



Middle School Pre-Service Mathematics Teachers' Opinions related to Mathematics Education for Sustainability*

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ARTICLE INFO

Article History:

Received: 26 Dec. 2018

Received in revised form: 15 Aug. 2020

Accepted: 07 Sept. 2020

DOI: 10.14689/ejer.2020.89.6

Keywords

Education for sustainability,
sustainability, mathematics
teaching, middle school pre-service
mathematics teachers

ABSTRACT

Purpose: Subject teachers can contribute to education for sustainability by integrating sustainability concept into their courses. By relating mathematics topics with today's world problems, mathematics teachers can realize the significance of teaching sustainability. As a starting point, this study aimed to investigate the opinions of middle school pre-service mathematics teachers related to incorporating sustainability to their teaching.

Method: In this study, a basic qualitative research design was used. The data were collected using semi-structured interviews with 10 middle school pre-service mathematics teachers. A coding manual was developed considering the relevant literature.

Findings: The findings revealed that pre-service mathematics teachers, except one of them, were aware of the concept of sustainability. However, most of them could not describe multiple aspects of sustainability; particularly, they defined sustainability concerning its environmental dimension. They also defined the purpose of education for sustainability as increasing individuals' environmental awareness. Pre-service mathematics teachers stated that while teaching mathematics, sustainability can be both a goal and a context or sustainability can be used as a context.

Implications for Research and Practice: While teaching mathematics, sustainability topics can be used to design worthwhile problems using real-life examples. As a follow-up study, when these pre-service mathematics teachers start their profession, they can be asked to prepare sustainability integrated mathematics lessons and implement with their students. They can be observed and interviews can be conducted to understand their perceptions and experiences related to sustainability integrated mathematics teaching.

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* This study was partly presented at V. International Eurasian Educational Research Congress, 2-5 May 2018, Antalya

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Introduction

The concept of sustainability was first described in the Brundtland report by World Commission Environment and Development Commission in 1987. In this report, sustainability concept was defined as "Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development [WCED], 1987, p. 43). In the report of United Nations (UN) Decade of Education for Sustainable Development, United Nations Educational, Scientific and Cultural Organization (UNESCO) described sustainability as an evolving concept that is related to improving everyone's quality of life through considering social, economic development and environmental protection (UNESCO, 2005). As described in the definition of UNESCO, the concept of sustainability includes three crucial dimensions as economy, society and environment. These dimensions are not separated from each other; they are all linked to each other. For creating a healthy society, we need a clean environment, clean air, clean water and clean soil (McKeown, 2002). Accordingly, the United Nations Development Program [UNDP] determined 17 sustainable development goals. These goals are related to combating the threats of climate change, no poverty, qualified education, sustainable cities, zero hunger, gender equity, clean air, clean water, renewable energy and responsible production and consumption. Protecting our planet and providing peace and justice for everyone are the main goals determined by UNDP (2017). Education is the key tool to achieve these goals. The seeds of education for sustainable development (ESD) were planted in the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro (UNCED, 1992). ESD is a holistic and interdisciplinary approach to understand our personal responsibilities on the planet, realizing interdependencies among complex problems threatening our future, such as poverty, climate change and inequality and explore solutions to these problems (UNESCO, 2011). Unless the education system embraces sustainable development, it is challenging to transform our world for a sustainable lifestyle (UNESCO, 2017).

ESD develops individuals' knowledge, skills, attitudes and values to live and work in a sustainable way (UNESCO, 2018) and empowers people in all age groups to take responsible actions for sustainability (UNESCO, 2014). Therefore, ESD is not related to only one discipline. Instead, all disciplines can embrace ESD principles and make changes in their programs accordingly (UNESCO, 2018). Sustainability is an interdisciplinary concept; therefore, an interdisciplinary approach is necessary to integrate ESD into school education (Quinn, Littledyke & Taylor, 2015).

ESD can be integrated to all levels of education from early childhood to higher education and every discipline from art, history to science, and mathematics can contribute to ESD (McKeown & Hopkins, 2003). Therefore, interdisciplinary teaching is one of the essential elements of ESD. Teachers from different disciplines can contribute to ESD (Sund & Gericke, 2020). Teachers play a critical role in reorienting education towards sustainability (UNESCO, 2005). They hold great potential to shape students' worldviews, knowledge, attitude and skills towards sustainability (McKeown, 2012). Successful implementation of ESD depends on teachers' views and

understandings of sustainability and how they incorporate this concept into their pedagogy (Birdsall, 2015). All teachers should be equipped with ESD skills so that they could transfer these skills to future generations (UNESCO, 2005). However, it is still vague about how teachers can incorporate sustainability into their teaching to develop students' awareness of sustainability (Andersson, 2017). It is significant to ask how different subject teachers can implement ESD in their programs. In the literature, there are some research studies using sustainability issues as a cross-curricular teaching. For example, Sund and Gericke (2020) explored how teachers from different subject areas (science, social science and language) can contribute to ESD teaching. They discussed the potential of cross-curricular teaching in ESD. In science education context, a book namely "Educating Science Teachers for Sustainability," has been published by Stratton, Hagevik, Feldman and Bloom (2015) to indicate empirical examples from different countries related to integrating sustainability into science teaching. In some countries' policy documents and curricula, we see examples of integrating sustainability into the curriculum. For instance, the Swedish national curriculum incorporated sustainability concept into all subject areas and both primary and secondary school teachers were responsible for teaching and promoting sustainability (Sund & Gericke, 2020). In New Zealand, all teachers were suggested to include sustainability in their courses to have their students develop a sustainability vision (Quinn et al., 2015). In Turkey, the sustainability concept was included in Grades 3-8 science curriculum within the objective to grow responsible citizens for sustainability (Ministry of National Education [MoNEa], 2018). There are also several studies incorporating sustainability into science teacher education (e.g., Karaarslan-Semiz & Teksöz, 2019).

Concerning holistic and interdisciplinary nature of ESD, the sustainability concept can be linked to mathematics teaching as well. In the international literature, there is little research incorporating sustainability and mathematics teaching (Barwell, 2018). What role can sustainability play in teaching mathematics? Australian and New Zealand mathematics curricula included sustainability as a cross-curriculum priority. In these two curricula, it is emphasized that while exploring sustainability issues, mathematics teachers can develop students' skills to investigate data, evaluate and communicate findings and make predictions based on these findings (Serow, 2015). Hamilton and Pfaff (2014) noted that sustainability topics could provide entry points while teaching mathematics, such as learning statistics, through extreme weather events and income distributions. Mathematics education can make contributions to understanding and responding to environmental issues (Barwell, 2018). Then, the question that arises is what this all means for mathematics teachers. What do mathematics teachers think about integrating sustainability into teaching mathematics? As a first step, there is a need to investigate the opinions of pre-service mathematics teachers on integrating sustainability into mathematics teaching. Thus, based on their opinions, teacher education programs and teaching and learning resources associated with sustainability in mathematics education can be developed. All in all, this study focused on exploring opinions of middle school pre-service mathematics teachers related to incorporating sustainability into mathematics teaching.

