San Diego State University: Creating a Computer-Enhanced Geology Learning Environment

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Summary

Eric Frost: Sometimes I would walk out of a lecture that I gave and say, “That was a really powerful lecture, that was worth the money these guys paid.” But my students would say, “hmm?” indicating that they didn’t quite understand. And instead of saying, “Well, those stupid students,” I would say, “If all the students in there didn't understand what I was saying, then I didn't teach them what was necessary, and now I need to figure out how.”
The Setting
In this section, we introduce you to Eric Frost’s colleagues at San Diego State University (SDSU) and present the information necessary to understand the context within which they strive to achieve their goals for student learning.

Learning Problems and Goals
Here we examine, first, the learning problems that Eric faced, problems that ultimately motivated him to change his curriculum; then, we take a look at the goals he has set for student learning.

Creating the Learning Environment
In this section, we look closely at how Eric created a new learning environment—the tools he uses, and the activities he assigns. This section is deeply informative and includes links to both faculty and student discussions of learning activities.

Implementation
Wondering about the logistics? The SDSU faculty share how they did it: from acquiring the necessary resources (time, space, money, etc.), to networking, to responding to resistance to teaching approaches that require students to take more responsibility for their own learning.

Summing Up
*Using the technologies elevates your understanding.*
Introduction

Why use technology to teach geology?

In the past, students learned structural geology via textbooks, lectures, a multitude of pictures, and years of field-work. With current technologies, the necessary learning can occur at an accelerated pace while students simultaneously gain a deeper understanding of the processes that shape our earth. Numerous forms of geology have become dependent on technology and several new research areas have emerged from the use of digital imaging. Much of the work that geology professor Eric Frost carries out at San Diego State University (SDSU) has become possible with the advent of computer imaging techniques.

In his course Eric uses software that allows students to see complex three-dimensional shapes, and therefore understand geological processes in a way that would be very difficult without the use of technology. The tools he uses vary from simple color tools like Chromatek (http://www.chromatek.com) and VRML (http://www.web3d.org) to high-end tools such as VoxelGeo (http://www.paradigmgeo.com/products/voxelgeo.php) and GOCAD (http://www.ensg.u-nancy.fr/GOCAD). His classes also use numerous other software packages that allow for interactive processing of imagery such as Photoshop and commercial image processing programs such as ENVI (http://www.rsinc.com/envi), ER Mapper (http://www.ermapper.com and http://www.earthetc.com) and several ESRI products (http://www.esri.com) such as ArcView.

What happens on a typical day in Eric’s classroom?

Each one of Eric’s classroom sessions acts as a stepping stone. At the beginning of a semester he poses a broad question or research problem to his students who then collaborate in each class to solve it. To solve the problem, they use all of the visualization software mentioned above. Eric says that, “by focusing them on a research question whose solution is beyond any one member of the class, and which requires far more tools and expertise than any of them have, they see how coming together in a knowledge building, community effort can help them attain the goal.” Once he sets the process in motion, his role in the class is largely one of, as he puts it, a “cheerleader.” Students are left to come up with ideas on their own about how to solve the problem while Eric facilitates the process by sending emails between classes about relevant news items, URL’s of companies doing similar things.

Is Eric’s approach working?

According to Eric, his department chair and his students, the answer is yes. Eric told us, for instance, that technology is not only useful but essential if one is to fully comprehend certain geological processes.
Eric: Using the technologies elevates your understanding. It brings your understanding of the models and concepts to a much higher level. You can ask more challenging questions about the subject matter at hand and communicate at a level that industry is working at.

Gary Girty, Department Chair of Geological Sciences, says that when it comes to using technology to achieve this heightened understanding, Eric Frost has no equal.

Gary: I know of no one in my entire academic career who has been as successful as Eric has at what he does. I would put him on a pedestal and say if you want to chase technology, if you really want to try to use these things in a university, in a state school like we have, then you need to go talk to Eric Frost. And you need to watch, you need to look at how he's managing to do this. I just don't know anybody who does it better than he does.

Shane, one of Eric’s students, also testifies to his effectiveness as an instructor by pointing out his ability to challenge students to think.

Shane: His goal for any class is to get students to think in a way that they would not normally think. For example, he’ll give students a problem, but never, ever give the answer. He’ll give you a project on, say, the Middle East, and say, “Okay, here is a problem, see what you can dig up, see what new kinds of ideas you can formulate,” and then present it back to the class. He is not the traditional talking head kind of teacher. He pretty much lets the class teach themselves.

Wow, how can I get my students to learn like that?
Read on. Through the following links, we offer you a more complete and comprehensive story of Eric Frost’s efforts to improve the quality of student learning in the hopes that his experience may serve as a guide to others.

Reader’s Guide

Special terms appear in the Glossary. The first time one of these terms occurs in a major section, it appears underlined and the definition is available in a mouse-over box. These definitions appear as lettered footnotes.

All citations to which the case study refers are listed in the References.

Technical asides are indicated by a numbered footnote marker and available to the reader in a mouse-over box.

Lengthy quotes from participants that illustrate a point often are available in mouse-over boxes (and also as lettered footnotes), for the benefit of the reader who prefers to read the participants’ own words.
Various topics introduced in the study are developed at greater length in Discussions (specified by number) to which the reader is referred at relevant points.

The reader is referred at relevant points to various other Resources (specified by letter). Among these is a short description of the Methods Used to Produce this Case Study (Resource B).

Of note for users of the web version: Clicking the “previous page” button will take you to the previous linear section of the case study, not necessarily to the page which you last visited. Clicking the “back” button of your web browser will return you to the section last visited.

We use pseudonyms for the students who appear in the quoted material. To help avoid confusion, the researchers are identified as “interviewer” the first time their voice appears in an interview segment. Lengthier quotes appear in italics.

