

## **Results of a survey of educational IT applications evaluated against certain Gateway educational goals**

---

Norman Chonacky  
27 July 2000

I conducted a "literature" survey that identified institutions and curricula that use instructional technology for goals matching at least some of those of the Gateway coalition. The detailed results arranged by institution are reported in an appendix: An analysis linking characteristics of IT use to each Gateway Coalition educational objectives appears after the following.

I should mention first that my search was actually both broader and narrower. Broader in that it included instructional examples that serve coalition learning goals but do *not necessarily* use IT. It is my belief that "best practice" means using whatever means of conducting instruction that is most appropriate. I stress that consideration of IT use should *begin* with a well-founded specification of learning goals. Narrower in that I selected these practice cases using my intuition honed by broad experience in educational uses of computers. In most cases these choices are supported by the recognition associated with their being funded by the National Science Foundation or other well-respected foundations and agencies. In this sense they are perhaps better characterized as *Norman's favorite practices*, "best" instead suggesting a rating based on controlled studies. Such studies, and the implied existence of widely accepted assessment instruments and evaluation methodologies, simply do not currently exist.

The following is a phrasing of the Coalition objectives laid out as targets at the beginning of this project.

---

### **AY99-00 Columbia Gateway educational objectives**

Here is a list of specific task objectives which are to result from work for the Columbia SEAS Gateway Coalition during academic year 1999-2000.

- A. Conduct a national survey of educational best practices that use instructional technology to improve education in ways applicable to the coalition's targeted learning outcomes. Among these are:
    1. ability to effectively communicate in written and oral forms
    2. understanding interplay of marketing, economics, and organizational management with the engineering process
    3. understanding concepts of total quality management
    4. realizing the need for and the skills needed to conduct lifelong learning
  - B. Especially include educational best practices using instructional technology that can be applied to large-enrollment, introductory engineering and science courses
  - C. Develop specific examples that elucidate the character of three of these "best practices".
  - D. Design and implement one or more workshops to develop faculty capabilities in these best practices. These workshops should be designed in response to a recent survey of IT applications for curricular development in which faculty from Coalition schools revealed they were especially interested.
  - E. Conduct these workshops at Columbia and Coalition institutions during the academic year.
  - F. Experiment with Web technologies to "extend" the workshops themes into the cyclic process of continuous improvement of actual course curricula in the time and space of the participant's classrooms.
- 

We will now list in turn the objectives of points A and point B, indicating which survey examples relate to that objective and offering reasons for this. The index numbers accompanying each institution/project refer to those numbers by which they are referred in the list of institutions in the appendix.

---

### **Commentary on national *best practice* examples**

---

#### **Objective A.1 Ability to effectively communicate in written and oral forms.**

##### **1. Rensselaer Polytechnic Institute**

The principal paradigm is the "Studio Course", so-called because it is engineered from multi-media pieces much like studio art. It embodies the systematic use of technology to create a cooperative learning environment. Therefore, it relies on well-founded, inter-student and instructor/student communication. In

studio courses such communication is facilitated by having the students work in groups on such in-class exercises as analyzing the results of computer simulations or of computer acquired experimental data. Thus IT is used first to create realism in the content matter, and then as the centerpiece of discussion. The ability of the computer to respond to spontaneous, individual student questions invites hypothetico-deductive reasoning into the learning process.

### **3. Dartmouth College**

The *Mathematics Across the Curriculum* Program is a very innovative, multi-disciplinary college effort that I discovered. Although its most distinguishing characteristic is that it crosses disciplines - for example there are many applications in humanities areas - it does embody threaded discussions as a "discursive" facility that encourages students to learn by communicating. One such example is Leonardo's Tea Room an sample of which you may access at:

<http://www.dartmouth.edu/~matc/TeaRoom/comment1.html>

Here you may examine sample threaded discussions which have been generated by the participants in the Math-Art MATC project course.

### **6. University of Michigan**

A two semester, multi-disciplinary, environmental science course - *Introduction to Global Change* - uses a combination of traditional lecture and Web-based technology to teach the science base of global phenomena that are changing as well as the human consequences. The course methodology supported by IT includes laboratory and group/project work components. The project work strategy involves research and then considerable writing, first to articulate and assess one's interest in possible project ideas, and later to publish the results of a group-produced, research project as a poster on the WWW.

### **7. Georgia Tech**

*Classroom 2000* is an elaborate and automated system for capturing the classroom process, indexing it, and making it available via the WWW for later use. Students use this archived classroom material - most of it lectures - as a framework for BB-based discussions in between lecture sessions. These electronic discussions are stimulated by students questions or issues which they must formulate and write out. This methodology assumes that the lecture is the central focus of the course and that writing and thinking about lecture material is central to students' learning. Therefore, writing about the lecture material and the classroom questions is an important educational use of the *Classroom 2000* technology.

### **9. Harvard University**

"The language of physics is not mathematics," says Ed Mazur by way of introducing his subject to his class of students, "it is English (or any other particular general language)." This fundamental tenet shapes the classroom injunction that students learn to articulate their understanding of science in the own native language. They do this orally in small group discussions in class, but also in the form of "one minute essays". Both these classroom requirements, and a pre-class requirement to pose questions or comments on readings that are assigned for each lecture, require students to develop good communication skills and a talent for formulating their beliefs in written and oral forms.

