Place-based Inquiry: Advancing Environmental Education in Science Teacher Preparation

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Introduction

Future generations face unprecedented environmental challenges such as global climate change, worldwide food crises, species extinctions, and increasing demands for energy. Teachers play a vital role in preparing students to address such complex and interconnected problems. Place-based inquiry provides a rich setting to educate our science teachers so that they can help their students deal with these challenges. This teacher education strategy emphasizes the authentic practice of science, develops deeper content knowledge in an interdisciplinary context, and focuses on questions of environmental importance.

The Guidelines for Excellence by the North American Association for Environmental Education emphasize that, "Environmental education is learner-centered, providing students with opportunities to construct their own understandings through hands-on, minds-on investigations. … Environmental education provides real-world contexts and issues from which concepts and skills can be learned" (NAAEE 2004, p. 1). A comparable recommendation from the National Research Council has identified inquiry and direct experience with scientific phenomena as best practices in science teaching (National Research Council 1996). Place-based inquiry makes it possible to put these recommendations into action in the teaching and learning of science and to broaden the applicability of environmental education. Our approach defines inquiry as the practice of science (Duschl et al. 2007) and integrates environmental education through place-based pedagogy (Sobel 2004; Swope 2005).

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Place-based pedagogy uses a particular place for the context of investigation where the integration of a variety of scientific and environmental concepts occurs. Students make meaningful connections with the physical and natural world and seek solutions to environmental problems through a multidisciplinary approach. Investigations focus on places from a range of environments, such as a free-flowing stream, an untouched section of the schoolyard, a local park, or even the school building itself. Bodzin (2008), Cronin-Jones (2000), and Martin (2003) all discuss the potential of using the schoolyard itself as an important focus for science and environmental education.

Focusing on questions about a place and embedding the questions in an environmental context enable teachers and students to employ a wide variety of scientific protocols. Investigations can include field surveys, field experiments, naturalistic observations, and controlled laboratory experiments. When questions are tied to a particular place, students are likely to be familiar with the characteristics of the place. When the students are connected to the place, they take ownership of the investigations, and thus the investigation becomes personally meaningful. The combination of caring and science often leads to thoughtful action on the part of students. Placed-based pedagogy extends beyond the boundaries of traditional science lessons, and places science learning in a larger social and environmental context.

When a teacher knows the “right” answer to a question or problem and then directs students toward that answer, those students may never consider the scientific evidence and argument that lead to the best possible answer. On the other hand, when an answer is not predetermined for teachers and students, they have the opportunity to work together toward solutions that are grounded in evidence and reasoning and that are born of an authentic (rather than an authoritarian) practice of science.

This chapter describes a 3-year professional development project for inservice science teachers (Sarkar & Frazier 2008). The goal of the project was to develop teachers’ facility with content-rich inquiry in the context of a particular place. The chapter is divided into three sections. “Summer Learning Experience” details a summer workshop where teachers learned how to use place-based pedagogy effectively. “Application in the Classroom” presents three cases in detail and makes reference to additional studies. “Discussion” includes challenges, reflections on successes, and some recommendations for preservice science teacher preparation.

Summer Learning Experience

A 60-h summer workshop was offered annually for 3 years to provide the tools to implement place-based pedagogy and environmental education in science classrooms. More than 80 inservice teachers participated in the PD experience. Most taught the middle grades but the range extended from grades 5–12. Participants attended the summer workshops and conducted inquiry-based projects in their classes. One-third of the total participants continued for 3 years, and we accepted new teachers each year over the 3-year period.

We used examples that focused on air, water, and soil, three primary categories which incorporate big ideas in life science, physical science, and environmental education. We used a variety of data-gathering measures to help us design the activities. Ongoing formative data measures were employed to modify the activities on a continual basis. We assessed teachers' content knowledge and skills throughout the summer workshop with pretests, performance tasks, observations, and discussions. We were particularly interested in teachers' depth of knowledge in the sciences as well as their facility with skills central to inquiry.

In one of the initial place-based activities, teachers in small groups surveyed a local recreational area that included woods, lakes, heavily used grassy areas, small wetlands, streams, and small hills. The study area is surrounded by agricultural land, a golf course, and residential neighborhoods. We provided directions for surveys that focused on plant diversity along a trail; bird diversity in woods, grassy area, and lakeside; soil characteristics along the slope of a hill; humidity near the lake and at various distances from the lake; water quality (pH, dissolved oxygen, nitrate) and temperature of water at various locations along the lake; and the environmental impact of the proposed development of a conference center in this area.