Conceptual Framework and Literature Review

UNESCO reports played a key role to conceptualize ESD and determined dimensions of ESD. ESD was defined as an interdisciplinary, holistic and cross-curricular approach and included four dimensions (UNESCO, 2017). These dimensions are *learning content* (critical issues related to sustainability), *pedagogy and learning environments* (designing learner-centered and transformative pedagogical approaches), *learning outcomes* (promoting core competencies related to sustainability) and *societal transformation* (empowering learners to resolve global problems) (UNESCO, 2017). These dimensions characterize and conceptualize ESD implementation. To implement ESD in a successful way, it is crucial to strengthen the capacity of teachers related to teaching sustainability (UNESCO, 2017). In some disciplines like science, sustainability is part of the teaching tradition and core curriculum, while in other disciplines, the sustainability is not part of the teaching programs (Stables & Scott, 2002). This is also true for mathematics. Although many connections could be built between sustainability and mathematics, the sustainability concept attracted little attention to mathematics educators (Renert, 2011). Renert (2011) explained the reason for this as mathematics being perceived "as a pure body of knowledge, independent of its environment and value free" (p. 20). Sustainability is an interdisciplinary concept; thus, it could be connected to mathematics subjects. There is a need to rethink mathematics education to educate individuals who are environmentally conscious and aware of sustainability practices (Renert, 2011).

In the literature, there are some studies that connect sustainability and mathematics teaching (e.g., Barwell, 2018; Gutstein, 2007; Hamilton & Pfaff, 2014; Serow, 2015; Steffensen, Hansen, & Hauge, 2016). For instance, Gutstein (2007) brought a different perspective to mathematics education and he demonstrated how social justice could be integrated into mathematics classes. The author suggested that mathematics should be a vehicle for students to understand the socio-political context of their lives. Gutstein and Peterson (2005) stated that while solving mathematics problems, social justice subjects could be used as a catalyst. While investigating home-ownership, loans, mortgages and economic poverty in a math class, students can understand how capitalism works. Mathematics teaching for social justice provides students to act for social change and peacebuilding in the future (Gutstein, 2007). Students can learn to read and write the world with mathematics; however, first, teachers should learn it (Gutstein, 2018). Critical mathematics teaching has a relationship with the social aspect of sustainability as ESD promotes social justice and equity in our communities (UNESCO, 2017).

In addition to the social aspects of sustainability, there are examples indicating how to integrate environmental aspects of sustainability into mathematics teaching. Hamilton and Pfaff (2014) presented several examples. The authors described real-life examples related to sustainability that can be used in both calculus and statistics courses. They asked their students to examine yearly changes on glaciers in Antarctica or oil consumption rates around the world and how it changed over the years. Students used these data to create meaningful curves and analyzed these curves with calculus tools (Hamilton & Pfaff, 2014). Similarly, Serow (2015) suggested math

subjects, such as numbers, statistics, patterns, geometry and algebra, which could be linked to sustainability topics. Students can engage in active mathematical practices while developing their sustainability awareness. In another study, Steffensen et al. (2016) investigated how mathematics teachers connect climate change to mathematics modelling. The authors found that teachers had various aims to use climate change topic in mathematics courses, and they mostly used climate models to teach about mathematical modelling (Steffensen et al., 2016).

Hauge and Barwell (2017) offered a critical mathematics education approach as students could learn the role of mathematics in understanding social, economic, and environmental problems. For instance, the authors noted that in the context of climate change issues, students might use statistical concepts on emission levels, measuring temperatures at a place. Barwell (2018) also suggested critical mathematics education as a theoretical approach to frame research studies related to mathematics education and sustainability. The author argued that critical mathematics education could show students how mathematics can be part of their life and its connection to environmental topics. Barwell (2018) noted that mathematics education would not save the world, but it can help students to understand the current situation of the planet.

In a recent study, Nicol (2018) suggested to use place-based or community-based education for teaching mathematics and emphasized using local and social problems in mathematics education. In the study of Nicol (2018), logging and food production practices in the Haida Gwai region were used as a context for teaching mathematics subjects, which were data collection, data analysis, reading graph and communicating with the data. The author indicated how to integrate local and global sustainability problems into mathematics teaching.

There is a lack of research in Turkey that relates sustainability and mathematics teaching. Mehmetlioglu and Karaarslan (2015) investigated the opinions of Turkish pre-service early childhood teachers about incorporating sustainability into mathematics teaching. The participating pre-service teachers described mathematics topics, such as measurement, counting, classification and patterns, that could be related to sustainability issues, including recycling and reusing. In general, UNESCO's conceptualization of ESD and relevant literature guided this study to reveal middle school pre-service mathematics teachers' opinions related to the link between sustainability and mathematics teaching. Incorporating sustainability into mathematics teaching can enable students to integrate their mathematical knowledge and skills into different fields and, at the same time, promote the awareness of sustainability (Serow, 2015). Mathematics education can make valuable contributions to prepare students for critical citizenship and understanding the problems we face today. Mathematics teachers should realize the significance of sustainability topics in mathematics teaching and they should be able to make the connections between the world's problems and their subject area (Renert, 2011). First of all, mathematics teachers need to be aware of education for sustainability and learn how to use it in their mathematics classes. Therefore, there is a need to investigate the readiness of pre-service mathematics teachers concerning integrating the concept of sustainability into mathematics teaching. Accordingly, sustainability-related mathematics lessons can be

prepared by considering the pre-existing conceptions of pre-service mathematics teachers.

The Purpose of the Study

Each discipline can contribute to ESD by providing students the necessary knowledge, skills and values related to sustainability (McKeown & Hopkins, 2003). Mathematics education is one of these disciplines; however, relating sustainability with mathematics teaching is one of the research areas that have not been given the attention that it needs to get. Therefore, this study aimed to explore middle school pre-service mathematics teachers' opinions concerning incorporating sustainability into mathematics teaching. It is significant to integrate ESD into pre-service and in-service teacher education to strengthen teachers' capacity for teaching sustainability. This might be possible by integrating sustainability into different subject areas (UNESCO, 2014). This study can be a starting point by exploring pre-service teachers' opinions on making a connection between sustainability topics and mathematics teaching. The results of this study can provide implications for future studies about using sustainability topics in the mathematics classes to develop students' sustainability consciousness. Accordingly, the research questions of this study are;

1. What are the middle school pre-service mathematics teachers' opinions about relating sustainability and mathematics teaching?
 - a. What are the middle school pre-service mathematics teachers' opinions related to sustainability?
 - b. How do middle school pre-service mathematics teachers make connections between the concept of sustainability and mathematics teaching?
 - c. What are the middle school pre-service mathematics teachers' opinions in terms of which mathematics topics and sustainability issues can be related?

