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Case Studies of Science Teachers Designing Socioscientific Issues-Based Instruction*

Fen Bilimleri Öğretmenlerinin Sosyobilimsel Konular Temelli Öğretim Tasarımları: Durum Çalışması

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ABSTRACT: The qualitative case studies in socioscientific issues (SSI) focus on teachers' perceptions and opinions on teaching SSI, rather than individual teachers' involvement in teaching SSI. Thus, there is a need for in-depth case studies that focus on teachers' practices of teaching SSI and how these practices are influenced by teachers' deeper beliefs and motivations. This study investigated science teachers' design and implementation of SSI-based instruction. Using a multiple case study design, the participants were three science teachers. The data collected through semi-structured interviews, observational field notes, and reflective journals in this study. The data analysis procedure occurred in three stages: open coding, identification of patterns and categories, and building themes. The findings revealed that one participant embraced the inclusion of social aspects such as ethics and values in SSI instruction, whereas the other two participants intentionally excluded the social aspects and only focused on scientific data and findings in order to present the issue in a less biased and controversial way. In addition, teachers' epistemological and pedagogical beliefs about science and socioscientific issues, as well as the social and cultural structure of their school and community, strongly influenced their SSI-focused instructional practices.
Keywords: Socioscientific issues, beliefs, teaching practices, case studies

ÖZ: Sosyobilimsel konular odaklı durum çalışmaları incelendiğinde öğretmenlerin bu konuların öğretimine yönelik algı ve düşüncelerine odaklanılırken, sınıf içi uygulamaların ihmal edildiği görülmektedir. Alanyazındaki bu eksikliği karşılamak adına, nitel araştırma desenlerinden durum çalışması şeklinde gerçekleştirilen bu çalışmada üç ortaöğretim fen bilimleri öğretmenlerinin sosyobilimsel konuların öğretimindeki inanç ve motivasyonları ve bu faktörler ile birlikte bağlamsal faktörlerin de sosyobilimsel konular odaklı öğretim süreçleri tasarlama ve uygulamalarını nasıl şekillendirdiği incelenmektedir. Araştırmanın veri toplama araçlarını yarı yapılandırılmış görüşmeler, gözleme dayalı saha notları ve araştırmacı günlükleri oluşturmaktadır. Veri analizi süreci üç aşamada gerçekleşmiştir: açık kodlama, tema ve kategorilerin tanımlanması ve temaların oluşturulması. Araştırmanın bulgularına göre, katılımcılardan biri sosyobilimsel konular odaklı fen bilimleri dersinin etik, ekonomi gibi farklı sosyal boyutlar ile zenginleştirilmesinin konulara kapsamlı bir bakış açısı geliştirmek ve bilgiye dayalı karar verme becerileri geliştirme açısından vazgeçilmez olduğunu düşünürken, daha az deneyimli olan diğer iki katılımcı sosyobilimsel konular odaklı fen bilimleri derslerini problemleri objektif sunma adına bilimsel veri odaklı ve sosyal boyutlardan arındırılmış bir şekilde gerçekleştirmeyi tercih etmişlerdir. Buna ek olarak, öğretmenlerin içlerinde

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bulundukları okul ve toplumun sosyal ve kültürel özellikleri gerekse de öğretmenlerin sahip oldukları inançları gibi bağlamsal faktörlerin öğretmenlerin sosyobilimsel konular odaklı fen bilimleri dersi öğretimini güçlü bir şekilde şekillendirdiğini göstermiştir.
Anahtar Sözcükler: Sosyobilimsel konular, inançlar, öğretim uygulamaları, durum çalışması

1. INTRODUCTION

Teachers are central to any educational outcome and their epistemological and pedagogical beliefs guide their practices in the classrooms (Zeidler, 2014). Furthermore, a teacher's self-understanding, larger values, social awareness, and worldview are "important factors affecting his/her teaching practice and personal and professional growth and development, [thus, they demonstrate] numerous details of how that teacher would be related to new educational approaches" (Witz, Goodwin, Hart, & Thomas, 2001, p. 198). Even though teachers do not directly decide what is included in the standards, they are the ones who decide which standards are actually taught and how (Spillane & Callahan, 2000). One way to improve the practices of teaching is to use socioscientific issues to provide context for learning and teachers beliefs have been shown to impact implementation of such approaches.

"Socioscientific issues (SSI) are complex and open-ended problems that embed science content and practices within the social issues in which they occur" (Kinslow, Sadler, & Nguyen, 2018, p. 3). Addressing SSI has been one of the main focuses in science education since the Science, Technology, and Society (STS) movement in the 1970s (Levinson, 2006) and several educational reforms have called for teachers to address controversial SSI for enriching the scientific literacy of students to develop their abilities to intelligently engage in public discourse and social and political decision-making processes on matters involving science and technology. Educators from various areas considered SSI as productive and effective contexts in which students are engaged in learning processes bridging school experiences with broader societal contexts (Sadler, Foulk, & Friedrichsen, 2017). The learning gains from SSI-based instruction involved student competencies in reasoning, critical thinking, decision-making, and argumentation, while it "increases epistemic engagement and facilitates gains in scientific and environmental literacy" (Kinslow, Sadler, & Nguyen, 2018, p. 3). Despite the strong support for incorporating SSI into science curriculum in reform documents and research studies, the literature reports that science teachers still follow a traditional view in teaching science (Davis, 2003; Jenkins, 2002); teaching controversial SSI has always been challenging for teachers (Dillon, 1994; Osborne, Duschl, & Fairbrother, 2002). Although teachers exhibit positive attitudes for using controversial SSI in their science classrooms, only a small percentage of them actually incorporate SSI content into their science curricula on a regular basis (Lee & Witz, 2009; Sadler, Amirshokoohi, Kazempour, & Allspaw, 2006). Therefore, teacher beliefs play a significant role in the practices of teaching SSI due to the controversial and personally relevant nature of SSI.

The literature in science education has documented the relationships between teacher beliefs and teaching practices (Bryan & Atwater, 2002; King, Shumow, & Lietz, 2001; Tobin & LaMaster, 1995). Beliefs have been a focus of research in SSI, for example, teachers' motivations for teaching SSI were found to be mostly personal, including their values, ideals, philosophies, or personal concerns instead of the major reform efforts (Lee & Witz, 2009). However, while the literature indicates teachers exhibit positive attitudes for using controversial SSI in their science classrooms, only a small percentage of them actually incorporate SSI content into their science curricula on a regular basis (Lee & Witz, 2009; Sadler et al., 2006). Sadler et al. (2006) examined teacher perspectives on the use of SSI and on the inclusion of ethics in SSI instruction. They found five profiles that captured views and practices in SSI, ranging from teachers embracing the notion of infusing science curricula with SSI to teachers advocating that science education should be value-free. The SSI approach has been proposed as

an instructional framework that involves three key phases for enacting SSI as learning experiences (Owens, Sadler, & Zeidler, 2018). These phases were students (1) encountering the focal issue, (2) studying the science and engaging in reasoning about the social components undergirding the issue, and (3) attempting to reach a solution of the controversy by synthesizing key ideas and practices.

