



The Virtual Vee Map

A Template for Internet Inquiry

By Margaret Coffman and Leela Riggs

The Virtual Vee Map proved successful in promoting student learning in the areas of inquiry and data analysis using resources and data available on the internet. A postsurvey found that a majority of students enjoyed collecting and interpreting the data to find an answer to their own inquiry question.

With all of the information available on the internet, it can be a great resource to help bolster students' content knowledge. But what about using it to improve their higher-level thinking skills? If you consider the process skills that are necessary to conduct a strong inquiry project, you may come up with several—each challenging the student at a different level of thinking (see Table 1).

If you reflect upon the range of thinking that students are expected to exhibit during an inquiry project, it becomes necessary to ensure that your

students are armed with these skills in order for them to succeed with the project at hand. We have found that our students can successfully design and conduct a controlled experiment and collect reasonable data; however, their skills decline precipitously when asked to summarize and interpret their data and to place results in a larger context. In general, students often struggle in reorganizing the concepts and data involved in an inquiry project; without these skills at the comprehension level, it is difficult for them to progress to the higher levels of thinking (analysis, synthesis, and evaluation) needed

to complete the project (Takayama 1993). Others have also reported that many students need practice in data analysis and interpretation (Harwood 2004). Overall, we found that most of our students were successful in the skills at the knowledge and comprehension levels, and that some were able to perform skills at the application level, but most were unable to analyze and evaluate the implications of their project outcomes. Therefore, we felt that it was important to focus on the skills at the higher thinking levels.

Our students are elementary preservice teachers, with the majority being nonscience majors. The elementary science methods course focuses on the best practices for teaching science, but restricts its content to life science. (These students are also required to take courses in physical science and Earth science.) Each semester, there are approximately 250 preservice teachers enrolled in the elementary life science methods course. The course is a hybrid—students meet in class three hours a week and are expected to spend approximately two hours a week completing online assignments using the WebCT platform. Due to its hybrid nature, course objectives include increasing confidence in using technology and online resources. Our course objectives also include gaining confidence and practice in inquiry as one method for teaching science. Overall, we strive for our students to complete our course armed with the knowledge and skill levels to successfully implement inquiry projects and activities in their own elementary classrooms.

Because our students were capable of designing a sound experiment, we decided to focus on the latter half of an inquiry project, those steps that required higher levels of thinking. Instead of concocting data sets for students to work with, we turned to the internet. Students were already logged on each week, therefore it seemed like a natural extension to ask students to work with online data and submit their projects online through the Web CT site. Information on the internet has long been used by instructors to

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supplement students' content knowledge and by students in writing term papers. However, there is a plethora of information on the internet that does not come neatly organized in clickable outlines. This information is such that

students cannot simply cut and paste and forget to reference. Real-world data collected by working scientists are available from several reliable sources, including many federal and state government agencies.

We searched the internet for data sets that we felt our students would be able to utilize and decided on eight websites (Table 2) that emphasized real-world connections by offering data concerned with the students' environment (e.g., water and air quality) or with activities that had been performed during face-to-face class time (e.g., inheritable traits). Many of the websites focused on data collected in Michigan (our home state) because our hope was to spark student interest in the local community or environment. In fact, many students did want to investigate the air and water quality in the areas where they lived or vacationed. You may find similar data by visiting the comparable sites for your own state. Alternatively, you may find data that support or relate to your specific science discipline.

TABLE 1

Process skills and associated thinking levels involved in conducting an inquiry project.

Process skill	Thinking level (Bloom's)
Observation	Knowledge
Predicting	Comprehension
Hypothesizing	Application
Identifying and controlling variables	Application
Collecting data	Comprehension
Interpreting data	Analysis
Inferring	Analysis
Making tables and graphs	Analysis
Communicating	Analysis, synthesis, evaluation

TABLE 2

Web-based inquiry sites. Students were directed to examine the data provided at these sites and use one or more sites to conduct their inquiry project.