The instructors and administrators who are identified in the case study read the document and gave us permission to use the quotes we attribute to them. These SDSU readers also affirmed that this case study conveys the essence of what Eric Frost was doing in the Fall of 1999.

**The Setting**

San Diego State University. Founded as a teacher's college in 1897, SDSU continues to train teachers, and also offers bachelor's degrees in 76 areas, master's degrees in 59 and doctoral degrees granted jointly with cooperating institutions in 13 areas. Approximately 30,000 students attend SDSU. Fifty-five percent were female with an average undergraduate age of 24 and an average graduate age of 32. Two percent were foreign students and 84% transferred from a community college. Ethnically, the population is approximately 46% white, 19% Chicano or other Hispanic, 5% African American, with the rest Asian (12% declined providing data on ethnicity). (To find out more about SDSU and its instructors, see Resource A. Institutional Context.)

The name of the course that we feature in this case study is Collaborative Visualization. Other graduate classes taught in a similar fashion at SDSU are Extensional Tectonics, Compressional Tectonics, and Earth Systems Science. Undergraduate class is Photogeology and Remote Sensing.

**Dramatis Personnae**
**Dr. Eric Frost** is a Professor of Geological Sciences who teaches geology and visualization at San Diego State University (SDSU). He is very actively involved in using technology as a tool to solve real-world problems, both for his own and his students’ work. He is

- Director of CARRE (Central Asia Research and Remediation Exchange),
- Director of the Visualization Laboratory, a laboratory primarily designed for teaching and research using visualization in the areas of tectonics, fluid flow modeling, Geographic Information Systems, remote sensing, seismology, seismic reflection processing, and environmental geology and,
- Co-founder of CIVAC (Computer Imaging, Visualization, and Animation Center).

**Dr. Kris Stewart** has been a Professor of Math and Computer Sciences at SDSU since 1987. Since 1986 she has been involved with the educational uses of supercomputing. In 1992 she founded the NSF-funded program STEP (Supercomputer Teacher Enhancement Program) to introduce computational science and high performance computing and communications (HPCC) to high school teachers in the San Diego county area. Kris later received a medal of recognition from the Smithsonian Institution for the STEP program. In 1994 she had received the Department of Energy Undergraduate Computational Science Award. In fall 1997 she became the founder and Director of the Education Center for Computational Science & Engineering on behalf of the CSU system.

**Dr. Yusuf Ozturk** is an SDSU Professor of Electrical and Computer Engineering. His course offerings have included: computer organization, computer networks, how to build communication systems, signals and systems, probability and statistics, and engineering problem solving. His research is focused on neural networks, communications, and image processing. Yosuf
has extensive experience creating and using technology in education, both via customized hardware and use of software. For example, Yosuf has developed computerized blackboards for instruction and collaboration.

Shane DeGross was a third semester graduate student in geology at the time of our site visit. He had taken three courses offered by Eric Frost: Extensional Tectonics, Compressional Tectonics, and Collaborative Visualization. The collaborative visualization class involved Shane in thinking about, and experimenting with, the physical setup of highly technological environments for sharing of geological information. Shane is now a geology instructor at Grossmont Community College and San Diego State University.

Dr. Gary Girty Department Chair of Geological Sciences, a department consisting of 20 senior track faculty and research scientists. A professor at SDSU for 20 years, Gary also has served as the coordinator of Geology 101, Dynamics of the Earth, and has supervised over 50 Master’s Thesis students.

Learning Problems and Goals

When a faculty member considers curriculum reform, there are usually problems or learning environment challenges that the faculty member is attempting to address. This section of the San Diego State University case presents those challenges as well as the philosophy and goals that motivated Eric Frost to depend heavily on computer-based learning strategies.

Problems that Motivate Eric Frost to Utilize Computer-Dependent Learning Strategies

Eric: Sometimes I would walk out of a lecture that I gave and say, “That was a really powerful lecture, that was worth the money these guys paid.” But my students would say, “hmm?” indicating that they didn’t quite understand. And instead of saying, “Well, those stupid students,” I would say, “If all the students in there didn't understand what I was saying, then I didn't teach them what was necessary, and now I need to figure out how.”

At SDSU, low student performance and engagement were the two main reasons encouraging Eric Frost to try a new approach.
Eric Frost’s decision to reform his teaching methods arose from a sense that, despite his efforts, students weren’t grasping the geological concepts that he was trying to impart to them. Although these concepts were perfectly clear to him, he was unable to transfer this knowledge while standing in front of class. Even his students who received top grades fell short in their ability to comprehend the subject material that he presented to them. Specifically, his students had difficulty visualizing geological processes in three dimensions, an ability that is crucial to success in geology. Because of their inability to visualize, Eric said his students could only see the complexity of geological processes, and failed to see the patterns in them. Because of these shortcomings that he experienced in trying to get his student to learn meaningfully, Eric resolved to change the way he taught his classes. Below, we examine the goals that Eric set for himself in order to carry out that change.

### Learning Goals that Eric Frost Seeks to Achieve

The technology-enhanced *learning environment* that Eric Frost created was largely influenced by the goals that he set for student learning. As we mentioned in the section on *Learning Problems*, Eric felt that simply standing in front of his class and talking about geology wasn’t fostering what he considered to be meaningful learning. He wasn’t providing his students a *learning environment* that was conducive to their future professional success in geology.

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1. **Eric:** The information that I saw in an image was not the information that they were understanding. I can look at an image and it's really obvious to me, there's a whole series of different kinds of things taking place, and I would show students these kinds of images and they'd say, “It's a pretty picture.” It would boggle my mind why they couldn't see all of the different interactions that were taking place.

