

Place-based SSI Instruction: Current Status and Prospects

Umran Betul Cebesoy

Usak University

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Introduction

Socioscientific issues (SSI) have been prevalent over two decades in science education. While these issues have a significant role in the advancement of scientific literacy (Zeidler et al., 2019), they also develop moral reasoning, ethical consideration, and social and character development of individuals (Zeidler & Lewis, 2003; Zeidler & Keefer, 2003; Zeidler et al., 2005). A wide range of issues including genetic engineering, cloning, renewable energy, genetically modified foods, and climate change could be labeled as SSI since they are complex and ill-structured issues that do not have clear-cut solutions (Herman et al., 2020; Sadler, 2004a; Sadler & Zeidler, 2004). Among them, some are closely related to the environment. Individuals need to make informed decisions while considering varying viewpoints, environmental considerations, and nature itself (Herman, 2018; Herman et al., 2020). However, to develop informed decision-making skills of individuals, appropriate contexts where they could develop these skills in addition to developing affective and cognitive skills need to be provided (Herman, 2020; Sadler, 2004b). This is possible with deliberately and intentionally designed SSI-based instruction. Place-based SSI instruction has been lately used for this purpose in science education research (e.g., Herman, 2018; Herman et al., 2019, 2020). This chapter first explored the meaning of place-based education and the characteristics of place-based instruction. Then, place-based science education research and how it can be adapted to SSI-based instruction are presented.

Place-based Education

Place-based education (PBE) can be described as the process of teaching ideas in different disciplines such as language, arts, mathematics, social studies, science, and other subjects across the curriculum by using the local community and environment as an integrating framework for learning on all levels (Powers, 2004; Sobel, 2004). The power of PBE lies in leveraging a sense of place. PBE uses the sense of place to connect students to local communities and the wider world (Teton Science Schools, 2019; Woodhouse & Knapp, 2000). The term "sense of place" can be described as a collection of personal or collective meanings and attachments to specific locations (Semken, 2005).

This educational strategy emphasizes hands-on, real-world learning experiences (Knapp, 2005; Sobel, 2004). PBE is not a new development, and it backs to an early experiment in connecting student interests to contextual learning in the neighborhood (Smith, 2002). In this sense, PBE is closely related to outdoor education. It typically incorporates traditional outdoor education methodologies as promoted by John Dewey (Woodhouse & Knapp, 2000). Like outdoor education, PBE also has similar characteristics to environmental education (EE) such as being

interdisciplinary and learner-centered as well as requiring informed decision-making. In addition, both help students to develop and comprehend their "sense of place" by considering it not only from an ecological but also from an economic and cultural standpoint. The difference between the two lies in the scope and priority. While PBE offers a much wider scope, EE concentrates specifically on issues about the environment and sustainability and typically takes place in informal learning environments like camps, nature centers, and outdoor education institutes. PBE can be implemented anytime and anywhere, including formal learning environments like K–12 schools, colleges, and universities (Teton Science Schools, 2019).

Sense of place is an important attribution of PBE (Semken, 2005). Sense of place includes three important aspects that also need to be addressed during PBE:

- (a) cognitive domain (knowledge as place meaning),
- (b) affective domain (place attachment; attitudes and preferences as place meanings)
- (c) psychomotor domain (kinesthetic abilities acquired or used in particular physical locations) (Semken & Freeman, 2008).

The main benefit of PBE is that it helps students feel more a part of their communities and the areas they live in (Smith, 2002). In this sense, students' sense of place is enriched through PBE (Semken, 2005). In addition to creating stronger ties between the community and learners, it increases students' appreciation for the natural world and fosters a stronger commitment to serving as active, contributing citizens (Sobel, 2004). PBE also raises student achievement while also enhancing a community's social and economic vitality (Powers, 2004; Sobel, 2004). Similar benefits are also endorsed for teachers: It enriches teachers' sense of place, enables them to access a wide range of perspectives, and resources, and fosters their confidence (Powers, 2004; Semken et al., 2017; Semken, 2005).