The complex nature of the SSI requires researchers to investigate teachers' beliefs and practices deeply. The qualitative case studies in SSI focus on teachers' perceptions and opinions on teaching SSI, rather than individual teachers' involvement in teaching SSI (Lee & Witz, 2009). Although research presents a relatively detailed picture of teachers' values and motivations for teaching SSI (e.g. Lee, 2006; Lee & Witz, 2009; Reis & Galvao, 2004), these case studies do not explore the actual SSI practices of these teachers. Thus, there is a need for in-depth case studies that focus on teachers' practices of designing and teaching SSI-based learning environments and how these practices are influenced by teachers' deeper beliefs and motivations for teaching SSI (Lee, 2006). In response to this need in the SSI literature, this study investigated science teachers' practices of designing and implementing SSI-based instruction, as well as the impacts of contextual factors on those practices.

2. METHOD

This multiple case study was designed to gain insights into how science school teachers design and implement learning environments within the context of a local controversial socioscientific issue. Specifically, the following research questions were addressed:

- How do science teachers design and implement SSI-based instruction?
- How do contextual factors influence science teachers' design and implementation of SSI-based instruction?

Yin (2017) defines a case study as investigating a phenomenon (e.g. teachers' ways of designing and implementing SSI based instruction) which occurs within authentic contexts (e.g. in the secondary schools within a large watershed in the Midwest US) especially when the boundaries between the phenomenon and context are unclear. Because the contextual factors for the SSI addressed in each case were so distinct, each classroom within the context of the community it is located in was represented as its own case and then compared and contrasted to the others in order to understand the experiences of teachers in each setting.

In order to describe the contexts where the phenomena occur, Porras-Hernandes and Salinas-Amescua's (2013) three-level context model was employed. The first level, the macro context, relates to social, political, technological, and economic conditions that include the worldwide developments and trends, as well as national and global reforms. The meso context level includes social, cultural, political, organizational, and economic conditions established in the local community and the educational institution. The last level, the micro context, involves the expectations, beliefs, preferences, and goals of teachers and students as they interact. Since the national and global efforts around SSI (macro context), which are addressed in the literature review section, was not different for each participant, each case is presented within the meso and micro levels that impacted the phenomena significantly.

2.1. Participants

Participant teachers for this study were chosen based on their involvement in a National Science Foundation (NSF) funded project. All teachers holding a science teaching license in the project participated in the study. The teachers (male=2, female=1) represented a range of years of experience from 2-7 years. Their teaching assignments were mostly high school grade levels

including biology, ecology, environmental science, environmental biology, and earth science, with some teachers assigned to multiple subject areas and grade levels (see Table 1).

Table 1: Information about participant teachers

	Thom	Amy	Jonny
Age	27-30	24-26	20-23
Teaching Experience	7 years	3 years	2 years
Teaching in Current School	7 years	1 year	2 years
Subjects Currently Teaching	Biology (10th Grade), Environmental Science (11-12th Grade), Earth Science (7-8th Grade), Life Science (7-8th Grade), Anatomy (11-12th Grade)	Algebra-based Physics, Biology, Ecology	Biology (10th Grade), Earth Science (8th Grade)
Subjects Previously Taught	Biology (7 years), Environmental Science (7 years), Life Science (4 years), Earth Science (4 years), Anatomy (3 years)	Physics (3 years), Biology (1 year), Ecology (3 years), Astronomy/Meteorology (1 year)	Biology (2 years), Earth Science (2 years), Earth and Space Science (1 year), Environmental Science (1 year)
Classes/Specific MRB Content	11/12th Grade Environmental Science (MN River Water Quality), 10th Grade Biology (Ecological interactions)	Biology (Ecosystems, nutrient cycles, biological interactions, environmental issues), Wildlife Ecology (Ecosystems, nutrient cycles, water issues, runoff, water cycle)	10th Grade Biology (Ecology)
Degrees Held	Biology (BS), Education	Biology (BA), Secondary Education (BA)	Biology (BA)
Teaching License	5-8th Grade Middle School, 9-12th Grade Life Science	Biology Teaching, Middle School Science, Coaching Certificate	9-12th Grade Life Science

2.2. Data Collection Methods

The data collected for this case study took on three different forms: interviews, observational field notes, and reflective journals. The first semi-structured interview protocol explored participant teachers' epistemological and pedagogical beliefs about SSI, specifically those related to the MRB. The second semi-structured interview protocol targeted participant teachers' knowledge and beliefs about teaching SSI. In addition, the observation data from each participant teacher's classroom, with the complementary reflection journals, was included to support and validate the primary interview sources. The researchers contacted the participants to determine the times to observe their classes in order to make sense of their SSI-based instruction. Last, the researchers wrote reflection journals after each observation to complement the observation data in order to find a reflective balance (Clandinin & Connelly, 2000).

2.3. Data Analysis

Qualitative data analyses of the individual cases were done through the use of NVivo 10.0 software. Thematic analyses of data were done via this qualitative analysis software. The data analysis procedure in this study occurred in three stages: (1) open coding, (2) identification of patterns and categories, and (3) building themes (Miles & Huberman, 1994). After gathering all the open codes, main ideas emerged as patterns. These patterns represented each participant's beliefs and classroom practices of SSI integration. Lastly, the researcher examined the patterns in each individual case to find common themes that were used in cross-case analysis. In order to

provide the validity and reliability of the study, triangulation method was used by considering the codes emerging from one data source with other data sources, essentially triangulating the code against multiple data sources.

3. FINDINGS

In this section, the cases of the three teachers are presented. Based on Porras-Hernandes and Salinas-Amescua's (2013) three-level context model, each case includes the social, cultural, and economic conditions established in the local community and the educational institution (meso context level), the expectations, beliefs, preferences, and goals of the participant teachers (micro context level), and the instructional experiences of those teachers during the academic semester.

