The Delaware Geography-Health Initiative: Lessons Learned in Designing a GIS-Based Curriculum

Peter W. Rees and Jordan A. Silberman

ABSTRACT

The Delaware Geography-Health Initiative is a Web- and GIS-based set of lesson units for teaching geographic concepts and research methods within the context of the state's high school geography standards. Each unit follows a research-based, inquiry-centered model addressing questions of health because of Delaware's high incidence of cancer, HIV/AIDS, and infant mortality. Topics focus on cancer and the environment, the geography of HIV/AIDS, the diffusion of West Nile fever, provision of emergency ambulance services, the location of the state's next hospital, infant mortality and the location of prenatal care, and identification of healthy places. Results from piloting and early formative assessments were used to modify the final product. Lessons learned in developing this project may assist those seeking to create GIS-based state-specific teaching units for geography and other related subjects.

Key Words: *health lessons, GIS, spatial analysis, public health, epidemiology*

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INTRODUCTION

The high school has long been considered the most resistant of the K–12 education levels to engage in expanded geography teaching and learning in the United States. Reasons include the preponderance of social studies teachers trained in history, the homogenization of individual subjects under the rubric of social studies that began in the 1960s, dilution by environmental education, a curriculum crowded with competing disciplines, and a nation slow to accept the value of geography (de Blij 2005, 15; Thrift 2002, 295–296; Johnston 2002, 423; Grossman 1995). The establishment of the state geographic alliance network by the National Geographic Society in 1986, the publication of the National Geography Standards in 1994 (Geography Education Standards Project 1994), and subsequent adoption of geography standards by most states revived interest in geography instruction, particularly in elementary grades. But changes in high school geography have come more slowly. Despite introduction of the Human Geography Advanced Placement (AP) exam in 2001 and a three-fold increase in the number of schools offering AP geography by 2007, this number represented only six percent of U.S. high schools. Moreover, as more students have taken the exam, mean scores have declined (Johnson 2008; College Board 2007). Broader indices are no more encouraging. When comparing performance on the 1994 and 2001 geography tests, the National Assessment of Educational Progress found improvement in the scores of students in grades four and eight but no change in grade 12 (Weiss *et al.* 2002, 14).

The condition in Delaware parallels national trends (Rees 2002). The state's geographic alliance was established in 1989. Geography is a separately identified subject in the state's social studies standards, adopted in 1994, and geography questions are regularly asked on the statewide student assessment test. Yet, while classroom geography instruction in elementary and middle schools has been strengthened, weaknesses remain in the high schools. Only 21 percent of active alliance members teach at the high school level. Among Delaware's thirty-four public high schools, only four offer a general geography course and an additional four offer AP Human Geography. Although private and parochial schools (seventy-eight teach to the 12th grade) serve a higher proportion of the student population than in most other states, none provide formal geography courses at the high school level. In a majority of high schools throughout the state, geography is taught as part of courses in history, world cultures, or economics and civics. This dilution of the subject is reflected in statewide test scores. In 2006 and 2007 geography ranked lowest of the four social studies subjects (history, civics, geography, and economics) tested at the eleventh grade (Delaware Department of Education 2007).

Efforts to encourage social studies teachers to address the absence of formal geography instruction are hindered by a dearth of problem-based teaching materials available to support the geography curriculum. Inquiry-oriented teaching materials suitable for high school geography classes do exist, notably the now out-of-print *Geography in an Urban Age* (High School Geography Project 1969) and the more recent *Activities and Readings in the Geography of the United States* and *Activities and Resources for the Geography of the World*, developed at the initiative of the Association of American Geographers (1995, 2003), as well as *Geography Alive! Regions and People* series, published by the Teachers' Curriculum Institute (2006). Although admirable and innovative, they do not directly address a state's geography

standards. The Delaware Geography-Health Initiative (DG-HI) is designed to respond to this issue. Previously, the Delaware science education community developed a series of highly successful learning kits for elementary grades that it now intends to expand to the secondary schools (Gaston, Wood, and Collette 2002). The kits involved moving from a traditional, textbook-based instructional model to research-based, inquiry-centered science learning and teaching that focused on addressing real-world problems. The DG-HI's objective was to develop a similar series of teaching units that used mapping tools and analytical techniques of geography to address social issues of health and disease. The overall intent was to demonstrate explicitly Delaware's high school geography standards and convince teachers that by using the units they could be assured that they were teaching those standards. The present article has two purposes: to explore the problems faced in the development of the DG-HI in the hope that the lessons learned may be of assistance to others who contemplate the creation of state-specific instructional units; and to advocate for a research-oriented, topically focused mode of geography teaching and learning.

The Planning Process

The DG-HI project was conceived as part of a broader discussion by members of the Delaware Geographic Alliance concerning ways to improve geography education in the state. The planning process involved a number of steps. First, the high school level of instruction was identified as the weakest link in the Alliance's effort to advance geography. Second, discussion focused on the need for a set of distinctive teaching units that could demonstrate the geography standards. Third, health was selected as a topic of current public interest that would provide a focus for the units and attract student interest.

Project development involved selecting appropriate research questions in the health field that would illustrate each of the state geography standards, gathering data and writing inquiry-oriented text, and selecting the best delivery vehicle for the teaching materials. Once the decision was made to utilize a GIS-based stand-alone CD, the production phase was initiated. The beta-version of the CD was then piloted in several schools and distributed to other interested teachers. Responses from this formative assessment led to refinement of both pedagogical and technical issues before publication and distribution. Evaluation of adoption levels, individual adaptations by individual teachers, and use of the units in professional development will culminate in summative assessments that will evaluate the overall value of the project.

The DG-HI Program

Creation of a set of teaching units that appealed both to teachers with insufficient time to cover all aspects of the high school curriculum and students lacking exposure to geography learning required tying the units to a unifying theme. The choice of health and disease adopted by the DG-HI is very much in the forefront of the public's consciousness in Delaware. The state ranks third highest among states for deaths from AIDS and fifth highest for infant mortality; cancer death rates are 5.7 percent above the national average and ranked seventh highest among states; and Delaware's location in the industrial east and downwind from midwestern coal-generated power plants increases the chances for environmental health hazards (Kaiser Family Foundation 2003; Centers for Disease Control 2004, 2007; Division of Public Health 2006, 11). As a consequence, health issues are frequently highlighted by in-depth articles in the state's newspapers and are the focus of much concern by government officials (*Wilmington (DE) News Journal* 2007). In the schools, improving the health of the state's population is a target for health education, yet this subject is often relegated to subsidiary status because it is not included in the statewide testing program. Focusing the units on health offers the chance to combine this subject with teaching geography. A final advantage of the health and disease theme is the long history of using geographical analysis in epidemiological work that originates with John Snow's famous use of mapping to investigate the 1854 outbreak of cholera in London (Gatrell 2002, 216; Vinten-Johansen *et al.* 2003).