Characteristics of PBE

PBE has some basic characteristics: (a) the curriculum is based on surrounding phenomena; (b) the curriculum integrates self, others, and place by considering economic, multigenerational, ecological, and multicultural dimensions; (c) it focuses on learner experiences which make learners 'knowledge creators'; (d) students' questions and concerns play a central role in determining the context that is studied; (e) it frequently crosses the boundaries between the school and community; (f) student work is evaluated based on its contributions to sustainability and well-being of the community, and (g) it is interdisciplinary by nature (Smith, 2002; p. 593; Woodhouse & Knapp, 2002, p. 2).

Place-based Science Education Research

According to Sobel's (2004) definition of PBE, it could be used to teach ideas in different disciplines by using the local community and environment. PBE has long been used in science education research (Buxton, 2010; Lim & Calabrese Barton, 2006, Semken, 2005; Semken & Freeman, 2008; Semken et al., 2017; van Eijck & Roth, 2007a, 2007b, 2009). Semken et al. (2017) argue that indigenous (e.g., Native Americans, Native Alaskans), rural, and underrepresented groups (e.g., African Americans and other ethnicities) are forced to relocate from the places that are most meaningful to them. Consequently, Semken (Semken, 2005; Semken & Freeman, 2008) developed place-based geoscience programs for culturally diverse groups

(e.g., native Americans). In such a study, Semken (2005) created an Indigenous Physical Geology course, utilizing the geology, physiography, and hydrology of the Colorado Plateau which is based on the Colorado Plateau and Navajo culture. The semester-long course consisted of 12 modules covering various and significant facets of Plateau geology, climate, and environmental quality. He observed significant gains in students' place attachment and increased understanding of place.

In another study, Buxton (2010) developed a place-based project (The Social Problem Solving through Science) for disadvantaged middle school students about local environmental challenges with implications for human health and well-being. The results revealed that the students enhanced their science content knowledge and developed their sense of place as members of society.

Lim and Calabrese Barton (2006) explored how low-income urban middle school students' sense of place was leveraged and scientific ways of thinking enhanced during an environmental class that included field trips to school neighborhoods and playgrounds. The results revealed that students' scientific ways of thinking were enhanced. In addition, the sense of place approach provided learning opportunities for connected science. The authors addressed the importance of aligning science learning with the students' sense of place. If aligned carefully and science learning is contextualized in the students' sense of place, learning may become interesting, inspiring, and significant for the learners.

In another study, van Eijck and Roth (2007a) provided assistance to middle school teachers in the area to develop a curriculum that centers on the watershed of a single community in western Canada. The curriculum allowed students to study the main creek that drains the watershed and learn about biology, chemistry, physics, and environmental science. The curriculum was developed iteratively and involved scientists, environmentalists, water technicians, farmers, elders from the Aboriginal community, local politicians, and parents. The results were promising: The curriculum developed succeeded in increasing the scientific literacy of students. Student learning exceeded what they would have learned in a typical science class. In addition, they guided their neighborhood toward a sustainable future. These students took part in changing their community rather than just memorizing words for an exam or copying notes that would be forgotten after the unit.

Exploring narratives of scientists and aboriginal people's explanation of a local issue about the salmon run, van Eijck and Roth (2007b) concluded that traditional ecological knowledge and scientific knowledge are simultaneously available but also are incommensurable and irreducible to each other. The authors pointed out that even though the nature of scientific knowledge implies local heterogeneity, dynamics, and plurality, it is vice versa in local contexts.

The literature summarized above points out the importance of place-based science education for different groups (indigenous, rural, underrepresented, and economically disadvantaged groups). While it could be used in rural and local settings (van Eijck & Roth, 2007a; Semken, 2005), it could also be adapted to urban settings as in Lim and Calabrese Barton's (2006) study. The physical locations could be recreational (playground leisure: Lim & Calabrese Barton, 2006) or occupational (field trips: Lim & Calabrese Barton, 2006; Semken, 2005; van Eijck & Roth, 2007a). Nevertheless, the studies reported important gains for students: increased

science content knowledge and scientific understanding (Buxton, 2010; van Eijck & Roth, 2007a), enhanced scientific ways of thinking (Lim & Calabrese Barton, 2006), being active members of their community (van Eijck & Roth, 2007a), leveraged sense of place and place attachment (Lim & Calabrese Barton, 2006; Semken, 2005; van Eijck & Roth, 2007a). At the same time, Lim and Calabrese Barton (2006) pointed out the careful alignment and contextualization of science in students' sense of place. Specific features of place-based science education were addressed: For instance, Semken (2005, p.153) identified five essential characteristics of place-based geoscience education that also can be applied to place-based science education:

1. Its content needs to specifically focus on a location's geology and other natural features.
2. It incorporates—or at least, recognizes—the various meanings that place has for the community, the students, and the teacher.
3. It offers knowledge through firsthand encounters in that place or in a setting that vividly suggests that location.
4. It encourages and supports residing in a place by sustainably considering environmental and cultural aspects.
5. It enhances the instructor's and students' sense of place.

Place-based SSI Instruction and its Premises

PBE has been used more and more to promote SSI engagement (Herman et al., 2013). By combining PBE with SSI, students have firsthand interactions with individuals and the environment that are affected by environmental SSI (Herman et al., 2020). Place-based SSI instruction aims to strengthen students' sense of place and attachment to real "others" (people and the environment) that are impacted by SSI to promote ecological and cultural sustainability (Herman et al., 2018).

The studies using place-based SSI instruction demonstrated promising evidence. In one of the earlier studies, Herman et al. (2013) investigated undergraduate biology majors' attitudes toward waterways and content knowledge after participating in a local waterway cleanup project. The participants showed significantly higher pro-environmental attitudes and content knowledge about waterways over time than their peers who did not participate in the program.

Another study by Herman et al. (2018) explored how students' affective responses to nature and those affected by environmental issues were affected by place-based SSI instruction. This time the authentic setting was Yellowstone wolf reintroduction. The results revealed that the students' levels of compassion and care for people and the environment affected by environmental issues significantly increased. By using the same authentic context, Herman et al. (2019) explored how secondary students' trophic cascade explanations changed after participating in place-based SSI instruction. The results showed that students' trophic cascade explanations became significantly more accurate and complex implying a more nuanced nature of science (NOS) view.

Herman et al. (2020) explored how undergraduate emotive reasoning developed after participating in a local place-based SSI instruction held in the Greater Yellowstone Area. The researchers revealed that more students showed moderated

concern (higher sense of emotive reasoning) and deep compassion for nature and people who experience difficulties stemming from environmental SSI after participating in place-based SSI instruction.

A more recent study by Herman et al. (2023) explored how fourth-grade students' NOS views developed after participating in the Missouri River Socioscientific Issues Program. The program included after-school classroom and field trip instruction that was centered on the local Missouri River ecosystem, endangered species, and human use issues, as well as how scientists investigate these issues. When compared to the control group who did not participate in the Program, the participating students articulated much more nuanced, non-stereotypical opinions about how scientists investigate and comprehend Missouri River SSI and what role science plays in finding solutions to those problems.

As seen Herman and his colleagues (Herman et al., 2018; 2019; 2020; 2023) extensively used local authentic cases for place-based SSI instruction. Different contexts were used for place-based SSI instruction as well. In such a study, Powell (2021) used the hydraulic fracking issue as a local issue for place-based SSI instruction to develop middle school students' evidence-based reasoning and critical thinking dispositions. Powell (2021) reported that students receiving place-based SSI instruction could engage in evidence-based reasoning about the advantages and disadvantages of hydraulic fracturing for the environment, the economy, and public health by using the data they had gathered from their investigation. Moreover, the students were able to create persuasive arguments for and against authorizing hydraulic fracturing in their states by applying their scientific and engineering knowledge.

In the Korean context, Kim et al. (2020) developed a place-based SSI instruction by using fine dust, abandoned pets, and recycling issues and explored how the instruction affected middle school students' sense of place and character development. The statistical analysis revealed that both scores gathered in sense of place and character development improved after participating in the place-based SSI instruction.

Haze pollution, a local environmental problem in the northern region of Thailand, was used as a local authentic context by Ladachart et al. (2020). They interviewed 17 students (grades 7–12) by using an open-ended questionnaire on haze pollution about the causes, processes, effects, and solutions. They indicated that as haze pollution is a local SSI, it could be used as a context for place-based learning progression to develop a more sophisticated and consistent understanding of the causes, consequences, and solutions of haze pollution.

