P2.8 STUDENT LEARNING IN THE VISUAL GEOPHYSICAL EXPLORATION ENVIRONMENT: IDEAS FOR USING INQUIRY-BASED CURRICULA

Rajul Pandya[*1], and J. Yoder[2], Colleen Contrisciane[2], and Caryssa Seider[2]
(1) DLESE Program Center, Boulder, CO (2) West Chester University, West Chester, PA.

1. INTRODUCTION

The Visual Geophysical Exploration Environment (VGEE) attempts to implement national recommendations for science reform (e.g *Shaping the Future, Geoscience Education: A recommended Strategy, Project 2061: Science for all Americans*) within real classrooms. It is an inquiry and visualization-based learning environment designed to allow students to learn fundamental geophysical principles by exploring authentic data. As such, the VGEE addresses many of the national recommendations; it is hands-on, inquiry-based, and introduces learners to scientific tools and data. Further, by allowing students to build and navigate three-dimensional, multidimensional visualizations, the VGEE encourages students to develop an integrated view of geophysical phenomena.

The VGEE is also a research tool that can be used to examine some of the key research questions that emerge when implementing national recommendations. Questions like:

- What are the barriers and critical factors of inquiry-based curricula?
- How does these curricula influence student understanding compared to traditional curricula?
- Does time-spent on inquiry and visualization detract from scientific understanding?

In the spring of 2002, about 24 students used the VGEE in one of two otherwise introductory atmospheric science courses at West Chester University. Both classes met for a more traditional lecture/laboratory type class two days a week. On Fridays, one class used the VGEE to investigate data sets centered on El Nino, the other class made forecasts using a variety of web resources.

A number of methods were used to evaluate the effectiveness of the VGEE environment. Both classes took pre- and post-tests covering material from the syllabi. Both classes took Likert surveys indicating how they felt the class contributed to the university's general education goals. The VGEE group also completed four online surveys that addressed attitudes towards and learning within the VGEE. Finally, all visualizations and descriptions of visualizations from the VGEE group were analyzed.

2. LIKERT SURVEYS

At the end of the semester, each student was asked to complete a 6-question Likert Survey indicating how well they felt the class helped them develop numerical and communication skills. Students were asked to rate statements like "this class enhanced my ability to understand graphic information" on a scale from 1-5, with 5 indicating strong agreement and 1 indicating strong disagreement. The results of the survey are shown in Figure 1.

The overall trend of the surveys suggest that there isn't much difference between the VGEE and non-VGEE

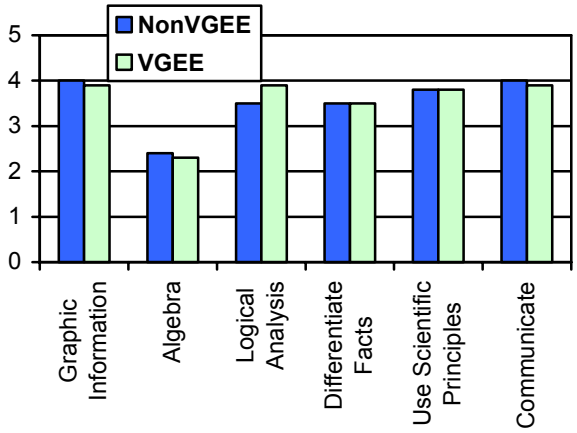

Figure 1: Student Responses to four online surveys.

group, although the VGEE group felt that the class contributed slightly more to their ability to "apply rules of logic and analysis to develop an argument." This is probably due to the writing emphasis in the VGEE curriculum - students were asked to explain their visualizations in considerable detail. It might also be due to the fact most students worked together in the VGEE, while those working on forecasts tended to work alone. The more group-oriented work in the VGEE class probably meant more practice developing arguments in the process of reaching group consensus.

Surprisingly, the VGEE group didn't indicate stronger agreement with the statement "this class contributed to my ability to use and interpret graphical information," than the non-VGEE class, in spite of the spite of the visualization intensive nature of the VGEE. It is worth noting, however, that the non-VGEE group made heavy use of standard meteorological charts and maps in their weekly forecasts.

3. WHAT DO YOU KNOW / WANT TO KNOW SURVEYS

Four times during the course of the semester, VGEE users were invited to complete an online survey describing what they learned using the VGEE and what questions or comments they had as a result of their use of the VGEE. Student survey answers were divided into 4 categories (shown in Figure 2): science questions (dashed red line) science comments (solid red line), technical questions (dashed green line) and technical complaints (solid green line).

The drop in the number of technical complaints throughout the semester suggests increasing

Corresponding Author Address: Rajul Pandya, DLESE Program Center, P.O. Box 3000, Boulder, CO 80302

confidence with software and seems to validate the user interface. The peak in the number of science comments & questions at midterm represents peak in student exploration. At this point in the semester, students have lots of hypothesis (science comments) and seek additional information and techniques to test hypothesis in the form of science and technical questions. The drop in the number of questions and comments indicates subsequent synthesis and integration of new ideas.