Method

Research Design

To respond to the research questions, in this study, basic qualitative research was used. Basic qualitative research investigates how individuals make sense of a phenomenon based on their own life and experiences (Merriam, 2009). Basic qualitative research explores individuals' interpretations and meanings that they attributed to a phenomenon (Merriam, 2009). This study focused on pre-service mathematics teachers' meanings that they ascribed to the relationship between sustainability and mathematics education; therefore, researchers used basic qualitative research. Using the qualitative study, middle school pre-service mathematics teachers' opinions about the relationship between sustainability and mathematics education were examined.

Context

The participants of this study were fourth-year middle school pre-service teachers at a public university in Ankara. The teacher education program that they were enrolled in was a four-year-long program which aimed to bring up teachers that teach Grades 5-8. The program included mainly content courses (e.g., subject courses that they took from the Faculty of Arts and Sciences), educational sciences courses that they took from the Department of Educational Sciences and the courses that they took from their own program, Elementary Mathematics Education, such as Methods of Teaching Mathematics. The School Experience and Practice Teaching courses took place in the last two semesters. The teacher education program also required students to complete six elective courses. One of the elective courses that were offered to pre-service teachers was "Education and Awareness for Sustainability." This course aimed students to gain awareness of sustainability and help them develop a personal view about issues related to sustainability. In this study, three out 10 teachers stated that they were either taking this elective course at the time of the interview or have already taken in the previous semesters. This will be further elaborated in the findings section.

Participants

The participants of this study were ten fourth-year middle school pre-service mathematics teachers who were studying at a public university in Ankara. Nine out of the participants were female, while one of them was male. Participants' age ranged between 21 and 25. Using purposive sampling method, the participants were invited to this study by visiting two of the three sections of the School Experience course (a total of 24 students), ten pre-service teachers were included in this study within their interests. Purposive sampling method was used because fourth-year pre-service teachers were the target of the study as they had finished most of their teacher education courses and would be close to starting their profession.

Instrument and Data Collection

In this study, the data were collected during the 2017-2018 Fall semester after the Human Subjects Ethics Committee approval of the university was obtained. The data were collected using half hour long individual semi-structured interviews. The interviews were audio recorded to be transcribed later. The researchers had 14 open-ended questions to investigate participants' opinions about sustainability, and the relationship of mathematics education and sustainability (see the Appendix) based on the interview protocol developed by Mehmetlioglu and Karaarslan (2015). The authors in the previous study developed eight open ended questions about relating sustainability and mathematics teaching. In the current study, six more questions were added to the interview protocol to get deeper information about participants' insights, such as asking participants to share a sample activity about integrating sustainability into mathematics teaching.

First, the participants were asked whether they took a course related to sustainability or environment or if they attended a seminar. Then, they were asked whether they were interested in sustainability or environmental issues. Further

questions investigated how they defined sustainability and education for sustainability and how they related sustainability and mathematics teaching, which mathematics topics could be related to sustainability, whether they designed an activity about integrating sustainability into mathematics teaching, and if they did how they would do so.

Data Analysis

After the recorded interviews were transcribed, the data were coded. First, initial coding was used, which was defined as a “First Cycle”, an open-ended approach to coding with some recommended general guidelines” (Saldaña, 2009, p. 81). At this stage, some external codes related to the definition of sustainability and definition of education for sustainability were utilized based on Birdsall (2014), Kawaga (2007), Kilinc and Aydin (2011), and McKeown (2002). As new codes emerged, these were added to the coding manual. For example, for the definition of sustainability category, the codes, environmental, economic and social were external codes that come from the literature. Based on participants’ responses, “continuity” was added as an emerging code. The codes and categories in Table 1 were used in the data analysis.

Table 1

Categories and Codes Used in the Data Analysis

Categories	Codes
Definition of Sustainability	Environmental, Economic and Social Dimension, Continuity
Definition of Education for Sustainability	Gaining Environmental Awareness, Continuity of Education and Training
Purpose of the Mathematics Education	Relating Mathematics and Life, Gaining Mathematical Thinking Skills
The Relationship between Mathematics Education and Sustainability	Using Sustainability both as a Context and a Goal Using Sustainability as a Context
Mathematics Topics that can be related to Sustainability	Topic examples were provided across all learning domains except probability. (e.g., percent, algebra, modelling, geometry, measurement, data collection and interpretation)
Activities that relate Sustainability and Mathematics	Examples: Wastes – ratio and proportion, sustainable design – geometry, algebra and STEM

As seen in Table 1, each question in the interview protocol referred to a category and related codes were used to analyze responses provided to the question. After the initial coding, focused coding, a second cycle analytic process (Saldaña, 2009), was used to focus only on the codes that were of particular interest to the research questions. The researchers’ experiences in science and mathematics education helped them decide codes and categories in the data analysis. The first researcher’s academic background is in science education and was experienced in education for sustainability and the second researcher’s academic background is in mathematics education. Different academic backgrounds provided a rich source for analyzing the data. To increase the reliability of the coding and the study, the second researcher coded the four randomly

selected interviews, the codes were compared, and the inter-rater agreement among the raters was 80%. The codes and categories of the two coders were discussed, and the changes were reflected in the analysis.

Findings

As mentioned in the methods section, three out of ten middle school pre-service mathematics teachers (PSTs 1, 5 and 9) stated that they were either taking or have taken the "Education and Awareness for Sustainability" course at the time of the interview, while seven of them stated that they did not take such a course in their teacher education program. The ones who took a course stated that their interest in the subject increased. Several other PSTs stated that they were sensitive about environmental issues and provided examples of what they did in daily life. In general, the PSTs who participated in this study were not completely irrelevant to the environment and sustainability issues.

Definition of Sustainability

When PSTs were asked what they understand about the concept of sustainability, half of the pre-service mathematics teachers described the environmental dimension of sustainability, four of them related sustainability with both environmental and economic aspects. One participant defined sustainability as continuity. Those who defined it with the environmental dimension have talked about recycling, reuse, environmental protection and consumption. The following excerpt exemplifies the results:

PST-2: For example, I am very sensitive about throwing garbage on the ground; I do not.

R: What else could it be?

PST-2: Not to destroy nature or forest. Parks are important. And recycling.

PST-5: Sustainability is something to do with environmentally friendly materials. That's all I know. Things that don't harm the environment.

The participants who defined sustainability with their environmental and economic dimensions mentioned more about local production, reuse, savings, preserving natural resources and leaving a good environment for future generations. The following excerpts exemplify the results:

PST-1: To use what one has. To use whatever is grown up in the region. To reduce the dependency on the outside. To maintain its continuity. Energy, for instance, to increase [the use of] solar energy.

PST-9: Which materials we use are mixed in the soil, which we do not, we should consider the following years. We should invest. Soil, water, our basic nutrients come to my mind.