### **10. Tufts University**

Both the Workshop Physics and Real-time Physics curricula share the learning methodology that asks students to articulate their encounters with physical phenomena experienced through instrumented sensors and probes. This method uses the fast, quantitative feedback from these instruments as the material of oral discussion and reasoning about physical processes.

### **11. The Evergreen State College**

A threaded message list for extending the discussion of class material outside of the classroom is not an unusual example of educational technology applications. However, I chose Evergreen Web site because the core values of this institution state the importance of communication in the learning process. Evergreen asserts that a main purpose of a college is to "promote student learning by which students develop their capacities to "judge, speak, and act on the basis of their own reasoned beliefs". You may examine a sample archive of such threaded discussions at [<http://192.211.16.9/webx?>] Check the Academic Programs Discussion Groups conference category and measure these discussions against this goal.

---

**Objective A.2. Understanding interplay of many aspects of problem analyses: e.g. marketing, economics, and organizational management with the engineering process.**

### **3. Dartmouth College**

*Mathematics Across the Curriculum* consists of many cross-disciplinary modules, some small course supplements and some whole course curricula, blending mathematics into a wide range of other subject areas. Because these modules have been implemented in Web technology, many incorporate Java applets which allow students to calculate, simulate, and explore math in these various contexts. As such, these lessons illustrate how to use IT to extend the complexity of phenomena that can be treated and may offer inspiration for developing analogous exercises that carry the engineering process over into other these other features which interplay.

### **4. University of Oklahoma**

The School of Pharmacy has some on-line course syllabi with exercises which, in spirit, resemble those of the Dartmouth MATC program. Among the examples of "on-line" curricular exercises that are available, the ones in *A First Course in Pharmacokinetics* illustrate the power of Web-based instructional resources for dealing quantitatively with complex problems. For example, Java applets contained in the page that is delivered in one section permit the learner to recast quantitative data in many different forms in order to abet the search for meaning in those data. See:

<http://gaps.cpb.ouhsc.edu/gaps/pkbio/Ch05/Ch0503.html>

This kind of capability is used in these exercises for learners to model complex systems having several interacting, driving features. This course thus offers a paradigm for creating learning exercises that can demonstrate the interplay of several independent drivers.

### **6. University of Michigan**

The course methodology supported by IT includes laboratory and group/project work components. The Laboratory component stresses quantitative analyses. Modeling is an important part of this analytic experience, and students use modeling programs such as *Stella* to design models carry out simulation calculations. These models can be very complex and reveal how several independent features interplay to produce various results.

---

**Objective A.3. Understanding concepts of total quality management such as feedback and successive improvements.**

### **6. University of Michigan**

This set of courses - *Introduction to Global Change* - uses a combination of traditional lecture and Web-based technology to teach the science base of global phenomena. The course methodology features group project work. The project work strategy employs quality management in the processes of topic choice and product (poster) production. This poster summarizes the research work whose outcome at various stages the students assess and successively improve.

### **9. Harvard University**

Mazur uses "classroom polling" hardware and software to challenge students during lecture to think carefully about what they believe. This, in turn, prepares students to compare their beliefs, to argue about and discuss them, and to successively refine their understanding of physics based upon feedback they acquire by these activities.

### **10. Tufts University**

The Workshop Physics and Real-time Physics instrumentation provide students with instantaneous feedback from measurements of physical phenomena in the form of readily interpretable visualizations. Following these curricula, students are encouraged to create and refine the physical regularities that are inherent in these phenomena. Gradually, through successive generalizations they can infer the physical laws responsible for these regularities and understand them in a way sufficiently robust so that they can apply them outside the context of their discovery.

---

**Objective A.4. Realizing the need for, and the skills needed to conduct, lifelong learning.**

**3. Dartmouth College**

The *Math Across the Curriculum* program is clearly intended to contextualize mathematics, and produce students in other fields who are literate in, and capable of, using math in their chosen disciplines. Because the program has produced so many different applications in such a wide variety, it documents the wide applicability of math even in areas beyond the particular course a given student chooses. Moreover, the applications of math in these other curricular areas are not superficial by any means. Thus there is value in the breadth which serves students' realization of possibility, and value in the depth which serves their realization of need for lifelong learning of mathematics.

**5. Rice University**

The Rice *Virtual Lab in Statistics* includes case studies, using real data from realistic situations. Users then analyze these data with basic statistical analysis tools that are provided with the Lab. The package can similarly serve as a "just in time" tutorial for field workers who need to refresh their knowledge of statistics and apply it to their own data. This is an effective example of classroom methodology that can stand alone and offer continuing opportunity for learning outside of the formal institutional context.

**6. University of Michigan**

This set of courses - *Introduction to Global Change* - uses Web technology to continually inject current topical issues into the course. It does this by "pipelining" current news stories and new discoveries about the environment as they unfold. This feature is a fixture of the Web site for the courses. The course design explicitly and deliberately emphasizes that Global Change is a continuing challenge; that solutions to its problems are not yet known, nor even known to exist. Clearly this is a tactic intended to prepare students for the transition to a life-long engagement in such learning.

