USING THE LAND

A project-based learning activity to determine how best to redevelop the site of a demolished shopping mall

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Land use and development are complex issues rooted in ecology and environmental science as well as in politics and economics. This complexity lends itself to a problem-based learning (PBL) lesson for environmental science students. In PBL, teachers guide student groups as they define assignment objectives, identify problems, research solutions, and prepare a final solution to the problem (Pecore 2013; Torp and Sage 1998).

Various land-use issues exist in rural, suburban, and urban communities, including redevelopment of industrial sites, use of abandoned malls or storefronts, development of farmland or open space, establishment of recreational areas, and uses of empty lots. In this lesson, students investigated developing a city-owned, 13-acre site where a shopping mall had been demolished, leaving open land and a parking lot. The community had debated alternatives for using the property and had engaged with multiple developers and planners for nearly a decade, which heightened student interest in the lesson.

Local news coverage of the various development plans centered on possible outcomes for the property and not the processes, impacts, and guiding regulations involved. To engage students in learning more about the process, we contacted the city planner to discuss the site. The city planner proved to be enthusiastic in providing resources and offering time and support to our students, and provided his e-mail address so they could ask him questions. To aid student research, the city planner recommended we use the city's own geographic information system (GIS) site, which provided localized information (Madsen and Rump 2012), instead of our original plan of using Google Earth (Bodzin, Anastasio, and Kulo 2014).

We started the lesson by showing students pictures of the property and asked them to brainstorm questions about the site. Their initial questions were variations of, "Why hasn't any-

FIGURE 1

Map of site with topography overlay and student solutions to runoff from the site. Students added arrows to show flow of water and developed models of possible solutions.

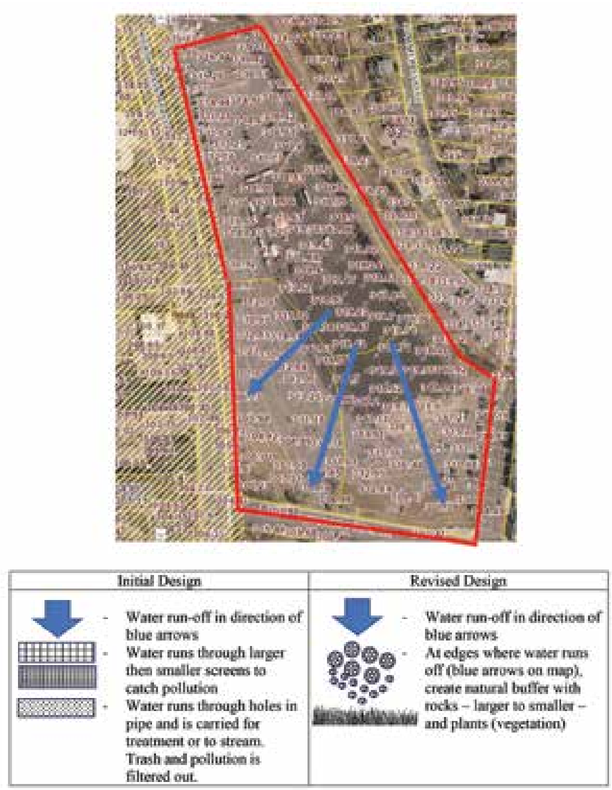
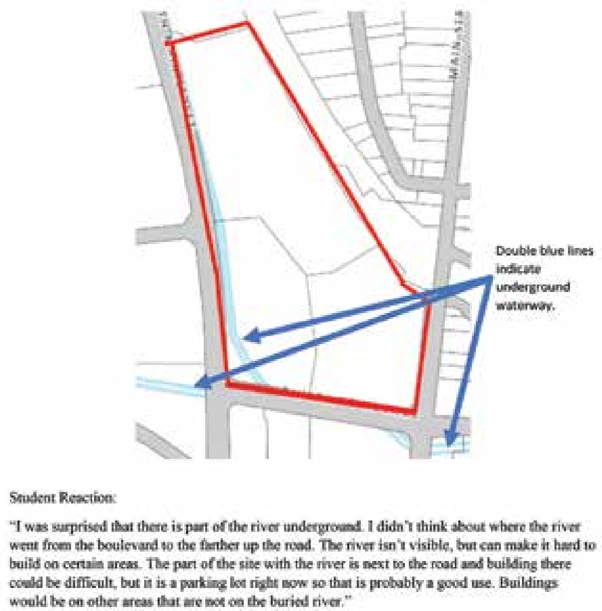


FIGURE 2

Map of site showing underground waterways. Students added arrows to point out areas of concern for their plans.



thing been done?" and "What are the issues with developing the site?" Students then needed to refine and focus their questions and start formulating possible solutions.

