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What do pre-service and mentor teachers learn from collaborative professional development on socioscientific issues?

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ABSTRACT The aim of this study is to investigate the outcomes of a professional development program on socioscientific issues (SSI) to enhance pre-service and mentor teachers' engagement with SSI supported by technology-supported teaching. It aims to explore the learning outcomes for both groups and the influence of their perspectives on science education on these outcomes. The method involves collaborative SSI material development and implementation in classrooms. The study involved 11 senior (10 female; 1 male) pre-service biology teachers and four biology teachers who mentored them in schools during their Teaching Practice courses. The data was collected through semi-structured interviews, reflective diaries, and meeting recordings and were analyzed using a thematic analysis approach. The findings show that pre-service teachers gained multidimensional reasoning, technology integration skills, and ethical and moral reasoning abilities, with gains influenced by their science teaching perspectives. Mentor teachers with progressive views in science teaching understanding had greater benefits, such as improved SSI understanding and student engagement techniques, than those with traditional views.

Keywords: *Mentor teachers, Pre-service teachers, Professional development, Science teaching understanding, Socioscientific issues*

Uygulama ve aday öğretmenler sosyobilimsel konularda işbirliğine dayalı mesleki gelişim programından neler öğreniyor?

ÖZ Bu çalışmanın amacı, öğretmen adaylarının ve uygulama öğretmenlerinin teknoloji destekli öğretimle desteklenen ve sosyobilimsel konular öğretimi ile ilgili anlayış ve pratiklerini artırmayı amaçlayan bir mesleki gelişim programının sonuçlarını araştırmaktır. Bu doğrultuda, her iki grup katılımcının mesleki gelişim programından elde ettiği kazanımları ve fen öğretimi anlayışlarının bu kazanımlar üzerine etkisini araştırmak amaçlanmaktadır. Katılımcılar, biyoloji öğretmenliği lisans programında öğrenim gören 11 (10 kadın; 1 erkek) son sınıf öğretmen adayı ve Öğretmenlik Uygulaması I-II derslerinde onlara okullarda mentorluk yapan 4 biyoloji öğretmenidir. Çalışmada yarı yapılandırılmış görüşmeler, yansıtıcı günlükler ve toplantı kayıtları yardımıyla toplanan veriler tematik analiz yaklaşımı ile analiz edilmiştir. Bulgular, öğretmen adaylarının çok boyutlu muhakeme, teknoloji entegrasyonu becerileri ile etik ve ahlaki muhakeme becerileri kazandıklarını ve bu kazanımların fen öğretimi perspektiflerinden etkilendiğini göstermektedir. Fen öğretimi anlayışı açısından ilerlemeci görüşe sahip uygulama öğretmenleri, katıldıkları mesleki gelişim programından geleneksel görüşlere sahip olanlara kıyasla, derin bir sosyobilimsel konular anlayışı ve öğrenci motivasyon teknikleri gibi daha fazla kazanım elde etmişlerdir.

Anahtar Sözcükler: *Aday öğretmenler, Fen eğitimine bakış açıları, Mesleki gelişim programı, Sosyobilimsel konular, Uygulama öğretmenleri*

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INTRODUCTION

Recently, there has been a significant focus on integrating scientific knowledge with social issues in science education to enhance scientific literacy (Chen & Xiao, 2021). Students should apply scientific knowledge and reasoning to make decisions that benefit the global community, while also participating in social debates and discussions on controversial issues, thus exercising their right to express their opinions (Zeidler et al., 2005). Therefore, students need to understand and appreciate socioscientific issues (SSIs) since these topics represent real-world problems at the intersection of science, society, and ethics, thereby contributing to scientific literacy.

SSIs are defined as multifaceted societal issues with no clear solutions are debatable, and are discussed continuously (Sadler, 2004). They have no clear solution; therefore, scientists or other members of society share their opinions and are willing to listen to the opinions of others and interpret them (Carson & Dawson, 2016). The COVID-19 pandemic, the latest global health problem represents an example of SSI with its controversial challenges and requires consideration of social, ethical, economic, and political aspects of science to solve emerging problems (Reiss, 2020). When people make judgments on such terrifying and abrupt health or environment-related issues, it is important to use scientific knowledge, procedures, and evidence, especially when the matter in question is scientific. Therefore, the pandemic has once again emphasized the importance of SSIs in science education.

SSIs aim to enhance students' critical thinking abilities, such as analyzing issues from diverse viewpoints, solving problems, applying informal logic, and making informed decisions (Sadler & Zeidler, 2004). In addition, these issues promote the growth of conscientious individuals who are knowledgeable about the issues that are happening in society and are capable of making the right moral decisions (Sadler et al., 2006). Among those individuals, teachers are in a critical position to introduce and integrate SSIs into science classes. To enhance the quality of teaching SSIs, teachers must have adequate knowledge of SSIs and skills in these issues (Tosunoğlu & İrez, 2019). Studies found that pre-service (Foulk et al., 2020) and in-service teachers (Kutluca, 2021) are challenged when it comes to the teaching of SSIs. This is mainly because they do not have the pedagogical knowledge to implement SSIs with proper teaching techniques, and are unable to motivate students to discuss these issues. Research has shown that many educators, particularly those still in training, feel unprepared to teach SSIs due to insufficient training in both content and pedagogy, leading to lower confidence in facilitating student discussions (e.g. Chen & Xiao, 2021; Kinskey & Zeidler, 2021).

Pre-service teachers acquire pedagogical knowledge and skills by observing mentor teachers’ classroom practices and through teaching practice courses (Anderson & Stillman, 2013). Mentor teachers are essential for guiding pre-service teachers in creating and delivering lesson plans, impacting their cognitive development. This interaction also enhances the professional growth of mentor teachers. Various professional development programs aim to enhance instructors' teaching methods and classroom strategies, focusing on their pedagogical skills, subject expertise, and adoption of innovative approaches.

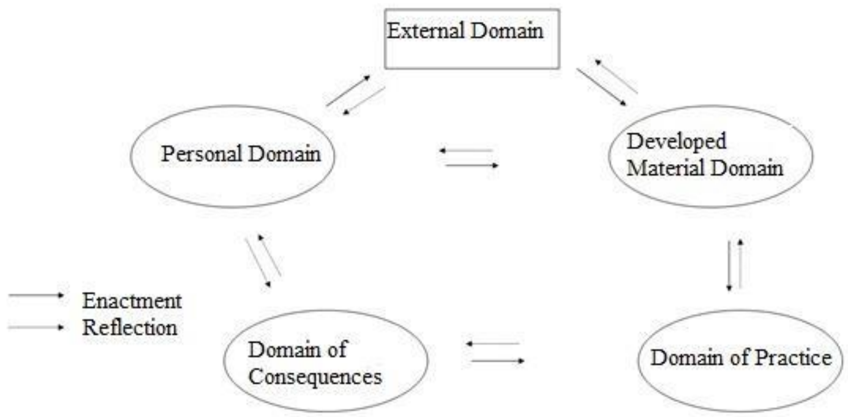
This study employed the “Extended Interconnected Model of Professional Growth (E-IMPG)” (Coenders & Terlouws, 2015). This model illustrates a multifaceted process involving the interaction of the Personal Domain, External Domain, Domain of Practice, and Domain of Consequences and Developed Material Domain. The model describes how a teacher’s personal domain including knowledge, attitude, and skills evolves through processes such as enactment and reflection in multiple domains (External Domain, Material Development Domain, Domain of Practice, and Domain of Consequences) (Coenders & Verhoef, 2019). In this study, the material domain which was planned to be technology-supported, was expected to enhance pre-service teachers’ collaboration with their mentor teachers and also among themselves. Within the E-IMPG model, pre-service teachers will collaborate with their mentor teachers in technology-supported environments as a part of teaching practice courses I and II to develop SSI materials and implement them in a classroom environment. The study anticipates that pre-service teachers collaborate with mentor teachers to develop lesson plans and materials that are pertinent to SSIs, and then implement these materials in the classroom. Additionally, mentor teachers are anticipated to investigate classroom practices and materials, as well as acquire additional knowledge regarding SSIs and technology-supported teaching experiences (Friedrichsen et al. 2021). Consequently, the collaborative efforts of both groups is expected to result in positive outcomes. The research questions are:

1. What are the outcomes of the PD for the mentor and pre-service teachers?
2. What is the relationship between the perspectives on science education of the mentor and pre-service teachers and their outcomes from the PD?
3. What are the outcomes of PD for the pre-service teachers during their collaboration with the mentor teachers?
4. What is the relationship between pre-service teachers' outcomes from their collaboration with mentor teachers and the mentor teachers' perspectives on science education?