**12. University of California - Berkeley**

The Department of Statistics has designed a set of on-line instructional modules called: *Tools for an Interactive Learning Environment (TILE)*. These tools developed at Bell Labs, and elsewhere, especially those in *Omega* environment, provide an extensible and customizable toolkit for statistical analyses. Like the Rice *Virtual Labs*, TILE tools can be used to create lab exercises for teaching statistics. Also like the Rice tools, the TILE tools can readily be applied to one's own, real life data. Thus they encourage students to think of their formal education in the context of, and as a preparation for, a life of learning. Significantly, the project that produced these tools was a partnership with the Bell Labs, hence included perspectives on learning that were outside the formal academic environment.

---

**Objective B. Applying to large-enrollment, introductory engineering and science courses.**

**1. Rensselaer Polytechnic Institute**

The first implementation of a studio course, from which the generalized notion of "studio course", was drawn was an introductory physics course. At Rensselaer, an engineering school, these are necessarily large physics is a required course for all engineering programs. In this case, elaborate multi-media technology supports active learning in which students analyze real data, hypothesize, and test predictions while gathered in small groups around computer stations in their classroom.

**2. Pew Learning and Technology Program - RPI**

Rensselaer conducts its academic innovation and faculty development via a collection of "centers". The *Center for Academic Transformation* is one of these, and is primarily responsible for helping extend and implement the notion of studio course design. Within this Center, the Pew Learning and Technology Program focuses on implementing studio-course-like strategies in *large class settings*. This program invokes the participation of other, outside institutions in developing and testing a broad range of such IT-based strategies. It has sponsored conferences to identify the problems specific to this goal and offers awards to schools experimenting with promising solutions. Thus, the Program's Web site offers white papers on these subjects and descriptions of the programs of awardees. Presumably it will disseminate the successful results and lessons learned in future conferences.

A report - *Improving Learning & Reducing Costs: Redesigning Large-Enrollment Courses* - from an initial conference was prepared by Carol Twigg of the Center and appears in its entirety at:

<http://www.center.rpi.edu/PewSym1.html>

There are also several other Centers of similar ilk at RPI. I will not detail these but rather refer the reader to the Appendix to this report for a full accounting. My synopsis of Twigg's paper also is in this Appendix.

### **7. Georgia Tech**

The *Classroom 2000* innovations are clearly intended to address the challenge of improving teaching in large classes. The major part of the facility is aimed at archiving and transmitting information. However, the threaded discussion application of the classroom information archive demonstrates that the same information can be "re-purposed" to server other means, such as greater student involvement in reflecting upon and reformulating class information to suit their own perspectives.

### **9. Harvard University**

Mazur has spent much time and effort to face the challenge of reforming student learning in his large classes by creating opportunities, requirements, and facilities for students to take an active role in creating their individual understanding of the material. His work was motivated by research in teaching and learning. In particular, he was provoked to re-examine his own teaching methods after he used a research-tested assessment tool (the Force Concept Inventory) on his own students. The result of such testing was his discovery of how shallow was their understanding of the material he had taught them in mechanics. The results of his labors include extensive use of the Web to keep information about how students are thinking flowing to him. This helps him to prepare to manage his own presentations "dynamically", modifying what and how he treats the material to better serve any particular set of misconceptions. This is his way of individualizing through careful perception a course that otherwise would be taught in corporate blindness.

---

## **Collaborative curricular reform experiment at Columbia with Ohio State University**

---

The report for this work, conducted in **spring 1999**, is included as a separate document accompanying this report. <Gateway-I.final.report> The outcomes of this project work included the following:

- Improvements to the general chemistry course C1404 of which many students are majoring in engineering. These include a demonstration that small group, in-class discussions in response to key questions are both feasible and effective for producing students' active involvement in their learning. And it is educationally valuable to add contextual examples of the subject matter as it is applied to understand and solve practical and important problems in the environment.
- Identification of critical requirements for TA preparation that will be needed to be able to extend and reinforce active learning processes in the recitations sections. These requirements pertain to active learning in recitation sections whether or not they are accompanying active learning processes in the large, lecture portion of the course.
- Creation and evaluation of prototypical interface forms for portraying multiple views of the documentation created in the course of the curriculum improvement work and archived to assist in the collaborative work of the development process.
- Emergence of a new lines of inquiry and experimentation for the conduct of a next stage of interface research development.
- Demonstration that process consultation to help faculty innovate in areas where they need help is feasible but of limited help absent a reliable and efficient system for telecommunication in support of collaborative development work.
- Demonstration to the NSF coalition evaluation team visiting Columbia of this portion of the Gateway Coalition collaborative educational development work and IT to support it.

### Research seminar at Ohio State University

---

In early October 1999 I was invited to give a seminar to the Physics Education Research Group in the Department of Physics at Ohio State University. I entitled this seminar **Object-Oriented Instructional Design**. Its content was a report of exploratory work in progress to develop a system for curriculum design that would improve the coherence and effectiveness of any curriculum design that includes multiple approaches to instruction. Typically such designs have various instructional components which must be coordinated. Increasingly, these days, one wishes to implement new designs using multimedia and to base these on Web servers. My explorations, reported here, seek to define a system of specifying instructional designs that:

- provide coherence;
- follow sound instructional principles emerging from current research on teaching and learning; and
- separate the design from the implementation parts of the instructional material creation process.