One participant defined sustainability as continuity, as presented in the following excerpt:

PST-8: To maintain and sustain something. You learn something, you teach it to others. If I've learned something, I can use it elsewhere.

Based on the above-mentioned results, it can be inferred that pre-service mathematics teachers had some knowledge related to sustainability, but they mostly defined it with environmental dimensions. They did not have a holistic perspective of sustainability as integrating three pillars of sustainability (social, environmental and economic).

Definition of Education for Sustainability

When asked what education for sustainability meant to them, eight out of ten participants defined it as gaining environmental awareness, two participants mentioned the continuity of education and training (e.g., PST-8).

PST-3: Helping students gain environmental awareness. Energy resources, for example, if we continuously consume, they will be over. Students need to realize that.

PST-10: Not disturbing the order of things, not polluting, environmental awareness [...] These are the first things I can think of. A lot of garbage is thrown into the sea. The sea sounds infinite. People do it because they don't know that they shouldn't.

PST-8: To be able to sustain, understand, apply, and to teach this in education

These results suggest that pre-service mathematics teachers did not have much knowledgeable about education for sustainability. They did not have enough understanding of the holistic and interdisciplinary aspect of education for sustainability.

The Purpose of Mathematics Education

Pre-service mathematics teachers were asked about the purpose of mathematics education before they were asked how they relate mathematics education and sustainability. Four out of ten pre-service mathematics teaches mentioned the relation of mathematics and life. Two participants stated helping students gain mathematical thinking skills (e.g., problem-solving skills), and four participants reported both when they were asked the purpose of mathematics education, such as PST-8 explained the relation of mathematics and life, as presented in the following excerpt:

PST-8: A student is interested in swimming. Relationship between swimming and mathematics. Or the relationship between music and mathematics. For example, when you see the notes, you make 1/2, 1 full strokes according to this. How many angles do you keep your head at swimming? [...] Mathematics is crucial to continue our life. Nature, life teaches mathematics in a way.

PST-7 especially noted the significance of mathematical thinking ability for life:

PST-7: I think mathematics is a more reasonable thing than understanding that $2+2$ makes 4. It helps us shape our thoughts in daily life, providing us

with logical thinking and making decisions. Our choices in daily life, making analysis, problem solving, improving that side of our brain.

PST-4 mentioned the relation of mathematics and life and the purpose of mathematics education as gaining mathematics skills:

PST-4: It can be associated with problem solving ability. Reasoning, problem solving. We need mathematics everywhere. I can't imagine life without mathematics. I think, as teachers, we need to explain where we can use it [mathematics] in all topics.

When asked the purpose of mathematics education, pre-service mathematics teachers generally described the relation of mathematics education and real life. They were aware that mathematics and mathematical thinking hold a crucial place in every part of life. Several teachers focused on the importance of thinking skills to be gained through mathematics education, including problem solving, analysis, reasoning, which are also emphasized in the goals of the Grades 1-8 Turkish mathematics curriculum (MoNEb, 2018)

The Relationship between Mathematics Education and Sustainability

When the pre-service teachers were asked whether they see a relationship between mathematics course and sustainability, two main codes emerged: 1. Using sustainability as both a goal and a context. 2. Using sustainability as a context. Six of the participants stated that they could include sustainability issues (e.g., energy, water and wastes) in mathematics. Thus, they can help develop sustainability awareness of students. These participants stated that in mathematics classes, students' awareness of sustainability could be increased. For instance, PST-4 stated:

PST-4: Data analysis, for instance, about sustainability, graphs can be used to analyze how much waste there is over the years. If we give real graphs, we can see how serious the situation is. We can both interpret graphs and realize the seriousness of the situation.

Three pre-service teachers stated the use of sustainability as a context in mathematics education. In other words, they mentioned that mathematics could be taught through sustainability topics. These participants emphasized that sustainability awareness could be given implicitly but not directly. For example, PST-1 said:

PST-1: When discussing a topic, for example, percentages, a percentage of something can be associated with sustainability issues. Using 2.5% of the world's water, for instance, is related to mathematics.

One participant, PST-8, on the other hand, mentioned the order of the mathematics topics and teaching them in a related way when asked about the relationship between mathematics education and sustainability. PST-8 said:

PST-8: In mathematics, I learned numbers in the first-grade. In the second-grade addition and subtraction, then integers, rational numbers and I did addition and subtraction of rational numbers. Thus, they are all interrelated.

You learn something; you do not leave it there; they are related. The continuation of mathematics provides sustainability.

Based on the above-mentioned results, almost all pre-service mathematics teachers had some ideas about integrating sustainability into mathematics teaching. While several of them described that sustainability topics could be used as both a goal and a context, others stated that sustainability topics could be used as a context in teaching mathematics. This finding suggests, for them, increasing awareness of sustainability may not be the goal of the mathematics course, but students can gain some awareness of sustainability while learning mathematics. Table 2 summarizes the results mentioned so far.

Table 2

Frequency of the Codes and Categories of Pre-service Mathematics Teachers' Opinions

Categories	Codes	Frequency
Definition of Sustainability	a. Environmental Dimension b. Environmental and Economical Dimensions c. Continuity	5 4 1
Definition of Education for Sustainability	a. Gaining Environmental Awareness b. Continuity of Education and Training	8 2
Purpose of the Mathematics Education	a. Relating Mathematics and Life b. Gaining Mathematical Thinking Skills c. Both of them	4 2 4
The Relationship Between Mathematics Education and Sustainability	a. Using Sustainability both as a Context and a Goal b. Using Sustainability as a Context c. Interrelationship between Mathematics Topics	6 3 1

The Learning Areas that were related to Sustainability

When pre-service mathematics teachers were asked which mathematics subjects could be related to sustainability, they gave examples from all learning domains except probability. PSTs' most common examples for the sub-learning domains were percentages, ratio and proportion, measurement of perimeter and area, geometry and data analysis. Some PSTs emphasized more than one learning domain. Table 3 shows the learning and sub-learning domains and their frequencies, which PSTs related to sustainability.

Table 3

Mathematics Learning Domains that PSTs related to Sustainability

Learning Domains	Frequency	Examples for Sub-learning Domains
Numbers and Operations	5	Percentages, ratio and proportion, integers
Geometry and Measurement	3	Measurement of perimeter and area, geometric solids and shapes, angles, transformational geometry
Data Processing	3	Data collection and analysis
Algebra	1*	-
Probability	-	-

*A sub-learning domain for algebra is not mentioned specifically.

Activity Examples that Relate Sustainability with Mathematics Education

During the interview, pre-service mathematics teachers were asked to give sample activities about the mathematics topics that they had mentioned to relate with sustainability in the previous question. Table 4 shows the sustainability issues and mathematics topics in their activity examples.