The DG-HI consists of eight teaching units, beginning with an introduction that allows students to learn the difference between geographic and nongeographic approaches to problem solving, followed by a demonstration of the nature and use of a geographic information system (GIS) as an analysis of thematic overlays. Seven additional units examine subjects and scenarios that illustrate each aspect of Delaware's four geography standards (Table 1). To enhance the relevancy of the units to students, five address problems and use data that focus on Delaware; two examine Delaware in a regional and national context. Determining the best location for the state's next hospital addresses an issue that utilizes the concept of hierarchy. The principle of accessibility is used to evaluate coverage within the state by emergency medical services. Examining the geographical patterns of HIV across the state supports the standard that calls for students to understand the use of geographical analysis to address societal problems. A comparison of the rates for six different cancers in Delaware allows students to explore the possible role of environmental causes. Determining the location and regional boundaries of prenatal clinics in underserved areas of the state may help reduce high rates of infant mortality. The exceptions to problems that focus only on Delaware are a unit on the spread of West Nile fever, examined at a continental scale because its emphasis on diffusion requires a broader geographical canvas than could be provided at the scale of a small state, and a unit on the location of healthy places, explored at a regional, county scale to allow a greater range of data diversity, since Delaware has only three counties.

Table 1. The Delaware Geography-Health Initiative units and Delaware state geography standards addressed.

Delaware Geography-Health Initiative Lesson Units		
Unit	**Title**	**Delaware High School Geography Standard**
Introduction	a. Data to maps. We need a doctor. b. Using GIS. Can we get to a doctor?	
Hospital	Planning medical services: locating Delaware's next hospital.	Standard 1-a. Applying the principle of *hierarchy* to the analysis of mapped patterns.
EMS	How long a wait? Analyzing Delaware's emergency services.	Standard 1-a. Applying the principle of *accessibility* to the analysis of mapped patterns.
West Nile Fever	Predicting the spread of West Nile fever.	Standard 1-a. Applying the principle of *diffusion* to the analysis of mapped patterns.
AIDS	AIDs plays no favorites.	Standard 1-b: Applying the analysis of mapped patterns to the solution of problems.
Cancer	Cancer and the environment. Is there a connection?	Standard 2: Understanding the ways humans have perceived, reacted to, and changed environments.
Healthy Places	Where are the healthy places? A lesson in the nature of place.	Standard 3: Understanding the processes that result in distinctive. . . locations.
Infant Mortality	Getting care to everyone: developing a network of prenatal care centers. An exercise in regional analysis.	Standard 4: Applying knowledge of the types of regions and methods of drawing boundaries.

Format

Each unit follows the same format. Students first adopt real-life roles and are presented with a specific problem. For instance, in the West Nile fever unit, they are members of a marketing committee within a pharmaceutical company that has developed a vaccine for West Nile fever and are asked to recommend where on the continent to focus marketing efforts based on the location of future outbreaks. For the HIV/AIDS unit, students work for an advertising agency that has a contract to prepare a public service video to alert people that all segments of society can be at risk from catching the disease. The agency has decided to use maps to dramatize this point and has charged its creative team to prepare a draft script for the video. In the case of the cancer unit, students must advise the Division of Public Health on whether any of the common cancers found in Delaware could have an environmental cause that may require closer analysis by officials. In real-life, this issue had in the past split public opinion in Delaware between those who suspected environmental causes and those who felt a lack of prompt diagnosis was behind the state's high cancer rates (*Wilmington (DE) News Journal* 2007). Since completion of the DG-HI, public health officials have released data that purports to identify eight cancer clusters across the state and public opinion once again is focused on environmental causation (*Wilmington (DE) News-Journal* 2008).

Students are next introduced to the geography standard. For example, determining the location of Delaware's next hospital requires understanding the application of the concept of hierarchy so a short lesson is provided demonstrating how settlements in an area are hierarchically ordered with a small number of large centers offering high threshold services and a large number of smaller ones supporting only lower threshold functions. In the unit on identifying healthy places, a beginning lesson explores how the concepts of site and situation can be used to characterize a location.

Each unit follows with some background reading on the subject that is also designed to address knowledge usually imparted in health education classes. The HIV/AIDS unit emphasizes the nature of HIV and the ways in which it is spread. Care was especially needed in writing this script because of public debate about the steps students can take to prevent HIV infection, but the overall message of the student reading—that no one is invulnerable to the disease—was made clear by the unit's title "AIDS Plays No Favorites." A short questionnaire is then provided with each unit that allows the teacher to check that students have completed the reading and understood its content.

The heart of the unit requires a geographic analysis of the problem. Here, the technique adopted might be termed *leading the witness*. Students are presented with data and asked to follow certain steps of inquiry. They are given flexibility to come up with their own conclusions but research previously undertaken by the authors allows students to be pointed subtly via a route of stepped inquiry towards the direction of possible research discoveries, without these being made explicit. For instance, when the sequence of maps showing the spread of West Nile fever is compared, a classic diffusion wave can be seen as successive states show a peak in human incidence of the disease. Once the peak has passed, however, places exposed to the virus over a longer time period seem to have lower infection rates, which might lead students to hypothesize that greater