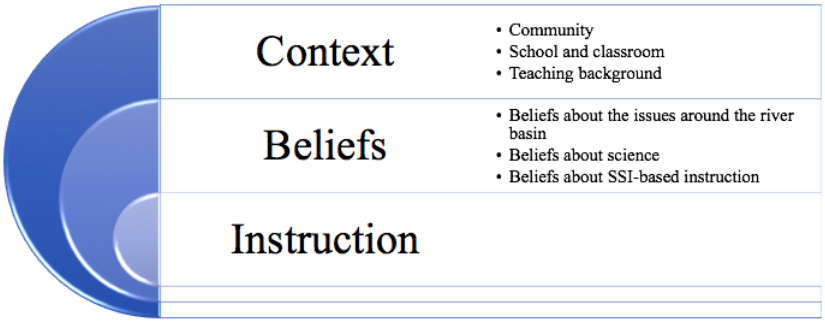

Figure 1. *The themes for each case*

3.1. Case I: Thom

3.1.1. The community

Thom lives in a rural community located on the upper part of the Minnesota River. It is well watered and drained by both the Minnesota River and two tributaries. The population of the community has been decreasing since the 1960s. This pattern is projected to continue over the next few decades. Thom described farming as the longstanding economic driver of the community, as well as the transformation of agriculture over the last 25 years, specifically the takeover of corporate farms. The two main issues people in the town have experienced related to the river were a dam removal conducted by the Department of Natural Resources (DNR) and various flooding events that occur almost every spring.

3.1.2. The school and classroom

Thom's school district has experienced a 30-40% decrease in enrollment in the last decade. The school serves students in grades 6 through 12. Thom's environmental science class is comprised of 26 students (14 female and 12 male) including eight students with special needs supported by a paraprofessional. Due to his extended knowledge of the environment, forestry, and agriculture, the paraprofessional frequently helped Thom during instruction. Thom's classroom was a traditional science room with an additional space for teachers to use as an office. The classroom was arranged for students to work in groups. There were various technology tools in the classroom, which students could use in and out of class.

3.1.3. Teaching background

Thom is a very active member of his community, and he has been an important actor in decision-making processes for his school and community. He is very involved in programs outside of science class and committed to positive growth in both the school environment and his community. As he plans his instruction, Thom tries to use different teaching strategies in

order to address the needs of students with different learning styles. Overall, he is quite confident trying new instructional strategies, as well as new technologies. He specifically noted that he is not the kind of a teacher who lectures all the time.

3.1.4. Thom's beliefs

3.1.4.1. Beliefs about the issues around the river basin

Being an active member of his community and focusing on community-based issues in his classes, Thom was well aware of and involved in the social and environmental changes around his community. He recognized the complexity of environmental issues and the necessity of taking a multi-perspective approach in order to understand and solve them. Thom added that the involvement of different interest groups required people with a variety of different positions putting their heads together to solve problems.

Growing up on a farm and talking with the farmers in his community, he was usually supportive of farmers even though he did not ignore the role of farmers in adding more sediment and chemicals into the river system. He empathized with farmers by recognizing their feelings about the bad reputation they have in their communities,

> *You know because farmers don't want to have a bad name for what's going on, they wanna be good stewards of the land. Growing up on a farm and talking with a few farmers in the area, they're proud…They feel that they do a fairly good job already and they don't like the finger pointing at them. #TI*

He believed that farmers had recently worked hard to minimize the runoff from their fields. In order to support his perspective about farmers, he provided examples of their efforts in his community such as participation in the Future Farmers of America (FFA) program in order to improve their agricultural practices. To support the farmers' side of the sediment and chemical load issue in the river, Thom referred to his own observations that the water coming from the drainage tiles gets to the river faster than it used to, which could indicate a positive change in farming practices. Even though he often supported farmers, Thom also claimed that people living in cities have the right to say no to spending tax dollars on an issue where farming activities in rural towns are to blame.

In addition to farmers, Thom also shared his point of view about the other actors taking part in the issues around the river basin. For example, he believed that despite their critical position on the issue, policymakers were not fully able to understand those issues because they almost never visit farm country and make observations firsthand. Furthermore, he recognized the fact that the businesses owned by policymakers could potentially impact their decision-making. Lastly, Thom believed that the environmental agencies are the most neutral and unbiased actors in the scenario because they have no stake unlike the other actors such as farmers and local residents in the community.

3.1.4.2. Beliefs about science

Overall, Thom was quite skeptical about the research going on around the Minnesota River Basin. He claimed that the sources of funding and groups' agendas could potentially drive the scientific research at different points of the studies, such as testing or data collection and interpretations. He also pointed out the separate entities and groups with set agendas that are conducting their own data collection and testing processes:

> *I think when you look at the watershed itself and all the problems we are dealing with it, there are so many opinions and there is even research to back up these different opinions. (Pauses) There could be you know it is certain groups pushing*

their agenda, and their data is driven by what their agenda is instead of being truly scientifically objective. #TI

In contrast to researchers supported by private corporations, he expected researchers from universities to be less biased, as he believed that the funding of their studies mostly came from taxes. However, funding was not the only factor he considered as an effect on scientific research. He believed that peer pressure in the research world could cause some researchers to be hesitant about presenting data different from their peers. In order to fully trust the scientific findings, Thom specifically wanted to see the trend in long-term data. He added that the trend in data could have potential to reveal whether the main causes of the sediment load in the Minnesota River were agricultural activities or bluff erosion.

3.1.4.3. Beliefs about SSI based instruction

Thom's ultimate goal for including SSI in his environmental sciences class was to help his students develop informed opinions and thus become educated voters. He believed that his efforts would eventually cause positive changes in his community. In addition to his long-term goals, Thom aimed to encourage his students to take active roles in their community. He suggested two ways to involve his students in community-based environmental problems: conducting community-based service learning projects and educating their community about environmental issues. As he highlighted the community involvement projects for his environmental science class, Thom added that it was important to first build conceptual understanding before students started their projects.

Thom was well aware that, in addition to the science, there were a variety of different social aspects he needed to cover in order to present the full picture to his students. Thus, he made an effort to include social aspects of river basin issues, such as economics and ethics. He stated that science teachers need to cover not only science content, but they also need to address aspects of social studies in environmental science,

I don't wanna just be too sciency, science-like because there economics, there is ethics, there is a lot of things that are going on drives policy…What I really want to get into and we spend some time talking about it, the policy-making things. You know what drives that is it ethics, is it science. Really, we are juggling between being a science teacher and social studies teacher. #TI

While including social aspects of environmental issues, Thom stated the importance of being neutral and not giving his opinions about these different perspectives and positions. He believed that it was the way to help students have their own opinions. Thom also believed that students were not fully able to be skeptical about the information presented about environmental issues. He stated that it was a challenge for him to teach his students to be skeptical of information without considering the level of authority factor.

3.1.5. Instruction

Thom divided his curriculum into two parts: i) building a conceptual scientific understanding about community-based environmental issues and ii) student-driven service learning projects and public service announcement projects that documented students' experiences while working on their service learning projects. His curriculum dealt with a wide range of different environmental issues, such as stormwater management; land use and agricultural practices; and economics, policymaking and the future. Thom decided to integrate content related to issues around the river basin into his existing environmental science curriculum instead of adding a new unit about the Minnesota River Basin. Describing the overall structure of the academic year, he stated that the integration of community-focused river

basin content throughout the academic year was very critical for students' civic development while working on their projects,

> *I think that using the first semester and a half to give our students a bunch of information about the MN river watershed helped prepare our kids for the service-learning projects. #TII*

As one strategy to build conceptual understanding, Thom introduced authentic case studies in order to help his students develop their own opinions, which was the overarching objective he identified for his class. These authentic case studies involved scenarios related to river pollution and various contextual facts around it.