From the surveys, teachers gleaned a long list of relevant concepts that corresponded to those in their schools' science curriculum. In focus groups, teachers considered a big idea such as "water quality" or "air quality" and developed concept maps completed with specific details from the survey activities. They also generated more focused questions for subsequent investigations.

The investigation of place-based problems requires understanding multiple dynamic and interacting factors in the environment and having the necessary skills to isolate variables for measurement. Before conducting subsequent investigations in the field, we helped teachers perform controlled experiments in the laboratory to learn about the importance of isolation, manipulation, and measurement of specific variables. The experience of conducting investigations under controlled conditions prepared them for deeper and more meaningful place-based inquiry. In one example, we chose to investigate the rate of evaporation of water under controlled conditions because during discussion teachers developed questions about the effects of various physical parameters on the lakes at the survey site. Some of these questions involved variables that required careful isolation and accurate measurement. For example, one group, who proposed that the temperatures of water in sunny areas should be higher compared to shady areas, did not take account of currents in the lakes or the "movement" of shade as the day progressed.

In response to a question about how wind speed might affect the rate of evaporation and humidity at the lake, we guided teachers to perform an experiment in the laboratory with fans set at different speeds at fixed distances from equal amounts of water placed in containers of the same size, shape, and composition. This experiment isolated the wind-speed variable from all other variables such as light intensity, humidity, temperature, atmospheric pressure, and properties of the container. In another experiment, teachers set up hot plates at different temperature settings and compared the effect of temperature on the rate of evaporation. In this case, the temperature was the isolated variable and the rest of the variables that could have affected the rate of evaporation were kept constant throughout the experiment. In all experiments, groups gathered and analyzed data and then presented their conclusions to the entire class.

From the initial surveys, controlled experiments, and continual discussion, teachers in groups modified their questions pertaining to the survey site. We provided equipment and taught them the necessary skills of measurement before the teachers returned to the site to investigate their specific place-based questions. Since the lakes are located near agricultural land and a golf course, one of the questions a group of teachers investigated had to do with the water quality of one lake and whether this was affected by runoff that entered the lake through several inlet streams. Teachers tested for nitrates, dissolved oxygen, phosphates, and pH at various locations of the lake and also gathered water-quality data from the inlet and outlet streams. Teachers found that there were no appreciable differences in their results from the lake and the streams and inferred that the streams were not influencing the level of these pollutants in the lake. As they compiled their results, they asked what parameters were used by the state water-quality monitoring agencies. They knew that nitrates and phosphates are commonly used fertilizers and that an excess of these pollutants in water would result in less dissolved oxygen. They wondered if the city had taken any measures to control runoff and what those measures might be. These follow-up questions were not investigated during the workshop because of time constraints but illustrate how place-based studies lead to deeper inquiry in an interdisciplinary context.

Teachers employed technology in appropriate and effective ways during their summer investigations. They used topographic maps, GPS systems, field microscopes, digital cameras, and a number of other measuring devices. Teachers also built instruments to measure variables defined in their specific experiments. This design activity helped them to understand the nature of measurement including concepts of accuracy and precision. In a representative soil study, one of the teachers designed and built a compaction tester. The device consisted of a cylinder in which a sliding rod could be dropped from a standard height. To use the compaction tester, the foot of the cylinder was placed over the spot to be sampled and then the rod was raised to a fixed height and dropped. The rod penetrated the soil to some measurable depth and provided nonstandard, but controlled values for soil compaction. These values were correlated with types of soil, plant diversity, and plant health across various areas.

During the last phase of the summer workshop, teachers developed a “task analysis plan” focused on a place in their schoolyard or local environment. The guidelines for the task analysis plan are provided in Appendix 1. Teachers developed questions associated with air, water, soil, or other science areas connected with their curriculum. Their plans included testable place-based questions, investigation design, assessment items, concepts and standards covered, time management, organization, and safety. The plan served as a flexible tool to guide investigations.