This system would be based on object oriented design principles, which are frequently used in computer program design. The material presented in this seminar is in PowerPoint format in a separate document accompanying this report. <OODseminar.1.ppt>

---

### Report on the biennial conference for Computer Supported Collaborative Learning-1999

---

The report from my experiences at this conference, held in December 1999, is included as a separate document accompanying this report. <CSCL'99.Report.from> My summary judgement of this experience is that it was very valuable. Some of the reasons for my judgement:

- It introduced me to a body of scholarship and group of scholars of which I was entirely unaware.
- The presentations were varied - plenary lectures, workshops, contributed papers, working seminars, posters - providing means suitable to every type of tutorial and communication need.
- The scope of the work - from abstract theories of semantics to practical demonstrations of what works in the classroom - enabled one to draw together many intellectual resources from many traditions to reinforce one's comprehensive understanding of this highly multi-disciplinary field.

My attendance at this conference was at the suggestion to the Gateway Coalition of Susan Kemnitzer - NSF Deputy Director of the Engineering Centers and Education Division.

---

### Commentary on workshops developed in conjunction with the CCNMTL

---

An important part of the AY1999-2000 Project work was for me to research and identify "best practice" examples of the use of information technology for education. It is my belief that "best practice" means using whatever means of conducting instruction that is most appropriate. I stress that consideration of IT use should *begin* with a well-founded specification of learning goals. I developed this notion throughout this series of workshops on IT. In the first workshop, for example, I used Alan Van Heuvelen's *Active Learning* physics course as the case study.

The development of these workshops was an interesting experiment in intra-institutional collaboration. Both Gateway and the CCNMTL sponsored this work Each had somewhat different needs for the products offered, but both had an interest in developing faculty capability to use IT in their instruction. The overall plan was to develop **one workshop first**, this for Gateway to be presented at the joint Gateway and SUCCEED Conference - *Share Our Future: A Working Conference*. Alan Van Heuvelen and I would jointly develop this workshop, which in turn would be a prototype for **three more** that I would develop myself for the CCNMTL. The common thread through all would be that each dealt with "best instructional practice" as identified by my research survey.

Here is a list of titles of these workshops in order of their creation:

1. *Active Learning: Introducing Students to Communities of Practice - I*
2. *Active Learning: Introducing Students to Communities of Practice - II*
3. ***Large Class IT Strategies***
4. *Large Class Strategies - II* ( better titled, and hereinafter referred to as: ***Introduction to Web-based Instructional Design***)

The four workshops were each formulated in a Power Point presentation. The names of the four files that contain the presentations are in <> as follows:

1. *Active Learning: Introducing Students to Communities of Practice-I*: <Gateway-SUCCEED-final>
2. *Active Learning: Introducing Students to Communities of Practice-II*: <CCNMTL/Gateway.proto#2.final>
3. ***Large Class IT Strategies***: <CCNMTL-Wrkshp.proto#3.rev.3>
4. ***Introduction to Web-based Instructional Design***: <Workshop.LargeClass-II.final>

Except for the first, each presentation is annotated giving the substantive content in narrative form. You must view those presentations in the Power Point mode which displays notes in order to see them. The first presentation has its content elaborated in the form of notes made during the preparation of the workshop material. As such, they give a view into the collaborative work process that we used in creating this workshop. These **workshop preparation notes** are contained in the first appendix, following the next section. I have detailed notes from reflection subsequent to the first workshop - *i.e.* Gateway-SUCCEED. These follow immediately.

---

### Concluding thoughts from the Gateway-Succeed Conference workshop - *Active Learning*

---

Norman Chonacky  
4 April 2000

#### Brainstorming:

The workshop was over-planned and overloaded, but was fairly well conducted. Alan and I did a lot of fast self-editing. Ryan Kelsey has already proved very helpful with his critique of what worked and what didn't.

Alan and I had a de-briefing session for about 30 minutes just after the workshop ending and before he left. There is record of this and I will use it to design the brief assessment questionnaire that I will put on our Web site tomorrow.

Here is what I have committed myself to provide via the Web:

- "Protocol" for the instructors' cohort to use as a guide (really an input form) for their creation of the prototype exercises that they are committed(?) to produce for testing in their classes.
- The presentation material as a printable, pdf file.
- Certain links to other URL's that they expressed interest in examining. For example, some want to access Mazur's Physics 1b materials. Someone else asked me about Alan's experiment problem examples.
- I have told them that we would manage the post-workshop prototype production process and testing exchange via the Web-site. I discussed this with Mort who seemed enthusiastic. I will now describe the elements of this in the following narrative.

What can we expect this group to accomplish and what are the key elements that I can help them with? There were five/six participants that volunteered they might produce lessons. Of these I would guess that two might be expected to honor this commitment. Ryan guessed that two of these might be Mimi and the "finite element" instructor. I agree with this calculation. My obligation is to see that they are informed of and get from me the support that they need to carry through on this initial willingness.