2. **Eric:** Before I started using the visualization tools, students could say the right words, but the understanding was not in their mind. There was a real frustration on my part because they could answer the questions to get a grade in the class, but they didn’t get it. The light didn't go on. They actually just didn't see why this is important.

3. **Eric:** Students normally can't look at an image and perceive the fact that they're looking at a three-dimensional surface. They don't see that what appears in one place is down underneath the surface, and what appears another place is above the surface—that there's a three-dimensional puzzle.

4. **Eric:** A lot of these geological processes are analogous to cutting a head of red cabbage. Most of the time when you cut it you get a very complex pattern. If you cut it horizontally, you get a much different pattern than you would by cutting it vertically. And by looking at the complexity of geological processes, like the red cabbage, most students just see the complexity, they don't see the order. And so the thing that I found in teaching this class is that there had to be a better way than just to teach people how to process on the computer, or how to look at a hard copy, because they obviously weren't getting it. The information that I saw was not the information that they were understanding. No matter what kind of words I used, they still didn't get it.
His efforts to reform began with the realization that his students did not lack the ability to understand, but that he himself was coming up short in presenting the material. Therefore, instead of simply lecturing on the things he knew best, Eric decided instead to make it his goal to teach his students how to think. To him, this meant examining his own processes, as an educator, and then altering what he does.

**Eric:** I happen to be very good at visualizing these things on my own and there was nothing that I did to gain that ability. I can look at and turn three-dimensional geological models in my head. What I needed to do is put that knowledge, which was obvious to me, into three dimensions and allow the students to turn it and look at it as well. Then it would be totally obvious.

As a result of reconsidering his own thinking on how he teaches, he began providing students with tools that allowed them to visualize three-dimensional, geological processes, and placing them in real-life situations, like group settings, where they could collaborate to solve geology problems.

### Creating the Learning Environment

Eric Frost is among the growing number of faculty who are designing their courses as learning environments. A learning environment is a place where learners may work together and support each other as they use a variety of tools and information resources in their pursuits of learning goals and problem-solving activities (Wilson 1995).

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5 **Eric:** Instead of saying, “Well, those stupid students,” I would say, “If all the students in there didn’t understand what I was saying, then I didn’t teach what was necessary.” And I’m trying to figure out why they didn’t learn.

6 **Eric:** The world is moving very quickly and what students want me to do is help them figure out what they are trying to do in it. Once they figure that out, they want to know how the university can help them go that direction. So, rather than conveying the specifics of that narrow part of the science that I have really done all of my work in, I have switched to trying to convey the wisdom and insight of how they can use tools and understanding to accomplish what they set out to do. I’m trying to teach them, basically, how to think, and also to be motivated to take ownership of their ideas, and to take responsibility for their own learning.

7 **Eric:** The real world does not work like the university system where individuals fend for themselves. You don’t pursue a problem in an oil company just by yourself and expect to learn your little piece of the puzzle. That is not the way the world works; not in geology anyway. We get a whole bunch of people working together on the same problem in a group setting. That, as far as I know, is the way the industry works.
In structuring his learning environment, Eric adheres closely to the teaching philosophy that teachers should shift the major responsibility for learning from the faculty to the students.

His department chair summed up this strategy by saying, “His teaching strategy is that the student must learn that they are in control.” We learned that, for Eric, shifting responsibility for learning to his students entails actively engaging them in a set of mental processes during which they learn, restructure and add to what they already know, individually and as a group. These processes lie at the core of a theory of learning called “constructivism” in the cognitive psychology and education literature.

To implement his teaching principle, Eric has chosen a set of activities that he weaves together to achieve his goals for student learning. These activities include:

- **Computer-dependent learning activities**—that faculty believe simply would not be possible, or at least not feasible, without computers.

- **Computer-independent activities** that can be done without technology.

Although the topics that Eric covers in his class could be taught without technology, student learning would suffer greatly.8 The computer-independent aspects of Eric’s class, namely group work and connection to real-world data, almost inevitably occur alongside the computer-dependent ones, where they work synergistically to help Eric help his students learn in the most effective manner. His department chair made this point as

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8 Gary Girty, Department Chair of Geological Sciences: The earth is an extremely dynamic environment. There are no processes that operate on the earth that one could possibly view as static. Because of the dynamics of the very thing that we're trying to understand, it is literally impossible for a two-dimensional black and white--or even a flamboyantly colored textbook--to get across the dynamics of the earth. It can't be done. What that leads us to is: How do we get the modern day student interested in the earth that they live on? How do we get across the dynamic, exciting processes that affect their daily lives? why does an earthquake occur, and what's going on when an earthquake occurs? Why does a volcano erupt? Why do mudflows coming down the side of a mountain after a volcanic eruption, destroy villages in South America year after year?

When you read the newspaper, when you listen to the news on the radio or the TV, every day, every week, there is some geological process that has affected society in some tremendous fashion. How do we then do this--get away from the stale, black and white textbook use? There's only one answer to that path. The computer. That's the only way that you can do it. That is the philosophy that we're trying to take in this Dynamics of the Earth lab. That is the philosophy that Eric came up with ten years ago. My perception is that Eric has decided he will never again teach with a piece of chalk in his hand. But it's taken the rest of us ten years to understand how we can use the technology in our favor.
follows, “There really isn’t much of a choice not to use technology because it has become a vital part of conveying the dynamic nature of our planet.”