Application in the Classroom

In this section we describe three cases where teachers employed place-based pedagogy in their schools. Additional projects are mentioned briefly. There were a variety of ways in which projects were conceived and developed. With information from various assessments (such as pretests, concept maps, and performance tasks), teachers refined their initial question(s) and modified their task analysis plans. Three retired university science faculty served as mentors and provided necessary help to the teachers throughout the project. Mentors played an important role right from the beginning by visiting teachers and their students regularly to offer guidance. Teachers and mentors communicated electronically with each other extensively throughout the project. Mentors answered queries, directed teachers to relevant resources, and provided assistance in organization, evaluation, and analysis of student-generated data. Sometimes mentors even facilitated discussion among students and the teacher to help them draw reasonable conclusions and generate new questions for further inquiry. Teachers occasionally asked experts from external agencies to provide guidance in relevant areas. Whenever findings suggested any potential impact on human health, experts were consulted.

The projects varied in terms of organization, instructional design, management style, and resources available to the teachers. All projects followed school safety protocols aligned with NSTA recommendations. In most projects, groups of students gathered data for different parts of an investigation and then contributed their results to a combined database for the entire class or classes. Students recorded their observations and data in journals and periodically discussed them in class. The journals contributed to students' growing science literacy and provided a tool for both reflection and assessment.

Many of the projects showed a transition from teacher-led investigation to student-directed inquiry. Teachers observed students' actions, discussions, and journal writing throughout the investigations, and they used students' reports and posttests for summative evaluation. At the end of the school year, students attended a science symposium at our university. They displayed and discussed posters and made oral presentations to an audience of their peers from other schools, teachers, administrators, parents, and university students and faculty.

Case Study I: Mystery Water

In a rural school in the Missouri Ozarks, teachers and students had wondered about the source of a small stream that seemed to originate from a seep in the playground. Ms. S. and her sixth-grade class of 20 students decided to investigate the nature of the source. Although this seep was in the schoolyard, students found out that nobody in the school really knew the source of the water. Students observed that the flow of the stream was fairly constant and concluded that storm water was not a primary contributor to the seepage. Students then suspected that the source was a sewer leak. With the help of their mentor, the teacher and students designed a study to gather evidence to test their suspicion. They measured the depth of the water for several weeks at different sites on Mondays and Fridays to rule out the possibility that the use of water from school facilities contributed to the flow. If it were from the school facilities, students reasoned that there would be more water on Friday compared to Monday because of very little water use during the weekend.

Students tested the seep water and a control (tap water) for dissolved oxygen, nitrates, phosphates, pH, chlorine, and bacteria, all indicators of water quality. Students had considered possible sources as storm water drainage, a sewer leak, a leak from the public water supply, and a spring. The set of tests in combination with observations of rainfall and flow rate were designed to rule out any three out of the four possibilities. Results indicated that the seep water in the playground was spring water. Enthusiastic about the finding, the students named the previously undocumented spring. Afterwards the Missouri Department of Natural Resources was contacted and experts from the agency recommended a plan to preserve the character of the spring.

Over the next 2 years the project evolved from a teacher-led investigation to inquiries more centered on students' questions. Students asked what organisms they could find in the stream originating from the spring, and if the kinds and number of organisms would change with distance downstream. In the last year of the project, students traced changes in water quality, vegetation, and faunal diversity along the water course that eventually led to a large lake.

This project began with a scientific question, and the investigation proceeded in accord with accepted scientific practice. Students used concepts from physics, such as the flow rate and velocity, from chemistry such as solubility and physical change, and from biology such as the diversity of bacteria, macro-invertebrates, and plants. Students responded to their conclusions by naming the spring and initiating plans for its preservation and enhancement as a school resource.

Case Study 2: They're Buggin' Me

In a large middle school in a suburban district in central Missouri, Ms. H., a sixth-grade science teacher, noticed an area in the schoolyard, previously developed as an outdoor classroom but neglected for years. Ms. H. realized that the site could provide engaging learning opportunities for her 120 students. During the initial exploration of the site just after the school had opened in late summer, Ms. H. and her students identified three distinct areas (called nature centers) with characteristics of prairie, wetland, and woodland habitats. During the initial exploration, Ms. H. observed that her students were intrigued with the insects they found. Ms. H. helped the students develop a survey question on how the types of insect might vary across these three habitats. She and her mentor designed a protocol to count the types of insects in a consistent and scientific manner.