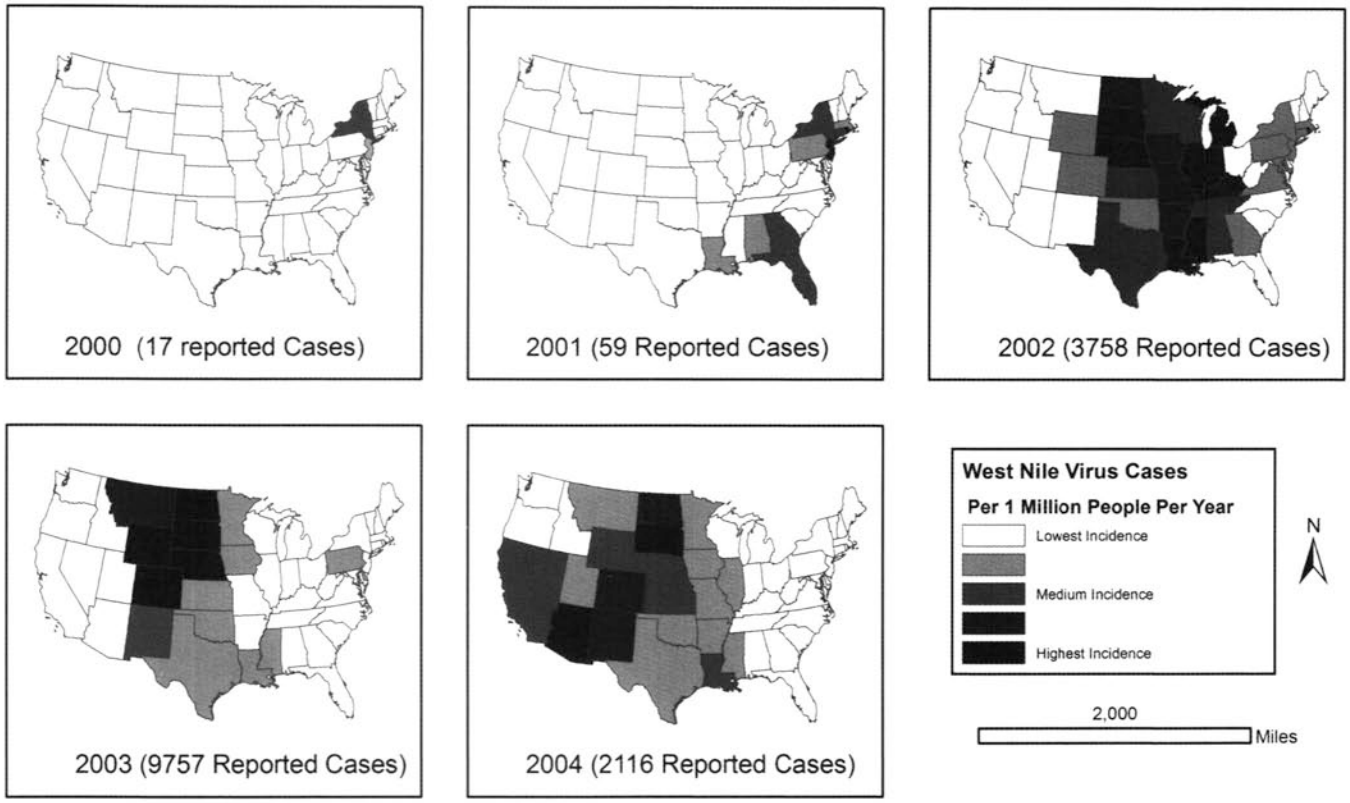

Figure 1. Spread of the incidence of West Nile fever in the continental United States: Reported human cases per million people, by state, by year (2000–2004) (original maps in color). (Data source: Centers for Disease Control 2008.)

exposure can lead to an increased level of immunity (Fig. 1).

In the cancer unit, six different types of cancer are displayed in such a way that the distribution patterns of two maps can be analyzed side-by-side in any combination (Fig. 2). It quickly becomes clear that the locations of the highest incidence of cancer vary greatly, even within a state as small as Delaware. Students hopefully will draw the conclusion that cancer is a term for a family of diseases, each with its own patterns of causation and that the location of disease clusters can expand, contract, or even disappear based on the levels of data aggregation and spatial units used to display the information—the modified areal unit problem (Openshaw and Alvandies 1999). The unit that examines what makes a healthy place offers students the opportunity to select from up to twenty-nine different ranking criteria and to discover that their choice will affect the definition of what constitutes a healthy place.

The EMS unit presents maps of the state showing the average time it takes to reach all locations from existing service centers (mostly fire stations). Students are asked whether poorer people are among the less well-served. The cartographic evidence suggests this conclusion to be true along the western edges of Delaware's southern two counties; however, it is also true in the state's wealthiest district, a region along the northern Piedmont boundary with Pennsylvania known locally as the "Chateau Country." (Figs. 3a and 3b) The conclusion students should draw is that the level of EMS service is more a function of proximity to major transport arteries than of social factors. Distance is also a criterion to consider in the unit that examines where Delaware's next hospital should be built. Students are introduced to the hierarchical ordering of the state's places and asked to determine the minimum size of settlements where existing hospitals are found. Students then explore which settlements of that size not served by a hospital might be a potential location for a new medical facility. Five places fit that criterion, and students must determine the reasons for their final choice.

Throughout the process of guided geographic analysis, students are asked to keep a research notebook of data observations and conclusions from each research step that is then used to aid in the final product of their work. The EMS and hospital location units require a map to justify a recommendation; the infant mortality unit asks for recommended locations for new prenatal clinics; the healthy places unit calls for a report that not only identifies the healthiest county in the mid-Atlantic region but also