THEORETICAL FRAMEWORK

PD is essential for enhancing teachers' understanding of the subject matter and their teaching methods (Eidin & Shwartz, 2023). The process of teacher education is long and growing in terms of teacher career development. Many models have been put forward to facilitate this process. Guskey (1986) proposed a framework linking professional development activities to enhance classroom practices, which subsequently influence teachers' knowledge and beliefs. Guskey (1986) was highly criticized by Clarke (1988) because his model of change was linear and did not identify the observed changes. As a result, Clarke (1988) modified Guskey's (1986) model and introduced a new PD model. Clarke's (1988) model encompasses identical components to Guskey's (1986) model. However, it differs from the model proposed by Guskey (1986) in that the change takes place in a continuous cyclical manner and allows for the possibility of adding or removing any component to the model.

Figure 1.
Extended Interconnected Model of Professional Growth Model (Coenders and Terlouw, 2015)



Clarke and Peter (1993) further developed the model developed by Clarke (1988) from Guskey's (1986) model and added two constructs to the model: analytic domains and mediation processes. Then, Clarke and Hollingsworth (2002) generated The "Interconnected Model of Professional Growth (IMPG)" based on the complex structure of teachers' professional activities and learning processes by considering the components explained by Guskey (1986) in his model as interactive with each other. Clarke and Hollingsworth (2002) identified four areas in which teachers experience change: the Personal Domain (where teachers' content knowledge, beliefs, and attitudes are embedded), the External Domain (all sources of information or support emerging from outside the teachers' daily professional world), the

Domain of Practice (all kinds of professional experimentation, including the enactment of learning material in class), and the Domain of Consequences (encompassing all salient outcomes of the experimentation domain). Coenders and Terlouw (2015) suggested incorporating a fifth domain, known as the Developed Material Domain, into Clarke and Hollingsworth's (2002) interconnected model of four domains. This domain includes the processes of designing instructional materials to be used in the classroom. This new model is referred to as the E-IMPG model (Figure 1). These domains can influence one another through mediation processes of reflection and enactment. Since this study focuses on developing and implementing SSI materials through the collaboration of mentors and pre-service teachers, the E-IMPG model, which incorporates the material development domain, was chosen over the IMPG model.

LITERATURE REVIEW

SSI-Based Instruction: Benefits and Challenges in Implementation

SSIs are multifaceted, which are contentious social, and societal issues connected to scientific phenomena and issues (Zeidler & Sadler, 2023). Understanding the nature of SSIs requires critical thinking skills to assess scientific claims and arguments considering ethical, moral, social, economic, and epistemological aspects (Kolstø et al., 2006). While reasoning about SSIs, one has to evaluate the implications and consequences that come with the issues, ask questions, and analyze the data, information, and sources that are being used (Dawson & Venville, 2010).

There are numerous advantages to incorporating SSIs into science classes, such as enhancing content knowledge, and argumentation skills, and fostering informal, ethical, and moral reasoning (Dawson & Venville, 2010;Khishfe & Lederman, 2006; Klosterman & Sadler, 2010). However, science teachers are still reluctant to teach these topics. There are several difficulties that teachers face when using SSIs in the classroom. Science teachers often avoid using SSI in their teaching due to factors such as inadequate knowledge, lack of time, and insufficient skills in applying teaching strategies (Aivelo & Uitto 2019).

As stated, several factors may prevent teachers from including SSIs in their teaching, these factors might be related to (i) the inconsistencies between SSI pedagogy and teachers' identities and beliefs (Kılınç et al., 2017); (ii) limited experience in using argumentation as a teaching method (Tidemand & Nielsen, 2017); and (iii) content-oriented curricula, insufficient support for teachers and school environment (Tidemand & Nielsen, 2017). Teachers' lack of confidence in teaching SSIs is also a significant factor. Teachers face challenges due to insufficient opportunities to enhance skills and understanding for teaching SSI. Moreover, Türkmen et al. (2017) identified inadequate understanding of SSIs as a challenge for pre-service teachers. Nevertheless, they had the required tools, skills, methods, and techniques, for instance, argumentation to address these concerns.

The lack of resources and tools that would facilitate teachers' attempts to integrate SSIs into lessons has been identified as the major factor that hinders the application of the SSI approach (Sadler et al., 2016). In particular, it is necessary to conduct studies that would provide teachers with the means of enhancing the pedagogical competencies required for SSI teaching.

PD Programs Related to SSIs: In-service teacher

PD models are beneficial for the enhancement of teaching skills. Hence, the most promising approach to help teachers in the application of SSIs and to prepare them for the enactment process is through PD programs that empower teachers to include SSIs in their teaching (Eidin & Shwartz, 2023; Zhang & Hsu, 2022).

Some studies are devoted to the identification of effective approaches and resources for teaching SSIs in literature (Badeo & Duque, 2022; Carson & Dawson, 2016; Friedrichsen et al., 2016). Various professional development programs for teachers have encouraged the integration of SSIs into their classrooms (Mang et al., 2023; Leung, 2022). In their study, Peel et al. (2018) developed a PD aimed at middle school science teachers who have different degrees of expertise and interest in in teaching science. During the activity, the participants were able to successfully create an SSI unit. In this PD, teachers participated as learners and engaged in various activities.

Eidin and Shwartz (2023) designed a 3-year PD program for 137 science teachers aiming at integrating SSIs into their teaching. The program was, refined annually, and proved to be effective in enhancing teachers' attitudes toward SSIs and argumentation. Likewise, Topçu et al. (2022) developed a PD program with three stages: firstly, the teachers themselves become the students of SSI; secondly, the analysis of the teaching model is conducted; thirdly, the development and realization of SSI lessons by teachers underlines the significance of PD in raising the SSI awareness and confidence of teachers.

PD Programs Related to SSIs: Pre-Service Teachers

Lumpe et al. (1998) found that pre-service teachers are more willing to use SSIs than in-service teachers because they have no experience. Research in the present context is quite limited but available research is noteworthy. Yapıcıoğlu and Aycan (2018) concluded that the nuclear power plant activities influenced the pre-service teachers' decisions as they developed views against nuclear power plants. The PD is designed to positively influence pre-service teachers' attitudes towards SSI teaching. In a similar vein, Kinskey and Zeidler (2021) showed, that PD programs can be useful in practical and teaching contexts, thus helping pre-service teachers overcome difficulties in creating SSI-based lessons.