Several times a week for 6 weeks, students surveyed the number and the types of insects from the three areas, described and photographed the specimens, and identified them from field guides. During the surveys students noticed that the number of insects they found seemed to vary from the beginning of the study in late summer to the end of the study in early fall. Ms. H. also noticed that the number of insects depended on the time of the day. While analyzing the data during a class discussion, students studied the varying numbers over the course of a day as well as over the duration of the 6-week study. They wondered how temperature related to the number and the kinds of insect found. The original question, which had been introduced by Ms. H., involved insect populations across habitat. New questions from the students retained this interest but added the effect of temperature on insect numbers and on insect diversity.

In the second year of the study students measured the air temperature with a handheld thermometer and used graphs to correlate different types of insects with temperature. The large set of data gathered by her students from different periods provided the opportunity for making the study a sound field-based investigation. In the third year, students kept the same questions but refined the technique by directly measuring the temperature of the insects using an infrared (IR) thermometer. The IR thermometer provided accurate and precise information about insect body temperature.

Ms. H. reflected on several aspects of the project. She noted that the use of her SMART Board greatly enhanced the collaborative nature of data entry and analysis on an ongoing basis. Students could see the emerging patterns and would point out data that appeared discrepant. She remarked that her own attempts to make sense of class data led her to pay more attention to students' ideas and thinking.

The size and complexity of the project involved such a variety of tasks that all students found areas in which to be successful. In addition, the project provided a rich set of examples that enabled students to measure physical properties and understand concepts in ecology. Students referred to their project experience throughout their science curriculum. In the case of food chains and food webs in the study of ecology, textbooks often use dramatic examples like a mountain lion killing a deer. Children who were involved in the place-based investigation referred to their observations of spiders and praying mantises taking insects as prey. According to the teacher, her students developed a richer understanding of the pervasive importance of food chains and predator–prey relationships due to their experiences in the outdoor classroom study of insect diversity.

In addition to the refined questions and techniques, the project grew in other ways, especially in response to students' concerns and interests. Ms. H. invited her companion special-education teacher and her students to participate in the project. They embarked upon restoration and expansion of the nature centers, another example of a place-based investigation resulting in caring for the environment. The enthusiasm of these teachers and their students established the project as an integral and recognized part of the school science curriculum.

Case Study 3: Structures in the School Environment

In an urban school, Ms. M wanted to engage her seventh-grade students in a place-based problem to explore concepts in physical science. She proposed to her students that they design and conduct an experiment on the effect of temperature on cracks in the schoolyard concrete. Initially, students used calipers to measure the width of the cracks in different parts of the schoolyard at different times of the day for a week. Ms. M's mentor suspected that calipers would not adequately register changes because of the irregularity of the cracks and the magnitude of the change that would occur during heating and cooling. With suggestions from her mentor, Ms. M. developed a technique to measure the changes of the width in the cracks in the concrete. The method involved taking a digital image of a ruler laid across the crack and marking the position for subsequent photos. The pictures were blown up and a scale was devised to convert the width in the magnified view to that of the actual crack. Students used graphs to correlate widths with air temperatures for the dates and times and found that the width decreased with increasing temperature.

In the following semester, students took up a different project, but one that also involved the human-made environment of the school and other buildings. During a class discussion on the inclined plane, Ms. M's students wanted to know more about the design of access ramps. Because of the students' interest in this topic and Ms. M's previous positive experience with place-based pedagogy, she advised students on a procedure to address their question. They determined the slopes of the ramps and also carried out force measurements on several ramps using a wheelchair, spring scale, and a student as a load. During the investigation, Ms. M presented information to students about building codes for accessibility. The students reported their findings in a letter to the principal, stating that while all ramps met the legal requirements, new construction should follow guidelines that would provide easier access. This investigation led to a thoughtful action on the part of the student showing care and concern for their school environment.

Ms. M. became so convinced of the value of a place-based approach for student learning that when she was assigned to teach life sciences, she applied the approach to another schoolyard project. She led a group of students and teachers in selecting an area in the schoolyard in order to design and construct a rain garden to solve an erosion problem. In the beginning, students analyzed storm water drainage patterns and conducted soil percolation tests in different parts of the schoolyard to find the best place to build a rain garden. While the size, position, and the physical parameters of the rain garden were being established, students investigated native plants in order to identify those best suited to the particular habitat. A number of classes joined in the planting and began to use the rain garden for their own place-based investigations. The project brought greater educational value by involving additional students and enhancing the ecological resources of the school.