Table 4

Sustainability and Mathematics in PSTs' Activity Examples

Pre-service teachers	Sustainability and Mathematics Topics
PST-1	a) The use of water resources – percentages b) Renewable energy resources – measuring area and modeling
PST-2	The impact of the waste on the environment – ratio and proportion
PST-3	Recycling, reusing – geometry
PST-4	Sustainable design (biomimicry) – geometry, algebra, STEM, designing a research question – data processing
PST-5	Water consumption – data processing
PST-6	a) Science activity (living creatures and life) – measurement b) Sustainable design – STEM
PST-7	Energy consumption – ratio and proportion
PST-8	Relationships between mathematics topics (e.g., integers and rational numbers)
PST-9	Waste (making compost) – percentages, measurement, geometry
PST-10	Sustainable use of natural resources – the concept of infinity

For instance, PST-5 stated that water consumption and data processing could be related, and she presented the following example:

PST-5: Data processing, for example. We graph the amount of water by years. First, we give the data, we ask the students to graph it. We tell students about sustainability [...] I think this is in the 7th-grade level. Let's ask them to make predictions according to the data [...] In a year, for example, how much will have changed [...] We compare how much water we consume in a year. I ask them to have them aware of sustainability.

PST-2 gave an example of the impacts of the waste on the environment and its relation with ratio and proportion as presented in the below excerpt:

PST-2: Seas, for example. I'd do some research. How are living creatures affected by the amount of garbage thrown into the sea? Then, some information could be provided, and ratio and proportion can be set up. If a person is throwing that much garbage in a day and living creatures are being affected that much, how much are the sea creatures in the area affected if there are that many people living there?

PST-4 related sustainable design (biomimicry), geometry and STEM. The participant also mentioned designing a research question. Her response is presented in the below excerpt:

PST-4: They find a solution from nature and make the design using the solution. It could be geometry. In transportation, in clothing, we come up with problems from daily life, what kind of problems there are in nature, and what kinds of solutions there are, they make designs. Geometry, algebra concepts come to my mind. We can give a theme like transportation. We can ask them to find problems. I'm always thinking about mathematics at the design stage. I think the STEM class. For example, we used it [mathematics] while designing a ship, making a parachute. We did it by finding the surface area.

Participants stated that they had never thought that mathematics teaching could be related to the sustainability concept, and they stated that they could make connections between sustainability issues and many mathematical topics. All of them stated that they need to further develop themselves about how to integrate sustainability topics into mathematics teaching, and they were willing to participate in a workshop that relate to sustainability and mathematics teaching.

Discussion and Conclusion

In this study, middle school pre-service mathematics teachers' opinions about integrating sustainability to mathematics teaching were investigated. According to results, pre-service mathematics teachers, except one of them, were aware of the concept of sustainability. Only three of them stated that they were taking or already have taken an elective course related to sustainability; however, others stated that they had a personal awareness of environmental and sustainability issues. Sustainability is not a new concept in our education system. Turkey started to integrate sustainability into education programs from 2012 with the preparation of The Sustainable Development Report (Teksoz, 2014). Recently, the sustainability concept has been included in both school and higher education programs. Thus, it is not unusual that pre-service mathematics teachers have some awareness about sustainability.

When pre-service mathematics teachers were asked about the definition of sustainability, most of them could not describe multiple aspects of sustainability. Particularly they defined sustainability concerning its environmental dimension. The concept of sustainability is not only related to environmental subjects, it is also linked to social and economic subjects, such as poverty, equity, social justice and fair trade (McKeown, 2002; UNESCO, 2013). In previous studies, a similar tendency was

observed that pre-service teachers from different disciplines had a limited understanding of sustainability and they mostly equated sustainability with environmental issues (e.g., Birdsall, 2014; Kilinc & Aydin, 2013; Summers & Childs, 2007; Tuncer, Tekkaya, & Sungur, 2006). One of the reasons for this result may be that the concept of sustainability has been mostly associated with environmental subjects in the school curriculum (Petersen & Alkis, 2009). For example, in Grades 3-8 Turkish science education curriculum (MoNEa, 2018), sustainability is described as efficient use of resources and recycling; economic and social aspects of sustainability are not included much. While two of the pre-service mathematics teachers defined education for sustainability as continuity of education and training, eight participants defined education for sustainability as related to increasing students' environmental awareness. As participants mostly emphasized the environmental dimension of sustainability, they defined education for sustainability concerning its environmental aspect. Similarly, in different studies that were conducted with pre-service teachers, the results showed that education for sustainability was mostly defined concerning environmental subjects (e.g., Burmeister, Jacob & Eilks, 2013; Evans, Whitehouse, & Hickey, 2012). The reason why pre-service mathematics teachers may not have comprehensive understanding of sustainability could be that lecturers from science, mathematics, and arts education departments do not integrate sustainability in their courses. They mostly describe one dimension of sustainability (Cavas, Ertepinar, & Teksoz, 2014).

Another outcome of this study was that pre-service mathematics teachers described the purpose of mathematics education as relating mathematics and life and helping students gain mathematical thinking skills, such as problem solving. There is a significant relationship between teachers' beliefs related to mathematics education and their practice (Wilkins, 2008). In this study, the majority of the participants described the purpose of mathematics education as relating mathematics and life. Sustainability oriented content can provide real-life examples that can be used in mathematics teaching. For instance, the climate change issue can provide real data for worthwhile mathematics problems. Mathematical models can be used in describing, predicting and communicating climate change (Barwell, 2013). This could also help students develop their mathematical thinking skills, such as problem solving. More than half of the pre-service teachers stated that sustainability could be used both as a goal and a context in mathematics. They suggested sustainability subjects to be included in mathematics to increase students' awareness of sustainability. Other participants except one of them stated that sustainability topics could be used as a context in mathematics lessons. Hamilton and Pfaff (2014) suggested a framework, including sustainability in mathematics courses without sacrificing the course content. The authors noted that a sustainability-oriented context could be used in mathematics teaching and this can help students develop their knowledge and skills related to sustainability. UNESCO (2017) also emphasized that sustainability issues can be integrated into teaching and learning to empower learners to make responsible decisions for the future. The findings obtained in this study suggest that pre-service mathematics teachers were willing to include sustainability topics in mathematics courses. During the interviews, they gave examples of some environmental subjects,

such as environmental pollution, water consumption, recycling, that can be related to mathematics. Renert (2011) mentioned that sustainability solutions, such as carbon storage, zero waste and renewable energy sources, could be possible entry points for sustainable mathematics education. Barwell also (2013, 2018) discussed the role of mathematics in understanding environmental issues, such as climate change, species loss and deforestation. Many laws and policies to overcome climate change threats are prepared based on the predictions of mathematical models related to climate change (Barwell, 2018). Serow (2015) pointed out that while students are exploring sustainability subjects, they can also gain knowledge and skills related to mathematics like problem solving, data collection and data analysis. Furthermore, Erkan, Pfaff, Hamilton and Rogers (2012) suggested that sustainability-themed problems can be used in computing classes for teaching data structures and algorithms. The authors noted that students could learn core computing concepts, and also, they can understand climate change, energy and food issues. Therefore, mathematics education can play a crucial role in preparing students to deal with problems of the world and produce sustainable solutions for these complex problems (Barwell, 2018).