The PD programs that deal with SSIs have benefits for teachers and depend on factors such as moral decisions, SSI knowledge, and beliefs about science education. Cebesoy and Chang Rundgren (2023) designed a Genetics and Biotechnology course and found that the pre-service teachers' decision-making was influenced by ethical and moral factors. Friedrichsen et al. (2021) analyzed secondary science teachers within an SSI PD program by applying the IMPG model, which revealed that teachers' beliefs influenced their learning and curriculum planning. Topçu et al. (2022) classified the teachers into three groups, enterprising, moderate, and hesitant, according to their adoption of SSI instructional methods due to their motivation and individual beliefs. As for the findings of Leung et al. (2020), the pre-service teachers at first understood SSIs as a means for transmitting content, but after the PD they had developed an awareness that the goals of education were broader. These studies suggest that the teachers' views and beliefs should not be ignored in the PD programs for successful SSI practice.

Overall, the collaborative relationship between in-service teachers and pre-service teachers plays an important role in shaping the PD of both parts. However, despite its importance, this collaboration is often hindered by several challenges. The challenges that arise in their interactions include mentor availability, knowledge gaps, and institutional support. A lack of commitment from mentors can lead to insufficient guidance, leaving pre-service teachers feeling unsupported (Dorsah et al., 2023). Mentor teachers may face difficulties balancing their teaching responsibilities with the additional role of mentoring, while pre-service teachers may struggle with navigating the feedback they receive and understanding their role within the classroom (Dorsah et al., 2023; Hoben, 2021). These interactions are further complicated by institutional constraints, such as limited resources or time for effective mentoring (Baartman, 2020). Effective collaboration requires both groups to navigate a variety of issues, such as role ambiguity, communication barriers, and differing expectations. Addressing these challenges is crucial for fostering a productive mentor-pre-service teacher relationship, as doing so can lead to more meaningful PD outcomes. By enhancing collaboration and aligning perspectives on science education, both groups can experience improved growth and development in their professional practice.

METHODOLOGY

Participants

The participants included 11 senior biology pre-service teachers (10 female and 1 male) at a public university in Istanbul, Türkiye. Additionally, four in-service biology teachers who mentored these pre-service teachers during the Teaching Practice I-II courses were also part of the study. For all participants, pseudonyms like PT1 and MT1 were used.

The pre-service teachers were randomly with mentor teachers in their practicum school. Each mentor was responsible for two or three pre-service teachers during teaching practice. Table 1 shows the groups established by the participant teachers. Both pre-service and in-service teachers have no prior experience with SSI teaching.

Table 1.
Pre-service and Mentor Teachers' Groups

Mentor teachers	Pre-service teachers
MT1	PT6
	PT7
MT2	PT2
	PT10
	PT11
MT3	PT3
	PT8
	PT9
MT4	PT1
	PT4
	PT5

Procedure

The procedure consisted of the "development" and "implementation" of the PD program for teaching SSI and SSI classroom implementation.

PD Program for SSI Teaching

The PD program for teaching SSI in this study was designed using Coenders and Terlouw's (2015) E-IMPG model as the theoretical framework to capture the complexity of teacher learning. E-IMPG views teachers as active learners, with professional development shaped by interactions across four domains: Personal (teacher's knowledge, skills, beliefs), External (new information or stimuli, such as the SSI PD), Practice (classroom experimentation with new practices), and Consequences (perceptions of outcomes from new approaches). The developed material domain represents the process and product of SSI material development.

There were two phases of the PD program which (1) encompassed the theoretical aspects, and (2) involved collaborative material development. The first phase focused on the theoretical aspect since the participants had no prior knowledge of SSI. The process included the implementation of SSI in classroom practices, emphasizing the significance of SSI education, and providing an opportunity for experiencing SSI classroom activities. Phase 1 was carried out during the last three weeks of Teaching Practice I and the first three weeks of Teaching Practices II for preservice teachers. Mentor teachers attended the theoretical phase online.

In the second phase, the pre-service teachers were required to collaboratively produce teaching materials for SSI. During this stage, pre-service teachers were organized into small groups of 3-4 individuals, based on the groups they were already a part of in the school. They were tasked with creating lessons and educational materials focused on the biology curriculum, incorporating technology. This process took approximately 6-8 hours. During the second phase, pre-service teachers collaborated with their mentor teachers, while the researchers offered guidance and assistance with lesson designs and instructional materials.

SSI Implementation in the Classroom

During the SSI teaching, pre-service teachers implemented the modules they had developed. Their mentor teachers and researchers observed the implementation process. Each pre-service teacher completed the process within 3-4 weeks. The classroom implementation for all pre-service teachers was carried out between March 2023 and June 2023.

After the SSI implementation, pre-service and mentor teachers held weekly feedback meetings online or face-to-face. During these meetings, mentor teachers provided feedback on pre-service teachers' instruction and discussed organizing upcoming lessons. The provided feedback should align with the nature of SSI teaching and be related to lesson flow, learning outcomes, methods and techniques, class and time management, and content improvement.

The study involved eleven pre-service teachers (PTs) implementing SSI (socio-scientific issues) topics across various class levels and subjects.

PT1: Taught Antibiotics (11.1. Human Physiology) to 11th-grade students. Classroom management was challenging, with some students losing interest. Technological problems occurred with Google Forms.

PT2: Covered Would you want to design your own baby in the future? (10.2. Heredity and Biological Diversity) with 10th-grade students. Demonstrated effective classroom management and maintained student interest. No technological issues were reported.

PT3: Addressed Vaccination (9.3. Living Things) with 9th-grade students. Initially struggled with classroom management but improved by engaging students through questions.

PT4: Implemented Antibiotics (11.1. Human Physiology) with 11th-grade students. Managed the classroom effectively and engaged students through questions. The technological infrastructure was stable.

PT5: Conducted Vaccination (9.3. Living Things) with 9th-grade students. Utilized frequent questioning for engagement and managed the class well. No technological problems were observed.

PT6: Taught Should a factory be built in your local area? (10.3. Ecosystem Ecology and Current Environmental Issues) to 10th-grade students. Demonstrated strong classroom management and engaged all students.

PT7: Addressed Should a factory be built in your local area? (10.3. Ecosystem Ecology and Current Environmental Issues) with 10th-grade students. Exhibited excellent classroom management and frequent questioning. The classroom experienced intermittent internet issues.

PT8: Taught Vaccination (9.3. Living Things) to 9th-grade students. Showed strong subject knowledge and effective classroom management, but faced occasional internet issues.

PT9: Covered Organic Agriculture (11.2. Community and Population Ecology) with 11th-grade students. Faced challenges with student participation and frequent mentor teacher interventions. The technological infrastructure functioned well.

PT10: Implemented Would you want to design your own baby in the future? (10.2. Heredity and Biological Diversity) with 10th-grade students. Managed the classroom effectively and addressed technological issues promptly.

PT11: Addressed The use of animals in experiments (9.3. Living Things) with 9th-grade students. Demonstrated strong subject knowledge, though some students did not participate. Technological infrastructure was functional.

The study included PTs across different subjects and grade levels, with a focus on SSI topics integrated into the curriculum. The technological infrastructure generally supported the lessons, though occasional issues were noted. This detailed description of the teaching context and technological support provides insight into the sample's representativeness and the specific conditions under which SSI topics were taught.

Data Collection

Interviews, pre-service teachers' reflective diaries, and feedback meeting records were utilized to collect data in the study. These tools were developed considing the E-IMPG Model (Clarke & Hollingsworth, 2002; Coenders & Terlouw 2015). The interviews were the primary data collection method in the study, while additional methods were used to ensure data triangulation. Ethics committee permission for the research was obtained from Marmara University (Institute of Educational Sciences, 06.12.2022 - 425028). Table 2 illustrates the research questions and data collection instruments.