Other Participant-Place-Based Projects

Other projects carried out by the participant teachers and their students suggest the range of possibilities for place-based inquiry. These investigations, like those described in more detail above, involved a variety of scientific protocols and included surveys, experiments, measurements, tests, and counts. Water was the topic for several studies. Students from one school investigated water quality in a favorite swimming stream. At a different school, students wondered about the quality of drinking water from wells in their homes. In another location, a schoolyard pond was rejuvenated and changes in flora and fauna were monitored. In a school near a popular recreation lake, students were concerned about the effect of old and inadequate septic systems. They studied the difference in levels of nitrogen, potassium, phosphorus, and pH in soil collected from both populated and non-populated areas near the lake. Weather captured the attention of a class who wondered about the extent that weather indicators would vary across the schoolyard from data reported in weather broadcasts. Grasshoppers appeared on walls at one school, and students investigated the effect of solar heating on the temperature of the bricks and possible correlations with the number of insects seen. At a school near heavily travelled streets, students designed collection devices and sampled particulate matter from the air at a number of locations on the school site. These projects developed in a variety of ways, but all were shaped by students' concerns about the local environment, their questions and ideas, their teachers' instructional interests, and mentors' suggestions and assistance.

Discussion

One of the most important questions in science is: "How do we know what we know?" Practicing scientists study background literature, gather initial exploratory data, formulate testable questions, design and conduct experiments, and analyze and interpret results in order to reach reasonable conclusions. The knowledge becomes the foundation for asking new questions. A scientist makes decisions about a course of action at different stages of the process and revisits issues. Scientific inquiry methods are sometimes perceived to be linear but rather they are cyclic and dynamic in nature. Our approach to integrating environmental education in science teacher preparation involves taking the teachers through learning experiences where they function like practicing scientists. They use their experiences to develop strategies for teaching science in an environmental context.

National organizations such as AAAS, NSTA, NRC, and NAAEE advocate hands-on, minds-on scientific investigations as the best way to teach science, but the lists of recommended concepts remain lengthy. When teachers think that they have to cover these concepts separately, they face the problem of not having enough time to engage students in deeper inquiry. The case studies described above show that each placed-based investigation incorporates several science concepts and skills within a unit. These concepts are covered in an integrated rather than in an isolated fashion, and the skills are developed within a context. Place-based pedagogy provides a solution to the challenges related to the coverage of a broad range of topics in science curriculum through deeper and more meaningful inquiry.

Successful implementation of the place-based approach required us to individualize instruction because teachers were at different stages of professional growth. These differences included their depth and breadth of content knowledge and their ability to engage their students in inquiry science practices. In particular, teachers' skills varied in devising testable questions, designing experiments, acquiring data, conducting analysis, and drawing conclusions. We assisted individual teachers in areas such as learning a new instrument, analyzing data to recognize patterns, designing instruction assessments, understanding particular science content, and finding additional resources. Mentors played an important role in this aspect. For example, in the case of the insect diversity study, the mentor assisted the teacher in organizing a vast amount of data in order to examine patterns and draw conclusions. In the study of the schoolyard spring, the mentor provided the teacher with additional content knowledge about macro-invertebrates and vegetation that related to healthy water. Even though this individualized instruction was time-consuming, we felt that the successes in professional growth and student achievement made it worth pursuing.

We noticed that in successful projects teachers were flexible and prepared. They exhibited clear learning goals, provided opportunities for students to take ownership, used assessment to tailor instruction, and made use of assistance from mentors. A common characteristic of successful investigations included extensive dialogue between teachers and their students, teachers and the mentors, and the teachers and the project investigators. Most importantly, in all projects the dialogue centered on data.

The participant teachers grew in several ways throughout the project. They took more action for themselves and became more self-directed. They addressed questions where they did not know the answers in advance, and they learned the necessary skills to develop possible answers. They felt confident in pursuing new directions and learning new teaching methods when they felt that their students would learn better. They also started to integrate their curriculum and delved into extended in-depth inquiry instead of small segregated units.

Participant teachers also demonstrated professional leadership by working with their administrators and fellow teachers in reshaping school curriculum and programs. They often recruited other teachers into school-wide place-based projects. Some teachers presented their work at regional and national meetings to share their successes. They also reflected on how place-based pedagogy enabled them to foster deeper inquiry within the existing demands of school curriculum (Frazier et al. 2008).