Website host and address	Website description	Example student inquiry question given by instructor
Michigan Department of Environmental Quality (MI DEQ), Michigan Air Quality Index www.deq.state.mi.us/aqi	Provides data concerning the overall air quality at various locations around Michigan.	Does air quality differ with the days of the week?
Michigan Department of Environmental Quality (MI DEQ), Michigan Particulate Concentrations www.deq.state.mi.us/aqi/pm.asp	Provides data concerning the particulate matter in the air for various locations around Michigan.	How do the average air-particulate-matter readings vary over the course of 24 hours?
Michigan Department of Environmental Quality (MI DEQ) Michigan Beach Monitoring System www.deq.state.mi.us/beach/public/default.aspx	Provides data concerning the <i>E. coli</i> bacteria count at public beaches in different counties around Michigan.	How do the <i>E. coli</i> counts compare between the Upper Peninsula beaches and beaches in southeast Michigan?
Down the Drain http://k12science2.org/curriculum/drainproj (Bodzin and Cates 2003)	Provides data concerning water use by participating schools from around the world.	How does water usage differ between midwestern and southwestern states?
Human Genetics: A worldwide search for the dominant trait http://k12science.org/curriculum/genproj	Provides data collected from real people around the world regarding seven human traits: ear lobes, forelock color, dimples, thumb shape, pinky shape, mid-digit hair, and colorblindness.	How does the distribution of traits compare between New Jersey and Texas?
National Biological Information Infrastructure Invasive Species Information http://invasivespecies.nbii.gov/index.html	Provides information about invasive species throughout the United States.	How does the habitat of the native range compare to the invaded habitats for six species (nutria, fire ants, zebra mussels, African bees, Asian clams, and brown tree snakes)?
River Rouge Bird Banding Data www.umd.umich.edu/dept/rouge_river/banding.html	Provides information concerning various species of birds that have been banded in the River Rouge area of Michigan since 1992.	Are the birds that are most commonly banded also the birds most commonly recovered?
Michigan Natural Feature Inventory, Michigan State University http://web4.msue.msu.edu/mnfi	Provides information concerning many of the different species that call Michigan home, including their status (endangered, threatened).	How does the rank of listed birds from Michigan compare with their global ranking?

FIGURE 1**Virtual Vee Map template.**

Students completed this template and then attached their finished project to the WebCT assignment page.

Inquiry Question:	
<i>Conceptual (Knowing)</i> Word List: Thinking Map or Graphic Organizer: Hypothesis: Websites used during Inquiry:	<i>Methodological (Doing)</i> Conclusion: Data:

Once we had found these websites, the next challenge was designing a template for students to use in reporting their inquiry project. With 250 projects to grade, we felt that the template had to be concise but still allow students the freedom to express their strengths in data analysis and interpretation. A colleague introduced us to the Vee Map, and we felt that it would make the perfect template for our internet inquiry project.

The Vee Map

The Vee Map, also called the Vee diagram or Vee heuristic, was first introduced in 1977 by Gowin (Novak and Gowin 1984) and has since been used as a template for students to record course laboratory activities (Roehrig, Luft, and Edwards 2001; Roth 1990), a tool to aid students in deciphering primary scientific literature (Gurley-Dilger 1992), and even as an evaluation record for interviews associated with performance assessments (Novak and Gowin 1984).

The overall purpose of the Vee Map is to highlight the interrelationship of concepts and methods that interact during knowledge construction

or analysis. Students begin by describing the known concepts that support their investigation. Next, they record the events that occur during their investigation and analyze how to summarize this new information. Finally, students must interpret these new events in light of the known concepts.

The main function of the Vee Map is to promote learning through student investigation. It seemed that we had been given the perfect tool. Students could investigate the data sets, decided on an inquiry question, tease out the relevant data from the larger set, and focus on summarizing and interpreting their findings in light of their inquiry question. In all of the examples we had encountered, such as those described above, the Vee Map had proven useful in hands-on or face-to-face science settings. Due to our internet setting, however, the Vee Map was in need of some revision in order to focus on the knowledge and events that our students would be encountering. We began with the Versatile Vee Map designed by Roehrig, Luft, and Edwards (2001) and modified it to fit a virtual environment rather than a physical one.

The Virtual Vee Map Inquiry Project

The Virtual Vee Map Inquiry Project was designed with two main objectives in mind:

1. To strengthen student inquiry skills at the analysis, synthesis, and evaluation levels.
2. To introduce students to internet resources that parallel class content and may be used for inquiry projects with their future students.