Of course students can think without computers. They can even visualize and engage in real-world problems all on their own. But when working on complex, dynamic earth processes that are an integral part of the geological work around the world today, technology is essential. In fact, when we asked Eric Frost whether he could do his teaching without technology, he quickly and surely responded:

**Eric:** No. I think without the technology I would still not be able to communicate what it is that they are trying to see. When we go up to the Chevron offices, we look at their large screen visualization in stereo. In an hour, the students learn more about how faults work than most of our faculty learned in their thirty years of experience. Just by looking at it they go, “Oh, this motion passes from here to here to here.” They just look at it and it’s pretty obvious. And they would not get that by any amount of talking that I did. These large data sets in stereoscopic 3D are really showing what takes place. The words and drawings just can't convey the way it is turning. I wouldn’t be doing this if the technology was not there because I would find it too frustrating to convey those ideas.

Below, we explain in greater detail the computer-dependent and the computer-independent learning activities that make Eric’s learning environment so effective in preparing students for their post-graduation activities and careers.

**Computer-Dependent Learning Activities**

Many of the learning activities that Eric Frost uses in his classroom are not teachable without the use of technology because they are born out of the technology, enabling new geological relationships to come to light for his students. For example, Eric’s visualization exercises have students analyzing satellite imagery to discover the most efficient placement of a pipeline, as well as the earth’s subsurface geometry as it relates to fault lines. Two Supercomputing Centers at National Center for Supercomputing

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9 For our purposes, “visualization” is the process of understanding simple to complex geological processes that result from observing one or more objects, or a graphical representation of those objects, in a still or animated manner, from different perspectives or orientations.

10 **Eric:** Some of the visuals use satellite imagery to show the terrain. For example, if you want to build a pipeline across Turkey, the visuals would show how you would lay out that pipeline in order to avoid earthquake areas that would disrupt it.

11 **Shane:** We have data sets of 3D cubes where you could find and pick the faults and surfaces. You can pick a reflection, a seismic reflection, and follow that through the cube to see where it faulted. You are trying to figure out the subsurface geometry, what the faults are doing and how the rocks are behaving. You can go through in Photoshop
Applications (NCSA) http://www.ncsa.edu: the first supercomputer center in the US, and the San Diego Supercomputer Center (SDSC) http://www.sdsc.edu have provided many of the visualization exercises that Eric uses.

To read a student and faculty discussion of computer-dependent learning activities, see Discussion A.

Computer-Independent Learning Activities

Not all activities that are done without computers involve paper, pencils and lectures. Eric Frost incorporates computer-independent learning activities into his classes that work together with the computer-dependent ones to achieve his goals for student learning. The computer-independent activities that he uses include:

- Group work
- Connection to real-world data

Group Work

Eric constantly requires his students to collaborate in order to give them what Shane calls a “broader grasp of a lot more things.” Eric also feels that when students are being watched by supportive fellow students, they are likely to achieve at a higher level. This is especially true when students in related though not identical fields are paired together. To encourage group work, Eric uses some uncommon methods such as software and draw a line where all the faults are and pick that out in a 3D setting, in a 3D cube. So you are using some 2D applications and then transferring them to 3D.

12 Shane, former graduate student: In a traditional class setting, the amount of what you learn is significantly less because you only learn what you turn back to that teacher. You are only learning the assignment he gave you. In the group setting you are learning a lot more than what the teacher even expected for the class. You are learning how to present things in various different media. I got a more general and a broader grasp of a lot more things by doing it in a group setting. And I feel I’ve retained everything that I learned in that class. Whereas in other classes I have completely forgotten everything that the teacher taught. If anybody gets stuck, it is the job of the group to bring that person up to speed. So I have never seen a student get stuck by not being able to figure out a concept.

13 Eric: There is a different sense of doing something when somebody is watching you. When a friendly person is watching them, students seem to learn distinctly better than if they are just in there doing it themselves. It’s kind of like when people play games, and they can play better when somebody else is going to watch them.

14 Shane: There is one person in our group who is a geophysicist. As far as any basic geology, he didn’t have much course work in that. He had a general idea of what was going on, but it actually worked out to our benefit because he knew a lot of things that we didn’t know in looking at different kinds of data sets. So actually, our differences made the group much richer in learning because he was able to explain the geophysics behind some of the data sets we were looking at, and then we could figure out and help him along with the geology.
intentionally not having enough computers, or utilizing older equipment that is likely to fail, at which time students are forced to fix the problem together.15

**Connects Students to Real-world Data and Problems**

Along with group work, Eric emphasizes real-world geological phenomena when challenging his students with problems. His students pick international problems related to geology that have, as of yet, remained unsolved. They find and collect real data, and present possible solutions to governments. Eric helps students pick problems that potentially have multiple possible solutions.

**Implementation**

In the course of describing the learning environment Eric created to achieve his goals for student learning, we have focused, for the most part, on what Eric chose to do, and presented information indicating that these activities were achieving the instructors’ goals and why they worked. We considered only in passing the matter of how they created these environments.

During our interviews with Eric and his colleagues, we explicitly asked “how” questions, such as: “What kinds of new resources did you need?” “What forms of support or hindrance did you encounter?” “How did you deal with the stresses that come with change?” We also asked them for advice they’d like us to pass along to others who are about to embark on this path—things they would have appreciated knowing before they got started.

Drawing on their responses to these questions, we present SDSU faculty insights and advice on how to implement the kind of learning environments Eric has developed. We start with the personal resources that made Eric’s reforms possible. We then consider both technical and non-technical institutional resources. Last, but not least, we turn to a set of issues that have more to do with cultural factors that shape faculty teaching practices. We have chosen to organize these latter issues under the header, “Managing the Dissolution of the ‘Atlas Complex’.” The “Atlas Complex” is a term from Finkel and Monk’s article, “Teachers and Learning Groups: Dissolution of the Atlas Complex.” With this term, Finkel and Monk identify a constellation of implementation issues that are experienced by nearly all the faculty we know who are seeking to help students take more responsibility for their own learning.