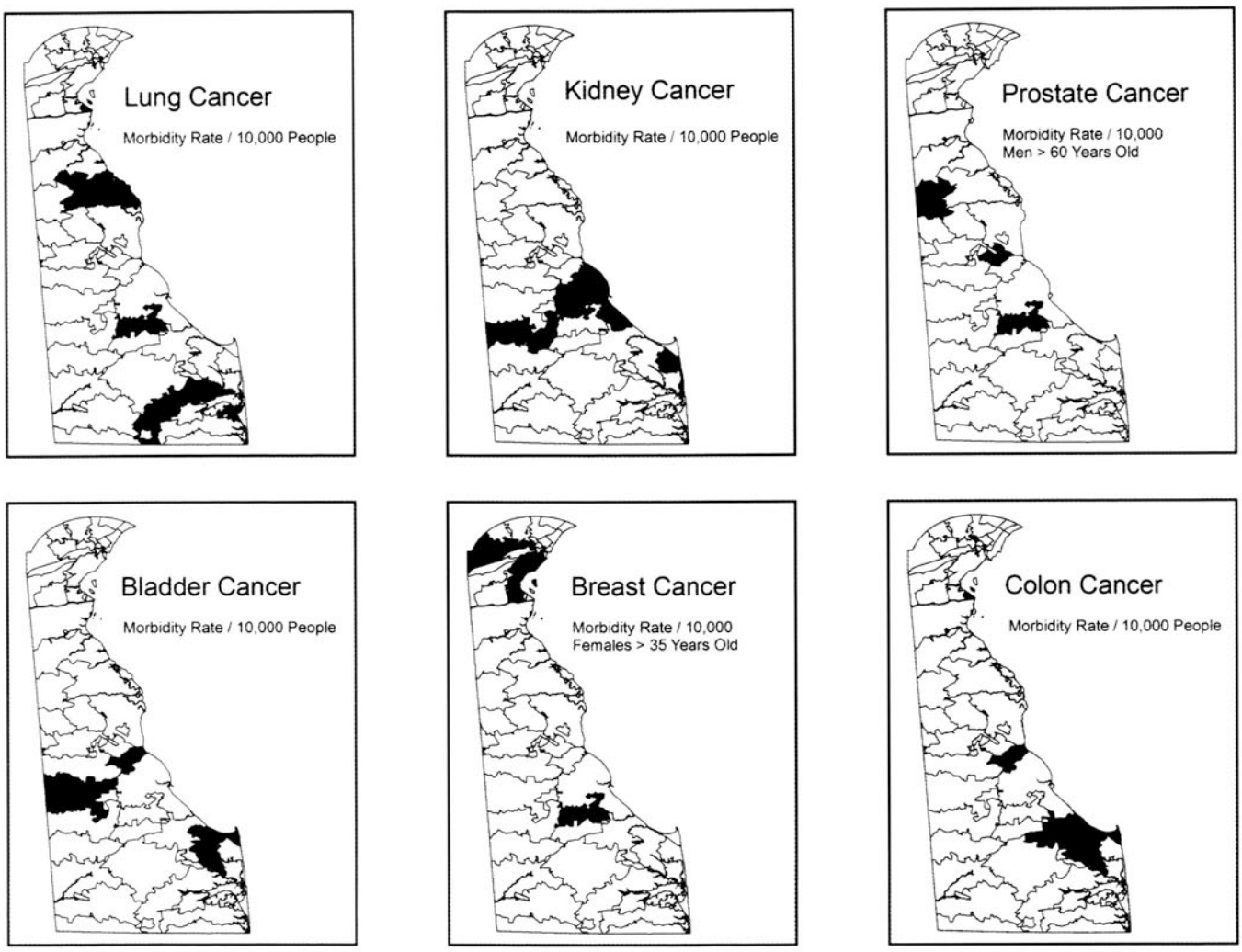

Figure 2. Cancer morbidity rates in Delaware. Cumulative total of cases, 1999–2002 by zip code. The dark shading identifies the top ten percent of zip codes with the highest incidence of cancer cases (original maps in color). (Data source: Delaware Division of Public Health.)

the criteria selected to support the recommendation. All the tasks have more than one correct answer and the students are judged on the quality of evidence assembled to support their position. Considerable additional learning can come from a debriefing when students compare their results and recommendations. Extensions for each activity are provided and the culmination of the unit is an assessment, designed in the format of questions posed on the Delaware State Testing Program (DSTP). Each assessment question requires students to apply in a quite different factual context the geographic principle that is the focus of each unit, thereby testing transference of what has been learned (Wiggins and McTighe 2005).

Two versions of the DG-HI have been developed. The teacher version reproduces what the students see but also contains detailed suggestions on how to teach the unit (Fig. 4). It begins with a description in text and visual illustrations about the geography standard and high school benchmark that is the focus of each unit. This background is necessary since many teachers lack a complete understanding of the standards. An introductory lesson then helps the teacher to introduce students to the geographic principle involved. The heart of the teacher version is the guide to student research that inserts extensive commentary within the student text, providing observations on what students should be looking for in their research, as well as completed charts that students use to enter and analyze data observations that help them to draw conclusions from a comparison of mapped data. Since many of the research tasks involve exploring causation, the teacher version urges the instructor at the appropriate moment to introduce students to differences between cause and association. Similarly, there are times when other geographic concepts are necessary, such as the types and behavior of diffusion

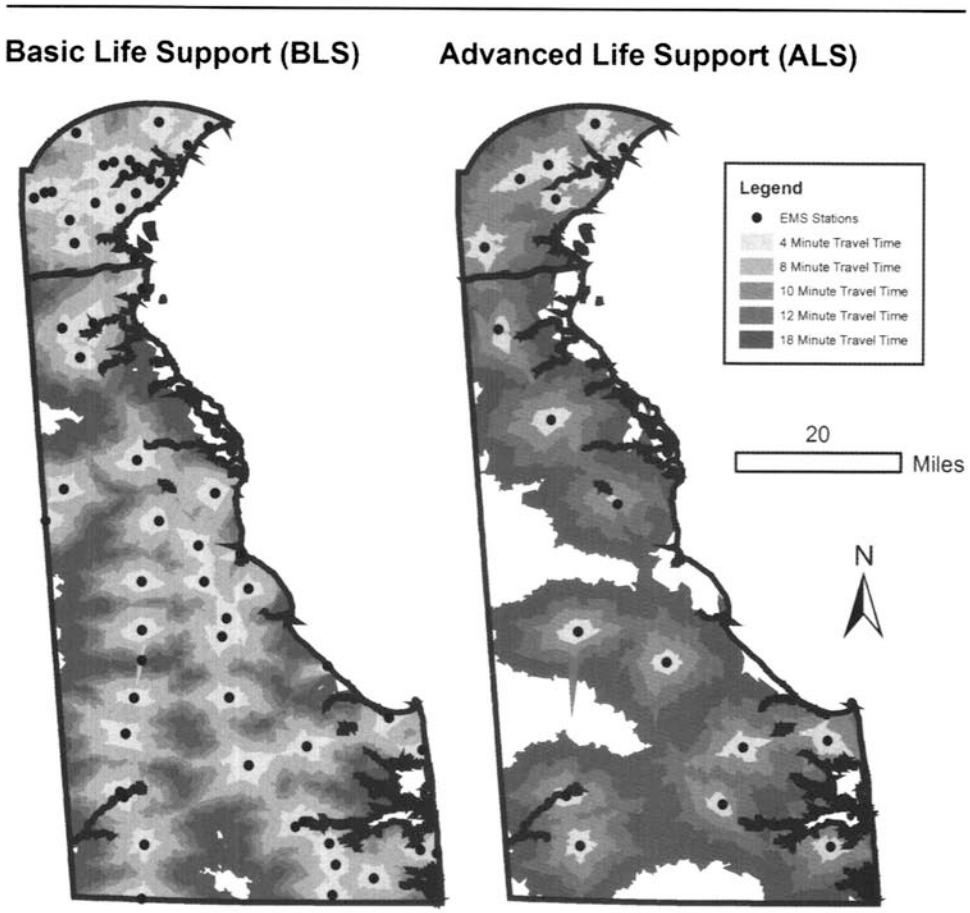

Figure 3. (a) Emergency medical service areas in Delaware by travel time from basic life support (BLS) stations (original map in color). (b) Emergency medical service areas in Delaware by travel time from advanced life support (ALS) stations (original maps in color). (*Source*: The Delaware Geography-Health Initiative CD-ROM [Rees *et al.* 2007]. Used with permission of the Delaware Geographic Alliance.)

waves or the different types of regions and boundaries. The teacher version indicates when and how these concepts can be introduced. Finally, it includes the student reading quiz and assessment, together with the answers. The student version is less complex, containing the scenario that describes the role students play, background reading to support the unit objectives, the research steps students should follow, and the needed cartographic and statistical data. The student reading quiz and assessment are not included to preserve testing security.