Progressing from questions to solutions

During class discussion students eventually arrived at the driving question for the project: "How can we responsibly develop the site to minimize environmental impact and provide value to the city?"

Students discussed constraints for the problem, including city zoning and use regulations, environmental impacts to be mitigated, and funding. The students set a budget of $150 million, based on similar developments in the region.

Students were assigned to groups of three by subject interest. Each group included a student interested in math to assist with calculations and budgeting; a student interested in government, politics, or policy to aid in adherence to regulations; and a student interested in design or art who could offer creative approaches and assist in creating representations of proposed uses for the site. All students were expected to develop and apply an understanding of environmental science concepts related to land use, assume different roles, and make contributions to the overall plan. Alternatively, the students could

FIGURE 3

The "soil triangle."

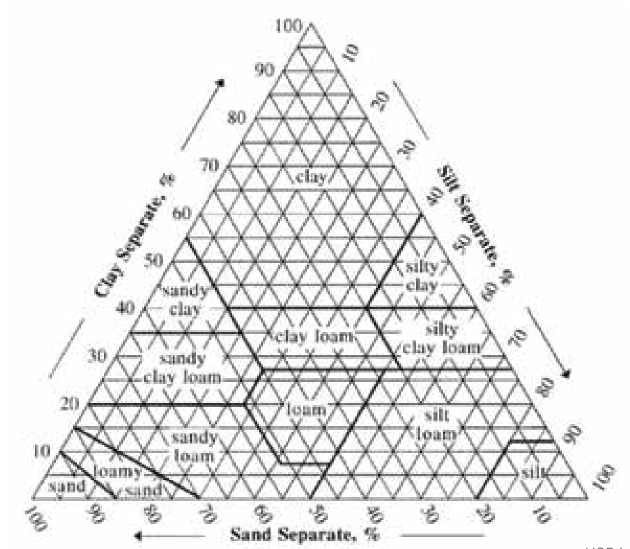


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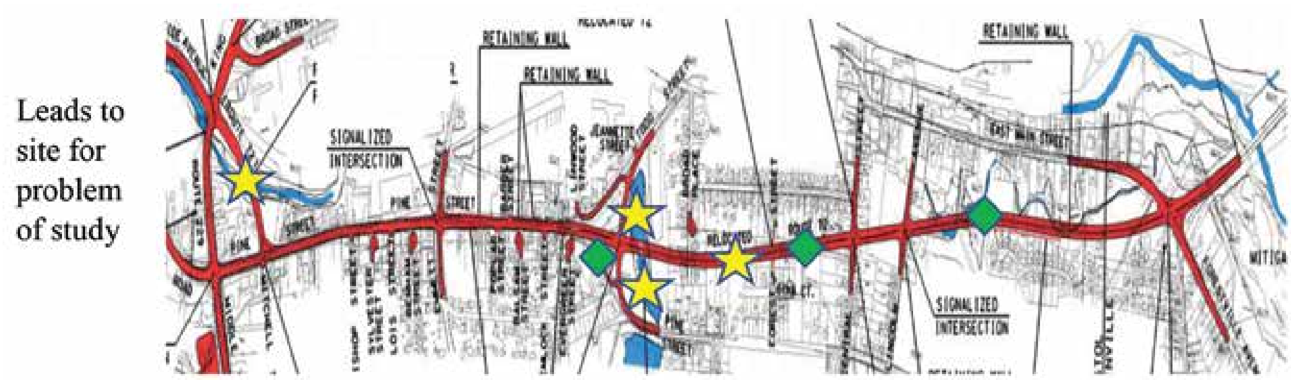
FIGURE 4

A highway expansion project that leads to the site of the demolished mall with student-identified advantages and disadvantages of the highway. This case study shed light on the redevelopment project.



Pros	Cons
- Easier access to property - Better for businesses - Better for people that live there and need to get to a job - If finished sooner, could have saved old mall	- More pollution (noise, air) - Divides habitats (indicated by stars on map) - Separates neighborhoods (indicated by diamonds on map)

FIGURE 5

Sample formative assessments.