**Personal Resources**

Eric was not alone in experiencing a diverse array of difficulties when trying to carry out his education reform efforts. Educators featured in the LT2 web site commonly experienced obstacles ranging from difficulty securing funds to resistance from their

15 **Eric:** And that's one of the reasons we often have fewer numbers of computers. You force the students to work together and once you say it is okay to do that, they see that somebody else knows how to do something and they go faster.
colleagues. Likewise, these educators often are characterized by particular personal characteristics that allowed them to overcome those obstacles. Eric is no different. In talking with him, his colleagues and students, we discovered that Eric shares many of the same personal characteristics with other successful education reformers. These include:

- a willingness to put in extra time above ones normal duties;
- determination to keep going ahead with efforts despite lack of financial and personal support, and despite the professional damage that can sometimes accompany a concentration on teaching efforts; and
- a joy of seeing students succeed, especially when they surpass your own level of knowledge of a particular aspect of the field.

To read a faculty and student discussion of these characteristics and the integral role they play in the successful implementation of a new way of teaching, see Discussion B.

**Reward Structure**

Eric has found that, for the most part, personal satisfaction has been the reward for his work with technology and innovation.\(^{16}\) Even though he is in a university that is focused on teaching, research still comes out on top when salaries and tenure considerations are at issue.\(^{17}\) And, despite the fact that things are beginning to change,\(^{18}\) Eric’s department

\(^{16}\) **Eric:** I think the rewards are internal. The rewards are from you, you are doing what you want to do.

**The last position advertised in the College of Sciences was for somebody who could do this kind of science education in geology. So what five years ago was seen as being a stupid thing to do is now seen by the people who are leading us as what we want to go with. The prevailing understanding of the faculty role has changed in that way and the reward system needs to [change as well].**

In a sense, our department still clearly values writing papers as the most important thing to do. But I have chosen a different direction. For me the reward is going over to a country like Khasakstan and making a difference. There is no way that you can describe the significance of that feeling.

\(^{17}\) **Eric:** The way that you are promoted is on the basis of research papers. With all the verbage aside, teaching counts for very little as far as promotion is concerned. However, although research is something we are encouraged to do here in the California State System, it's not part of our “live or die,” like in the University of California system. A focus on research papers is not part of the “live or die” at the CSU system because teaching is so much more part of what the faculty are expected to do. However, we functionally choose to make research output also the measure by which most promotion decisions are made. The university is growing in its willingness to consider contributions to science and teaching outside the traditional research paper measure of success. Future work by teachers to develop technology in the curriculum as a significant part of their contribution to the university will be recognized as a viable contribution. And, yet, we do more research here than the faculty at two or three of the UC schools do. We were set up with teaching as the focus, but we're strongly encouraged to do research.
chair said that it will take an entire restructuring, at the college and university level, to substantially change the way salaries and tenure are considered.  

Funding

Although Eric has received financial support from his college for his efforts to incorporate technology into his classroom, Eric’s main sources of funding, have been from industry and from people who want to buy the images. Interestingly, Eric uses administrative issues like funding as learning opportunities for his students. By involving them in these processes, they learn organizational skills that carry over to their future occupations, according to him. And when it comes to finding money to fund his

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18 **Kris Stewart:** I don't think Eric is appreciated as well as he should be. He's got tenure, but he feels that his department will not support him for promotion because he focuses so much on his teaching and his outreach activities that he is unable to publish extensively. Publishing is rated very highly in his department. But I am an example of how the reward system is starting to change. I was promoted last year. I don't even try to hide the fact that I do not publish in the traditional sense. I give invited presentations, and present papers at conferences, and therefore, many of my own peers dismiss me as a researcher. But I was promoted to full professor based on an evaluation of all activities in terms of service, research and teaching.

19 **Gary Girty, Department Chair of Geological Sciences:** I guess the biggest problem here is that the retention, tenure, and promotion decision is made at different levels. I've been on the College of Sciences retention, tenure, and promotion committee. The problem here is that you have to make [changes] at the college and the university level in order that a person who is not publishing a lot can be successful. Right now I don't see that happening. I mean we might, for example, recommend someone who we think is doing wonderful things for the department, but without the solid, hardcore publication record to back it up and support it, I don't think it would go past the college level.

20 According to Eric, “Imagery is satellite image of a particular area, which might be used by a commercial company to help find minerals or oil, help study environmental effects, help find water or manage water, help study crops, help build pipelines, or help identify faults and other dangers for man. Generally our students have processed Landsat Thematic Mapper or Landsat 7 data and provided it to companies or government groups to help solve problems such as these. Students are basically helping lead companies toward the use of these remote sensing tools and are therefore learning to add value to image products (data sets) by their processing and interpretation. This is basically what they would be doing as the manager of such a lab within a company.”

21 **Eric:** We normally get funding through either companies, or through people who want the image. The students actually interact with the people who want the image. They find it and write up the purchase order, so they develop the whole understanding of how you do something. And then the image comes and they appreciate the time frame for this process, which is a couple weeks now.
students’ overseas voyages, Eric relies on overseas companies to provide travel funds, and on his students’ own excitement and willingness to do vital work on a volunteer basis.22

Processes for Getting Going
No less critical than the personal and institutional resources described above is knowledge about how to actually implement innovative learning activities in your courses. We know that every faculty member develops their own style, and only rarely will simply “adopt” a new approach—this characteristic of faculty is one of the greatest strengths of higher education. At the same time, we suspect that, with respect to knowledge about how to implement new learning activities, the vast majority of faculty innovators and early adapters end up “reinventing the wheel.” Rather than being necessary to maintaining faculty individuality and creativity, reinventing the wheel may be a poor use of faculty time and effort. With this point in mind, we asked Eric and his colleagues for their advice on “getting going.” They stressed the importance of getting to know and work with people outside your department and school, including faculty members, non-faculty members, and people in industry.