Acquiring and Analyzing Data

The Challenge of Finding Data

Obtaining data at a scale that provides meaningful geographic patterns for a small state proved a major challenge. Information on health and disease is closely guarded to preserve personal privacy and most health statistics are unavailable below the county level. With only three counties in Delaware, information needed to be available at the zip code or census tract level to identify any meaningful geographic patterns. Many months of discussion with public health officials were required to obtain such detailed data on cancer and HIV/AIDS and, when it was finally obtained from the state Division of Public Health, it was organized by zip codes and represented the number of patients discharged from area hospitals with a cancer diagnosis. A compromise was reached that no zip code with raw numbers of five or less would be provided for any given data area. This restriction did not prove a problem for analysis because our interest was with areas with the greatest incidence rather than the least. Another example of the difficulty of data acquisition was the need to obtain the location and number of units of all EMS services throughout the state. Despite the existence of a state Office of Emergency Services, there was apparently no single statewide count of EMS sites, so one had to be generated by calling every fire and ambulance service in Delaware and confirming the nature of the services provided.

GIS-Based or Interactive GIS?

Beyond acquiring information, a fundamental design issue was how GIS should be used. GIS involves both a computer software technology for creating spatial data images and a set of analytical techniques. But a practical question was whether to make the units fully interactive, requiring students to learn GIS software commands and manipulate data themselves. The question of GIS use in K–12 education has generated divergent opinion. Some argue that it stimulates geographic inquiry, insight, and enthusiasm among students (Audet and Ludwig 2000; Kerski 2003; Baker 2005; ESRI 2007). Others caution that the currently available GIS programs are all designed for professionals rather than for K–12 education (National Research Council 2006, 218–219). Learning GIS program commands, even when selectively introduced as in *Mapping Our World* (Malone, Palmer, and Voigt 2002), represents a steep learning curve that takes more time than the average social studies class provides. Additional difficulties faced in schools include computer equipment that is sometimes unavailable or has insufficient memory for GIS programs and school instructional technologists who are frequently uninformed

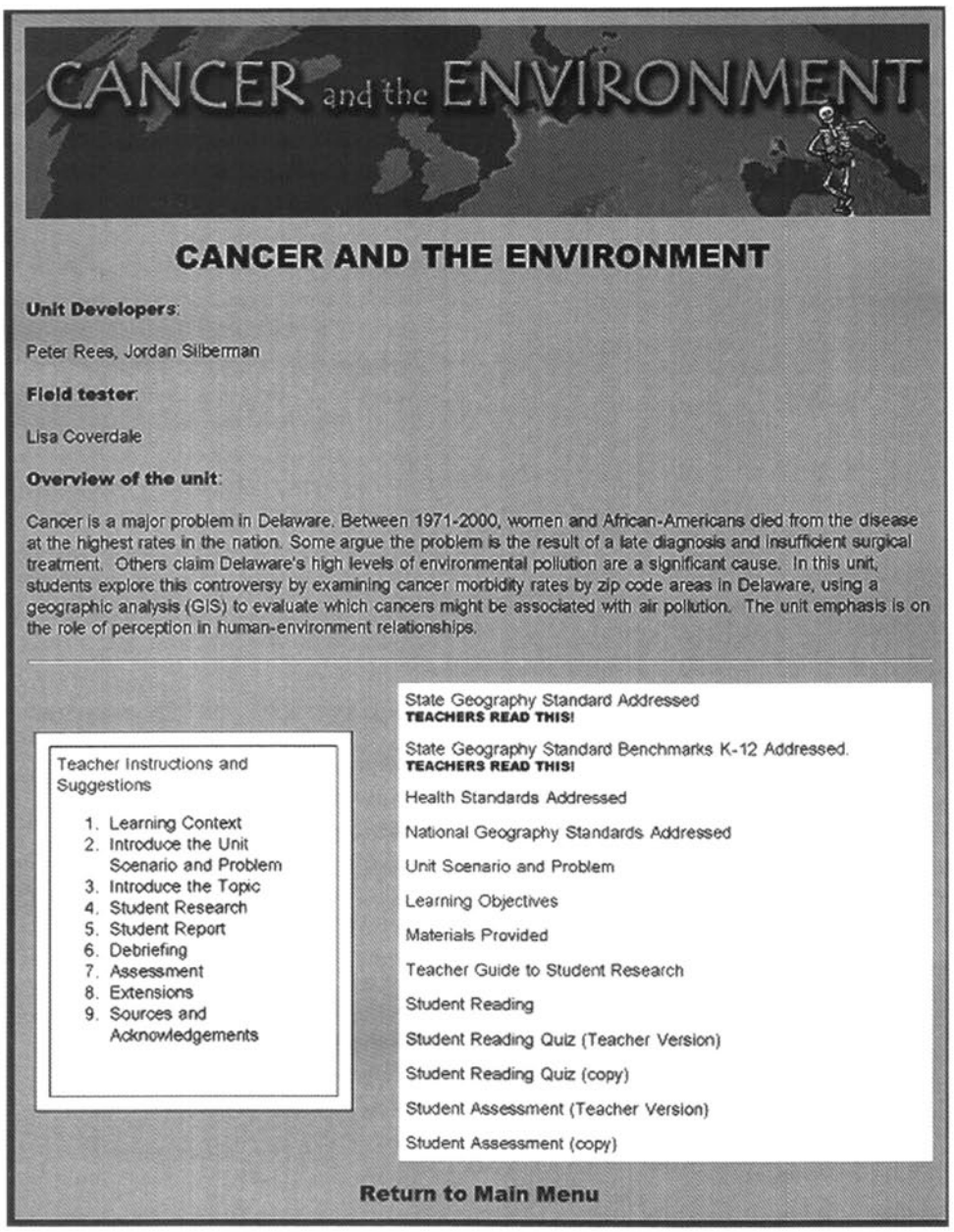

Figure 4. Sample of the unit menu, teacher's version. (*Source*: The Delaware Geography-Health Initiative CD-ROM [Rees *et al.* 2007]. Used with permission of the Delaware Geographic Alliance.)

or unsympathetic towards using computer equipment for GIS use (Meyer *et al.* 1999).