The second semester was mostly dedicated to students working in small groups on the service learning and complementary public service announcement projects on topics of interest from the first semester. Aligned with the service-learning projects, Thom asked his students to document their experiences, as well as an expert's view of their chosen issues. The projects chosen by students were explorations of six topics experienced in their community: a rain garden, wood duck houses, a bio-retention area, compost barrels, rain barrels, and river sediment. When students completed their projects, they presented their videos in the class, and put those videos on Thom's YouTube channel for the public. Overall, Thom's teaching approaches were aimed at not only awakening his students' consciousness about environmental problems, but also to encourage them to take active roles in their communities to address these issues. He believed in the significant role his school could play in his community.

3.2. Case II: Amy

3.2.1. The community

Amy's town is located along a large bend of the Minnesota River downstream from Thom's community. The town recently experienced a significant growth in the marketplace attributed to the gains in private sector jobs, specifically goods-producing and service-providing jobs. As Amy described the general population, she stated that her community was mainly composed of white collar and well-educated people. She added that, due to the recent economic changes, it was no longer possible to call her town an agriculture-based community. However, that the farming-based communities surrounding the town supplied the town with a student body with agricultural backgrounds.

3.2.2. The school and classroom

Enrollment in Amy's school district slightly increased in the last decade (10%). The school serves students in grades 9 through 12. Amy's biology classroom included a pretty wide space which allowed students to move chairs around while working in small groups. Amy had a small library of biology books and magazines for student use. At the other side of the hallway, a laboratory room was available for Amy to reserve. She frequently asked her students to move to the laboratory during the middle of the class period. In addition, students were able to use computers in the media center whenever they needed.

3.2.3. Teaching background

As a relatively new teacher, Amy was quite motivated to change the traditional science classes which she described as isolated in the school building. Therefore, she frequently planned field trips for her students and invited guest speakers to her classes. Amy usually asks students to work in groups on an activity she prepares related to the instruction. Aligned with the activities, she frequently brings handouts that help students follow directions. She was also quite motivated to use new technologies and instructional strategies in her classes. She designed a

personal webpage and created an email group to share news, resources, and updates related to course content, as well as communicating with her students outside of the class.

3.2.4. Amy's beliefs

3.2.4.1. Beliefs about the issues around the river basin

In describing the complexity of the issues around the MRB, Amy addressed different variables playing a role in controversial environmental issues, such as economic concerns. She stated that it was necessary to identify all these different variables in order to fully understand the river basin issues. In addition, the involvement of different actors and the perspectives they held made the controversies harder to resolve.

When Amy addressed the sediment load in Lake Pepin, as well as other locations downstream, she believed that the problems experienced by downstream communities experienced would not affect her personally, thus she did not really care about those problems. Even though she recognized the other factors contributing to the sediment load in the river basin, Amy strongly believed that agriculture was the leading cause. As people have no control over natural factors, she believed that agricultural impacts needed to be focused on,

> *I think in this case, agriculture is the leading factor there and then there's also this continuing question 'could it be something else?' We can't control the rain so if that's what's really causing it, I feel like that's more out of our control, but we can control what farmers are doing in their fields and along river banks. #AI*

In preventing the sediment and nitrogen load in the river, Amy believed that it was not enough to tell farmers what to do, but some entity, preferably the government, had to regulate the agricultural practices negatively impacting the health of the river. However, she added that the general public, especially environmentalists, needed to be more open-minded to be aware of contributors other than agricultural practices.

3.2.4.2. Beliefs about science

Amy's understanding of science was mainly centered on quantitative perspectives. She often highlighted that numeric data and statistical analysis was very important for the trustworthiness of scientific studies. She added that scientists needed to quantify their arguments in order to make decisions. It was important for her to hear about the statistical findings when different researchers presented their studies. Only the researchers who were able to show a correlation in their data were unbiased,

> *"What's the data telling us?" That's what science is all about…I think scientists have to have some significant – you have to quantify it somehow. To make a decision, you have to be able to say 'yeah, there is a positive correlation between these two variables' #AI*

Despite her strong emphasis on the role of data in science, Amy also noted that scientists included personal opinions and perspectives in their studies. She specifically pointed out those opinions and perspectives as a source of bias in science. Therefore, she concluded that scientific studies had to be the only factor affecting people's mind as long as scientists remained faithful to data and facts.

3.2.4.3. Beliefs about SSI based instruction

Similar to her views of science, Amy's beliefs about teaching SSI centered on learning processes focused on quantitative aspects. She strongly suggested that any information presented in the class needed to be supported by a quantitative data,

I think my bias then takes over as far as what I'm presenting to them. It's kind of sad, but it's the truth too. I guess my criteria would be, especially being in a science class, that whatever anyone is saying has some quantitative support for it…As a science teacher, it's about the data. #AII

Amy also believed in keeping her students away from less factual opinion-based resources and encouraging them to find resources supported by quantitative data. The resources involving more quantitative support and less opinion would be a better way to introduce SSI to her students,

Whenever my students are doing a research project, I try to steer them away from certain types of resources that are less factual and more opinion…When I'm looking for resources to bring to them or I'm encouraging them to find other resources, yeah. I'm trying to steer them toward anything supported by numbers. #AII

Amy highlighted her intention to bring different perspectives related to the issue in her classes. Describing the resources that could potentially be used in teaching SSI, she pointed out the use of different types of articles from local media and academic journals which, in her opinion, were reliable resources to use in her science classes. Lastly, she recognized her bias in selecting the resources that she used in her science classes. As she sought for the truly unbiased information resources, Amy's criteria were quantitative support in arguments, as well as less opinionated points of views.

3.2.5. Instruction

Amy taught a Wild Life Ecology class in the fall and a Biology class in the spring semester. Instead of integrating SSI based content in her existing curriculum, she decided to develop a separate unit and spend a couple weeks on water analysis and related activities. Being a strong advocate of quantitative focus in her science classes, Amy stated that she covered the SSI based content factually based on the data. Even though she recognized the different aspects of the issue such as ethics, Amy did not attempt to cover those aspects.