For a faculty discussion of networking, see Discussion C.

Managing the Dissolution of the “Atlas Complex”
As we explained at the beginning of this case study, a growing number of science, math, and engineering instructors are acting on the conviction that their courses need to be designed in ways that help students take more responsibility for their own learning. This is the first teaching principle that informs Eric’s decisions about which learning activities to use in structuring his courses. This section of our case study makes clear that having the necessary internal and external resources isn’t all you need to implement these new activities that force students to take responsibility for their own learning. In addition, you must be willing to forego old patterns and try new ways of interacting with your students. Most faculty and students—including those featured in this case study—bring to college courses complex assumptions about teacher and student roles, plus a whole set of social and psychological habits associated with these roles, that present formidable barriers to implementing this teaching philosophy. Donald Finkel and Stephen Monk put these barriers in a nutshell with their phrase, the “Atlas Complex” (see References).

Encouraging students to take more responsibility for their own learning requires faculty to relinquish some responsibility—in other words to abandon the notion that they must, like Atlas, bear the weight of the entire classroom world on their shoulders. Breaking out

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22 Eric: And in that context, we've been going out to projects in the north end of the Caspian, and the companies we work with have funded our travel and lodging over there. They're not attractive grants because they provide no overhead and no salaries. ... But in the context of what we're doing, you can accomplish things because they [the governments we work with] have no money to pay. And they say, “We don't have any money,” and he [the student] says, “Well, that doesn't matter, I'm still going to help you.”
of the Atlas complex involves a willingness to step aside from the authority and power of center-stage and a desire to empower students; it requires asking questions instead of providing answers, listening instead of talking, feeling comfortable with student confusion instead of rushing to fix things. In Discussion D, faculty discuss the challenges that accompany the transition from “expert provider” to “guide on the side”:
**Summing Up**
In many of the case studies on the LT² web site, faculty discuss one potential danger of using technology in the classroom, which is that it may be used for the sake of providing glitzy entertainment than an actual learning advantage. In this case, Eric Frost has discussed how his use of technology is not a superfluous amusement, but rather an absolutely essential ingredient for helping students meaningfully conceptualize complex geological processes.

Making significant changes, however, is not easy. Like all others who attempt to incorporate technology into their classrooms in innovative ways, Eric has run into his share of problems with funding, personnel, and other bureaucratic obstacles that accompany such efforts. However, as he said in the body of this case study, one cannot expect to implement changes like his without encountering opposition, and must maintain determination in order to achieve success.
Discussion A. Students and faculty discuss computer-dependent learning activities

As we stated elsewhere, although it is possible to teach those topics that make up the focus of Eric’s classes without a computer, the concepts are illuminated considerably by the three-dimensional visualization programs and other computer-dependent activities that he incorporates. Shane discussed the advantage those activities have over paper and pencil explanations in fostering students’ abilities to meaningfully understand complex geological concepts.

Shane: In my old school, visualizing things in three dimensions had to be done with paper, diagrams, and models. I found it very difficult to try and visualize things. In just one class at SDSU, I learned more than I did in probably a year and a half at my old school about how faults work in three dimensions. Geology is such a visual subject anyway that without being able to see things in three dimensions, move them around, and physically go into a data set and pull things apart, you are at a great disadvantage.

Seeing things in three dimensions is one of the hardest concepts to grasp for most geology students. Having the new technologies and being able to work with the programs in three dimensions increases the class’s learning by one hundred fold. If, for instance, we were all given the same data set, and the same problems, everybody would interpret the data cube and devise their own model. Then we’d get back together. I guarantee that not a single one of the models would be the same. But each person who presented their little piece of the project would greatly increase the understanding of how things work in three dimensions.

Seismic cubes are shot in horizontal distance versus time. The time it takes for a sound to be shot through the air and bounced back up is a seismic reflection. So with the visualization program, you can pick the top surface of the cube as a time slice, a paleosurface, or a stream channel in the second and third dimension as you rotate the cube.

Eric agreed with Shane and explained that if students cannot see and manipulate the three-dimensional model themselves, the concept will not stick in their brain.

Eric: It is important to be able to manipulate the visualization. If they can rotate and move the model, they get much more out of it than they would by just looking at it and listening to me explain it. If you can look straight down the fault you can see the relationship. With any other view, you don't see the right relationship. It affects much more of their brain and sticks in their mind. It is embedded in other parts of their brain when they are able to do the manipulation.
As a result of the computer-dependent learning activities that Eric assigned, Shane’s entire approach to problems changed to the point where he now concentrates more on the process of finding a solution to a problem rather than on the solution itself.

Shane: I look at problems differently. It is not so much, “What is the exact answer?” but, “How you get to that point?” It is the process that matters. Your answers can change, given somebody else’s new idea.

It is the understanding of this process, according to him, that has, “helped, especially in the job market.”

Shane: There is a huge void in geology between the university system and industry as far as understanding how the earth and rocks behave. Being able to use these technologies through the help of industry brings the whole class up to that same level.

And it is not only the process of solving problems that Shane has learned, but also the process of working with equipment that is not always as reliable as he would like it to be.

Shane: Sometimes it's a blessing when a computer breaks in class, because we all sit there and go, “We're dead meat if we don't get this thing fixed,” and then we figure out ways to fix it. And then there's sense of accomplishment, and then the next time it breaks, it's not a big emotional falling apart.