Teachers brought their students to annual science symposiums to disseminate findings from their investigations. Students consistently demonstrated high levels of enthusiasm and excitement during their oral and poster presentations. They explained their findings to an audience consisting of their peers, teachers, school administrators, and others. Students responded to questions from the audience with confidence and clarity. The level of exchange reflected the depth of engagement of students in their place-based investigations. The communication that occurred among teachers and their students during the symposiums displayed the characteristics of a scientific community.

Implications for Preservice Teacher Education

The project described in this chapter was designed for the professional development of inservice teachers. However, several elements are applicable to preservice teacher preparation. The investigation of questions tied to a familiar place can have a great impact on preservice teachers' understanding of science. When preservice teachers view science as a body of "fixed and furnished" information, they encounter great difficulty in addressing new questions and challenges. Experiences with place-based investigation can mitigate the effects of such preconceptions about science and can move a preservice teacher's view toward an understanding of science as a way of knowing. Learning how to investigate new questions, using the practices and tools of science, promotes the realization that teachers do not need to know answers to all questions in advance in order to teach science effectively.

From our multiple assessments, we realized that some inservice teachers in our project had difficulty in recognizing significant variables, and some would overestimate the effect of a suspected variable. We also observed that many teachers found it challenging to recognize patterns in data and to develop testable hypotheses. In one example, a group of teachers predicted that air and soil temperature would decrease as they ascended a hill with an elevation of only 50 ft. They measured the land and the air temperature at different points along the trail to the top and found that the temperature did not follow any correlation with altitude. They had not realized that what might be true for a change in altitude of 6,000 ft in the Colorado Rockies would not be observed over a much smaller change in elevation. Place-based investigations would provide preservice teachers with greater experience in the meaningful interpretation of data and the generation of reasonable explanations. Such an experience will help them respond to students when they encounter anomalous results.

It is important for preservice science teachers to have opportunities to work with K-12 students in schools as part of their field experience. Some of the projects and ideas described in this chapter can form the basis of appropriately scaled projects conducted by interns and students under the supervision of host teachers and university faculty. It is equally important for preservice science teachers to have the opportunity to conduct their own place-based investigations so that they gain experience in the practice of science. Such opportunities could be a part of science content courses designed for teachers as well as courses on science teaching methods. Any university or college campus could serve as the setting for projects similar to those conducted by the teachers and students described in this chapter.

The application of the content knowledge in a place-based setting encourages the development of deeper content knowledge. For example, in the first case study on the schoolyard spring, the investigation of water quality through chemical tests led to further inquiry into organisms that live in healthy water. Place-based investigations provide the opportunity for preservice teachers to apply their content knowledge in ways that go beyond their regular science courses. Setting the context of inquiry in familiar places brings immediate relevance and provides multiple opportunities to connect a variety of disciplines, concepts, and concerns. Place-based inquiry equips teachers for the vital role in preparing students to solve multifaceted environmental problems of the present and the future.

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Appendix 1: Task Analysis Plan Guidelines

Design Phase: Curricular details

- Question(s), problem(s), and the general topic that the project will be based on
- Rationale for why the question(s) are worthy of investigation
- A detailed concept list, map, or web that will be part of this field project (relate to national science standards and environmental education standards for the specific grade)
- Experimental design (tentative procedure). An indication of the types of measurement students will make
- A list of individual skills that a student needs in order to carry out the specific investigation

Resource Evaluation: Opportunities and Constraints

- Place of study, time frame of the project, space, materials including approximate budget, people, which class, number of students, school schedules, school policies, safety considerations and precautions, travel arrangements including cost

Implementation Phase: Questions to Consider

- How will you introduce the investigation?
- How will you assess students' prior knowledge (e.g., pre-tests, concept maps, performance events)?
- How will you solicit input from students regarding the question being investigated and the design of the investigation?
- What in-class activities will lead to the field project and what in-class activities will follow the field project?

- What will students produce?
- How will students be assessed (e.g., post-test, concept maps, student generated reports)?
- How will the students be encouraged to evaluate the research findings and their explanations?
- How will the individual differences among students be handled so that everybody is included (students of different abilities and different interests)?
- How will students disseminate their results (e.g., report, posters, video documentaries, web sites)?

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