All of the information that students needed to complete their Virtual Vee Map was posted in a learning module on the course WebCT site. Students were first asked to read “Versatile Vee Maps” by Roehrig, Luft, and Edwards (2001). Students were then directed to read the descriptions of the eight recommended web-based inquiry (WBI) sites (Table 2) document and choose one or more to investigate. Directions on how to navigate to the data on each site were given in the WBI sites document. In addition, students were given two sample questions to guide them in designing an acceptable inquiry question. Students were allowed to use a website not designated on the WBI sites document if it was approved prior to the start of their project.

A Virtual Vee Map template (Figure 1) was provided for students to download, complete, and submit by attaching it to an assignment page in the WebCT learning module. In addition, we provided students with a completed sample Virtual Vee Map and a rubric (Figure 2) to help them in completing their own project and achieving the grade that they desired.

After choosing and investigating a website, students were asked to design a question that could be answered using the available data. Over 98% of our students succeeded in this task. To assist them in researching their chosen topic, students were directed to generate a list of 6–10 words that they could use to search the internet. Information gained from an internet search using the word list could help students throughout the project: from

FIGURE 2

The Virtual Vee Map rubric.

Inquiry question

What do I want to find out? What do I need to know? Refer to the List of Approved Websites for example questions.

- 8 Inquiry question is clearly stated and directly relates to the data from the chosen website. Inquiry question requires analysis of more than one subset of data from the chosen website in order to be answered (for example, a comparison.) Inquiry question may also require data from additional websites in order to be answered.
- 6 Inquiry question is clearly stated and directly relates to the data from the chosen website. Inquiry question requires analysis of more than one subset of data from the chosen website in order to be answered (for example, a comparison.)
- 4 Inquiry question is clearly stated and directly relates to the data from the chosen website.
- 2 An inquiry question is stated but only marginally related to the chosen website.
- 0 An inquiry question may be stated but is not clear or not related to the chosen website, or no attempt was made to complete the section.

Word list

What do I know? What words should I use to search and find more information? List 6-10 words/phrases that you will use to search the internet for background or additional information that will help you design a question, conduct your inquiry, and draw your conclusions.

- 8 Thorough list of relevant key words encompassing the inquiry topic.
- 6 Relevant key words describing the inquiry topic.
- 4 Associated words listed, but some key words are missing.
- 2 Limited list of associated key words.
- 0 Sparse list or no attempt made to complete the section.

Graphic Organizer/Thinking Map (GO/TM)

How are these ideas connected? Design a thinking map or graphic organizer that displays the relationship among the words from your word list. Save your GO/TM as a .doc file.

- 12 Almost all words in the word list are used. Words are organized correctly and the GO/TM addresses the inquiry topic. GO/TM is appropriate for the type of organization displayed (e.g., flow map for organizing ideas in a sequence, bubble map for organizing descriptors around a central idea). The GO/TM includes a complex organization of the key words (e.g., a combination of two or more thinking maps: flow map + bubble map).
- 9 Most words from the word list are used and linked accurately. The GO/TM addresses the inquiry topic, and an attempt is made to display a complex or hierarchical organization of the key words (e.g., brace map, tree map). The GO/TM is appropriate for the type of organization displayed (e.g., flow map for organizing ideas in a sequence, bubble map for organizing descriptors around a central idea).

- 6 Some words are used from the word list. The GO/TM needs additional clarification. There may or may not be an attempt at a complex organization of the key words.
- 3 The GO/TM does not directly address the inquiry topic. Some words are used from the word list, and the organization is simple (e.g., bubble map).
- 0 Limited GO/TM with few words, or no attempt was made to complete the section.

Hypothesis

What statement do you think the data from your chosen website will support?

- 8 The hypothesis is presented as an IF...THEN statement. The hypothesis is testable and falsifiable by the data provided at the chosen website(s). The hypothesis is clearly stated and directly relates to the inquiry question. The hypothesis reflects a clear understanding of the inquiry topic.
- 6 The hypothesis is presented as an IF...THEN statement. The hypothesis is testable and falsifiable by the data provided at the chosen website(s). The hypothesis is clearly stated and addresses the inquiry question.
- 4 The hypothesis is presented as an IF...THEN statement. The hypothesis is clearly stated and addresses the inquiry question.
- 2 The hypothesis may or may not be presented as an IF...THEN statement. The hypothesis may lack clarity or a clear connection to the inquiry topic.
- 0 A hypothesis may be stated but is not clear or not related to the chosen website, or no attempt was made to complete the section.