In this study, pre-service mathematics teachers described different mathematics learning domains that can be linked to sustainability. They mostly gave examples related to numbers, geometry, measurement and data processing. Probability was the learning domain that they did not describe in their sustainability and mathematics teaching linked examples. Similarly, Serow (2015) stated that geometry, data analysis and counting can be linked to sustainability. The author also described sustainability examples that can be related to mathematics education, such as water consumption, energy consumption, population growth, renewable energy sources, food production, waste reduction and the greenhouse effect. In this study, pre-service mathematics teachers reported some environmental topics, such as water consumption, wastes, recycling and energy consumption, which can be linked to mathematics education. However, they did not mention climate change, economic development and social justice issues that can be related to mathematics education. Social justice as a social aspect of sustainability takes attention in the literature. Several researchers (e.g., Gutstein, 2007; Karaali & Khadjavi, 2019) describe mathematics for social justice that refers to bringing social justice issues into mathematics classes. Moreover, Hamilton and Pfaff (2019) suggest that social and environmental aspects of sustainability can be linked while teaching mathematics to find solutions to the complex problems of the world. Lastly, in the national literature, Mehmetlioglu and Karaarslan (2015) found similar results concerning integrating sustainability into mathematics teaching. The authors reported that pre-service early childhood teachers were mostly aware of the environmental aspect of sustainability and they were willing to use sustainability issues as a context in their future mathematics classes. Although pre-service mathematics teachers were not so much aware or prepared about how to integrate three dimensions of sustainability into their mathematics classes, they all had a tendency and motivation to connect sustainability and mathematics teaching. Sustainability issues can be utilized in mathematics lessons, which could increase students' awareness of global problems in turn.

Recommendations and Limitations

In this study, it was explored that middle school pre-service mathematics teachers were aware of environmental sustainability, and they had some opinions about how to link sustainability and mathematics teaching. This study was an initial attempt to explore pre-service mathematics teachers' opinions related to sustainability-oriented mathematics lessons. More empirical studies are needed to investigate teachers' ways of engaging sustainability topics into mathematics lessons. Education for sustainability is mostly viewed as challenging for many subject teachers. Teachers need more concrete examples to integrate sustainability into school objectives and their teaching (Waltner et al., 2020). Therefore, teachers' competencies to implement ESD should be developed (UNECE, 2011). Pre-service mathematics teachers should be taught a holistic perspective of sustainability integrating social, environmental and economic aspects. Instead of teaching sustainability topics in isolation, in teaching mathematics, sustainability topics can be used as a context and teaching and learning resources can be developed based on real-life examples. To increase pre-service mathematics teachers' competencies related to ESD, pre-service mathematics teachers could be encouraged to take courses related to environment and sustainability. Recently, the "Sustainable Development and Education" course was included in the elementary mathematics teacher education program (Higher Education Council, 2018) as an elective course. This is progress in increasing sustainability awareness of pre-service mathematics teachers. Additionally, sustainability topics should be incorporated into pedagogical content courses (i.e., courses related to teaching mathematics). In this way, pre-service mathematics teachers can find more opportunities to relate to sustainability and mathematics teaching.

There are several limitations of this study. The study is limited to the data obtained from 10 participants' responses to the interview questions. Also, pre-service mathematics teachers were likely to have more informed opinions than the group they represent because they were a self-selected group. Thus, in further studies, more comprehensive and diverse samples can be chosen. Furthermore, when these pre-service teachers start their profession, they can be asked to prepare and implement sustainability integrated mathematics lessons. They can be observed, and interviews can be conducted to understand their perceptions and experiences related to sustainability integrated mathematics teaching.

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Appendix

Interview Questions

These interview questions are prepared to get your opinions about how sustainability can be related to mathematics education. We request that you sincerely respond to the questions. If you would like to withdraw from the study for any reason, please let us know.

1. Have you taken any course so far related to sustainability or the environment?
Which courses did you take?
2. To what extent are you related to sustainability or environmental issues?
(Prompts: Have you participated in an activity? Or do you read books or articles about these issues?)
3. What do you understand from the concept of sustainability? Can you explain it?
4. What does education for sustainability mean to you?
5. What do you think the purpose of mathematics education is? Why is mathematics education important?
6. Do you think there is a link or relation between mathematics education and sustainability? Can you explain it?

7. Which mathematics topics or objectives can be related to sustainability? Can you give an example?
8. Have you seen an activity or a lesson plan that sustainability and mathematics education was linked together? Can you explain it?
9. Have you designed an activity that related sustainability with mathematics education? Can you explain it?
10. Can you share a short activity that helps integrate the concept of sustainability into elementary or middle school mathematics education?
11. Do you feel yourself confident in integrating the concept of sustainability into mathematics education? Can you explain it?
12. Would you like to improve yourself about mathematics education for sustainability?
13. Would you like to attend a one-day seminar and workshop “Mathematics Education for Sustainability”?
14. Is there anything you would like to add?

Ortaokul Matematik Öğretmen Adaylarının Sürdürülebilirlik için Matematik Eğitimi Üzerine Görüşleri

Atıf:

Karaarslan, Semiz, G., & Isler, Baykal, I. (2020). Middle school pre-service mathematics teachers' opinions related to mathematics education for sustainability. *Eurasian Journal of Educational Research* 89, 111-136, DOI: 10.14689/ejer.2020.89.6

Özet

Problem Durumu: Sürdürülebilirlik için eğitim, bireylerin yaşadığı gezegende kendi rolünü anlaması, geleceği tehdit eden yoksulluk, iklim değişikliği, çevrenin bozulması, nüfus artışı, eşitsizlik gibi karmaşık problemlerin birbirleriyle nasıl ilişkili olduğunu fark etmesini ve sürdürülebilir çözüm yollarının keşfetmesini sağlayan bütüncül ve disiplinler arası bir yaklaşımdır (UNESCO, 2011). Sürdürülebilirlik için eğitim bireylerin sürdürülebilir bir yaşam için gerekli olan bilgi, beceri, tutum ve değerlerle donatılmasını sağlar (UNESCO, 2017). Sürdürülebilirlik kavramı tek bir disiplinle değil, sanat, tarih, fen bilimleri, matematik gibi tüm disiplinlerle ilişkilendirilebilir (McKeown ve Hopkins, 2003). Ancak öğretmenlerin sürdürülebilirlik kavramını öğrencilerine nasıl öğretebilecekleri, nasıl derslerinde kullanabilecekleri hala tartışılmıştır (Andersson, 2017). Literatürde fen bilimleri sosyal bilimler, dil bilgisi gibi derslerde sürdürülebilirlik için eğitimin nasıl uygulanacağı üzerinde çeşitli çalışmalar bulunmaktadır (örn., Sund & Gericke, 2020). Avustralya ve Yeni Zelanda gibi bazı ülkelerde ise sürdürülebilirlik kavramı tüm öğretim programlarında yer almaktır ve öğrencilerin sürdürülebilirlik vizyonuyla yetişirilmesi vurgulanmaktadır (Quinn vd., 2015). Türkiye'de genel olarak çevre ve sürdürülebilirlik kavramı özellikle fen bilimleri öğretimiyle ilişkilendirilmekte ve fen