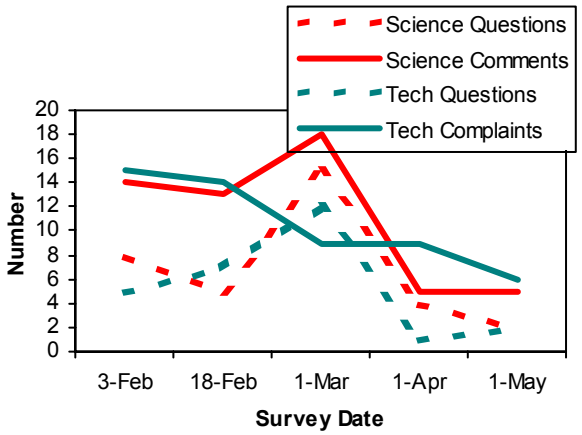

Figure 2: Student Responses to four online surveys.

4. PRE-POST CONTENT TESTS

At the beginning and end of the semester, both the VGEE and non-VGEE classes took a 10-question survey that covered science concepts that occurred throughout the curriculum. These tests were open ended essay type questions such as "Why does rising

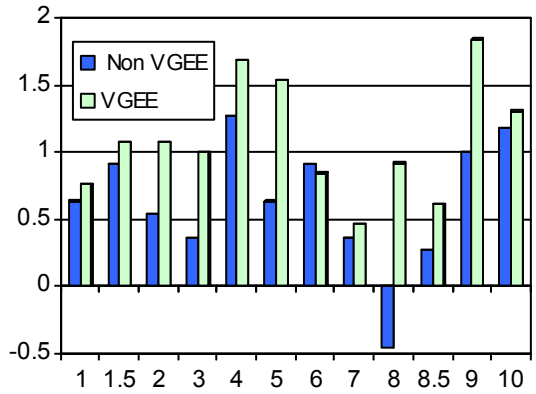

Figure 3: Student Responses to pre- and post- test questions.

motion often lead to cloud formation?" These questions were then graded on a 5 point scale, ranging from 1 (the answer showed no conception) to 5 (the answer showed a complete understanding including using the correct vocabulary and connecting other ideas from class).

Figure 3 shows a comparison of the average improvement, per questions, in the two classes. The VGEE group showed more improvement than the non-VGEE group on all questions, and this improvement was not restricted to material covered explicitly in the VGEE curriculum. The VGEE curriculum's emphasis on inquiry and explanation may have led to general improvement in understanding and ability to explain concepts in the VGEE group. This is consistent with the group's self-assessment of classes contribution to their ability to form logical arguments (Fig. 1). It is also worth noting that 3 of the 4 questions in which VGEE group most improved relative to the non-VGEE group were related to their inquiry into storm structure. This suggests that the inquiry-based exploration of these concepts in addition to traditional lecture-based explanations led to a more robust understanding than the traditional methods of instruction alone.

5. STUDENT COMMENTS

In addition to the formal analysis, the online surveys were evaluated qualitatively to identify any outstanding issues that impacted student learning in the VGEE group. One theme that quickly emerged was concern over evaluation. In the words of one student, "I am not sure how we will get credit for what we are doing." This seemed closely coupled with students concern over open-ended questions. Most students couldn't accept their own interpretations, at lease initially, and wanted to validate their answers externally, rather than based on their own careful testing. One student summed it up well, "The whole time I am doing things I am wondering if I am doing the right thing. How can we know without asking the professor?" This attitude seemed to express a fundamental misconception that science is chiefly concerned with finding right answers.

6. SUMMARY

In general, the inquiry-based approach of the VGEE appears to be a successful addition to the undergraduate general education classroom. In particular, students using the VGEE showed more improvement in reasoning and analysis than students who didn't use the VGEE. Although the VGEE class showed the most improvement in those concepts covered in the inquiry curriculum, their improvement was not limited to those areas.

The analysis of these results also reveals some trends that may be useful for inquiry processes in general. Most of the student activity and student demands happen in the middle of the inquiry process, this suggests that students require the most support then. We were also able to identify significant barriers to inquiry: concerns over evaluation, and a persistent misconception that science as static and concerned primarily with correct answers.

7. WEBSITE

http://www.dlese.org/vgee

8. ACKNOWLEDGEMENTS

The VGEE development was supported by NSF Cooperative Agreement #DUE-9972491. The Development team for the VGEE included: Dan Bramer, Dean Elliot, Kenneth E. Hay, Mary Marlino, Don Middleton, Mohan Ramamurthy, Tim Scheitlin, Marianne Weingroff and Robert Wilhelmson. Colleen Constriciane,

Caryssa Seider and John Yoder were supported by a Faculty Development Grant from West Chester University.

9. REFERENCES

AAAS (1989). *Project 2061 Science for All Americans*. Washington DC, American Association for the Advancement of Science (AAAS), 217.

NSF (1996). *Shaping the future: New expectations for undergraduate education in science, mathematics, engineering, and technology*. Arlington, VA, National Science Foundation, NSF 96-139, 90.

NSF (1997). *Geoscience education: A recommended strategy.* A report based on an August 29-30, 1996 Workshop from the Geoscience Education Working Group to the Advisory Committee for Geosciences and the Directorate for Geosciences of the National Science Foundation.