Recognizing these issues, Marsh, Golledge, and Battersby (2007) and Battersby, Golledge, and Marsh (2006) advocate development of a "Minimal GIS" that deemphasizes the role of technology learning in favor of teaching and learning geospatial concepts at grade-appropriate levels (Marsh, Golledge, and Battersby 2007, 696). The design of the DG-HI follows this approach, using a GIS-based program that gives preference to spatial analysis over technological knowledge. GIS software was used behind the scenes to create the maps that were the basis for analysis. Students were asked to select appropriate maps and other simple graphics among those presented to review, analyze, compare, and extract information. Misunderstandings and questions regarding these tasks, such as the difference between absolute and weighted values, were anticipated and addressed in the text of the unit with further explanations provided in the teacher version. Using an approach that offers well-thought out graphical maps allowed students to focus on the content and geographic principle of the lesson rather than learning software commands.

Addressing Analytical Techniques

The language of spatial analysis and methods of cartographic expression are specialized and it quickly became clear that students need to understand how the data were displayed before they could undertake research. Dividing and displaying mapped data in deciles and quintiles required explanation (Brewer and Pickle 2002). Data terminology also has a bearing on interpretation. For instance, cancer data are expressed as patients with cancer discharged from hospitals, requiring students to understand that the unit focused on cancer morbidity (the proportion of the population living with cancer), not mortality (deaths from cancer).

Prior to beginning the research part of each unit, students also need to be introduced to the importance of normalizing data for a given area, converting raw numbers to rates based on population so that data comparison was statistically valid. The infant mortality unit required a different design strategy as the number of infant deaths per census tract was often less than twenty, a sample size too small to be expressed statistically as a rate. In this case, the total births in a tract were multiplied by the overall state infant mortality rate to determine the number of infant deaths that would have occurred if the state rate had prevailed in every tract. Maps were then created identifying those tracts with numbers of

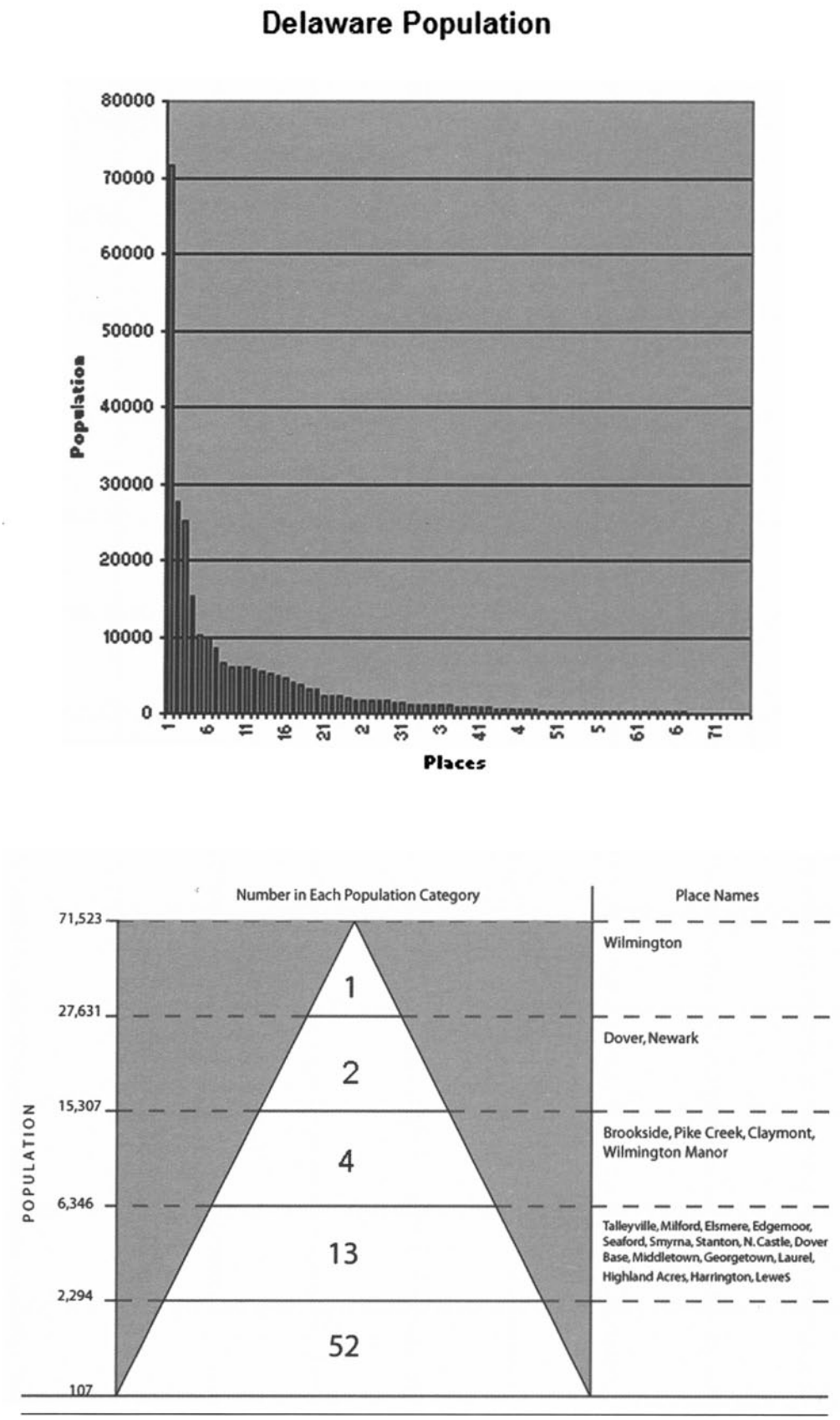

Figure 5. Graphic displays of Delaware's settlement hierarchy. (Data source: U.S. Census 2000.)

infant deaths that exceeded the number predicted by the state rate.