Table 2.
Research Questions and Data Collection Instruments

Research questions	Data collection tools
"What are the outcomes of the PD for the mentor and pre-service teachers?"	Interview II (After PD) and Interview III (After Implementation)
"What is the relationship between the science teaching understanding of the mentor and pre-service teachers and their outcomes from the PD?"	Interview I (before PD), Interview II (After PD), and Interview III (After implementation
"What are the outcomes of PD for the pre-service teachers during their collaboration with the mentor teachers?"	Reflective Diaries and feedback meeting records
"What is the relationship between pre-service teachers' outcomes from their collaboration with mentor teachers and the mentor teachers' perspectives on science education?"	Interview I (before PD), Reflective Diaries, and feedback meeting records

Interviews

Interviews were used to explore what participants learned from the PD program and the relationship between their outcomes and their perspectives on science education. Three different interviews were conducted. The first interview was conducted before PD, the second was utilized after PD, and the third was administered after classroom implementation. These interviews were adapted from Friedrichsen et al. (2021). Since Friedrichsen et al. (2021) utilized the IMPG model, questions exploring participants' developed material domain were not included in their study. In preparing questions related to the Developed Material Domain, Coenders and Terlouw's (2015) study was considered. Following the preparation of the interview questions, ultimate improvements were made based on expert opinions, and the questions were then included in the form. The interviews were conducted individually and online.

First Interview (Before PD) The first interview was utilized to assess pre-service and mentor teachers' perspectives on science education and SSI before PD implementation. The interview questions focused on the personal domain of E-IMPG.

Second Interview (After PD) The second interview was conducted with pre-service teachers after PD implementation to explore changes in their perspectives on science education and SSI as well as the outcomes from the PD (theoretical and collaborative material development). Furthermore, the questions in the second interview assessed the developed material domain, the "external domain", and the "personal domain" of E-IMPG.

Third Interview (After classroom implementation) The third interview was administered to pre-service and mentor teachers to track changes in their perspectives on science education and SSI after the classroom implementation. Additionally, the interview aimed to determine what they learned from the classroom implementation. Table 3 shows exemplary questions in the interviews.

Table 3.
Exemplary Questions in the Interviews

Interviews	Questions
First Interview (Before PD)	*How do you think students learn best?* *How would you describe effective learning environment?* *What do you think is the purpose of science education?* *Why is science education important for a citizen/society?* *How would you describe your role as a teacher in the classroom?*
Second Interview (After PD)	*Which aspects of your goals and beliefs about teaching and learning are compatible with the SSI teaching approach?* *When you evaluate the PD content and activities, do you think they contribute to your future teaching profession? In which areas do you think these contributions are?* *Did the PD content and activities lead to any changes in your perspective on teaching or in planning your classroom practices? If yes, how?*
Third Interview (After classroom implementation)	*Do you think you have learned anything new about SSI and science education during classroom implementation?* *What do you think about SSI material development and understanding of science teaching (compared to your ideas before PD) after SSI classroom implementation?* *After SSI classroom implementation, what do you think about the culminating part of SSI teaching, and how would you engage students in the social aspect of issues?*

Reflective Diaries

The weekly reflective diaries were used to study PTs' experiences with collaborative material development. PTs' were asked to express the challenges and benefits of the collaborative design process and how they designed their modules. Also, they utilized G-Drive to record their diaries.

Feedback Meeting Records

The SSI modules were developed collaboratively by pre-service and mentor teachers. During the process, they had weekly meetings to discuss the modules and give feedback to each other. The meetings were recorded to observe their interactions and contributions to the module design

Data Analysis

In the current study, qualitative research design was utilized to explore what participants learned from PD and the relationship between their outcomes and perspectives on science education. Data analysis was conducted using theme analysis. Table 4 displays the steps involved in the data analysis.

Table 4.
The Stages of Data Analysis

	Stage	Approach
Organization of data	Categorization of data based on the E-IMPG Model	Deductive Inductive
Open coding	Making sense of data using open coding	Inductive
Categorization of themes	Identification of the relationship between codes and themes	Inductive

Firstly, the interviews and feedback meeting records were transcribed. Semi-structured interviews, reflective diaries, and feedback meeting records were analyzed using inductive and deductive analysis techniques.

Using a deductive approach, the data were categorized based on the five domains of the E-IMPG model. For example, the responses to the personal domain questions in the E-IMPG model were examined to explore pre-service and mentor teachers' perspectives on science education and SSI. Furthermore, to identify pre-service and mentor teachers' outcomes of the PD, we focused on the questions related to the external domain in the interviews, the reflective diaries, and the feedback meeting records.

The inductive approach involved identifying themes from the data obtained and, thus, new ideas and trends can emerge from the study instead of using predetermined themes (Marshall & Rossman, 1995). In this study, we used the inductive approach to identify pre-service and mentor teachers' outcomes from PD. Codes were generated through open coding (Glaser, 1978) and categories were derived from the data by identifying their similarities and differences (Charmaz, 2006).

Credibility and transferability criteria were used to ensure the trustworthiness of the study (Lincoln & Guba, 1985). Data triangulation and researcher triangulation ensured credibility criteria. Detailed information regarding the research context was provided to resolve transferability. In order to determine inter-coder reliability, two researchers evaluated the data from all participants separately and reached a consensus rate of 80%. Then, the researchers engaged in a discussion until they reached a consensus on all classifications and categories.

FINDINGS

Mentor Teachers' Perspectives on Science Education and Outcomes of PD and Classroom Implementation

To understand the participants' perspectives on science education, the first interview was administered. The first interview was conducted with the participants before they were introduced to any theoretical knowledge. To ascertain the outcomes that participants obtained from working together, the third interview conducted after the implementation of classroom practices. Table 5 shows the outcomes that mentor teachers gained through their interaction with pre-service teachers and their perspectives on science education.

When considering the overall outcomes of all mentor teachers, it was observed that what they learned after the PD and classroom implementation is closely related to their perspectives on science education. Table 6 shows that MT3 and MT4 had a traditional perspective on science education, MT2 leaned towards experiential learning, and MT1 held a progressive perspective. Upon reviewing the outcomes of the mentor teachers, it became evident that MT1, who holds a progressive perspective on science education, demonstrated an increased interest in SSI practices. MT1 shared plans for implementing the SSI approach in his/her future classes, stating, "I don't know which classes I will teach at different levels, but I plan to do at least 2-3 such implementations in each class at least in one semester. I plan to include both experiments and these SSI issues" (3rd interview). In this context, it was observed that s/he more easily integrated SSI practices in line with the perspective compatible with the nature of SSI.