### The development protocols:

From the workshop whiteboard (with some embellishments):

- Elements of the **experiment problem** methodology for *Active Learning*
  - Start with a poorly defined problem
  - Divide and conquer - learning to parse and simplify it into identifiable parts; and then synthesize the piecemeal solutions into a whole
  - Separate students into small groups to work on parts; the gather together to synthesize an answer.
- How to build it - a model protocol for designing an Active Learning exercise:
  1. Set an **educational goal** - Describe the kind of student (capability / behavior / understanding) that you wish to develop.
  2. Set a **learning objective** - What is your most pressing problem/challenge in your classroom now that stands in the way of this goal? Think small!
  3. Set an **evaluative criterion** - State the concrete student change/product you would accept as evidence that this problem had been solved / challenge had been overcome.
  4. Chose an **Active Learning strategem** - Which do you think might be feasible and effective in addressing your objective:
    - Experiment problem
    - Interactive simulation / demonstration
    - Jeopardy problem
    - Concept test
    - Other?
  5. Select an **assessment instrument** - What tool can you use to obtain the student data you would need to evaluate in order to decide that your objective had been met:
    - Attitudinal survey
    - Standardized test
    - Student interview / oral quiz
    - Application test - ask students to apply the concept / manifest the new behavior / exercise the new skill - in a context different from the one of the active learning exercise.
  6. **Design the exercise** as a prototype - don't be too fussy if this is your first attempt to conduct Active Learning.

---

### Summary of the design part of the workshop:

We started an all-group discussion proceeding along the lines of a design protocol that I had on a PowerPoint slide, but that I simplified on the white board. I asked each of them to think concretely and to try to think of what was there most pressing problem, or most thorny problem, with their course right now. This is after acknowledging that we would try have each of them leave with some specific idea about an exercise that they would design and test with their classes. The discussion was not very successful. Then I asked each of them to state what course they were teaching now that might qualify. These ranged through:

- Dynamics
- Statistics
- Integrated circuits
- Finite element analysis (Statics of structures)
- Differential (sophomore) equations

I asked them how they would prefer to organize for the exercise design work. This discussion drifted from the question of organization into the details of what one might develop an *A-L* exercise about. This is expected in situations of uncertainty. People try to focus on details rather than larger issues. The question of organization is one such larger issue, and they resisted confronting it in order to get an idea of *what* they

might develop before deciding *how* they might develop it. Several expressed interest in doing something with the spring projectile.

As time passed, I tried to suggest ways in which they might proceed to discuss exercises as a committee-of-the-whole. First, I suggested that I thought I could see a commonality emerging. The projectile could be analyzed as dynamics, a differential equation, statistically, by finite (time) difference calculation (a bit of a stretch since they deal with spatial elements, not time), *etc.* However, I found myself at a loss to include integrated circuits. Someone suggested we could launch a circuit instead of a spring (laughter).

Finally, we ran close to the end of time, and we needed some closure. I promised to try to help with exercise selection via the Internet. On our Web site I placed the presentation materials and the design protocols. Now I must suggest activities. Here were some of the exercise ideas:

Projectile experiment problem to synthesize dynamics principles

Projectile data with many repetitive resets of angle, spring displacement, and by different launch persons upon which to perform factor analysis. (I might suggest he focus on sequences of trials by various individuals. Technique to evaluate is "excess": pull needed to overcome frictional effects. Variables are individuals, hit rate as function of position in the sequence, *etc.* His class should design the experiment and analyze the data.)

Rolling ball competition between different pathways. (Not disclosed what might be taught. I could suggest a numerical simulation in search of optimization.)

---

Specific suggestions (in anticipating adaptation of this for the CCNMTL environment):

1. Our workshop #2 goal is directed toward Active Learning. Therefore, I should de-emphasize or eliminate the material on assessment. (I will find it difficult to justify doing this!)
2. Reduce introductory material
3. Get rid of video, or select new video segments that show students interacting.

---

## Appendix 1: Workshop preparation notes - the collaborative design process for the Gateway-SUCCEED workshop on *Active Learning*

---

### *Active Learning: Introducing students to communities of practice - Introduction segment*

#### **Introduction:**

#### Goals and objectives of this workshop

#### GOALS:

- Faculty able to create active learning exercises and formative assessment instruments for enhancing student learning.
- Faculty and administrators able to understand the capabilities of active learning and the value of coherent assessment, and to relate these to programmatic / institutional goals.

We have designed this workshop to help produce:

- faculty having a demonstrated capability to produce for their classes, by a process of successive, iterative improvements, active learning exercises by means of which their students can achieve prescribed learning goals;
- administrators able to relate the coherent learning objectives favored by such exercises to prescribed, programmatic learning goals.