bilimleri öğretim programında yer almaktadır. Diğer taraftan matematik öğretiminin sürdürülebilirlikle ilişkilendirilmesi üzerine ulusal ve uluslararası literatürde henüz yeteri kadar çalışma bulunmamaktadır. Örneğin, İklim değişikliği konuları ve matematik konuları arasında yeteri kadar bağlantı kurulmamaktadır (Renert, 2011). Sürdürülebilirlikle ilgili konular gerçek yaşamdan örnekler verilerek matematik derslerinin öğretiminde kullanılabilir (Hamilton & Pfaff, 2014; Renert, 2011). Özellikle son yıllarda sürdürülebilirlik ve matematik öğretimi arasında nasıl bağlantı kurulabileceği üzerine araştırmaların artmaya başladığı söylenebilir (örn., Barwell, 2018; Hamilton & Pfaff, 2014; Hauge & Barwell, 2017; Nicol, 2018; Serow, 2015). Hauge ve Barwell (2017) sosyal, çevresel ve ekonomik problemlerde matematiğin rolünü anlamak için kritik matematik eğitimi yaklaşımını önermişlerdir. Yazarlara göre kritik matematik eğitimi öğrencilere matematiğin yaşamalarının bir parçası olduğunu ve çevre konularıyla ilişkisini gösterebilir. Barwell (2018) matematik eğitiminin dünyayı kurtarmayacak olsa da öğrencilere gezegenimizin durumunu anlamak için yardımcı olabileceğini belirtmiştir. Bu nedenle matematik öğretmenlerinin sürdürülebilirlik için eğitimde farkında olmaları ve sürdürülebilirlik konularının matematik öğretiminde nasıl kullanılabileceğini keşfetmeleri önemlidir. Türkiye’de ise bu alanda yeteri kadar argüman üretilmemiş, çalışma yapılmamıştır. Bu nedenle bu çalışmada sürdürülebilirlik bilincinin matematik derslerinde verilebileceğinden ve matematik öğretmenlerinin bu konuda bilgi ve becerilerinin artırılması gerektiğinden yola çıkılarak matematik öğretiminin sürdürülebilirlikle ilişkilendirilmesi üzerine ortaokul matematik öğretmen adaylarının görüşleri ve hazır bulunuşlukları araştırılmıştır.

Araştırmmanın Amacı: Bu çalışmanın amacı ortaokul matematik öğretmen adaylarının sürdürülebilirlik kavramının matematik öğretimi ile ilişkilendirilebilmesi üzerine görüşlerini araştırmak ve sürdürülebilirlik için matematik eğitimi hakkındaki farkındalıklarını ortaya çıkarmaktır. Bu kapsamda bu çalışmada aşağıdaki araştırma sorularına cevaplar aranmıştır:

- 1) Ortaokul matematik öğretmen adaylarının matematik öğretiminin sürdürülebilirlikle ilişkilendirilmesine yönelik görüşleri nelerdir?
 - a. Ortaokul matematik öğretmen adaylarının sürdürülebilirliğe yönelik görüşleri nelerdir?
 - b. Ortaokul matematik öğretmen adayları sürdürülebilirlik ile matematik öğretimi arasında nasıl bir ilişki kurmaktadır?
 - c. Ortaokul matematik öğretmen adayları hangi matematik konuları ve sürdürülebilirlik konularının ilişkilendirilebileceğini düşünmektedirler?

Araştırma Yöntemi: Araştırma sorularına cevap aramak için çalışma temel nitel araştırma deseni (Merriam, 2009) kullanılarak gerçekleştirilmiştir. Yorumlayıcı bir yaklaşımla matematik öğretmen adaylarının sürdürülebilirlik konuları ile matematik öğretiminin ilişkilendirilmesi üzerine sahip oldukları görüşler incelenmiştir. Katılımcılar, Ankara ilinde bulunan bir devlet üniversitesinin son sınıfında okuyan 10 ortaokul matematik öğretmen adayından oluşmaktadır. Katılımcıların 9'u kadın, 1'i erkektir. Katılımcıların kayıtlı oldukları öğretmen yetiştırme programı 5-8. sınıflara

matematik öğreten öğretmenler yetiştirmeyi amaçlayan 4 yıllık bir programdır. Program genel olarak Fen-Edebiyat Fakültesi'nden alınan alan dersleri, Eğitim Bilimleri Bölümü'nden alınan eğitim bilimleri dersleri ile öğretmen adaylarının kendi programlarından aldığı matematik öğretimiyle ilgili derslerden oluşmaktadır. Ayrıca program matematik öğretmen adaylarına 6 seçmeli ders önermektedir. Bu derslerin arasında "Sürdürülebilirlik için Eğitim ve Farkındalık" dersi de yer almaktadır. 10 öğretmen adayından 3'ü görüşmeler sırasında bu seçmeli dersi aldığına ya da almakta olduğunu belirtmiştir. Katılımcılar Matematik Öğretmenliği programında derslerinin çoğunu tamamlamış olmaları ve öğretmen olmaya yakın oldukları için amaçlı örnekleme yöntemiyle seçilmişlerdir. Çalışmanın verileri ise, 2017-2018 Güz yarıyılında yarı yapılandırılmış yaklaşık yarım saat süren bireysel görüşmeler yapılarak toplanmıştır. Görüşmeler deşifre edildikten sonra, çalışmanın verileri kodlanmıştır. İlk olarak, "Birinci Döngü, önerilen bazı genel yönergelerle kodlamaya açık uçlu yaklaşım" olarak tanımlanan ilk kodlama kullanılmıştır (Saldaña, 2009, s. 81). Bu aşamada, sürdürülebilirlik tanımı ve sürdürülebilirlik için eğitim tanımına ilişkin literatürden gelen kodlardan yararlanılmıştır. Örneğin, sürdürülebilirlik tanımı ve sürdürülebilirlik için eğitim tanımı ile ilgili kod ve kategoriler Birdsall (2014), Kawaga (2007), Kılinc ve Aydin (2011) ve McKeown (2002)'nin çalışmaları incelenerek oluşturulmuştur. Analiz sırasında yeni kodlar çıktıktan sonra eklenmiştir. İlk kodlamadan sonra, odaklanmış kodlama, ikinci döngü analitik süreç olarak (Saldaña, 2009), yalnızca araştırma sorularını ilgilendiren kodlara odaklanmak için kullanılmıştır. Verilerin analizinde kodlama güvenirligi için ikinci araştırmacı da rastgele seçilen dört görüşmeyi kodlamış, kodlar karşılaştırılmış ve güvenirlik %80 olarak bulunmuştur.

