale	MT48	1
Character and Values Scale	MT48	1
Inquiry Skills Scale	MT48	1
Metacognitive Ability Scale	DT1	1
Science Literacy Test	DT9	1

When the table is examined, it is observed that interviews (f=27) were the most frequently used data collection method in theses conducted within this subject context. This situation clearly shows that it is one of the primary methods preferred by researchers for understanding the complex, multidimensional, and often intertwined nature of SSIs (Socioscientific Issues) with individuals' personal values and beliefs. Interviews offer the opportunity to explore in depth participants' thoughts, reasoning processes, attitudes, experiences, and arguments regarding

SSIs. Their intensive use in both Master's (MT) and Doctoral (DT) theses emphasizes the importance placed on the richness of qualitative data. This contributes to obtaining in-depth information and allows for the detailed analysis of personal opinions.
After interviews, attitude scales are the second most frequently used tool. They offer a quantitative approach to measuring affective dispositions towards SSIs, science, or related topics. Since one of the important goals of SSI education is attitude change, the widespread use of these scales is understandable.

Data collection tools such as the Critical Thinking Scale (f=6) and the Decision-Making Scale (f=6) are preferred for measuring core higher-order thinking skills associated with SSIs in a standardized way. They are important for monitoring the development of these skills and evaluating the effectiveness of interventions.

The Academic Achievement Test (f=5) was used to measure the impact of SSI-based teaching on students' academic achievement in related subjects.
The Moral Thoughts/Reasoning Scale (f=5) and the Epistemological Belief Scale (f=4): These scales are specific measurement tools used to assess the ethical dimension of SSIs and individuals' beliefs about knowledge and knowing.

CONCLUSION, DISCUSSION AND SUGGESTIONS

This meta-synthesis study was conducted to determine the general trends, focal points, and potential research gaps in the field by examining postgraduate theses (N=58) on socioscientific issues (SSI) completed in Turkey between 2020 and 2024 through content analysis. The obtained findings are discussed in detail below in light of the research questions and relevant literature, and significant conclusions for the field have been drawn.

The distribution of the examined studies by year indicates that academic interest in the SSI field has remained active, especially in the last five years. The fact that master's theses peaked in 2021-2022 and doctoral theses in 2023 suggests a concentration in the field during certain periods. The shorter completion time for master's theses compared to doctoral theses (Cohen, Manion, & Morrison, 2018) and the more comprehensive, long-term nature of doctoral studies can be considered as primary reasons for this temporal differentiation. These trends are consistent with the general postgraduate education dynamics observed in similar literature reviews by Aydın and Mocan (2019), confirming that SSI has become an established topic in Turkey's educational research agenda.

Methodologically, qualitative and mixed research methods were found to be more dominant in the examined postgraduate theses compared to quantitative methods. This finding may contrast with general observations in the literature indicating that quantitative methods could be more dominant in certain periods; however, in the period covered by this study, qualitative and mixed methods were observed to be prominent. In this context, the prominence of qualitative and mixed methods can be considered a reflection of researchers' efforts to understand and interpret in-depth individuals' experiences, personal opinions, value judgments, ethical reasoning, and argumentation processes regarding SSIs (Creswell & Plano Clark, 2017). Such methods offer a more suitable ground for grasping the multidimensional nature of SSIs.

Regarding the aims of the postgraduate theses examined, it was determined that the vast majority aimed to develop or assess students' argumentation skills, attitudes towards SSIs, opinions, and reasoning abilities. This situation reflects a widespread acceptance of imparting

high-level cognitive skills such as critical thinking, evidence-based decision-making, and scientific literacy, which are fundamental objectives of SSI education (Driver, Newton, & Osborne, 2000; Jiménez-Aleixandre & Erduran, 2008).

When examining the study groups, middle school students were found to be the most frequently studied group in both master's and doctoral theses. This finding aligns with the results of Takaoğlu (2023) and other literature reviews (e.g., Aydın & Mocan, 2019; Değirmenci & Doğru, 2017). The middle school years, a period when students' abstract thinking skills begin to develop, yet their critical perspectives and argumentation abilities are still forming (Zeidler & Nichols, 2009), and when learning outcomes related to SSIs are prominently featured in the Science Curriculum (MEB, 2018), may have influenced researchers' preference for this group. Pre-service teachers and teachers were also frequently studied groups, especially at the master's level, reflecting the central role of current and future teachers' preparedness in the effective teaching of SSIs (Sadler, 2011). However, the complete absence of studies involving parents indicates that a significant stakeholder in SSI education has been overlooked, highlighting a serious research gap in this area. Considering the influence of families on children's value judgments and worldviews (Epstein, 2011), this omission is noteworthy. The fact that doctoral thesis authors worked with less diverse groups can be explained by the tendency for doctoral research to be more in-depth and specifically focused.