Websites

Where can I find an answer to my question? List the website you chose from the WBI Approved List, plus any websites you consulted while compiling your word list, gathering supporting data (weather, population), or writing your conclusion.

- 8 Three or more websites were consulted in completing the inquiry project (used for additional data or background information). Each of the websites, including the chosen Web-Based Inquiry (WBI) site, is listed by title, http:// address, and last date visited.
- 6 Two or more websites were consulted in completing the inquiry project. Each of the websites, including the chosen WBI site, is listed by title, http:// address, and last date visited.
- 4 The chosen WBI site is listed by title, http:// address, and last date visited.
- 2 The chosen WBI site is listed without proper documentation.
- 0 An unapproved website is listed or no attempt was made to complete the section.

Data and analysis

What did I find out?

You must display your summarized data in a table, chart, or graph of your own design.

- 16 Well-organized data table or graph, includes all data relevant to the inquiry question. Data is

accurate, units are present, and table headings or graph axes are labeled. The analysis (average, percent) is correct and complete.

- 12 The data table or graph is complete with units, headings, and axes labeled. Data is accurate and relevant to the inquiry question. The analysis is complete.
- 8 Data table or graph is complete with units, headings, and axes labeled, but additional data should have been collected and recorded. The analysis of data is acceptable and may or may not relate to the inquiry question.
- 4 Minimal data table or graph, lacking some relevant data. Data may or may not be accurate. Analysis is incomplete or inappropriate to answer the inquiry question.
- 0 Minimal data table or graph, incomplete analysis, or several problems with data collection and analysis, or no attempt was made to complete the section.

Conclusion

What did I learn? What do my results mean? How does my inquiry relate to the larger context of the real world?

- 20 Conclusion is written in five complete sentences, each addressing one of the following points:
 - a. Restate your hypothesis. Was your hypothesis supported or refuted?
 - b. Summarize important data or results.
 - c. Suggest implications of your findings. What does this mean on a larger scale?
 - d. State an additional unanswered question worthy of further investigation.
 - e. Present limitations/errors to your inquiry.
- Each sentence thoroughly addresses the outlined points and directly incorporates all relevant background information and data relating to the analysis of the inquiry topic. The understanding of the inquiry topic is advanced.
- 15 Conclusion is written in five complete sentences, each addressing one of the points above. Each sentence adequately addresses the outlined points and incorporates some background information and data relating to the inquiry topic.
- 10 Conclusion is written in five complete sentences, each addressing one of the points above. An attempt is made to incorporate background information.
- 5 Conclusion is limited and may not address each of the five points above. An attempt is made to incorporate data or background information.
- 0 Conclusion is limited and does not address each of the five points above. Conclusion does not relate to the inquiry topic, or no attempt was made to complete the section.