Place-based SSI instruction was used in different studies in Turkey as well. In such a study, Capkinoglu et al. (2020) used three different modalities (implementing outdoor field trips, reading newspapers about SSI, and visual and verbal presentations about SSI) by using five local SSI to investigate the quality of argumentation by middle school students. They concluded that the newspaper group performed better when compared to other groups (field trip and presentation groups) while the field trip group had the lowest overall quality of argumentation out of all three groups even though this group interacted with different stakeholders at the site. Capkioglu et al. (2020) interpreted this interesting finding that firsthand experiences

with SSI in real-world settings might be insufficient to produce compelling arguments unless the instruction about rational analysis of the situations, outcomes, and individuals affected by those SSI were included.

Lastly, Avsar Erumit et al. (2023) developed role-play activities that were integrated into place-based SSI instruction about climate issues. They examined the development of preservice teachers' understanding of the NOS views and their values as global citizens after participating in the place-based intervention. The results revealed that the place-based SSI intervention improved participants' perspectives on NOS and fostered their values as global citizens.

The literature reviewed here attests to the global significance of place-based SSI instruction. Different studies in different countries adopted place-based SSI instruction by using various local issues. The results pointed out important outcomes for the participants such as much more nuanced NOS views (Avsar Erumit et al., 2023; Herman et al., 2019; 2023), increased content knowledge (Herman et al. 2018), more sophisticated and consistent understanding of local SSI (Ladachart et al. 2020), a higher sense of emotive reasoning and deep compassion for nature and people who experience difficulties stemming from environmental SSI (Herman et al., 2020), engagement in evidence-based reasoning about the advantages and disadvantages of local SSI (Powell, 2021) and character development as global citizens (Avsar Erumit et al., 2023; Kim et al. 2020).

Prospects on place-based SSI instruction

Capkinoglu et al.'s (2020) findings showed the importance of careful scaffolding in place-based SSI instruction. Unless this kind of support, firsthand experiences with SSI in real-world settings might be insufficient to produce compelling arguments. Supporting this conclusion, Lim and Calabrese Barton (2006) pointed out the careful alignment and contextualization of science in students' sense of place. Thus, effective place-based SSI instruction needs to contain some aspects which are summarized in Figure 1.

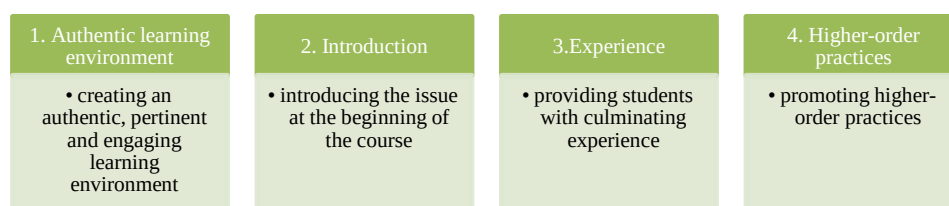


Figure 1. *Essential aspects of place-based SSI instruction*

1. **Creating a compelling issue:** The first step is creating an engaging, pertinent, and authentic learning environment for learners.
2. **Introduction of the issue at the beginning of the course:** The issue should be presented at the very beginning of the course.
3. **Providing experience:** A culminating experience should be incorporated into the design of the course so that students can apply the higher-order practices included in the learning experiences, integrate their own commitments, compare perspectives, and synthesize ideas.
4. **Higher-order practices:** The instruction should promote higher-order practices (e.g., scientific argumentation, reasoning, critical thinking, and

decision-making) through scaffolding experiences and encouraging students to engage with the topic by considering multiple perspectives (Herman et al., 2018, 2020).

Herman et al. (2018, 2020) developed a six-week place-based SSI instruction by considering the above-mentioned points. The course was split into three sections: (1) pre-departure instruction, (2) field experience, and (3) post-field experience coursework. Each section is summarized below:

Pre-departure Instruction

This phase is an important step in place-based SSI instruction. This phase corresponds to the second point that was addressed by Herman et al. (2018, 2020). This step includes many scaffolded opportunities for students to engage in emotive reasoning and perspective-taking before field experience. First, the researchers formally taught perspective-taking and the emotional nature of controversial topics. Then, a familiar issue (corresponding to the first step above) was presented: the continual expansion of their home university into the community. The students engaged with a range of members of the local community who had an interest in the university's expansion during this experience. The students interviewed locals about the university's expansion and how they felt about it. Group discussions on different perspectives and biases were held.