Table 5.
Mentor Teachers' Perspectives on Science Education and Outcomes from Collaboration with Pre-service Teachers

Mentors	Perspectives on Science Education	Outcomes	Quotes for outcome coding
MT1	Emphasize that communication between the teacher and the student is an important factor that determines the success of learning, states that the aim of science education is to improve scientific literacy, critical reasoning, and problem-solving abilities, and defines the role of the teacher as a provider of information and a leader for students.	Interest in SSI teaching	*"I don't know which classes I will teach at different levels, but I plan to do at least 2-3 such implementations (SSI imp.) in each class at least in one semester. I plan to include both experiments and these SSI issues." (3rd interview)*
MT2	Defines an ideal environment for learning as one where students learn by doing, defines the goal of science teaching as the ability to comprehend nature, and defines the teacher's role as the provider of knowledge.	Interest in SSI materials	*"I have never seen such a lecture, we focus more on content knowledge. But I will try to integrate these (SSI) topics into my courses as much as possible" (3rd interview)*
MT3	Describes an effective learning environment as one that incorporates technology and teaching materials, views the goals of science education as problem-solving, and acknowledges the teacher as the provider of knowledge.	Having information about SSI Interest in SSI materials Having information about technology integration Relating biology to everyday life	*"Let me put it this way, I wish we had more class hours so that we could teach all our lessons in this way (SSI teaching)" (3rd interview)* *"It is more effective when the lesson is planned with technology integrated SSI materials with the student participation and relating the content with their daily lives, but as I said, the curriculum is very intense and the lesson time is very limited." (3rd interview)*
MT4	Characterizes an effective learning environment as one where the question-and-answer technique is employed, believes that science education should include its applicability to everyday life and problem-solving, and describes his/her function in the classroom as that of a provider of information.	Having information about SSI Having information about technology integration	*"For example, I didn't know that there are such computer games (referring to SSI-based games), but I learned about them." (3rd interview)* *"...I didn't know about digital platforms and stuff like that, I saw it with the SSI training." (3rd interview)*

MT2, on the other hand, reported plans to incorporate experimental practices from SSI modules into his/her lessons, aligning them with an experiential learning perspective. This suggests that MT2 evaluates SSI practices through the lens of their existing educational approach, focusing more on experiments and activities rather than fully embracing the broader nature of SSI. As MT2 remarked, "I have never seen such a lecture; we focus more on content knowledge. But I will try to integrate these topics into my courses as much as possible" (3rd interview). MT3 and MT4, who had a more traditional perspective on science education, mentioned that they acquired information about new technologies (WEB 2.0 tools) used in the classroom and gained an understanding of SSI during SSI classroom implementation. In this context, it was observed that mentor teachers with a perspective on science education that is not aligned with the nature of SSI tend to focus on the by-products of SSI implementations rather than fully grasping the holistic nature of SSI.

When examining the outcomes achieved by mentor teachers (e.g., having information about SSI, interest in SSI materials, having information about technology integration, and relating biology to everyday life), it is evident that their focus was primarily on the external domain of the E-IMPG model.

Pre-Service Teachers' Perspectives on Science Education and Outcomes of PD and Classroom Implementation

To reveal the participants' perspectives on science education, the first interview (before PD) was conducted with the teachers before the theoretical training. The outcomes obtained from the PD and classroom implementation were revealed through the second interview (After PD) and the third interview after classroom interventions. Table 6 presents the outcomes and PTs' perspectives on science education.

In general, it can be noted that the PTs' perspectives on science education are quite similar as they have similar educational experiences. Most pre-service teachers stated that science teaching aims to apply scientific knowledge to daily life. Only PT10 and PT11 focused on the consequences of decisions made in the daily life of society. At this point, PT10 and PT11 understand that SSI encompasses not only personal but also social implications. The majority of the pre-service teachers have described the role of the teacher in the classroom as that of a facilitator. PT6 has also highlighted the role of teachers in connecting knowledge with real life. While others have not specified the functions of teachers in the classroom, PT2 identified the role of teaching morality. PT2 showed awareness of moral reasoning, which is beneficial for the development of student's character and is a significant element of SSI.

The pre-service teachers' outcomes are primarily concentrated on the cultivation of multidimensional thinking, the integration of technology, and argumentation abilities. The majority of the pre-service teachers focused on the aspect of multidimensionality in their learning progress. They have realized that SSI is not unidimensional but has psychological, economic, and social components. Most pre-service teachers also pointed to technology integration as an important area for teaching science and SSI. The study involved pre-service teachers who were introduced to WEB 2.0 tools. The emphasis on technology use in their achievements indicates that the training was positively received. Specifically, two of the pre-service teachers emphasized argumentation in their outcomes. Ethical and moral concepts were not emphasized by any participants except for PT7, who demonstrated a deeper understanding of the SSI approach. Ethical and moral reasoning is a promising component of SSI, and PT7 highlighted its importance by stating, "The questions we pose to students should not be mere superficial questions but should instead be thought-provoking from ethical or various other perspectives" (2nd interview). PT7 further noted that "argumentation and other approaches we use in SSIs support scientific literacy. Additionally, these topics align with ethical and moral values" (2nd interview).

The outcomes achieved by pre-service teachers are distributed across the personal (multidimensional thinking, ethical and moral reasoning), external (interest in SSI topics, technology integration), and practice (argumentation) domains of the E-IMPG model.

Table 6.

Pre-Service Teachers' Perspectives on Science Education and Outcomes from PD

Pre-service Teachers	Perspectives on Science Education	Outcomes	Quotes for Outcome Coding
PT1	Believes that an effective learning environment involves student participation, sees the aim of science education as the development of conscious citizens and awareness, and identifies the teacher's role as a guide.	Multidimensional thinking	*"Students need to be able to make this judgment within themselves. In other words, I think it would be more logical for them to think that there are different factors in health-related SSIs and make a decision in this way when there is a debate about vaccination in the future." (3rd Interview)*
PT2	Defines an effective learning environment as student-centered defines the goal of science education as the ability of students to communicate their ideas and comprehend nature, and asserts that the teacher should teach moral lessons.	Multidimensional thinking	*"I also learned that I can look at many different aspects of a topic while explaining it" (2nd Interview)*
PT3	Describes an ideal learning environment as one where students actively participate explains the goal of science education as making a connection between science and the real world and describes the role of the teacher in the classroom as a guide.	Technology integration	*"Students understand better with active participation. They can keep up with the new developing technology which is very important" (2nd Interview)*
PT4	Stresses the significance of the student-teacher relationship in developing an ideal learning environment, identifies the goal of science education as the development of conscious citizens and scientific literacy, and envisions the teacher as a guide.	Argumentation	*"Argumentation has truly been a turning point for me. I believe I will implement its principles in my courses (3rd interview)*
PT5	A successful learning environment engages students' attention and offers them an opportunity to express their thoughts, views the role of science education as a process of creating scientifically informed citizens and increasing their scientific literacy, and describes the teacher as a guide.	Multidimensional thinking	*When students connected the content to everyday life and approached various dimensions of SSIs from different perspectives, they began to think and question in new ways during the class" (3rd interview)*
PT6	Describes an ideal learning environment as student-centered, where students share their opinions, focuses on the goal of science education as nurturing scientifically literate citizens, and describes the teacher in the classroom as one who links science to everyday life.	Technology integration Multidimensional thinking	*"I had already learned most of the topics in educational technologies. However, I hadn't considered using them in my classes. This has been very useful in terms of planning, and we now have materials, both for my colleagues and myself." (2nd interview)* *"The students touched upon many dimensions of SSIs from the very first lessons." (3rd interview)*
PT7	Describes an ideal classroom environment that encourages student expression of opinions utilizes resources and technology effectively, aims to cultivate scientifically informed citizens through science education, and views the teacher as a facilitator.	Ethical and moral reasoning Technology integration Multidimensional thinking Argumentation Interest in SSI topics	*"The questions we pose to students should not be mere superficial questions but should instead be thought-provoking from ethical or various other perspectives." (2nd interview)* *"We use argumentation and other approaches (e.g. technology integrated) in SSIs to support scientific literacy.*

Table 6. (Continued)
Pre-Service Teachers' Perspectives on Science Education and Outcomes from PD