We didn't get into so much about the ethics or, the opinions as I maybe was expecting to. If I were I would, of course, try to get both sides, but of an angle, of an idea. But I don't know, I kind of kept it pretty factual and just this is what we think is happening based on the data. #AII

Amy started her unit with a field trip where students tested the water quality in two different locations, a creek in a well-maintained park and one of the tributaries of the Minnesota River. Eight student groups collected four different types of data (pH levels, turbidity, nitrate, and phosphate), so that they had two sets of data from each type of analysis unit. Following the field trip, students brought back their data to the media center in the school and used computer programs to create data tables and graphs. Based on their findings in the water analysis process, Amy encouraged the student groups to build a hypothesis and use the data they collected to test their hypothesis.

3.3. Case III: Jonny

3.3.1. The community

Jonny's school is in a small rural community located in the upper area of the Minnesota River. It is located in a double river valley and predominantly surrounded by farmland and prairies, as well as river valleys with small bluffs. Even though historically the town was an agricultural center, Jonny noted that corporate farms have taken over the small family farms in the last few decades. As a result, people in his town started commuting to other towns that

created job opportunities for people living in his community. Describing how river-related issues have directly impacted his community, Jonny shared the high nitrate levels in city water. Consequently, most people in his community drink bottled water instead of city water, which has increased the people's awareness about the river issues.

3.3.2. The school and classroom

Jonny's school district has a predominantly White student population, followed by Hispanic students (8%) who are the children of migrant workers who often relocate from school to school. The school serves students in grades 9 through 12. Jonny taught four sections of the same Biology course. Jonny and another science teacher interchangeably used two different classrooms connected to each other, although these classrooms were not different from each other physically. Both classrooms contained a smartboard and a loudspeaker system. In general, all student chairs were turned to the front side of the room where the smart board was located. Despite the limited space to move the chairs around easily, Jonny frequently asked his students to work in groups.

3.3.3. Teaching background

In teaching environmental science topics, Jonny often took advantage of the prior experiences of his more experienced colleague who was close to retirement. In addition, Jonny aimed to continue his tradition of taking kids down to the river after his colleague's retirement. In describing his teaching, Jonny repeatedly noted that his main goal was to increase students' engagement in his classes. Jonny often stated that students in this generation have a hard time staying focused, so he aimed at having shorter activities in one class period. Influenced by his colleague who was a strong storyteller, Jonny believed in the power of stories in keeping students engaged. Thus, he frequently started his classes with short interesting stories, either personal or related to science. Jonny also used different technologies, such as online response systems, in order to engage students.

3.3.4. Jonny's beliefs

3.3.4.1. Beliefs about the issues around the river basin

As he highlighted the complexity of the issues around the river basin, Jonny noted that it was not a black or white issue. Hence, the ideas based on different perspectives could all be relatively correct from the perspectives and values different people or groups held. Furthermore, he believed that the economic consequences of proposed actions made those issues more complex. In addition to agricultural impacts on the river, Jonny also addressed the increased precipitation and its impacts on riverbank erosion. Because increased precipitation was something hard to manage, he believed that people needed to focus on the contributors that could be controlled,

> *I would look at what are the problems, what are the things we can control to stop it from coming? If it's something we can't control, necessarily–it could be the increased precipitation–we can't really control that. #JI*

Jonny also addressed the negative connotations people held about farmers because of their role on the sediment load in the river. Empathizing with the farmers in his community, he stated that farmers had the right to not to listen other groups, such as environmentalists and media, because of the ignorance of those groups about the economic consequences for them. Jonny added that he personally preferred listening to scientists over other groups because they held no bias in presenting information,

> *Because I'm kind of a nerd, I would listen to scientists and hear what they're saying because researchers have no bias in most cases. #JI*

3.3.4.2. Beliefs about science

Jonny believed in the significance of data in the overall trustworthiness of a scientific study. He stated that he would expect researchers to focus only on data and that the data itself was enough to show the problem,

I like just seeing the raw data. It tells what the problem is. #JI

In order to decide the stronger side in a scientific argument, Jonny noted that evidence and the interpretation of data played a critical role. Describing the disagreement in the scientific research around the river basin, Jonny believed that the scientists reached different conclusions because of the difference in data and the methods of inquiry,

I would say they used different data. I would have to look at where they got their data and at what specific spots…I think they took two different types of inquiries – two different ways to come to their own opinion. #Semi-structured interview I

Lastly, Jonny believed that the reputation of the scientists did not affect the quality of their report, but funding from private corporations needed to be considered. He provided examples of researchers with a good reputation disgracing themselves in the scientific community due to producing low-quality reports to meet the demands of biased funders.

3.3.4.3. Beliefs about SSI based instruction

Jonny's main objective for his SSI instruction was aimed at creating scientifically literate students able to think critically in dealing with SSI. While describing what he meant by critical thinking, Jonny addressed asking critical questions before deciding whether to accept or reject an idea, as well as making up their own minds based on the different sources of information,

I would want them to be able to read something, understand it, and choose for themselves if they want to believe it…Make up their own mind, instead of reading, understand 'okay, that's true' but there's all this other research over here that says it isn't true. That's a kind of critical thinking I want my students to have. #JI

In terms of the resources that could be used in SSI focused science classes, Jonny strongly suggested the use of scientific studies and reports over other kinds of resources that he considered potentially biased. He added that scientific studies and reports had the potential to create rich discussions and lead to critical thinking. Lastly, relevant to his beliefs about science, Jonny suggested providing students with opportunities to interact with unbiased researchers and the data those researchers could provide.

3.3.5. Instruction

Jonny frequently mentioned that the extensive standards in biology prevented him from including more river basin content. Therefore, in his yearlong biology class, Jonny planned only a week-long unit that involved water quality analysis and debate around the issue of sediment load in the river. During water analysis, students working in groups of 4-6 were assigned different kinds of data sets from each aspect such as pH levels, turbidity, nitrate, phosphate, and temperature. After the field trip, students brought back their data to the classroom for analysis, and then presented their findings to the whole class. Jonny stated that the water analysis on the field helped his students to become aware of the sediment and chemical related issues in the river, as well as the connection between different water analysis units such as sediment, nitrate, phosphate, temperature, and turbidity levels in the river.

The in-class activity that followed the water analysis was having a debate around the sediment load issue in the river. Jonny assigned each group made up of 4-8 students one of the interest groups in the issue, such as farmers and environmentalists. Spending the first day on

doing research, collecting information, and preparing presentations for their arguments, students did the actual debate on the following day. Students in debate groups were very motivated and engaged during this particular activity, according to Jonny,

> *We did the debate that we did this summer. The debate where one group is scientists, one group is agriculture, business, and environmentalists. That one got them really fired up. They were really excited about that. I got to see a little fire from some kids I haven't seen it from in a while. #Semi-structured interview II*

Even though he covered these two activities as part of the isolated river basin unit, Jonny also addressed the history of the Minnesota River in his class via readings and stories he shared during the academic year.

