Using Visualization Tools for Project-Based Science: A Longitudinal Study of Teacher's Stage of Development

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NETS summary
Our paper will report on research in which teachers learned to use scientific visualization tools for image processing, geospatial analysis, molecular visualization, and systems modeling and then used at least one of these tools in a technology enhanced project with students. Teachers learning these tools in the workshop addresses NETS•T II and III. Students learning to use these tools in technology enhanced science projects addresses NETS•S 3 and 6. Administrators are interested in these kinds of enhanced technology projects to the extent that they are part of better learning and teaching environments--NETS•A II.

Purpose
The purpose of this study is to better describe and understand the stages that teachers progress through in incorporating advanced scientific visualization tools into their classroom teaching and what effect these tools have in helping them do project-based scientific investigations with their students. The study investigates thirty teachers who took part in Project Visualization in Science and Mathematics (VISM), a three-year NSF-funded project intended to help middle school and high school math and science teachers learn the techniques and application of data visualization for their own classroom. Data has been collected from these teachers one to three years following the initial VISM workshop.

Significance of the study:
Scientific visualization tools have shown great promise in drawing today's increasingly visual learners into in-depth study of scientific and mathematical topics (Baker and Case, 2000; Greenberg et. al, 1993; Gordin and Pea, 1995; Jonassen, 2000; Thomas et. al, 1996; Malinowski, Klevickis & Kolvoord, 2001). But using these more advanced tools in classrooms can prove to be a formidable challenge, even following a very successful workshop experience. There is a particular need for better detailed and more theoretically sophisticated descriptions of actual teacher use of promising advanced technological tools in the field of science education. There is a dearth of data about how teachers actually employ scientific visualization tools in their own classrooms.

Theoretical framework:
This study began by describing the stages which teachers go through in adopting advanced scientific visualization tools into their teaching practice using the VISM matrix (Charles and Kolvoord, 2001). This matrix was developed based on an interpretation of the Apple Classrooms of Tomorrow (ACOT) model. The ACOT model predicts four stages of use of a technological tool: entry, adopt, adapt, and innovate. The VISM matrix describes each of these four stages of use for four readily available scientific visualization

tools based on the feedback of the instructors in Project VISM. These tools are used for image processing, geospatial analysis, molecular visualization, and systems modeling. This matrix could be adapted to describing the integration of many of the more advanced and discipline specific tools, and then used to track the stages of teacher development in using these tools.

Methods

This inquiry summarizes current findings from thirty of the participants in Project VISM as they implemented scientific visualization tools in their teaching practice in the years following the workshop. Descriptions are the self-report data of the teachers.

Data sources

Data sources are a "follow-on" questionnaires and interviews conducted in person or by phone after one, two, or three years of use of the tools. Teachers selected for the initial set of interviews were chosen as a sample of interest—in our follow-up discussions with them there seemed to be intriguing things happening in their work with students following the workshop. The central question for both the interview and the questionnaire was for the participants to describe one project they had undertaken with their students that used one of the tools they learned in the workshop. Interviews are based on a structured set of questions drafted in advance, but also include open-ended questions for more in-depth follow-up. The questionnaire was developed for participants in a follow-on workshop that some of the workshop participants voluntarily took part in one to two years following their initial VISM workshop experience.

Method of analysis

Questionnaires and interviews were summarized by the investigators. Each participant was placed on the VISM matrix based on their responses, and their comments were coded and categorized using constant comparative analysis around the central issues of the study. Member checks were performed with those who were interviewed.

Results

Our results are spread out across the continuum of the VISM matrix. At this writing we are still completing our analysis of the data, but we will map the data to the VISM matrix to see what percentage of the teachers are using the tools at the adopt, the adapt, and the innovate levels respectively. We will describe what has happened to the participants' skills in using these tools, and summarize the obstacles teachers they have encountered in putting these tools into practice. We will also include brief case studies that describe some of the particularly interesting cases.

We have completed four case studies as of this proposal. We include a short summary of these as a sample of the findings. One of our four cases was working at the innovate level with two of the tools prior to the workshop. A year following the workshop he has further developed his skills at innovating with those tools. Of the two tools that were new to him in the workshop, he is using one of them at the adopt level and the other at the adapt level. He is the one teacher who was able to use multiple tools as part of a single student project.

Our second two cases can both be described as having successfully moved one or more of the tools into their teaching practice. One of the teachers adopted the image processing tool into one of his courses, using it for a particular activity. He has also designed an entire course around one of the other tools, which he is using at the adapt or arguably the innovate level. He is actively seeking out further training in this tool. The other two tools he has not used in his classroom, nor does he expect to. The second teacher in this group has used three of the four tools with his students, but only as a part of teacher demonstrations. He is looking forward to using them as part of student projects next year as he is teaching some upper division high school classes that would better use these advanced tools. He does not expect to use the fourth tool with his students.

Our final case has not used any of the four tools taught in Project VISM. He found that the learning the VISM tools became a vehicle that helped him learn different tools that became available in his classroom following his return from the workshop. Those tools are probeware and astronomy simulation software, both of which he is using in technology enhanced lab experiences with his students.

Implications
This study will add to the discussion of the nature of effective professional development experiences for teachers that use advanced technological tools. We notice that in many of the discussions of professional development there is a good deal of discussion about "building capacity" in the system and "ramping up technological change." To our ears these sound like production metaphors. And while they may be helpful in reminding us to strive to create "sustainable" professional development efforts, they may also miss the fundamentally constructivist nature of teacher learning.

Higher Order Applications
Scientific visualization tools offer a very rich and powerful use of the computers. They are a set of tools that inquiry-based. In fact, most of them were designed to help scientists understand and explore different datasets or physical phenomena. These tools can help students visualize some of the more abstract processes that are routinely studied in science courses, from the shapes of molecules to simulations of predator/prey populations, leading to a better understanding of these topics and a greater engagement in the inquiry process.

Acknowledgements
This research was carried out as a part of Project Visualization in Science and Mathematics (VISM), a project of the Integrated Science and Technology program at James Madison University, with the sponsorship of the National Science Foundation. Project VISM was held during the summers of 2001-2003; more information available at http://www.isat.jmu.edu/common/projects/VISM/.

Primary URL:
http://education.ed.pacificu.edu/charlesm/presentations/necc2004vism.html

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