Discussion B. Faculty and students discuss the personal characteristics necessary to the success of reform efforts

As we stated in the section on Personal Resources, determination was a characteristic that helped Eric overcome the obstructions that stood in the way of his reform efforts. For instance, despite the little time that Eric had in addition to his regular schedule at the university, he decided that bringing helpful technology into his classroom was something that was too important to neglect.

Eric: A lot of the things I have done in terms of figuring things out [technologically] are things that I just decided I wanted to pursue. Often times it was to help solve a problem. The only way that you get something done that is new and different is you just decide you are going to do it and at the same time do your normal duties.

One Central Administrator told us that it is not just other duties that can get in the way, but even fellow faculty members.

Central Administrator: Eric really is a pioneer and all pioneers carry with them a double edged sword. The pioneer part is he has his eye twenty years down the road. And in that way some people support him greatly. In other ways, people say
he is just off in the wilderness, he doesn't know what he is talking about. So, I would say he is a scientific pioneer in education.

Also, in departing from traditional academic methods, Eric has had to exercise determination after having suffered professionally for his emphasis on education.

Kris Stewart, Math and Computer Science Professor (Eric’s colleague): One of the things I would like to pass on to other people would be about this enthusiasm that Eric has and his selflessness at putting so much of his effort into things that benefit his class—often at the expense, perhaps, of the professional recognition that he should have.

And has all of his determination paid off? According to his department chair, Gary Girty, yes.

Gary: The lesson that I've learned from watching Eric over the last 17 years is, “Always look to the future. Always stick to what you're after.” He’s been incredibly successful, phenomenally successful at what he does.

Discussion C. Faculty discuss the process of networking

As we stated in the section on “The Process of Getting Going,” the faculty members at SDSU place a premium on networking both outside of one’s own department and even outside the university.

Eric: To adopt new ways of teaching, people have to get involved with people who are doing it already. I think as soon as people actually see concrete examples of how somebody is using technology, they realize what science can do. Once you see that and imagine yourself teaching that way, it is a downhill ride that would be hard to stop even if you tried to.

I teach within the corporate world, for Chevron. They have a “Top Gun” school kind of a thing. I teach people who have been in the oil industry for a while and are brought in to raise their skill level. So, a lot more than most of the faculty, I have a sense of where our students (on campus) need to go, and that they will be using much higher technology than is usually available at the university.

One of the other big lessons I’ve learned is that a lot of the most creative people in the university are not on the faculty. I've found that there are a lot of really creative, talented people that would fit in as sort of quasi-faculty, staff people, volunteers or alumni. The things you try to do with them often move forward much more rapidly because they often times have thought about things for a long time. They have technical capabilities to do things and often do so in a better time frame because they don’t have as many distractions as a lot of faculty members do.
One of the lessons that I have really used is that if you want to work on accomplishing a lot of things like this, you have to go work outside of your own department with other people who know something about cognition and/or learning. It is really helpful to work with people from other universities. It helps you appreciate what you have in a positive way, see what things other people have that you would like to mimic.

Also, because of Eric’s interest and knowledge in working with supercomputer applications at the San Diego Super Computer Center (SDSC), he was much more aware of new technological innovations. Kris Stewart, professor of math and computer sciences, explains this point:

Marco (interviewer): *How did you get Eric, and why him? What did you like in him that made you somewhat embrace him as a member of your academic family?*

Kris: *He respected high performance computing, he knew of its value. I had actually known of his work with the San Diego Super Computer Center from many years ago. So there is a long time association with Eric. He really believes in his teaching and benefiting his students, so it is a natural thing to help him.*

Discussion D. Faculty discuss the dissolution of the “Atlas complex”

Eric’s method of making students primarily responsible for their own learning has come up against resistance both from faculty members and students. The resistance comes in the form of:

- faculty viewing technology as providing “activity and no content”;
- students not wanting to take responsibility for their own learning; and
- faculty not willing to make students primarily responsible for their own learning.

Gary Girty, Department Chair of Geological Sciences, made the point about “activity and no content” by pointing out that certain faculty think that technology is all glitz and no substance:

Gary: *There are some faculty who just refuse to get involved. We still have some faculty members that think technology provides activity and no content. They think that the students think they're learning because they're clicking buttons and looking at screens, but they're not really learning anything.*

Moreover, according to Eric, a large number of faculty members are committed to the “knowledge delivery” model of teaching, which is not conducive to an effective use of technology.

Eric: *We have a substantial part of our faculty that is very much about, “Here's the knowledge. You write it down. I'll give you a very difficult test and that will measure your capabilities. If you do really well on it, then you must be really smart.”*
But faculty are not the only ones resistant to a more student-centered teaching approach. Eric has felt resistance from his students, who are also accustomed to the “knowledge delivery” model.

**Eric:** One of the biggest frustrations is that a lot of students don't want to take responsibility for their own learning. They just want you to tell them something, and then they'll write it down and they'll give it back to you on a test. I've realized that I can't please everybody, and if someone doesn't like what I do, I have to come to grips with it and accept that they don't like me.

Shane, Eric’s former student, has also noticed the student resistance.

**Shane:** He is very good at facilitating which way the group should go. If you are thinking in the wrong pattern, he is going to steer you back in the right way. But a lot of students aren't used to learning in that kind of environment. They are used to learning from a teacher who is standing up in a classroom telling you the answer instead of helping you discover things for yourself, make your own discoveries, and learning in that way. Myself, I've learned ten times more in that way than I have in the [traditional way].

Even Gary Girty, the Department Chair of Geological Sciences, has been approached by students in Eric’s courses who cling to the read, memorize, regurgitate method.

**Gary:** There have been a couple instances now where Eric’s students have talked to me and said, “I don't want to put my stuff on the Web. I don't want to get involved in this. I think that's ridiculous.” And I suggested, calmly, that they have a quiet talk with Eric and explain this. And I think everything will work out fine. And that's exactly what has happened. Eric will work with them, help facilitate whichever direction they want to go. His main strategy is, “You're in control.”