3.4. Cross-case Analysis

Using the themes that emerged from each case, the similarities and differences across the three portraits were explored to build themes for the cross-case model. The following five themes were developed through the cross-case analysis (see Table 2).

Table 2: Cross-case themes

Beliefs	Beliefs about the SSI around the river basin	The complexity of the issue and taking multiple perspectives
	Beliefs about science	The role of data and evidence in science
	Beliefs about the SSI-based instruction	The inclusion of social domains
		Students having informed opinions about the issue
Instruction		The structure of the SSI-based unit

3.4.1. Teacher beliefs

3.4.1.1. Beliefs about the SSI around the river basin

3.4.1.1.1. The complexity of the issue and taking multiple perspectives

Participant teachers' beliefs about the issues around the Minnesota River Basin mainly centered around its complexity. All teachers recognized the complexity of the issues at different levels. For instance, Thom stated that "there was no magic bullet," because "the system was so dynamic" that one action to prevent the issue could potentially trigger another issue. Amy similarly believed that there were "many variables playing a role" in the issues around the river basin. Jonny also brought a unique perspective about the complexity of the issue by stating that, since "it was not a black or white issue", it was not possible to find one true position or argument.

As Thom highlighted the complexity of river basin issues, he strongly suggested "taking multiple perspectives and approaches" in order to fully be able to understand the issues. On the other hand, even though Amy and Jonny also believed that the issue was so complex, they both believed that people needed to focus on the agricultural impacts because it was "hard to control the other factors" such as increased precipitation. In contrast to Thom's opinions about taking a multi-perspective approach to deal with the issue, Amy believed that "different perspectives caused loss of focus" which resulted in making the issue more complex to resolve. Thus, she believed that the actions that needed to be taken should be agriculture focused. Lastly, Jonny believed that people dealing with controversial issues similar to the ones around the river basin needed to be open to different perspectives and arguments because all arguments could be right from the perspectives, interests, and values of different people or groups.

3.4.1.2. Beliefs about science

3.4.1.2.1. The role of data and evidence in science

In general, there were two perspectives on the role data and evidence played in science represented in the teachers' responses. Amy and Jonny strongly highlighted the significance of data in the trustworthiness of scientific studies, whereas Thom was more skeptical. To illustrate, Amy believed that "data was what science was all about." Using the term 'quantitative' frequently in her interviews, she stated that the actors needed to provide "numerical data in order to back up their argument." Similar to Amy, Jonny also valued scientific data most in scientific controversies. He argued that scientists needed to focus on only data because "the data was enough to portray the problem." Both Amy and Jonny believed that although science itself could be biased, the scientific data was isolated from the bias. Thus, scientists' arguments about SSI should mainly focus on their data. However, Thom was not convinced about the exclusion of scientific data from the idea of bias in science. Specifically addressing the funding factors in scientific studies around the river basin, Thom stated that "sources of funding potentially drove scientific research" including the processes of data collection and analysis.

All three participants believed that scientists were the least biased group in the controversy around the river basin issues. Both Amy and Jonny stated that scientists were the least biased group in the river basin scenario, as long as they supported their arguments with data. That is why "science should be the only factor affecting people's mind," according to Amy. On the other hand, Thom was more skeptical about the credibility of scientists and their studies. He listed some of the factors affecting the credibility of scientific studies, such as sources of funding or peer pressure. Therefore, according to Thom, people dealing with SSI "needed more than scientific data and evidence to get the full picture."

3.4.1.3. Beliefs about the SSI-based instruction

3.4.1.3.1. The inclusion of social domains in SSI instruction

In terms of structuring SSI-focused units, the main challenge of the participant teachers was whether to include social aspects of the issues or to stay focused on the science behind those issues. Because their classes were all science-focused, it was a challenge for them to address the social domains of those controversial issues. Thom was the one who thought that it was "necessary to address the social aspects" of the river basin issue. As he described his efforts to cover both scientific and social aspects of the issue in his classes, Thom stated that he often "juggled between being a science and social studies teacher." On the other hand, both Amy and Jonny believed that it was their role to stay focused on the science as science teachers. Saying, "science is all about data," Amy believed that her role as a science teacher was to take a quantitative perspective in covering SSI. She also believed that any information presented in science classes needed quantitative support, specifically scientific data. Similar to Amy, Jonny also believed that there was no need to cover social aspects in SSI-based instruction because "the data itself was enough to portray the problem." Both argued that designing SSI-based units around scientific data and isolating it from social aspects was the way to present unbiased information to their students.

3.4.1.3.1. Students having informed opinions about the issue

The participant teachers all noted objectives of their SSI instruction for their students to develop opinions about the issues around the river basin. However, the ways in which they structured their SSI units in order to achieve that goal were varied. As previously mentioned, Amy and Jonny believed that the scientific data itself was enough for students to make decisions about the issue. In particular, Amy believed that as long as "students interpreted their own data", they would be able to have their own perspectives and opinions. Jonny also said that "students

needed to be able to ask critical questions to make decisions and have opinions." Thus, he was strongly motivated to have a debate activity where students took the role of different interest groups and argued about their positions. Similarly, Thom believed that students needed to be skeptical and critical to have opinions. In order to do that, Thom suggested "being neutral and not giving his opinions" about the issue when he presented. In addition, he said it was effective to "play devil's advocate" to challenge students. Lastly, Thom believed that using actual case studies and providing real-world examples could help students have informed opinions.

3.4.1.4. Instruction

3.4.1.4.1. The structure of the SSI unit

Even though there were some common activities in their units, such as water analysis in the field, participant teachers designed their SSI units quite differently. Amy's SSI unit mainly focused on the water analysis activities that involved data collection and analysis, as well as presenting an argument that was evident in student-collected data. For example, students who found high nitrate level in their samples investigated the possible sources of elevated nitrate levels, then presented their findings to the whole class. Parallel to her stated beliefs, Amy "kept her instruction factual" based on the data they collected in the field. Similarly, the water analysis activity was a big part of Jonny's SSI unit. However, he also included a debate activity in order to be able to cover different interest groups and their perspectives about the sediment and chemical load issue in the river. Different from the other two participants, Thom's unit was mainly centered on student-driven community involvement projects. As they explored the community-based SSI, Thom explicitly addressed the social domains of those issues such as economics, culture, and ethics. Since he believed that "it was necessary to build conceptual understanding before starting the projects", Thom connected every piece of his unit to those community-based projects. His main goal was to help his students "actively engage in community-based issues".