Pre-service Teachers	Perspectives on Science Education	Outcomes	Quotes for Outcome Coding
(…)PT7	(…)	(…)	*Additionally, these topics align with ethical and moral values" (2nd interview)* *"In the courses I am currently designing, I will be integrating socio-scientific topics, incorporating those that are appropriate to the content, and evaluating this integration throughout the process" (2nd interview)*
PT8	Defines an effective learning environment as one that incorporates the use of learning materials, describes science education as motivating students and helping them understand the practical applications of science in their daily lives, with the teacher's role being that of a facilitator.	Multidimensional thinking	*"I tried to address all the dimensions. Our topic was vaccines, and I covered various aspects, including psychological, economic, and tourism-related ones, along with any examples that could come to mind in our country." (3rd interview)*
PT9	Describes an ideal learning environment as one that incorporates the use of materials and questioning and answering interactions, defines the aim of science education as making students aware of science and linking it with everyday activities, and defines the role of the teacher in the classroom as that of a facilitator.	Multidimensional thinking	*"In the lessons, instead of just learning the content theoretically, we can see how we can use it in our lives and where we can encounter it." (2nd interview)*
PT10	An ideal learning environment is described as one where students can express their ideas democratically. Believes that science education enhances students' understanding of nature and how science is relevant in daily life and society, and maintain that the teacher is a facilitator.	Technology integration Argumentation	(Regarding how the goals and beliefs related to teaching and learning align with the SSI approach) *"For example, technology integration, questioning, or argumentation." (2nd interview)*
PT11	Defines an effective learning environment as one that allows students to express their ideas democratically, sees the aim of science education as making science relevant to daily life and society, as well as fostering scientifically informed citizens, and identifies the teacher's role as a facilitator.	Multidimensional Thinking Interest in SSI topics	*"More dimensions emerged than I had even found through research, and all of them were addressed in the classroom." (3rd interview)* *"This process made it clear that I need to do much more reading and research to identify SSI topics and encouraged me to follow current events and ecology much more closely." (2nd interview)*

Mentor Teachers' Perspectives on Science Education and Pre-service Teachers' Outcomes of Collaboration

To ascertain the participants' science teaching understandings, the first interview (before PD) was conducted. Additionally, to establish the benefits of mentor teachers for pre-service teachers, data was collected through the second interview (after PD), feedback meeting records, and reflective diaries of pre-service teachers in developing SSI materials. Table 7 presents the outcomes of pre-service teachers working with mentor teachers and participants' perspectives on science education.

Table 7.
Pre-service Teachers' Outcomes from Collaboration with Mentor Teachers and Participants' Perspectives on Science Education

Mentor Teachers	Mentor Teachers' Perspectives on Science Education	Pre-service Teachers	Pre-service Teachers' Perspectives on Science Education	Pre-service Teachers' Outcomes (During Collaboration with Their Mentors)
MT1	Underscores the importance of teacher-student interaction in an effective learning environment. Defines the objective of science education is to foster the development of problem-solving and critical thinking abilities, and scientific literacy, and describes their functions in the classroom as knowledge providers and facilitators.	PT6	Describes an effective learning environment as student-centered in which students articulate their ideas, aims to produce scientifically literate citizens through science education, and defines the teacher's responsibility as linking science to life.	To relate SSI materials to daily life Question-answer Time management Classroom management
		PT7	Describes an ideal classroom setting where students can share their thoughts, together with the use of materials and technology, and considers the aim of science education as producing scientifically informed citizens and explaining the function of the teacher as a facilitator.	
MT2	Defines an effective learning environment as one where students learn by doing, describes science education as one of understanding nature, and sees the teacher in the classroom as one who transfers knowledge.	PT2	Emphasizes the learner-centered approach, underlining that science education aims to give students a voice and help them make sense of the world, and suggests that the teacher is there to teach students right from wrong.	Content knowledge Time management Classroom management Question-answer Student readiness
		PT10	Describes a successful classroom environment for presenting and discussing ideas and defines the goals of science education as learning about nature and applying science to real-life and societal problems. States that the teacher is the leader in the classroom.	
		PT11	Describes an effective classroom environment where students share their ideas, and science education connects science to daily and societal life and fosters scientifically literate citizens. Also describes the teacher as a facilitator in the classroom.	
MT3	Outlines a good learning context that involves educational technology and instructional materials, perceives the aim of science education as problem-solving, and views teachers as sources of knowledge.	PT3	Define an effective learning environment as one in which students are actively involved and engaged. Science education in school aims to make science meaningful and applicable to students' everyday lives. The teacher's function in this setting is that of a facilitator, guiding and supporting students in their learning process.	Content knowledge Facilitating student engagement Assessment (related to content knowledge)

Table 7. (Continued)
Pre-service Teachers' Outcomes from Collaboration with Mentor Teachers and Participants' Perspectives on Science Education

Mentor Teachers	Mentor Teachers' Perspectives on Science Education	Pre-service Teachers	Pre-service Teachers' Perspectives on Science Education	Pre-service Teachers' Outcomes (During Collaboration with Their Mentors)
(…) MT3	(…)	PT8	Describes learning as taking place place through the use of learning materials and question-answer interaction, stating that science education in school means to have students apply science to their everyday lives, and sees the teacher as a facilitator in the classroom.	(…)
		PT9	An effective learning environment is described as one where there is the use of material and questioning, with the goal of science education being to enhance students' understanding and make connections between science and their everyday lives. The teacher in the classroom is seen as a facilitator.	
MT4	Describes an ideal classroom where the question-answer method is used, believes that the purpose of science education is for everyday life and problem-solving, and views themselves as instructors who convey information.	PT1	Defines an effective learning environment as one that engages the students and sees the role of science education as producing informed citizens and raising awareness. The role of the teacher is described as facilitator.	Content knowledge Time management Classroom management Question-answer Student readiness
		PT4	Depicts a good learning environment by emphasizing the importance of student-teacher interaction, explaining that science education aims to produce responsible citizens and promote scientific literacy, and describing the teacher as a facilitator.	
		PT5	Describes an ideal learning environment as one where students are active and feel free to share their thoughts, for science education as a means of producing scientifically informed citizens, and for the teacher as a facilitator.	

The following outcomes for pre-service teachers were derived from their collaboration process with mentor teachers: relating SSI materials to daily life, conducting question-answer activities, time management, classroom management, content knowledge, planning lessons according to the student's readiness, and involving the students in the lesson. It was observed that the mentor teachers' perspectives on science education had a direct influence on the progress made by the pre-service teachers. For instance, MT1 provided feedback to PT6 and PT7 during the material development process, suggesting that they enhanced the SSI topics that would capture students' interest and offer alternative SSI examples. MT1 emphasized the importance of using examples from the students' local environment, particularly in the experimental design process. Additionally, MT1 provided feedback indicating that using a question-and-answer approach would further enrich SSI discussions.

> *"In the video, the highlighted point was that humans are the cause of environmental problems, but our instructor (MT1) mentioned that we should also include non-human factors like volcanic eruptions and other natural events by asking students questions." (PT6, Diaries)*

> *"They also noted that the concept of the water footprint is currently popular and emphasized that we should highlight this in the main activity as well." (PT7, Diaries)*

Quotes from feedback meeting:

> *PT6: "We want to design an experiment on water pollution, but our experiment is not fully developed yet. If you were to demonstrate something like this, how would you design an experiment on the characteristics of water pollution and its effects on living organisms? Could you help us with this?"*

> *MT1: "Since there are many factors affecting pollution, for example, you could focus solely on the air-related dimension and do a lot with that. For instance, at the very least, you could take a glass of water—say, regular drinking water—and place it by the window for a week. This is a classic experiment, perhaps you've done it before. Even though the Bosporus is a place with strong currents, it's also one of the dirtiest parts of the sea. There are many tour boats, ships, and ferries passing through as well. So, you could conduct a study related to that in such a polluted area as I mentioned."*

On the other hand, MT2 primarily provided feedback to PT2, PT10, and PT11 focused on improving the content knowledge of their material.