Among the SSI contexts addressed, "Genetically Modified Organisms (GMOs)," "global warming," and "nuclear energy" were prominent, stemming from their scientific complexities as well as their societal, ethical, and economic dimensions, which are continuously debated in public and create dilemmas for individuals (Oulton, Dillon, & Grace, 2004). These topics are also frequently presented as examples of SSIs in the literature (e.g., Topçu, Sadler, & Yılmaz-Tüzün, 2010). Less studied topics such as consanguineous marriage, euthanasia, and antibiotic use, while demonstrating the broad spectrum SSIs can cover, also indicate a need for more research in these areas. The inclusion of a current topic like "Vaccines/Pandemic vaccines" in theses underscores that SSIs are not limited to science or medicine but are also related to fields like education and ethics.

Regarding the implementation durations in postgraduate theses, it is noteworthy that short-term applications, such as "1 class hour (40 min)," were the most frequently preferred. Such brief interventions might focus on understanding a specific concept or an instantaneous attitude change; however, it can be argued that they may not be sufficient for the in-depth understanding, development of complex skills, and lasting attitude changes required by SSIs (Dawson & Venville, 2010). The prevalence of medium-term implementation periods, such as 6, 8, and 10 weeks, indicates that researchers tend to examine the effects of SSI education through more structured and process-oriented interventions.

The overwhelming predominance of interviews among data collection tools is consistent with researchers' quest to understand in-depth individuals' experiences, thought processes, and arguments regarding SSIs (Kvale & Brinkmann, 2009). The use of argumentation, attitude, decision-making, and critical thinking scales, as well as various scenarios and observation forms, reflects an effort to evaluate the multidimensional nature of SSIs from different perspectives. This diversity of tools also entails a methodological richness aimed at developing high-level thinking skills (Kolstø, 2001), argumentation (Özturna & Atasoy, 2024; Topçu & Atabey, 2017), and scientific literacy (Lomas & Ritchie, 2014; Yapıcıoğlu & Kaptan, 2017), which are fundamental objectives of SSI education.

In conclusion, this meta-synthesis study has comprehensively revealed the current state of SSI research in Turkey, identifying its strengths and areas for development. The findings and suggestions presented are expected to guide future researchers, educators, and policymakers in enhancing the quality of SSI education. Considering the key role of SSIs in fostering individuals as scientifically literate, critical thinking, ethically sensitive, and socially responsible citizens (Sadler, Chambers, & Zeidler, 2004), the continuity and deepening of research in this field are of great importance.

Recommendations

While the focus of current research on middle school students is understandable, it is important to include different age and experience groups to evaluate the effectiveness of SSI education from a broader perspective. In particular, the potential of high school and university students to cope with more complex SSIs and their different cognitive-affective responses (King & Kitchener, 1994; Perry, 1970) would make studies with these groups valuable. Furthermore, including the perspectives of families, and especially parents (Epstein, 2011), who play a significant role in shaping students' attitudes and opinions towards SSIs, in the scope of research will contribute to addressing SSI education with a holistic approach.

The development of high-level abilities such as critical thinking, decision-making skills, and scientific literacy, which are among the fundamental objectives of SSI education, requires time and continuous exposure (Dawson & Venville, 2010; Zeidler, Sadler, Simmons, & Howes, 2005). Therefore, in addition to short and medium-term cross-sectional studies, there is a clear need for longitudinal research designs that examine the long-term effects of SSI education, the retention of learning, and the transfer of skills to different contexts.

There is a need for studies that comparatively examine the effectiveness of different SSI teaching strategies (e.g., inquiry-based approaches, argumentation-focused activities) on various learning outcomes (Sadler, 2011). In this process, research centered on teachers' pedagogical content knowledge (Shulman, 1987) necessary for effectively teaching SSIs, and their skills in translating this knowledge into classroom practices (Lee, Abd-El-Khalick, & Choi, 2006), will play a key role in improving the quality of SSI education.

SSIs often involve complex and uncertain problems that do not have a single, definitive answer. To effectively cope with such problems, it is critically important for individuals to use metacognitive strategies (Flavell, 1979; Schraw & Dennison, 1994), which are their abilities to monitor, evaluate, and regulate their own thinking processes. Similarly, individuals' epistemological beliefs regarding the nature of knowledge and knowing processes (Hofer & Pintrich, 1997; Schommer, 1990) also influence how they address SSIs and the quality of their arguments (Zeidler et al., 2002). Consequently, more research is needed on how these constructs can be developed in the context of SSIs and how they affect learning processes.

In addition to popular and global SSIs, addressing issues directly related to students' daily lives, local environments, and cultural experiences as SSIs can increase motivation for and engagement in learning (Aikenhead, 2006; Levinson, 2006). Such contextualized SSIs can enable students to integrate scientific knowledge with their own life experiences and to produce more meaningful solutions to problems.

For teachers to effectively bring SSIs into the classroom environment, they need to possess adequate knowledge and skills regarding the nature of these issues, relevant pedagogical approaches, and assessment strategies (Sadler, Foulk, & Friedrichsen, 2017). Therefore, it is of

great importance to design comprehensive, practice-oriented, and sustainable training programs for SSI education in both pre-service teacher education programs and in-service professional development activities, and to research the effects of these trainings on teacher competencies and student outcomes.

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