Araştırma Bulguları: Ortaokul matematik öğretmen adayları ile yapılan görüşmeler sonucunda 10 katılımcıdan 3'ü araştırma esnasında çevre ve sürdürülebilirlikle ilgili bir seçmeli ders alıyor olduğunu ya da aldığına belirtirken, 7'si lisans programında böyle bir ders almadıklarını ifade etmişlerdir. Ders almakta olan katılımcılar sürdürülebilirlik ve çevre ile ilgili konulara daha fazla ilgililerinin arttığını belirtmişlerdir. Analizde edilen sonuçlara göre toplam 6 kategori altında kodlar oluşturulmuştur. Bu kategoriler şöyledir: "Sürdürülebilirliğin Tanımı", "Sürdürülebilirlik için Eğitim'in Tanımı", Matematik Eğitimi'nin Amacı", "Matematik Öğretimi ve Sürdürülebilirlik Arasındaki İlişki", "Sürdürülebilirlikle İlişkilendirilebilen Matematik Konuları" ve "Sürdürülebilirlikle ve Matematiği İlişkilendiren Etkinlik Örnekleri". Katılımcılar daha önce matematik eğitiminin sürdürülebilirlik kavramıyla ilişkilendirilebileceğini hiç düşünmediklerini dile getirmiştirlerdir. Ancak görüşmeler sırasında verdikleri yanıtlarından çeşitli matematik ve sürdürülebilirlik konuları arasında bağlantı kurulabileceğini ifade etmişlerdir. Sürdürülebilirlik ve matematik öğretimi arasındaki ilişkiyi açıklarken iki temel kod ortaya çıkmıştır: 1. *Sürdürülebilirliğin hem amaç hem de bağlam olarak kullanılması* ve 2. *Sürdürülebilirliğin sadece bağlam olarak kullanılması*. Katılımcılardan 6'sı matematik konularını anlatırken sürdürülebilirlik konularına (örn., enerji, su, atıklar) yer verilmesi gerektiğini ve böylece öğrencilerde sürdürülebilirlik bilincinin de kazandırılabilceğini ifade etmişlerdir. Üç öğretmen adayı ise matematik öğretiminde sürdürülebilirliği bağlam olarak kullanmasından yani sürdürülebilirlik konuları

temel alınarak matematik derslerinin işlenebileceğini belirtmişlerdir. Bu katılımcılar sürdürülebilirlik bilincinin doğrudan değil ancak örtük olarak verilebileceğini vurgulamışlardır. Katılımcılar sürdürülebilirlik konularıyla ilişkilendirilebilecek çeşitli matematik konu alanlarından da bahsetmişlerdir. Örneğin, sayılar, işlemler, veri işleme, geometri ve ölçme gibi konular en çok örnek verdikleri alanlardır. Sürdürülebilirlik ile ilgili konulardan ise özellikle su tüketimi, geri dönüşüm, atıklar ve enerji tüketimi gibi konuların matematik öğretimiyle ilişkilendirilebileceğini ifade etmişlerdir.

Araştırma Sonuçları ve Öneriler: Bu çalışmada öğretmen adaylarının açıklamaları sürdürülebilirlik konularının matematik dersi ile nasıl ilişkilendirilebileceği ile ilgili yol göstermektedir. Öğrenciler sürdürülebilirlikle ilgili konuları keşfederken aynı zamanda matematikle ilgili veri toplama, verileri analiz etme, problem çözme gibi pek çok beceriyi kazanabilirler (Serow, 2015). Çalışma sırasında matematik öğretmen adayları verdikleri örneklerde matematikle ilgili pek çok öğrenme alanından bahsetmişlerdir. En çok örnek verdikleri matematik öğrenme alanları, sayılar, geometri, ölçme ve veri işlemedir. Benzer şekilde, Serow (2015) geometri, veri analizi ve sayılar gibi matematik öğrenme alanlarının sürdürülebilirlikle ilişkilendirilebileceğini ifade etmiştir. Serow (2015) aynı zamanda su tüketimi, enerji kullanımı, nüfus artışı, yemelenebilir enerji kaynakları, atıkların azaltılması, sürdürülebilir gıda üretimi, sera gazı etkisi gibi sürdürülebilirlikle ilgili çeşitli konulara yer vermiştir. Bu çalışmada ise matematik öğretmen adaylarının sürdürülebilirlikle ilgili verdikleri örnekler özellikle çevresel sürdürülebilirlik üzerine bulunmuştur. Sürdürülebilir gıda üretimi, iklim değişikliği, ekonomik gelişme, sosyal adalet gibi konularla ilgili yeteri kadar örnek sunulmamıştır. Çalışmaya katılan ortaokul matematik öğretmen adaylarının sürdürülebilirlikle matematik konularının ilişkilendirilebilmesine yönelik olumlu yaklaşılara sahip oldukları gözlemlenmiştir. Barwell (2018) sürdürülebilirlik konularının matematik eğitimiyle ilişkilendirilmesi üzerine yeteri kadar argüman üretmediğini, bu konuda daha fazla araştırma yapılması gerektiğini vurgulamaktadır. Buradan yola çıkarak bu çalışmada öğretmen adaylarının verdikleri örnekler sürdürülebilirlik kavramının matematik konularının öğretimiyle nasıl ilişkilendirileceği üzerine bazı öneriler sunmaktadır. Matematik konularını öğretirken sürdürülebilirliğin hem bağlam hem de amaç olarak kullanılabileceği algısı ortaya çıkmaktadır. İleriki çalışmalarda matematik öğretmenlerinin derslerinde sürdürülebilirlik konularıyla matematiği nasıl ilişkilendirdiği ile ilgili araştırmalar yapılabılır ve öğretmenler için somut örnekler sunulabilir. Matematik öğretmen adaylarına sürdürülebilirliğin sosyal, çevresel ve ekonomik boyutlarını da anlatarak daha bütüncül bir bakış açısı geliştirmeleri sağlanabilir. Lisans eğitimi sırasında matematik öğretmen adaylarına matematik öğretimi derslerinde sürdürülebilirlik konularını da ilişkilendirebilecekleri fırsatlar sunulabilir. Bu çalışmanın devamı olarak adayların matematik öğretmeni olduklarında kendi sınıflarında sürdürülebilirlik konularını matematik derslerinde nasıl ilişkilendirdikleri gözlemlenebilir ve öğretmenlerin konuya ilgili deneyimleri ve algıları üzerine görüşmeler yapılabilir.

Anahtar Kelimeler: Sürdürülebilirlik için eğitim, sürdürülebilirlik, matematik öğretimi, ortaokul matematik öğretmen adayları