To answer many of the research questions posed in the units, students must compare mapped patterns. Spatial autocorrelation and regression coefficients are at the heart of spatial pattern data analysis, yet these statistical techniques are often well beyond the capability or interest of most high school students. Solving this problem involved developing simple graphical solutions. In the cancer unit, students are asked to record on a chart the five zip codes in the state displaying the highest rates of cancer and on the same chart the zip codes with a potential dependent variable such as the highest incidence of poverty. The visual association made on the chart is equivalent to the position of zip codes on a regression curve. Another graphical technique was used to convey the concept of hierarchy in the hospital unit (Fig. 5).

Theissen polygons used to determine regional boundaries of prenatal clinics in the infant mortality unit are explained by drawing a line equidistant between two settlements and using different colors to identify the areas closer to each settlement. Additional settlements can be added, repeating the steps for the first two but using different colors. A frame-by-frame illustration of the process was then converted to an animation. This graphical approach using color was found through trials with teachers and students to be far easier to comprehend than explanations that use tick marks on lines drawn between settlement points as used by Kuby, Harner, and Gober, (2004, 266).

Technical Design Issues

Design issues are a critical component of any computer-based curriculum and consume as much preparation time as assembling content. They are therefore discussed in some detail. A Web-based format was chosen for the DG-HI

to facilitate dissemination of the final product on a CD-ROM. Because schools have many different computer configurations and often use older computer models, the CD-ROM was designed on a Web-based platform that was thought to be the most adaptable presentation method for the units. Microsoft Frontpage was used for the Web design because it could be easily modified and updated in the future by an average Microsoft Office user. Hence, with limited knowledge, teachers could alter their copy of the CD-ROM to fit their own requirements or add new sources of data.

Maps were prepared and manipulated with ESRI's ArcGIS software suite. Care was taken to select a screen size for the Web template that could be displayed on most computer monitors, even though this decision restricted the use of the full monitor screen to display images. In many cases, reducing a map's size to fit on the standard screen obscured information the map was trying to convey, minimizing print text and legend symbols. In such instances, smaller maps presented within the standard screen size window were hyperlinked to a larger display so that students could use their browser to scroll through and read the map's content.

All units required students to compare maps and rather than having to switch back and forth between screen displays, a means of making side-by-side map comparison was needed. In the DG-HI, we used several methods to achieve this objective. One solution involved placing two maps in a series of HTML-based inline frames contained within a single parent page. Each map was then hyperlinked to a larger version, providing the user with the ability to enlarge any single map so that it could be seen in greater detail while still being able to compare the overall mapped pattern with other maps. In the case of the cancer maps, this strategy was further refined so that any of thirty-six map-pair combinations among the six types of cancer chosen can be displayed. Likewise, for the West Nile fever maps, small thumbnail versions of previously displayed maps were provided that could be enlarged when more detail was required.

Finally, particular attention was given to building redundancy into the navigation links, allowing users to move intuitively within the screen pages without first reading long instructions on how to use the program. And although the DG-HI is designed to be used solely on computer screens, it was recognized that paper copies would sometimes be needed, particularly for analysis worksheets and student assessments. These were provided in PDF files.

Field Testing, Assessment, and Review

Assessing any educational program involves formative and summative assessments. Typically, formative assessment involves piloting or field testing the program, making improvements and revisions based on feedback, and subsequent responses as the program is introduced and adopted by the educational community. Formative assessments are frequently subjective rather than quantitative. Summative assessments often occur after eighteen months to two years following implementation and require objective evaluations of the impact and educational worth of the program (McDavid and Hawthorn 2005). Since the DG-HI was only released in late 2007 and adoption began to accelerate in 2008, the assessment reported here is formative in nature.

Field testing of the cancer, infant mortality, and West Nile fever units was conducted by three Delaware high school teachers in a regular classroom setting. A total of 132 students each completed one of the units. A detailed twenty-one-question survey asked teachers to evaluate all aspects of the unit taught, ranging from the ease of navigation and organization of the CD-ROM and the clarity and appropriateness of teacher instructions to the pedagogical value of the unit, its attractiveness to students as a learning activity, and its relevance for achieving the state geography standard. One teacher provided copies of student responses to the end-of-unit assessment for West Nile fever and another made available copies of students' final research project assignment for the infant mortality unit.

Teachers made positive comments about the quality of the units and students were generally engaged by the topics (Table 2). They noted especially the interest in Delaware-centric problems and the timely nature of the issues examined. The commentary on how to guide student research and the results that might be expected, as well as the background information on the state geography standards and benchmarks, were considered to be positive. They reported that students found reading levels appropriate and that a number had learned new information about health and disease. In general, teachers found that the units were good representations of state geography standards. However, they remarked that students more used to writing reports based on reading found using maps as evidence to be unusual and difficult, requiring more teacher guidance to become more comfortable with this (geographic) method of analysis. Both these last two observations underscored central objectives of the DG-HI.

As expected, a number of valuable suggestions for improvement were generated by the field testing, ranging from minor cases of misspelling and links that did not work to more substantive suggestions. Among the latter were technical issues such as the need to add an auto run program to load the CD-ROM and organizational improvements in the clarity of research instructions. Responses resulted in the addition of blank outline maps of North America that included Mexico and Central America for the West Nile unit and a reworking of the explanation of Theissen polygons in the infant mortality unit. One of the more unexpected responses concerned the amount of data collection assembly required of research that some students equated with "busy work." Students clearly did not realize that much research involves often tedious and patient effort to tease out exciting conclusions. However, in response to this complaint, the research instructions in the units were modified to suggest that data assembly and map comparison tasks be divided among students who could then pool their individual results to produce a collective result.

Table 2. Results from Pilot Testing Questionnaire.