10 points for successful attachment to the Submission Page

10 points for completing the post-survey immediately following your submission

100 points total

TABLE 3

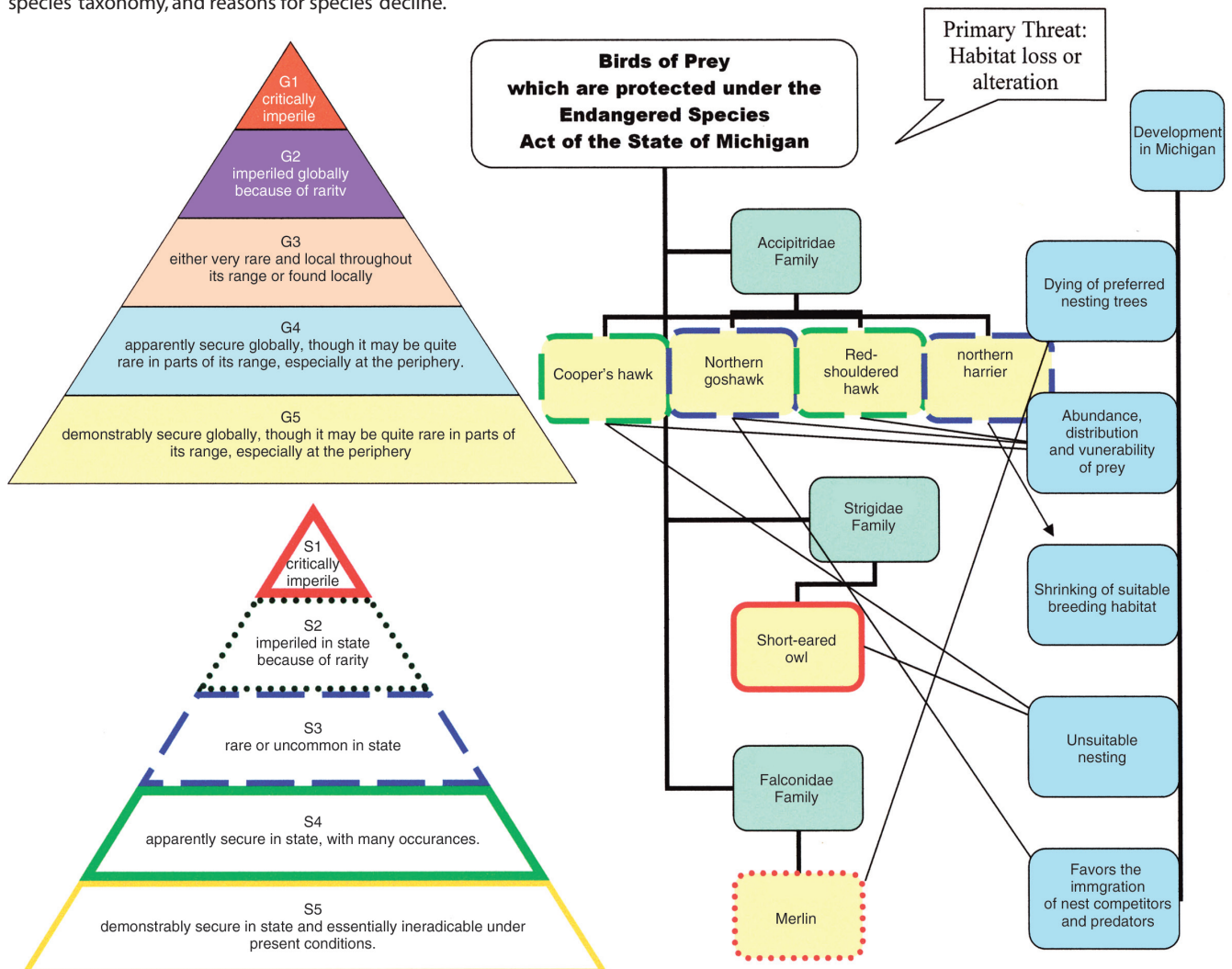
Percent of students responding positively and average student response to each survey question ($n = 123$).

Survey question	% Positive response (6–10)	Average response
I liked being able to choose a website and investigate a question that interested me. (1 = strongly disagree, 10 = strongly agree)	80%	6.5
I liked figuring out for myself what data I should collect from the website(s). (1 = strongly disagree, 10 = strongly agree)	80%	7.4
I liked designing my own data tables or graphs instead of filling out pre-made tables or graphs. (1 = strongly disagree, 10 = strongly agree)	69%	7.2
What is the likelihood that you would have your students complete a Virtual Vee Map Project like the one you completed? (1 = not likely at all, 10 = highly likely)	62%	6.9
What is the likelihood that you would have your students complete another type of internet inquiry project? (1 = not likely at all, 10 = highly likely)	93%	5.9
On a scale of 1 (lowest) to 10 (highest), how would you rate the Virtual Vee Map Project as a useful assignment in your professional development?	73%	7.8

FIGURE 3

Example of a student graphic organizer that displays developed skill at the comprehension level.

The student incorporated four sets of information: species' global abundance, species' U.S. abundance, species' taxonomy, and reasons for species' decline.



generating a question to formulating a hypothesis to writing a conclusion. Only a few students (2%), who listed less than six words, lost points on the word list. To further conceptualize their topic, students were asked to construct a Thinking Map (www.thinkingmaps.com) or graphic organizer that appropriately described the relationship among the word list terms. Bubble maps and flow maps were the most popular style of graphic organizer; however, some students (~5%) were able to reorganize their thoughts in a way that implied a thorough comprehension of their topic (Figure 3). Approximately 10% of students were penalized for not submitting a graphic organizer. These students usually experienced technical difficulties in developing their graphic organizer or in pasting it into the template.