> *"Even though we dedicated the second lesson plan entirely to theory, the instructor found it insufficient. He/she mentioned that we needed to explain several points in more detail and emphasized certain key aspects of the topic." (PT10, Diaries)*

> *"Following their suggestion to utilize resources like videos and animations, we decided to include a short video explaining DNA replication." (PT2, Diaries)*

> *"In addition to everything else, the instructor mentioned that while we focused on DNA replication, we should emphasize that it's not just replication but also essential for the continuity and order of life. They also pointed out that we frequently discussed incorrect replication or changes in gene sequences, but asked us to include information about the importance of the cell division cycle functioning smoothly." (PT2, Diaries)*

Quotes from feedback meeting;

> *MT2: "In this case, what we ultimately want to explain is which mechanism in the DNA we're focusing on. We want to explain its double-helix structure and the replication mechanism."*

> *MT2: "During the explanation of the topic, I believe it's essential to use either an animation or a drawing on the board. Otherwise, this theory will feel very abstract. So, I strongly recommend illustrating it to provide a more detailed explanation."*

As for the outcomes of pre-service teachers, MT1's perspective on science teaching was more progressive than the others, which is to cultivate scientifically literate and critical thinking students, and the contribution is in SSI and understanding the nature of SSI by connecting SSI materials to daily life. Furthermore, MT1 discussed the issue of engaging students in lessons, which the other teachers did not discussed. Another factor that can be attributed to MT1's SSI-oriented outcomes is that the pre-service teachers in their group held views on science teaching and learning that were consistent with SSI. For example, PT6 described the teacher's role in the classroom as that of linking science to life, which is different from other pre-service teachers. Also, PT7 focused on the ethical and moral aspects of their gains. Since ethical and moral reasoning is an important aspect of SSI, it can be said that PT7 fully embraced the SSI model.

The only exception was MT1 while MT2, MT3, and MT4 had more traditional perceptions on science education. The pre-service teachers' outcomes were in content knowledge, time management, classroom management, question-answer techniques, student readiness, and student assessment. These outcomes are not directly related to the characteristics of SSI.

DISCUSSION AND CONCLUSION

In this study, within the framework of E-IMPG, pre-service teachers and mentor teachers were given training in the theoretical phase of the PD program and worked with pre-service teachers in the material development phase to design SSI modules enhanced by technology. The purpose of the study was to understand what pre-service and mentor teachers learned in this context and how they related it to their perspectives on science education. During the PD program, pre-service teachers collaborated with mentor teachers to design lesson plans and materials on SSI. The pre-service teachers then taught the lessons they developed while the mentor teachers observed the lessons, gaining insights into SSI and technology integration.

Upon analyzing the findings of the study, it can be concluded that the pre-service and mentor teachers benefited in some ways from the PD program. The outcomes for pre-service teachers are usually defined by the use of multidimensional thinking, technology integration, and argumentation. However, some pre-service teachers, besides these outcomes, have shown higher-order gain in terms of characteristics of SSI such as ethical and moral decision-making and interest in SSI topics. The study shows that the achievements of pre-service teachers are influenced by their perspectives on science education. The pre-service teachers who had perspectives closer to the nature of SSI included additional outcomes like ethical and moral concepts in their gains, however, the pre-service teachers who had more traditional perspectives on science education targeted simpler outcomes like identifying characteristics of SSI. Similarly, Foulk et al. (2020) found that pre-service teachers stated their intention to integrate SSI into their instruction.

After examining the results of the mentor teachers, it becomes evident that they aligned with the findings of the pre-service teachers. Out of the four MTs involved in the study, one had a progressive perspective on science education, one had an experimental view of learning, and the other two had a traditional perspective on science education. The results reveal that the outcomes of science education with a progressive perspective among mentor teachers are not similar to those of other approaches. MT1, who had a progressive perspective on science education, showed more interest in SSI practices and mentioned that they would also use the SSI approach in their classes. On the other hand, MT2, who had an experiential perspective, stated that they would apply the experimental practices contained in the SSI modules to their classes. MT 3 and 4, who held a traditional perspective on science education, mentioned that they had learned about new technologies used in the classroom during SSI practices (WEB 2. 0 tools) and an understanding of what SSI is. Thus, it can be seen that the views of mentor teachers who do not align with the nature of SSI in science teaching are limited in terms of the outcomes of SSI practices and their perspectives on science education. Also, they lack an understanding of all the dimensions of SSI. The results of this study are supported by the findings of Topçu et al. (2022). They found that teachers' perspectives on science education shaped how they perceived the outcomes of the PD, even though all the teachers received the same training.

During the PD, pre-service teachers and mentor teachers co-designed an SSI module after the theoretical training. In the design process, pre-service teachers met with their mentor teachers and received feedback from them. Therefore, it was deduced that the pre-service teachers' perspectives on science education influenced their progress in the collaborative design process of the SSI module with the mentor teachers. The outcomes of pre-service teachers are as follows: using SSI materials in their classroom, engaging in question-answer activities, managing time and classroom, improving content knowledge, planning lessons based on students' readiness, and engaging students in the lesson (Huang

& He, 2023). MT1, who has a more progressive understanding of science teaching, offered feedback to the pre-service teachers that is consistent with the nature of SSI, noting that SSI materials should be connected to topics that can be talked about in students' everyday lives. The other mentor teachers, except MT1, had more traditional perspectives on science education and thus provided more general instructional feedback than MT1. Therefore, it was deduced that the mentor teachers' perspectives on science education affect the gains of pre-service teachers.

The factors influencing the outcomes of pre-service teachers included not only the perspectives of their mentors on science education but also those of the pre-service teachers themselves. Thus, it can be argued that the outcomes had by the pre-service teachers in group MT1in line with the SSI approach, as their perspectives on science education are consistent with these views.

In conclusion, it was found that the PD program and collaboration offered several gains for pre-service and mentor teachers, but these gains were related to their perspectives on science education. This finding is supported by Friedrichsen et al. (2021) who emphasized the importance of teacher beliefs (Personal Domain). They argue that the teachers' attitudes and beliefs about science education influence the other three domains outside the Personal Domain in the E-IMPG model.

Thus, it may be useful to determine the science education perspectives of both pre-service and mentor teachers before initiating PD programs designed to enhance their progress. This can assist in making the PD program more relevant to their needs. Furthermore, while pre-service teachers go through the same education during their university training and therefore expectedly hold similar gains, the gains of mentor teachers are likely to be insufficient. Hence, it is suggested to provide mentor teachers with enhanced scholarly guidance during the PD program and develop various SSI-based PD models as suggested by Topçu et al. (2022).

Finally, it is necessary to address some of the limitations of the study. These include the number of participants and contextual factors (e.g., content, framework, school type, and environment). Future studies on PD programs could explore how these different contextual factors impact the collaboration between mentors and pre-service teachers within the model.

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TÜRKÇE GENİŞLETİLMİŞ ÖZET

Son yıllarda bilimsel okuryazarlık kapsamında fen eğitiminde, toplumsal önemi olan konular ve bilimsel bilgi arasındaki etkileşimler ve ilişkiler üzerine odaklanılmaktadır. Günümüzde, öğrencilerin sosyobilimsel konulara (SBK) duyarlı olmaları, küresel refahı sağlamak için bilime ve bilimsel bilgiye dayalı kararlar verebilmeleri ve SBK ile ilgili toplumsal tartışmalarda söz alabilmeleri, bilimsel okuryazarlığı sağlama noktasında önem taşımaktadır. SBK'ların öğretim kalitesini arttırmak için öğretmenlerin ve aday öğretmenlerin SBK ile ilgili yeterli bilgiye sahip olmaları ve bu konulara yönelik yeterliliklerinin de yüksek olması önemli bir unsurdur.