Assessment #1:

- What is runoff?
- What are possible sources of runoff?
- What are the consequences or impacts of runoff? How can these consequences or impacts be addressed?
- How is runoff related to developing or using land? How is runoff related to your site? How will your plan address runoff to minimize impacts?

Assessment #2:

- What are common characteristics of soil?
- How do soil characteristics relate to growth of plants and suitability for building?
- What types of soil are commonly found on the site? How does soil type influence your planning and use decisions?

Assessment #3:

- How does the expansion of the highway impact animal and plant habitats?
- How do the impacts of the highway expansion relate to impacts in developing your site?
- How do you plan to address these impacts?

have been grouped randomly, by their own choice, or based on either similarity or differences in their original brainstormed questions.

Using laptop computers, the groups accessed the city's GIS maps and applications on the city's website. The students used the GIS as an interactive data source that allowed them to combine observation, analysis, questioning, and inquiry into land-use decisions.

Uncovering environmental issues and impacts

With the GIS maps and overlays, students could view the property from various perspectives that focused on different factors. Students identified water, soil, and plant and animal life as environmental issues to be considered in their plans.

Applying the topography overlay, for example, students asked, "Doesn't runoff in the river hurt fish and animals? How can we stop it?" Students marked the flow of water on a topography map (Figure 1) and designed possible solutions for mitigating runoff. After research and discussion, students revised their methods (Figure 1, p. 35).

Students were surprised to discover that the site contained an underground river (Figure 2, p. 35) and agreed to avoid building structures over the river. "Building there could be difficult," one student said, "but it is a parking lot right now so that is probably a good use. Buildings would be on other areas that are not on the buried river."

Online and textbook research, as well as mini-lessons on buffer zones and methods for controlling erosion and runoff, helped students learn about protecting water resources.

Students applied the software's soil map overlays to discover predominant soil types on the site. Students initiated their investigation by asking: "How is soil different? Why does soil type matter?" While budgetary and time constraints prevented a field trip to the site, soil samples were brought into the classroom for testing with test kits (available at garden centers or from science suppliers). Students tested for levels of nutrients in the samples and for soil characteristics.

This activity brought to life the soil triangle (Figure 3)—a tool for characterizing soil as sand, clay, silt, or loam. Students researched which types of plants were best suited for the different soil types present at the site.

Students then considered animal habitats and requirements for supporting animal life. To facilitate discussion of habitat fragmentation and effects on animals, students used the GIS to study a highway expansion project completed three years prior (Figure 4). Students also viewed the effects of roads recently reconfigured to improve access to the downtown area, including the site. At first, students said the road work positively affected potential development of the site but after discussion identified negative impacts on animals. This led to a mini-lesson about how human activities fragment animal habitat. Studying the highway project while considering alternatives for redeveloping the mall site is an example of how using case studies enhances problem-based learning.

Impacts on human populations

Students next used information from their GIS investigations to address quality-of-life issues for people in accord with the "adding value to the community" part of the driving question. Students identified air and noise pollution caused by increased traffic in the area as negatively affecting quality of life. Also of concern were increased energy consumption related to both transportation and electric power for the development. Students weighed the value of the development in revenue, jobs, and entertainment balanced with the consequences associated with identified impacts.

Balancing wants and needs

As students balanced desired uses, influx of people to the site, and environmental and quality-of-life concerns, they remarked that they thought the process would be easier. "I don't know if we can solve all of these problems," one student commented. "It seems there is always something else that goes wrong."

This project became a lesson in the politics of groups,

Connecting to the *Next Generation Science Standards* (NGSS Lead States 2013)

Standard

HS-ESS3 Earth and Human Activity

Performance Expectations

- The chart below makes one set of connections between the instruction outlined in this article and the *NGSS*. Other valid connections are likely; however, space restrictions prevent us from listing all possibilities.
- The materials, lessons, and activities outlined in the article are just one step toward reaching the performance expectations listed below.