#### **Schematic presentation slide #1**

#### **Aims:**

- Faculty producing effective Active Learning exercises efficiently
- Administrators linking Active Learning exercise objectives to programmatic goals

The workshop is based on a *case study* approach, and its pattern of events follows this outline:

- We present a single example with a description of context but no commentary.
- Participants answer several questions about the example, alone and then in small groups.
- We present a wider array of cases for comparison and contrast which participants discuss.
- There is a formal section presenting:
  - current theories and practice of *Active Learning*
  - principles of assessment and application of assessment results to corrective actions
- Participants reassess the case studies based upon the above elements.
- Participants identify specific learning goals they are individually interested in, and collaboratively develop exemplary Active Learning exercises that address them.

#### **Schematic presentation slide #4**

#### **Pattern of our case study approach to this workshop:**

- Introductory case - directed brain storming
- More cases - contrasts and comparisons
- Formal account of what we know about Active Learning based on research and development
- Formal account of how assessment can serve
- Movement to action - creating specific, exemplar Active Learning applications

### Schematic presentation slide #2

#### Effective exercises:

- Setting learning and content objectives
- Principles of Active Learning derived from research
- An epistemology - how does one know?
- Exemplary methods for activities
- Importance of an assessment component

### Schematic presentation slide #3

#### Efficient production process - Classroom Research:

- Iterative design and testing cycles
- Making a prototype
- Building-in effectiveness assessments
- Evaluation and refinement
- Including students in the process

---

Workshop for the Gateway/SUCCEED 2000 conference: Share Our Future  
**Active Learning: Introducing students to communities of practice - Exploration segment**  
13 March 2000

---

#### OBJECTIVES:

1. Analyze the ways in which initiative is taken and information about students thinking is obtained and used in each of several examples of active learning exercises in the classroom.

#### **Exploration:**

Demonstration of Active Learning - physics course from the OSU Gateway program.

*As a whole:* view video clips of several active learning examples in the classroom

Listen to brief introduction with conceptual questions about the classroom demos:

- ⇒ What are the instructor and student roles? c.f. use your own classes as a reference.
- ⇒ What are the kinds and sources of information being brokered?
- ⇒ What are the kinds and loci of judgements? e.g. validity checks, process decisions, etc..

*In small groups:* re-view and review video clips in the light of these questions

*As a whole:* draw a composite picture from the small group analyses of demos.

*Caveat: We may not have sufficient video material to illustrate several different examples of active learning. We will have at least some clip(s) from the OSU recitations for which Kathy Andre has given us source material. For the time being, suppose we have one clear example of (say) students collaboratively working on a problem. Hopefully, they are emulating group work techniques that they have learned to use in class. This would enable us to extrapolate with narrative what we might not be able to show with video (due to lack of source footage): use of "reverse logic", as in "Jeopardy" problems; reference to physical systems as in "experiment" problems; etc.. For now, we proceed with the plan as if we had the case studies already as video clips.*

Here are the types of activities that Alan enumerates as illustrative of active learning practices:

*Concept building and reasoning:*

- observing physical phenomena
- working with intuitions and counter-examples
- asking conceptual questions

*Developing and incorporating a mathematical language with "goal-free" problems:*

- Start with a word problem
- Learn to translate into and converse in math

*Working with multiple representations:*

- graphs, tables, diagrams, equations
- jeopardy problems - deriving phenomena from equations and graphs

*Developing higher-order learning through design, experiment problems, and multi-step problems:*

- analyses
- syntheses

These examples above are listed as categories in order of *increasing* sophistication and cognitive difficulty. Each of the scenarios that we depict below, whether in video or narrative form, should illustrate on each of these categories.

### Schematic presentation slide #1

**Exploration:**  
Take an "unbiased" (first) look at this scenario.

In this scenario (*Illustration of Concept building and reasoning*) we show a group of students talking over some problem in voices that are distinct and in a dialogue that is concise. It takes only one minute. Introduce the scenario only to extent of setting the context by giving the exercise's content. If there is a workbook sheet they are using, then have a copy to display on the screen.

After this first look, we ask the group if there are immediate comments or questions before we give you a frame of reference for analyzing this scenario. Depending on what they have observed and commented upon, we may wish to modify the list of "pointed questions" that follows.

### Schematic presentation slide #2

Replica of Activ Physics  
workbook sheet that  
students are engaged  
with.

We have a list of questions that we would like participants to consider in re-examining the scenario. Try to interpret these in relation to your own classroom experiences. The, using these interpretations, do the following analysis individually. We ask you to do this individually to elicit a *commitment* from you as an individual.

### Schematic presentation slide #3

#### Exploration:

##### Itemize:

- various student (and instructor) roles
- kinds and sources of brokered information
- loci of judgements and decisions

Now that you itemized these individually, work in small groups of neighbors to compare and contrast your lists. Give reasons or rationales to your partners, and arrive at a concise, consensus list. We ask this in small groups to exercise your ability to *negotiate* reasoned agreement.

From a random selection of these small groups we ask for sample of your analytic lists. We formulate a distillate of these as a list on the screen. Now we are ready to proceed and examine some additional cases using this distilled list as a guide.