Field Experience

During the field experience, the students interacted with a wide range of stakeholders (e.g., ranchers, members of the Native American Community, hunters, and wildlife biologists) who are impacted by the environmental SSI. Interacting with different stakeholders and group discussions with members of these groups was fruitful in helping students consider the intrinsic value of nature as an entity. Moreover, they had a chance to evaluate different stakeholders' and nature's points of view on environmental SSI resolution. In the end, the students used their experiences to consider different perspectives to resolve the Yellowstone environmental SSI of wolf reintroduction and hunting.

Post-field Instruction

The final three weeks were devoted to post-field instruction. Through this period, students applied the knowledge they gained during field experience about wolf management issues. The students wrote a letter of inquiry to the faculty, outlining the topic they wanted to write about and providing justifications. When the faculty approved the query, each student produced public documents (such as flyers, bumper stickers, and newsletters) and an executive dossier outlining various points of view on the matter (Herman et al., 2020).

As seen Herman et al.'s (2020) design of place-based SS instruction (pre-departure, field trip, and post-field instruction) can be considered a good and detailed instruction model for place-based SSI instruction. Their design consisted of four elements (creating a compelling issue, introducing the issue at the beginning, providing experience, and promoting higher-order practices) of SSI-based instruction proposed by Herman et al. (2018). Their design is also compatible with

Semken's (2005) five essential characteristics (focusing on a location's geology and other natural characteristics, incorporating various meanings of place for the community, the students, and the teacher, offering first-hand experience, residing in a place by sustainably considering environmental and cultural aspects, and finally enriching the sense of place for both teacher and students).

Place-based SSI instruction and Science Teacher Education Programs

Herman et al. (2018, 2020) created a six-week place-based SSI instruction for undergraduate students offered at a small university in Virginia. This instruction model can be adapted to teacher education programs in Türkiye. For this purpose, an elective course named 'Science and Technology Related Problems' offered in the 7th semester of science teacher education programs can be used. The researcher herself developed a six-week place-based SSI instruction focusing on a local issue about gold mining. Following Herman et al.'s (2020) sections (pre-departure, field trip, and post-instruction), the researcher created her course. The events in each section are presented below:



Figure 2. *The events held in SSI-based instruction*

This six-week instruction can be helpful for enhancing pre-service teachers' sense of place and place attachment. Moreover, they consider different stakeholders' views (locals who are against and support mining in the territory, MTA reports on how gold mining is beneficial for the Turkish economy, and TEMA reports about how mining is destructive for the soil, water, and humans). They interact with the locals and the senior geology engineer who directs the visit during the field trip to the

mine. These interactions help pre-service teachers to reconsider the issue after the field trip.

Planning and implementing a place-based SSI instruction in a formal course can be difficult as it requires planning, and obtaining required permissions from the university, and the mine itself. Moreover, transportation to gold mines requires attention as operated gold mines are usually located in the outer parts of cities. In addition, due to security reasons, only authorized entry is allowed, and the official paperwork needs to be completed beforehand.

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About The Author

Umran Betul CEBESoy is working as Assoc. Prof. in the Department of Mathematics and Science Education of Usak University. She was a visiting scholar at the department of Teacher Education at Stockholm University in 2019 and conducted a series of research about pre-service science teachers' decision-making skills in genetics-related SSI and the development of science teachers' pedagogical content knowledge in SSI-based instruction. She completed her Ph.D. at the Middle East Technical University in 2014. She investigated the genetics literacy levels of science teachers and their decision-making skills in genetics-related SSI.

E-mail: ubetulcebesoy@gmail.com, **ORCID ID:** 0000-0001-7753-1203

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of paper titled “**Place-based SSI instruction: Current status and prospects**” belongs to the author.

SECTION
3

MATHEMATICS
EDUCATION