4. DISCUSSION, CONCLUSION AND SUGGESTIONS

As participant teachers designed their SSI focused units, their main objective for students was to develop informed opinions about the issues around the river basin. However, the ways they structured their units based on this goal were quite different. Whereas Amy decided to center focus on scientific data collection and analysis and exclude the social aspects of the environmental issues, Thom tried to find a balance in covering both scientific and social domains. Even though Jonny's beliefs indicated the exclusion of social facets of the river basin issues in SSI-based science classrooms, he decided to integrate a debate activity around the sediment load issue in a local lake. Exploring teacher perspectives on teaching SSI and dealing with ethics and moral aspects in science classrooms, Sadler et al. (2006) delineated five profiles of teachers that characterized different perspectives of teachers on the inclusion of social aspects in science instructions. The findings of this study suggested that Thom fit into Profile A, a teacher who embraces the notion of infusing science curricula with SSI and the inclusion of social aspects such as ethics and values. Alternately, Amy fit into Profile D, a teacher who believes in the position that science and science education should be free of social facets such as ethics, morals, and values. Lastly, Jonny fit into in Profile C, a teacher who understands the link between social aspects and science in the context of SSI but finds it more appropriate to other subjects like social studies. Although they do not intentionally plan to include social aspects in their instruction, teachers in Profile C still possibly address those aspects when they arise in the classroom, as was the case with Jonny and his use of a debate.

The literature (e.g. Pedretti et al., 2007) shows that teachers in their early years are hesitant to teach controversial issues and question their place in the science curriculum. As she defended her instructional decisions, Amy stated that she intentionally excluded the social

aspects and only focused on scientific data and findings in order to provide students the least biased information, which was her way of presenting the issue in a less controversial way. On the other hand, Thom, who was the most experienced teacher among the three participants, tried to cover multiple facets of the issue, including both scientific and social ones, as he stated that 'there was no magic bullet'. Using different kinds of strategies such as playing devil's advocate in the class, Thom was quite confident about using controversy to help his students take their own position on the environmental issues. Jonny, another participant teacher in his early years, was hesitant to teach controversial issues comprehensively. However, after experiencing a successful application of a debate activity in the professional development workshop, he decided to integrate this particular activity in his SSI-focused unit. Therefore, this study suggested that providing professional development experiences and modeling learning activities around controversial topics has the potential to encourage teachers in their early years to include controversies in their SSI-based instruction.

As suggested by Zeidler (2014), pedagogical goals around SSI instruction aim at engaging students in dialogue, discussion, debate, and argument. Thom's confidence in presenting controversy in his environmental science class encouraged his students to discuss the controversial local environmental issues from different perspectives, and debate those issues based on the positions they held. In addition, Thom's community-based projects helped students create dialogues with the members of their community while exploring those issues. Even though Jonny's students engaged in a debate in order to explore multiple perspectives about the sediment load issue in Lake Pepin, the dialogue and debate around that particular issue occurred in smaller social circles for a limited time in Jonny's class. Even though teaching controversial topics in science classrooms has been considered a challenge for teachers (Dillon, 1994; Osborne et al., 2002), the findings of this study suggested that those controversial topics promote dialogue and discussion not only among students, but also between students and real actors outside of school borders.

The literature suggests that personally meaningful and relevant discussions around SSI provide students opportunities to learn complex decision-making processes (Burek & Zeidler, 2015). Because the controversial issues that the participant teachers focused on in their SSI-focused units were close to students' homes, the discussions around those controversial SSI were more personally relevant. While this provided opportunities for teachers to promote meaningful dialogue and discussions about the SSI around the river basin, teachers were sometimes hesitant to encourage their students to be part of the conversations in the classrooms, especially when there were conflicts with their backgrounds or beliefs. Therefore, it required teachers to find a balance by evaluating the advantages and disadvantages of addressing the controversy, as well as finding the right tone based on their student population.

The findings of this study suggest that there is a strong connection between the contextual levels demonstrated by Porras-Hernandes and Salinas-Amescua (2013) and participant teachers' design and implementation of SSI instructions. Teachers' epistemological and pedagogical beliefs and the culture of the school and community they lived in strongly impacted the way they structured their instruction. The literature indicates that the personal beliefs teachers hold have a great impact on their classroom instruction (Berkman et al., 2008; Rutledge & Mitchell, 2002), and variations in the participant teachers' understanding of the nature of science can lead to different instructional practices in their classrooms (Lederman, 1999). This study showed that teachers' epistemological and pedagogical beliefs about science and SSI drove their SSI-focused instructional practices. To illustrate, Amy's beliefs about science that "science is all about data" resulted in instruction that centered around data collection, analysis, and interpretation activities.

In addition to participant teachers' beliefs, the social and cultural structure of their school and community played an important role in designing their instruction around SSI. The literature indicated that teachers are usually hesitant to integrate community-based controversial issues because those issues can potentially cause conflicts between teachers, students, and community members (McGinnis & Simmons, 1999). However, participants of this study took advantage of the personal relevance of the sediment and chemical load issue, in spite of the possible conflicts. To illustrate, the preexisting bond between Thom's school and community encouraged his students to find connections and take actions in preventing community-based environmental issues. Both students and community members were more comfortable in engaging dialogue on the controversial topics such as the impacts of agricultural practices on their local river. Another example would be how Jonny intentionally structured the student groups in the debate activity, as the student body in his class involved a good number of students with farming backgrounds. Taking advantage of those students, he included the voice of farmers in this activity quite effectively.

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Uzun Özet

Sosyobilimsel konular, bilimsel, kanıta dayalı ve ahlaki muhakeme gerektiren sosyal boyutlara sahip bilimsel problemler olarak tanımlanmaktadır (Zeidler, 2014). Sosyobilimsel konular 1970'lerde ortaya çıkan Fen, Teknoloji, Toplum hareketi ile birlikte fen bilimleri öğretim programlarında temel odaklardan biri haline gelirken (Levinson, 2006), eğitim alanındaki birçok araştırmacı tartışmalı sosyobilimsel konuların sınıflarda öğretiminin öğrencilerin bilim okuryazarlığı becerilerini geliştirmede önemli rol oynadığının altını çizmektedir. Öğretmenler her ne kadar sosyobilimsel konuları fen bilimleri derslerinde uygulamak konusunda olumlu tutumlar sergileseler de, sınırlı sayıda öğretmen sosyobilimsel içerikleri düzenli olarak sınıflarında öğretmektedirler (Lee ve Witz, 2009; Sadler, Amirshokoohi, Kazempour ve Allspaw, 2006).

Sosyobilimsel konular odaklı durum çalışmaları incelendiğinde; öğretmenlerin algı ve düşüncelerine odaklanırlarken, öğretmenlerin sınıf içi öğretim uygulamalarını ihmal ettikleri ortaya çıkmaktadır (Lee ve Witz, 2009). Alanyazındaki bu eksikliği karşılamak adına bu çalışmanın amacı ortaöğretim fen bilimleri öğretmenlerinin sosyobilimsel konuların öğretimindeki inanç ve motivasyonları ve bu faktörler ile birlikte bağlamsal faktörlerin de sosyobilimsel konular odaklı öğretim süreçleri tasarlama ve uygulamalarını nasıl etkilediğini incelemektedir.