### Schematic presentation slide #4

#### Case #2: (*Illustration of developing and incorporating a mathematical language*)

- Item 1
- Item 2
- Item 3

### Schematic presentation slide #5

#### Case #3: (*Illustration of working with multiple representations*)

- Item 1
- Item 2
- Item 3

### Schematic presentation slide #6

**Case #4:** (*Illustration of developing higher-order learning*)

- Item 1
- Item 2
- Item 3

---

Workshop for the Gateway/SUCCEED 2000 conference: Share Our Future  
**Active Learning: Introducing students to communities of practice - Invention segment**  
14 March 2000

---

OBJECTIVES:

2. Learn principles of active learning and assessment that will enable you to create well-designed exercises of your own.
3. Determine if/how the information about students' thinking and work is being conveyed back to them for their use in self-assessment for each of the active learning stages depicted in the classroom examples.

---

**Invention:**

[Discourse on Principles of Active Learning.](#)

Research base

Elements:

- Objectives
- Epistemology
- Stages/categories

[Discourse on Principles of Assessment.](#)

Research base

Elements

- Context - scope, target, and cycle time
- Objectives / criteria / teaching & learning perspective
- Instruments
- Evaluation of results
- Use of results

[Role of assessment in active learning.](#)

Re-view a selection of classroom active learning examples and identify the elements of assessment principles in each of them.

In this second segment of the Workshop, we present some explicit material on Active Learning and Assessment that have grown out of the research in teaching and learning conducted over the past two decades.

**Schematic presentation slide #1**

**Principles of Active Learning**

**Research base: highlights**

Item 1

Item 2

Item 3

Item 4

*These highlights should trace significant contributions and contributors with references. **Alan's choices here.** If possible, pick these to coordinate with objectives for Active Learning, following.*

Next we delineate the objectives that Active Learning is designed to achieve. *These should be related to the highlights above if possible, for continuity and coherence. **This is for Alan to do.***

**Schematic presentation slide #2**

**Principles of Active Learning**

**Objectives:**

Item 1

Item 2

Item 3

Item 4

Next we an epistemology that distinguishes among data, information, and knowledge. These distinctions are sufficient, but not necessary, for design of *Active Learning*. However any systematic instructional strategy has an epistemology, whether tacit or explicit. Our contention is that is better for a successful design process if these are explicated. However, one of us (NJC) at least believes that is necessary for valid assessment that the epistemology - whether this or others - be explicit. ***This part is Norman's responsibility.***

**Schematic presentation slide #3**

**Principles of Active Learning**

**An Epistemology:**

A "case study" upon which to draw (*Internet nodes example from OOD seminar*).

Data: values connected to phenomena; also *metadata*

Information: data with interpretive structure

Knowledge: information with abstractive generalization

**Schematic presentation slide #4**

**Principles of Active Learning**

**A (constructivist) epistemology: Data**

(simple list of number of Internet nodes with their corresponding dates, listed in *random* order)

**Schematic presentation slide #5**

**Principles of Active Learning**

**An epistemology: Information**

(This is an *ordered* list of number of Internet nodes versus *time*. Notice the distinction I make between dates and times. Also, I show a corresponding graph, a visualization of the order imposed in the transition from data to information and a shift in interpretation from that of the table.)

**Schematic presentation slide #6**

**Principles of Active Learning**

**An epistemology: Knowledge**

(Now show a semi-log graph of the ordered data. This is a deliberate move to a higher order of generalization. The straight-line appearance of the graph now suggests a model - defined by a first order differential equation - that was only implicit in the linear graph or the table.)

Here is a list of stages in active learning processes that Alan has developed:

**Schematic presentation slide #7**

**Principles of Active Learning**

**Stages and steps in the *Active Learning* process:**

1. Concept building and reasoning
2. Developing and incorporating a mathematical language
3. Working with multiple representations
4. Developing higher-order learning

Here is an elaborated outline that I worked out based on my conversations with Alan. This might serve as a basis for him to organize his presentation. At the least, he should use the (lettered) categorical stages here (A, B, C, D) so that these coordinate to the scenarios that we depict as cases to study in the first segment of this Workshop. **Alan's responsibility.**

Stages and steps in the active learning process.

**A. Concept building and reasoning:**

- Description of various approaches
  - ⇒ observing physical phenomena
  - ⇒ working with intuitions and counter-examples
  - ⇒ asking conceptual questions
- *Example:* Simulated experiment comparing transit times of balls rolling along two different paths between identical end points.
- *Small group discussion:* What in the classroom examples expresses this motif?

**B. Developing and incorporating a mathematical language:**

- Description of various approaches
  - ⇒ starting with a word problem
  - ⇒ learning to translate into and converse in math
- *Example:* "Goal-free" problems
- *Small group discussion:* What in the classroom examples expresses this motif?

**C. Working with multiple representations:**

- Description of various approaches
  - ⇒ graphs, tables, equations
  - ⇒ diagrams, pictures, maps
- *Example:* "Jeopardy" problems
- *Small group discussion:* What in the classroom examples expresses this motif?

**D. Developing higher-order learning:**

- Description of various approaches
  - ⇒ design
  - ⇒ multi-step problems
- *Example:* "Experiment" problems
- *Small group discussion:* What in the classroom examples expresses this motif?