Questions	Teacher 1: West Nile fever unit	Teacher 2: Cancer unit	Teacher 3: Infant Mortality unit
Navigating the CD:			
1. Ease of navigation?	Yes, but include autorun.exe; hard to find info. for research report.	Yes, but many steps needed to open the unit.	Complicated to load.
2. Was student CD used?	Yes.	Yes; colon cancer map didn't display.	No. I had the lesson placed on computers in advance.
3. Computer environment?	Networked classroom, two students/computer.	Networked computers in Library lab. No format problems.	Twenty computers in Library lab.
4. All CD screen shots legible?	Yes; make words of project overview larger; need better text/background color contrast.	Students had difficulty distinguishing different colors on map displays, and some zip code areas were very small.	Yes.
CD Organization:			
5. Opinion of the topical organization of unit?	Easy and well done. Used main menu screen to navigate.	Well organized. Mostly used main menu screen to navigate.	Very clear.
6. Time needed to become familiar with teaching the unit?	Six hours	1.5 hours	1.5 hours
7. Helpfulness of section describing state standard and benchmark?	Very. Learned to discuss diffusion in new ways.	I glanced at them.	Very detailed with many examples.
8. Opinion of unit scenario?	Timely. No improvements needed.	Liked that it was based in Delaware.	Scenario is "catchy" and attractive to high school students. Some parts too wordy with too many maps.
9. Value of teaching strategies for introducing state standard and benchmark?	Very good. Idea of "S" curve diffusion waves hard for students to understand.	Added time to review what had been accomplished each day.	Maps in red and blue a problem b/c no access to a color printer; Thiessen polygons hard to explain and confusing explanation.
10. Ease and student interest in background reading?	Reading level; students found material interesting and new.	Students read together in small groups.	Used as warm-up since info. Covered in a previous class.
11. Student performance on reading quiz?	They did well. Some would have preferred to answer questions on the computer; one group used questions as they read to reinforce ideas.	Used the quiz as a reading guide. Questions helped reinforce info.	Used not as a quiz but to aid reading comprehension.
12. Student responses to research steps?	Research interesting, flow good; students had fun discussing results with partners. Some had difficulty using maps to support conclusions in final report.	Students had early interest but later found data collection "busy work." Suggest breaking work up into groups.	I created a research log to keep students organized. Honors students OK but for lower level students, too many maps to keep track of.
12. Mechanics of student research (worksheets, research notebook)?	Students worked individually or in pairs; they kept written notes; I printed a U.S. map for their report but a map of North America (incl. Canada and Mexico) also needed.	Students used the worksheets and a notebook to write responses.	Used paper copies and research notebook.

(Continued on next page)

13. Value of teacher guide to student research steps?	Very helpful. Less strong students needed help with map interpretation.	Very helpful. A completed sample copy of entire project might have helped.	Sometimes more confusing than helpful.
14. Quality of final student product?	Good. Some created a new map. Not clear that they could consider Canada and Mexico beyond the U.S.	Some took the work seriously; others produced a generic interpretation.	Perhaps students could be asked to created a new map with polygon boundaries around the new sites.
15. Ease of student interpretation of maps?	Students used to reading, then writing a report. Some found it difficult to do research using maps.	Color codes on maps sometimes difficult for students to distinguish.	Maps were good but overwhelming for many students.
Assessment:			
16. Student performance on assessment?	Results: 22 scored a two, 8 a one, and three a zero. Teacher version should identify crime wave moving southeasterly, not southwesterly.	Students generally did well—it was understandable.	No assessment on the disc so I created my own.
17. Application of assessment to state benchmark?	Great way to judge student mastery. Afterwards, we returned and reviewed types of diffusion.	Useful and good practice for the state test.	No response
18. How well did students understand transfer task?	Understood well—no changes needed.	Required a few additional explanations.	Students could see different factors affecting infant mortality; would be good to include global comparisons.
Overall:			
19. Did the unit achieve its purpose?	Yes—it was very well done.	Yes.	No, because I felt rushed and didn't have the class time to give this lesson what it deserved.
20. Will you teach additional units in future?	Yes. May consider joint teaching a unit with a health teacher.	Yes, but I teach civics/economics and geography doesn't always fit in.	Yes, with modifications b/c lessons are too Delaware-centric and I teach world geography.
21. Additional open-ended comments/reactions?	Unit exceptionally well thought-out.	Some typos—Rehoboth and governor misspelled.	I will recommend use to other teachers.

Table 3. Assessment of Student Performance.

Unit	Results % responses
Infant Mortality Unit: Attribute Assessed	(N = 71)
Demonstrates understanding of concepts of accessibility and changing regional boundaries	52
Correctly identifies from mapped data census tracts with highest infant mortality rates	77
Suggests new locations for prenatal clinics	66
Supports letter to governor with research evidence from unit	48
West Nile Fever Unit: Assessment Activity	(N = 34)
Student identifies correct location and gives a reason based on the behavior of diffusion waves	52
Student identifies correct location but gives no reason related to diffusion theory	45
Student identifies incorrect area and gives no reason	3

Results of student work were evaluated on the quality of the research assignment and the assessment modeled on the Delaware State Testing Program (Table 3). In the infant mortality unit, where students were asked to conclude their research by writing a sample letter to Delaware's governor, recommending new sites for prenatal clinics, they performed well on the tangible tasks of identifying where existing levels of service were poor and where new sites should be chosen. They did less well in demonstrating an understanding of the concept of accessibility and the significance of changing regional boundaries, as well as using research findings to support their arguments for new service locations. The conclusion from these initial results emphasizes the importance of teacher reinforcement of the geographic principles being demonstrated in each unit.

Students completing the West Nile fever unit were presented with an assessment based on the Delaware State Testing Program format that required them to transfer an understanding of the concept of diffusion to an unfamiliar situation, in this case the diffusion of crime in a hypothetical city. Presented with two sequential maps of the spread of crime over two years, students were asked to evaluate the expected direction of the crime wave, based on diffusion concepts they had learned in the diffusion of West Nile fever. Fifty-two percent of respondents were able to articulate diffusion concepts they had learned from the unit to apply to an unfamiliar case of crime diffusion while 45 percent correctly identified the location of the diffusion wave without adequately explaining its cause.

Conclusions

The DG-HI was developed in response to a lack of standards-specific curriculum materials in geography. Each unit was designed to illustrate one of the Delaware state geography standards, focused on health issues, a topic that resonates with the general public in Delaware. A GIS-based platform was used to encourage teachers and students to experience the value of spatial analysis in addressing societal questions. Constructing Web-based lessons is a complex and time-consuming process. The DG-HI rests on a platform of over 900 files of maps, data, and text. Nonetheless, it is a tempting enterprise to undertake because of positive teacher and student reception such a project receives, based on preliminary formative assessment. Within months of the availability of the beta version, Delaware's state department of education requested that the DG-HI units be incorporated in the model state social studies curriculum it is developing. Subsequently, as part of the state's continuing response to No Child Left Behind legislation, Delaware school districts have been charged to develop curricula in social studies that incorporate performance and transfer tasks. The DG-HI materials are being offered as examples of the type of learning materials districts must either develop or adopt. Finally, the state science advisor has proposed that the cancer unit be taught in conjunction with state science units to demonstrate the integration of science and social studies teaching and learning at the high school level. As such, the DG-HI project promises to help break down the barrier that keeps geography from making a stronger showing in the high school curriculum.

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Note

Individual copies of the Delaware Geography-Health Initiative project are available at no charge by contacting the author at rees@udel.edu.

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