Öğretmen adayları, öğretmenlik uygulaması dersleri kapsamında uygulama öğretmenlerinin sınıflarında gerçekleştirdikleri uygulama örneklerini ve öğretimlerini gözlemleyerek öğretmenlik yapmayı öğrenmektedirler. Uygulama öğretmenleri aday öğretmenlerin öğretimleri planlama, sınıf ortamında uygulama ve düşünme süreçlerinde rehber rolünde yer almaktadır. Aynı zamanda uygulama ve aday öğretmenler etkileşim içerisinden bulunduklarından dolayı uygulama öğretmenlerin mesleki gelişimleri (MG) desteklenerek güncel yaklaşımlar hakkında fikir sahibi olmaktadır.

Bu araştırmada Coenders ve Terlouw'un (2015) ortaya koyduğu genişletilmiş bağlantılı MG modeli (G-MGM) kullanılmıştır. Clarke ve Hollingsworth'ün (2002) geliştirdiği bağlantılı MG modeli (Interconnected Model of Professional Growth-IMPG) öğretmenlerin MG süreçlerinde aktif öğrenen rolünde oldukları varsayımına dayanmaktadır ve Kişisel Alan (Personal Domain), Dış Alan (External Domain), Uygulama Alanı (Domain of Practice) ve Sonuçlar Alanı (Domain of Consequences) arasındaki etkileşimlere dayanan karmaşık bir süreci açıklamaktadır. Coenders ve Terlouw (2015), modele Materyal Geliştirme Alanı adında beşinci bir alanın eklenmesini önermiştir.

Bu çalışmada "materyal geliştirme" alanı öğretmen adaylarının uygulama öğretmenleriyle ve aynı zamanda kendi aralarındaki etkileşimi artırmak için teknoloji destekli olarak planlanmaktadır. G-MGM kapsamında öğretmen adayları öğretmenlik uygulaması dersleri kapsamında uygulama öğretmenleri ile teknoloji destekli ortamlarda iş birliği ile çalışarak SBK materyalleri geliştirmeleri ve sınıf ortamında uygulayacaklardır. Bu model aday öğretmenlerin uygulama öğretmenleri ile SBK ile ilgili ders planı ve materyal tasarlamaları, öğretmen adaylarının tasarladıkları materyalleri uygulamaları aynı zamanda uygulama öğretmenlerinin ise bu uygulamaları gözlemleyerek SBK ve teknoloji destekli öğretim uygulamalar hakkında bilgi sahibi olmaları beklenmektedir (Friedrichsen vd. 2021). Geliştirilen SBK materyallerini incelemeleri ve SBK odaklı planlanan dersleri gözlemlemeleri her iki gruba da yarar sağlayacaktır. Çalışmanın araştırma soruları; (1) Uygulama ve aday öğretmenlerin MG modelinden elde ettikleri kazanımlar nelerdir?, (2) Uygulama ve aday öğretmenlerin fen eğitimi yaklaşımları ile MG modelinden elde ettikleri kazanımlar arasında nasıl bir ilişki vardır?, (3) Aday öğretmenlerinin, uygulama öğretmenleri ile yaptıkları iş birliğinden elde ettikleri kazanımlar nelerdir? ve (4) Aday öğretmenlerinin uygulama öğretmenleri ile yaptıkları iş birliğinden elde ettikleri kazanımlar ile uygulama öğretmenlerinin fen eğitimine bakış açıları arasında nasıl bir ilişki vardır? şeklindedir.

Çalışmaya İstanbul'da bulunan bir üniversitede biyoloji öğretmenliği bölümünde son sınıf öğrencisi olan Öğretmenlik Uygulaması I ve Öğretmenlik Uygulaması II dersini alan 11 öğretmen adayı katılmıştır. Öğretmen adaylarından 1 kişi erkek geriye kalan 10 kişi kadındır. Uygulama öğretmenleri ise Öğretmenlik Uygulaması I ve Öğretmenlik Uygulaması II dersinde okullarda onlara rehberlik eden İstanbul'da bir lisede öğretmenlik yapan dört uygulama öğretmenidir (biyoloji öğretmenleri).

Veri toplama sürecinde araştırmanın amacı doğrultusunda bu çalışmada nitel araştırma yönteminin doğasına uygun olan veri toplama araçları kullanılmıştır. Araştırmada görüşmelerde kullanılan MG öncesi, MG sonrası ve US olmak üzere üç görüşme formu, uygulama ve aday öğretmen toplantı kayıtları ve son olarak günlükler olmak üzere farklı veri kaynaklarından elde edilen veriler G-MGM modelinin boyutlarına göre tümdengelim ve tümevarım yaklaşımı kullanılarak kategorize edilmiştir.

Nitel araştırmalarda veri analizi verileri anlamlandırma sürecinde; katılımcıların neler söylediği, araştırmacının bunlardan neler çıkardığı, verilerin birleştirilmesi, indirgeme ve yorumlama aşamalarını içermektedir. Bu çalışmada nitel araştırma yöntemlerinden olan tematik analiz kullanılmıştır. Tematik analiz, araştırmacılara elde edilen verilerin ayrıntılı, esnek ama karmaşık şekilde açıklanabilmesine olanak sağlayacak kadar kullanışlı bir araştırma amacı sunmaktadır.

Çalışmanın bulguları incelendiğinde aday ve uygulama öğretmenlerinin uygulanan MG programından belirli kazanımlar elde ettiği gözlenmiştir. Aday öğretmenlerin elde ettiği kazanımlar genel olarak çok boyutlu düşünme, teknoloji entegrasyonu ve argümantasyondur. Fakat bazı aday öğretmenler bu kazanımlar dışında sosyobilimsel konuların doğası ile ilgili üst düzey kazanımlardan olan etik ve ahlaki sorgulama, SBK konularını benimseme ve delile dayalı tartışabilme kazanımlarını elde etmişlerdir. Uygulama öğretmenlerinin MG programından elde ettiği kazanımlar incelendiğinde ise aday öğretmenler ile benzer bulgular gösterdikleri saptanmıştır. Çalışmaya katılan dört uygulama öğretmeninden bir kişi ilerlemeci fen eğitimine bakış açısına, bir kişi yaparak- yaşayarak öğrenme bakış açısına sahipken kalan diğer iki uygulama öğretmeni geleneksel fen eğitimine bakış açısına sahiptir. İlerlemeci fen eğitimi bakış açısına sahip uygulama öğretmeninin MG programından elde ettiği kazanımların diğer uygulama öğretmenlerinin elde ettiği kazanımlardan net bir şekilde farklılık gösterdiği gözlenmiştir. Ek olarak aday öğretmenlerin kazanımlarına etki eden faktörün uygulama öğretmenlerinin fen eğitimine bakış açıları haricinde kendi bakış açılarının da etkili olduğu saptanmıştır. Sonuç olarak öğretmenlerin MG'lerine yardımcı olmak amacıyla uygulanacak MG programları uygulanmadan önce bu programa katılacak aday öğretmen ve uygulama öğretmenlerinin fen eğitimine bakış açılarının saptanması ve MG programının buna göre tekrardan yenilenmesi kazançların artması yönünden yararlı olabilir. Aynı zamanda aday öğretmenler üniversite eğitimi boyunca aynı eğitimden geçtikleri için kazançları büyük oranda benzerlik göstermesine rağmen uygulama öğretmenlerinin kazançları yetersiz kalmıştır.