At this point in the Virtual Vee Map, students confirmed their inquiry question, and then designed a hypothesis that addressed their question and could be tested by the data available on the website. Most students designed a suitable hypothesis; however, approximately 10% of students were penalized for not using the required if...then format. The data website and any other websites that students consulted were recorded as events at the bottom point of the Virtual Vee Map. In the laboratory classroom, events constitute a summary of the experimental procedure; however, for the Virtual Vee Map,

students consulted internet information to find answers to their questions. Of course, the veracity of the website can pose an issue when students are asked to explore internet information. In order to limit incorrect information, we chose websites from reliable sources (e.g., government, university, and world-renowned newspaper sites) and required students to clear an alternative website with us prior to designing their Virtual Vee Map. Most students (85%) correctly referenced their websites and received full credit.

Moving around the point and into the methodological side of the Virtual Vee Map, students displayed the results of their inquiry by recording the specific data from the website data set that addressed their hypothesis. The data was summarized (e.g., averages or totals) and organized into a table or graph form. Most students used a table to reorganize their data. However, a few students designed bar graphs or pie charts to display their results (Figure 4). Each of these students received full credit on their Virtual Vee Map assignment, reinforcing the observation that manipulation and reorganization of data can help students to reach even higher levels of thinking. Only a handful of students (2%) did not supply an adequate amount of data to support or refute their hypothesis.

Finally, students completed their inquiry by writing a conclusion. In

the past, we have discovered that students often fall short in the analysis of their inquiry. Usual conclusions consist of a restatement of the results and whether the hypothesis was supported or refuted but do not include any analysis as to the meaning of the results in a larger context. To assist students in reaching these higher levels of thinking, we prescribed a conclusion consisting of five thoughts, each to be expressed in one to two sentences (modified from Rutherford, Forthcoming):

1. Restate your hypothesis. Was your hypothesis supported or refuted?
2. Summarize important data or results.
3. Suggest implications of your findings. What do your results mean on a larger scale?
4. State an additional unanswered question worthy of further investigation.
5. Present limitations to or errors in your inquiry.

We observed that most students were able to answer these questions and display application and analysis levels of thinking concerning their topic (Figure 5). However, approximately 15% of students lost credit on their conclusion because they did not answer questions 4 or 5. These questions direct students to analyze and evaluate their project, the two highest levels of thinking.

FIGURE 4

Although most students displayed their data in a table, these students chose to further manipulate their data into a graph.

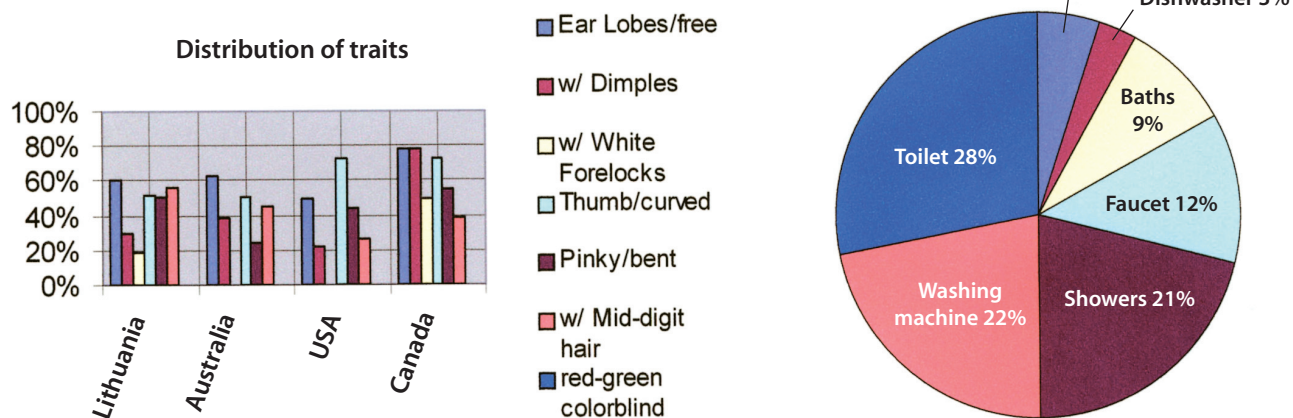
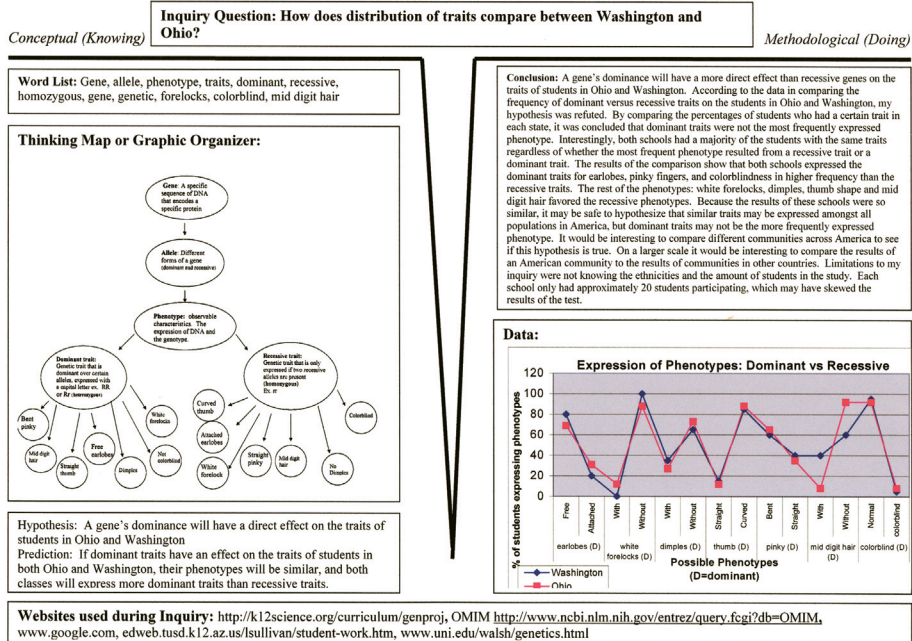