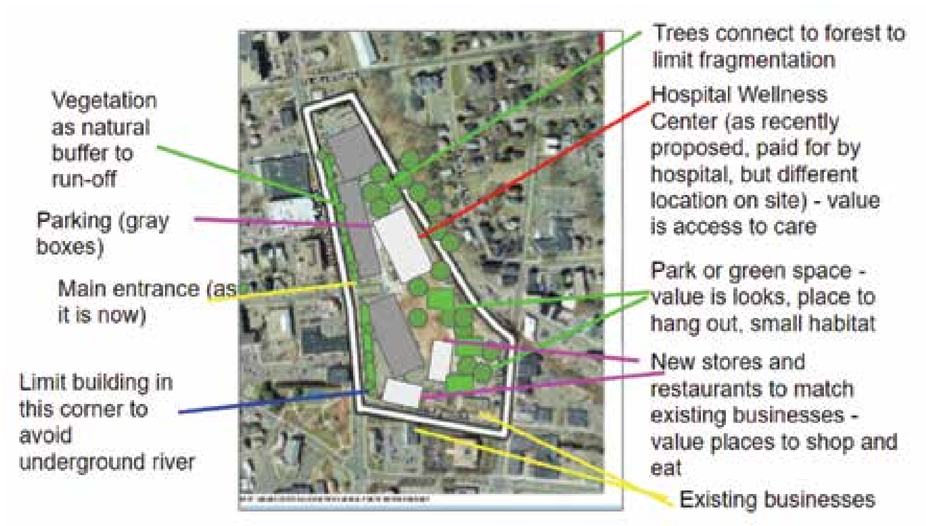
HS-ESS3-3. Create a computational simulation to illustrate the relationships among the management of natural resources, the sustainability of human populations, and biodiversity.

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

DIMENSIONS	CLASSROOM CONNECTIONS
Science and Engineering Practices	
Using Mathematics and Computational Thinking Create a computational model or simulation of a phenomenon-designed device, process, or system.	Students use online Geographic Information System (GIS) software to model various aspects of land use and planning.
Constructing Explanations and Designing Solutions Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review). Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	Students use information from various sources to explain possibilities and outcomes of land use as related to planning. Students use information from various sources to complete a possible land-use plan that is conscientious of environmental impacts by human activities and based on evidence from GIS, investigations, and other sources.
Disciplinary Core Ideas	
ESS3.A: Natural Resources Resource availability has guided the development of human society.	Student groups discuss and analyze the consequences of decisions on human-made constructs and natural ecosystems.
ESS3.C: Human Impacts on Earth Systems The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.	Students complete research and presentations about the effects of human impacts on the environment, including development of land, building and highway construction, and other consequences of decisions.
ETS1.B: Developing Possible Solutions When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	Student groups complete an evaluation of different land uses and determine a land-use plan that fits within constraints and consideration of impacts.
Crosscutting Concepts	
Cause and Effect Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	Students use GIS software to identify components of land use decision making.
Stability and Change Feedback (negative or positive) can stabilize or destabilize a system.	Students use information to identify possible causes and effects of decisions regarding land use. Students identify feedback within a system and determine possible outcomes of the feedback on the system.

FIGURE 6

Overview of a mixed-use development plan that was one slide in a larger presentation. Group presentations averaged 15 slides each. This slide includes text showing student ideas and reasoning.



addressing diverse interests, argumentation, and building consensus. Students engaged in science practices and authentic speaking and listening activities (NGSS Lead States 2013; NGAC and CCSSO 2010; see NGSS box).

Extensions

Although the city planner provided the students with initial information and was available to respond to questions, the lesson could be extended and enhanced through a presentation by a city planning or land use representative. Additionally, a field trip would allow students to study the site firsthand and from different perspectives.

Results and assessment

The various group plans included planning for a city park, building a new shopping mall, building a sports and recreation complex, and planning a mixed-use development (Figure 6). As groups worked, the teacher listened to student discussions and asked questions to prompt student research and formatively assess student understanding. Progress was also assessed as each group gave a daily briefing that addressed challenges and solutions and elicited questions and suggestions from other students and the teacher.

Artifacts, such as notes, sketches, or diagrams documenting student research or development plans were collected and provided opportunities for written feedback from the teacher. Brief, open-ended questions were given as formative assessments aligned with mini-lessons and student research (Figure 5, p. 37).

The project was summatively assessed via presentation and testing. Methods of presentation were not specified, but all the groups chose to do a slideshow presentation modeled after an actual presentation to the city council (see "On the web" for a rubric). Students were then given a traditional multiple-choice and constructed-response exam covering concepts of land use and planning.

Conclusion

This project allowed students to explore environmental science concepts and use science and engineering practices and communication skills. While students acknowledged that the process of considering multiple perspectives and devising a comprehensive plan was more challenging than they anticipated, all groups presented a final land use that was supported with evidence. ■

ON THE WEB

Project checklist, rubric: *www.nsta.org/highschool/connections.aspx*

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