Betimleyici durum çalışması olarak tasarlanan bu çalışmada, gerçekçi bağlamlar (Orta Batı bölgesinde yer alan bir nehir havzası) içerisinde konumlandırılmış olgular (öğretmenlerin sosyobilimsel konular odaklı öğretim süreçleri tasarımı ve uygulamaları) incelenmiştir. Bağlamsal faktörlerin sistematik olarak betimlenmesi adına Porras-Hernandes ve Salinas-Amescua'nın (2013) üç katmanlı bağlam modeli kullanılmıştır. Araştırmanın katılımcıları ise Amerika Birleşik Devletleri Ulusal Bilim Ajansı (NSF) tarafından desteklenen nehir havzaları çevresinde gerçekleşen sorunlar odaklı bir projeye katılan üç adet fen bilimleri öğretmenidir. Öğretmenlik deneyimleri iki ile yedi yıl arasında değişen üç öğretmen (iki erkek, bir kadın) araştırmanın katılımcılarını oluşturmaktadır.

Araştırmanın verilerini yarı yapılandırılmış görüşmeler, gözleme dayalı saha notları ve araştırmacı günlükleri oluşturmaktadır. İki adet olan yarı yapılandırılmış görüşmelerden ilki öğretmenlerin nehir havzası üzerindeki sosyobilimsel konular ile ilgili epistemolojik ve pedagojik inançlarını hedeflerken;

ikinci görüşme katılımcıların sosyobilimsel konuların öğretimine yönelik bilgi ve inançlarına odaklanmıştır. Verilerin analiz sürecinde açık kodlama, tema ve kategorilerin tanımlanması ve temaların oluşturulması adımları izlenmiştir. Sonrasında, araştırmacılar ortaya çıkan tema ve kategorileri detaylı inceleyerek çapraz durum analizleri için gerekli ortak temaları ortaya koymuşlardır.

Araştırmanın bulguları altı adet tema altında incelenmiştir. Bu temaların ilki sosyobilimsel konular altında ortaya çıkan sorunların karmaşıklığı ve çoklu bakış açısı kazanmadır. Bu kapsamda katılımcılar sosyobilimsel konuların karmaşık doğası gereği bu konuları anlamak için bireylerin birden fazla bakış açısı ile incelemeleri ve senaryodaki farklı aktörler ile empati kurmalarının gerekliliğinin altını çizmişlerdir. Bilim hakkındaki inançları kapsamında veri ve kanıtın bilimdeki rolü ön plana çıkarken, katılımcılardan ikisi bilimsel verilerin her zaman gerçeği ortaya koyacağını belirtirken, üçüncü katılımcı ise bilimsel verilere olguları ortaya koymaları noktasında daha kuşkucu bir bakış açısı ile bakmıştır. Sosyobilimsel konular odaklı öğretime dönük inançlar teması altında ise katılımcılar fen bilimleri derslerinde sosyobilimsel konuların ekonomi, etik, kültürel çalışmalar gibi sosyal boyutlarını içermesi ya da içermemesi gerektiğini güçlü bir şekilde sorgulamışlardır. Buna ek olarak sosyobilimsel odaklı öğretimin temel amacı noktasında öğrencilerin bilgiye dayalı karar verebilmelerinin önemi vurgulanmıştır. Son olarak, katılımcılar sosyobilimsel konular odaklı öğretim süreçlerinin yapılandırılması noktasında deneyimlerini paylaşmışlardır.

Araştırmanın bulguları doğrultusunda, çalışmanın katılımcılarının Sadler ve diğerlerinin (2006) öğretmenlerin sosyobilimsel konuların öğretimi yönelik sahip oldukları bakış açılarına göre geliştirdiği beş profil içerisindeki yerleri tespit edilmiştir. Amy (Profil D) ise sosyobilimsel konular odaklı fen bilimleri dersinin sosyal boyutlardan arındırılması ve sosyobilimsel konular odaklı fen bilimleri dersinin bilimsel süreç ve veriler ışığında anlatılması gerektiğini savunurken; Jonny (Profil C) bu sosyal boyutların fen bilimleri dersi ile ilişkisini kabul ederken bu boyutların sosyal bilgiler gibi diğer derslerde öğretilmesinin gerekliliğini vurgulamıştır. Thom (Profil A) ise sosyobilimsel konular odaklı fen bilimleri dersinin etik, ekonomi gibi farklı sosyal boyutlar ile zenginleştirilmesinin konulara kapsamlı bir bakış açısı geliştirmek açısından vazgeçilmez olduğunu ortaya koymuştur. Fen bilimleri alanyazında öğretmenlik kariyerlerinin başlarındaki daha az deneyimli öğretmenlerin tartışmalı konuların derslerde öğretimine soğuk yaklaştıkları ve bu konuların fen bilimleri öğretim programındaki yerlerini sorguladıkları belirtilmektedir (Pedretti ve diğerleri, 2007). Bu araştırmanın bulguları da Thom'un kendine göre daha az deneyimli Amy ve Jonny'e göre tartışmalı sosyobilimsel konuların öğretiminde daha özgüvenli ve esnek bir süreç izlemiştir. Bu noktada, öğrencilerine şeytanın avukatını oynayarak onların eleştirel düşünebilmelerini teşvik edebilmiştir. Diğer taraftan, Amy ise bilimsel verilerin tartışmaya uzak olduğunu belirterek derslerinin merkezine veri toplama ve yorumlama süreçlerini almıştır.

Araştırmanın bulguları ayrıca Thom'un tartışmalı sosyobilimsel konuları öğretiminde izlediği stratejilerin hem öğrenciler arasındaki hem de öğrenciler ile gerçek dünyadaki aktörler arasındaki iletişimi zenginleştirdiği görülmüştür. Burek ve Zeidler (2015) öğrencilerin yaşantıları ile ilişkili gerçek dünya problemlerinin öğretiminin karmaşık karar verme becerilerinin kazandırılmasında kilit rol oynadığını belirtmişlerdir. Bu araştırmada, öğrencilerin doğrudan yaşantılarının gerçekleştiği nehir havzası etrafındaki sosyobilimsel konuların öğretiminin öğrencilerin konu ile ilgili bilgiye dayalı karar vermelerinde güçlü bir rol oynadığı görülmüştür. Son olarak, araştırmanın bulguları gerek öğrencilerin ve öğretmenlerin içlerinde bulundukları okul ve toplumun sosyal ve kültürel özellikleri gerekse de öğretmenlerin sahip oldukları inançları gibi bağlamsal faktörlerin öğretmenlerin sosyobilimsel konular odaklı fen bilimleri dersi öğretimini güçlü bir şekilde şekillendirdiğini göstermiştir.