FIGURE 5

Virtual Vee Map for web-based inquiry project.

The Virtual Vee Map engages students in higher levels of thinking, such as reorganization of ideas and data analysis and interpretation.



Conclusion

Overall, we feel that the Virtual Vee Map assignment was successful in meeting both our course objectives and the objectives specific to the assignment. Over two semesters, 92% of students scored a B– or better on the assignment, with an average of 74% of students earning an A– or better. In addition, out of 463 students, only 10 were unable to properly attach their project to the WebCT submission page. Therefore, we feel that this project helped strengthen students' higher-level inquiry skills and technology skills.

We were also pleased with the amount of time the project took for students to complete and for the graduate assistant to grade. The time that students spent browsing the websites may have varied from one to five hours; however, once students chose a website, the project took an average of two to four hours to complete. This completion time is affected, in part, by the students' technological savvy in designing tables or graphs and graphic organizers as well as using the electronic template file. Due to the large enrollment in this course, this

assignment had to be straightforward to grade. For strong student work, Virtual Vee Maps were graded in 10 to 15 minutes. A poor Virtual Vee Map could take up to 20 minutes to grade. The comments made by the graduate assistant were kept brief and directed students to the rubric for a more detailed explanation of their grade.

Following submission of their project, students enrolled in the spring semester completed a survey. In general, over one-half of students responded positively (score of 6 to 10) to each of the survey questions (Table 3). Our students were more positive concerning data collection (80%) and presentation (69%) in the virtual environment than those surveyed by Lebowtiz (1998) in the more traditional laboratory setting: 37.8% and 57.8%, respectively. Removing the physical act of performing the experiment and allowing students to concentrate only on the meaning of the data may have helped them to achieve higher levels of thinking and therefore have a more positive perception of the experience.

Because our students are pre-service elementary teachers, we

were also interested in their opinion of using the internet to conduct inquiry projects with their future students. While 62% of the preservice teachers felt likely to engage their students in the Virtual Vee Map Project, an overwhelming 93% of preservice teachers felt that they would use the internet for a student-directed inquiry project. This difference in opinion may be due to the suitability of the Virtual Vee Map to upper- rather than lower-elementary grades.

Although our survey questions showed that students generally liked the template and student-directed nature of the project, we did receive some free-response comments to the contrary. Students expressed displeasure based on technical issues such as creating tables or graphs, graphic organizers, and using the electronic template form. In addition, some students felt that the project took a "long time" and that they had difficulty designing a question to get started.