**Resource A. Institutional Context for San Diego State University**

SDSU faculty members are awarded more than $95 million in private and government funding each year.

The faculty are organized into 7 colleges. The faculty member featured in this case study is a member of Department of Geological Sciences, one of 14 departments in the College of Sciences. This college contains approximately 22% of the overall faculty FTE. The Department of Geological Sciences has 20 senior faculty/research members, 17 adjunct professors and 7 lecturers. A complete faculty list can be obtained at http://www.geology.sdsu.edu/people/faculty/index.html.

**Resource B. Methods Used to Produce This Case Study.**

This report is the result of a case study conducted by the Institute on Learning Technology (ILT), a year long Institute of the National Institute for Science Education.
Marco Molinaro and Jean-Pierre Bayard, researchers for the Institute on Learning Technology, conducted interviews during early December, 1999, at San Diego State University. At that time, Eric Frost was finishing his course on Collaborative Visualization – Geology 600. Shane DeGross was selected as a student that had known Professor Frost under various circumstances, as both a student and as a mentee. We met with him privately and for lunch with Eric. Kris Stewart acted as an enabler for connecting Eric with the San Diego Supercomputing Center. We spoke to her to better understand the support given to Eric by his institution. Yusuf Ozturk gave us the perspective that comes from a colleague who is outside Eric’s department. All other interviewees were administrative personnel keenly aware of the work of Professor Frost via their promotion of his work.

The interviews were guided by the protocols used in all the Learning Through Technology case studies and were taped and transcribed. Marco analyzed the interview material to produce this case study. Andrew Beversdorf edited the case, with assistance from Susan Millar.

The instructors and administrators who are identified in the case study read the document and gave us permission to use the quotes we attribute to them. These SDSU readers also affirmed that this case study conveys the essence of what they were doing in fall 1999. To help readers who jump into the middle of this case avoid confusion, the researchers are identified as “interviewer” the first time their voice appears an interview segment.

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**Glossary: Special Terms Used in the LT² Website**

**Assessment** – What do faculty who are experimenting with interactive learning strategies (see *constructivism*) mean by “assessment”? In the simplest terms, assessment is a process for gathering and using data about student learning and performance. The LT² website distinguishes the following two types of assessment:

- **Formative assessments** – activities that simultaneously (1) provide instructors with feedback about how and what students are learning, which the instructors can then immediately use to adjust and improve their teaching efforts; and (2) foster student learning directly because the students in the process of performing such activities. (For more information, see the [FLAG website](#), which features classroom assessment techniques that have been show to improve learning.)

- **Summative assessments** – formal examinations or tests, the results of which faculty use to demonstrate in a way that is definitive and visible to people outside the course the degree to which students have accomplished the course’s learning goals.

Tom Angelo (1995) defines assessment as an ongoing *process* aimed at understanding and improving student learning. It involves:

- making our expectations explicit and public;
- setting appropriate criteria and high standards for learning quality;
- systematically gathering, analyzing, and interpreting evidence to determine how well performance matches these expectations and standards; and
- using the resulting information to document, explain, and improve performance.

When it is embedded effectively within larger institutional systems, assessment can help us focus our collective attention, examine our assumptions, and create a shared academic culture dedicated to assuring and improving the quality of higher education.

**Bricoleur** – a French term for a person who is adept at finding, or simply recognizing in their environment, resources that can be used to build something she or he believes is important and then putting resources together in a combination to achieve her or his goals.
Constructivism – According to Schwandt, constructivism is a “philosophical perspective interested in the ways in which human beings individually and collectively interpret or construct the social and psychological world in specific linguistic, social, and historical contexts” (1997, p.19). During the last 20 or so years, cognitive psychologists (James Wertsch, Barbara Rogoff, and Jean Lave, among many others) have found that constructivist theories of how people construct meaning are closely aligned with their observations of how people learn: knowledge is mediated by social interactions and many other features of cultural environments.

Learning activity – As used in the LT2 case studies, learning activity refers to specific pursuits that faculty expect students to undertake in order to learn. Thus, “Computer-enabled hands-on experimentation is a useful way to get students to take responsibility for their own learning” is a statement of belief that a particular learning activity (experimentation) helps realize a particular teaching principle.

Learning environment – According to Wilson, a learning environment is a place where learners may work together and support each other as they use a variety of tools and information resources in their pursuit of learning goals and problem-solving activities (1995). This definition of learning environments is informed by constructivist theories of learning.

Microcomputer-Based Laboratories (MBL) – A set of laboratories that involve the use of (1) electronic probes or other electronic input devices, such as video cameras, to gather data that students then feed into computers, which convert the data to digital format and which students analyze using graphical visualization software; and (2) a learning cycle process, which includes written prediction of the results of an experiment, small group discussions, observation of the physical event in real time with the MBL tools, and comparison of observations with predictions.

Seven Principles for Good Practice in Undergraduate Education – These principles, published in “Seven Principles for Good Practice in Undergraduate Education” by Zelda Gamson and Arthur Chickering, were synthesized from their research on undergraduate education (1991). According to their findings, good practice entails:

1. Encouraging student-faculty contact.
2. Encouraging cooperation among students.
3. Encouraging active learning.
5. Emphasizing time on task.
6. Communicating high expectations.
7. Respecting diverse talents and ways of learning.

Teaching principles – Teaching principles refer to a faculty member’s more general beliefs about, or philosophy of, learning. For example, the idea that “students should take responsibility for their own learning” is a teaching principle. It is general and informed by a theory of learning. It does not refer to something specific that one might actually do in a course.
References