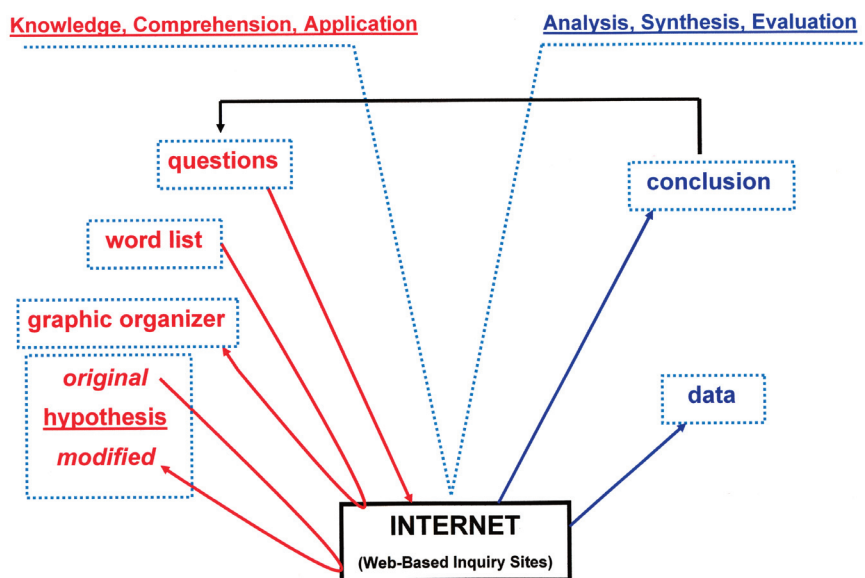
Overall, however, we received some great comments in support of the Virtual Vee Map Project. A majority of students liked the different components that made up the project. Comments included:

- ♦ "I liked the self-determined question, internet research, and the layout and design of the Vee Map. I think it is an excellent part of the science curriculum, and it can even be adopted by other core subject areas with some modifications in the design."
- ♦ "I liked the independent creativity that was allowed. It definitely enabled me to be much more engaged. I am now able to see how an inquiry lesson could be made out of most any type of data."
- ♦ "I enjoyed this layout much better than a lab report."

Students enjoyed researching topics that they were interested in, especially those topics that were not covered in depth in class or were directly related to their community (e.g., Michigan):

FIGURE 6

The Virtual Vee Map highlights the nature of scientific research.



- ♦ “I was able to find something that interested me and therefore I was more excited about doing it.”
- ♦ “I liked finding out about the different beaches and their *E. coli* counts. Before this assignment I didn’t even realize that the information was available to the public.”
- ♦ “I enjoyed it a great deal, although I am a research buff. At first I wasn’t sure I really cared about hawk distribution in Michigan, but by the time I finished the project I was very interested and felt I learned a lot.”

Students also enjoyed participating in the inquiry method that developed from this project, saying:

- ♦ “I liked the fact that it was interesting, and also brought up more questions in my mind about the website and information I was inquiring about. I also like that we complete projects in this class that can be used within our own classrooms.”
- ♦ “It really made me think a lot! I spent time rehashing ideas and rewriting and thinking about things...It was a bit like a puzzle for me.”

Part of the credit for students’ success in meeting the project’s objectives must be

given to Gowin and the design of his Vee Map. Students begin on the conceptual (left) side of the Vee Map where they are able to apply the thinking skills that they are most confident in using: knowledge, comprehension, and application (Figure 6). During the time that students are working on building their conceptual knowledge, the internet is their primary source for information. They can continually return to the internet for additional information in designing their graphic organizer and posing their hypothesis. Their depth of understanding of their topic now becomes evident in the inquiry question and hypothesis that they design and investigate using the methodological side of the Vee Map.

On the methodological (right) side of the Vee Map, the data and conclusion sections challenge students to employ higher-level skills to analyze and evaluate their data set in light of their conceptual research. Using the guided conclusion, students were able to place their small study into a larger context and describe missing pieces to their research that could warrant further investigation. In this way, the internet provides a common resource ground where students can continually find answers to their inquiry questions.

Due to its constructivist nature, the Virtual Vee Map gives students an appreciation for how scientists conduct investigations (Roehrig, Luft, and Edwards 2001). Rarely does science follow a linear progression through the scientific method. In fact, Harwood (2004) describes a model to help students and teachers understand the interplay among the steps of the scientific method that occurs when scientists perform investigations. The Virtual Vee Map also highlights the nature of scientific research and emphasizes how the answer to one investigation can lead to questions that spawn further investigations. ■

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