---

## Appendix 2: National *best practice* examples - a report of the search and survey

---

COLUMBIA GATEWAY COALITION PROJECT: 1999-2000

**Best Instruction IT Practices summary**

Last updated: 25 July 2000

### **List of institutions/programs reported:**

1. [Rensselaer Polytechnic Institute](#)
  2. [Pew Learning and Technology Program - RPI](#)
  3. [Dartmouth College](#)
  4. [University of Oklahoma](#)
  5. [Rice University](#)
  6. [University of Michigan](#)
  7. [Georgia Tech](#)
  8. [UCLA](#)
  9. [Harvard University](#)
  10. [Tufts University](#)
  11. [The Evergreen State College](#)
  12. [University of California - Berkeley](#)
- 

### **1. Rensselaer Polytechnic Institute**

*A summary of RPI educational use of information technology:*

*RPI has based its reformative educational practices on three principles:*

1. *Cognitive science has demonstrated the value of looking at learning as an active construction of understanding by the learner;*
  2. *Interactive exercises in context-rich environments are an effective way to facilitate such knowledge construction by students.*
  3. *Information technology can be used to create such learning environments, but will not automatically do so. Appropriate use of IT requires understanding of #1 and #2 on the part of the instructor/course designer.*
- 

### Studio Courses:

One of their earliest and most extensively developed approaches to incorporating IT for educational reform at RPI is called the *Studio Course*.

---

### Studio Teaching

Starting in 1988 Rensselaer began introducing a variety of courses incorporating the systematic use of technology in a cooperative learning environment. Over the past ten years that effort has continued to expand as Rensselaer pursued a campus-wide effort to re-engineer the undergraduate curriculum...

The intellectual foundation of curriculum renewal at Rensselaer is interactive learning. Since 1993 we have developed a unique model for interactive learning which we call the "studio". Studio courses emphasize a hands-on, learning by doing approach. The focus is on what the student does and not on what the faculty member does. Studio courses engage the student in various problem solving and active learning sessions that help the student construct their own understanding of course concepts. Studios go lighter on lectures and heavier on interaction, teamwork, and student discussion. In general, students take more responsibility for their own learning and much more learning goes on inside the classroom.

The movement ... began **in 1988** with *Maple Calculus* ... that gave students access to high-powered computing and the ability to focus on underlying principles rather than ... the mechanics of problem

solving. ... (a multimedia) physics course ... evolved into what is now *studio physics*. The 700 or more students enrolled each semester in introductory physics were divided into 12-15 sections of 48-64 persons. ... Biology ...introduced the studio approach in (its) undergraduate *genetics* course. ... Studio Chemistry ... Biomedical Engineering ... developed *Introduction to Engineering Analysis* and in Engineering ... created *Laboratory Introduction to Embedded Control (LITEC)*.

The series of stand-alone pilot courses became (an) Institute-wide initiative. ... **In 1993** Rensselaer ... convened a panel ... The recommendation of this group was to continue expanding interactive learning while integrating more team and cooperative learning experiences into our courses. Since 1993, many new studio courses have been created including eight new studio courses in engineering during the past year. **This year** Rensselaer ... will ... create new several studio courses in Humanities and Social Sciences. RPI's goal is to transform all introductory courses to the studio format by the year **2000**.

---

*There is a comprehensive story of the development of studio physics (nee CUPLE Physics) written by its creator at RPI, Jack Wilson, at:*

[http://ciue.rpi.edu/cuple\\_doc.html](http://ciue.rpi.edu/cuple_doc.html)

*Wilson's article contains a detailed theoretical foundation for the learning practice embodied in Studio courses in the form of research papers detailing controlled studies of their employment. These are in the references section of his paper.*

---

Academic leadership and support Centers:

*The following are a number of research and development centers that are dedicated to improving teaching and learning through information technology.*

---

Center for Academic Transformation

A source of expertise and support for those in higher education who wish to take advantage of the capabilities of information technology to transform their academic practices.

<http://www.center.rpi.edu>

The mission of the **Center for Academic Transformation** is to serve as a source of expertise and support for those in higher education who wish to take advantage of the capabilities of information technology to transform their academic practices

**The Pew Learning and Technology Program** is an \$8.8-million, four-year effort to place the national discussion about the impact that new technologies are having on the nation's campuses in the context of student learning and ways to achieve this learning cost-effectively. The program has three areas of work:

- The Pew Grant Program in Course Redesign
- The Pew Symposia on Learning and Technology
- The Pew Learning and Technology Program Newsletter

*Right now this center is primarily the Pew project. One of the "morals" is that if the CCNMTL seeks foundation funding (they already are, from Pew), that a national project can be used to leverage intra-institutional development. RPI has an on-going priority within academics to use IT to improve the cognitive outcomes of their large classes.*

---

The Academy of Electronic Media

Specialists in the creation of interactive multimedia, the development of new pedagogy and the discovery of new technology to aid in the development, deployment and dissemination of these materials.

<http://www.academy.rpi.edu>

Computers are now an integral part of our day-to-day regime and prevalent in all aspects of our society. Yet with all this available technology, we have only begun to scratch the surface of how we may harness the influence and power of the microprocessor.

The development and use of engaging interactive electronic media which simultaneously stimulate multiple senses will revolutionize the way in which knowledge is garnered and technology is utilized at all levels - from young child to lifelong learner.

We believe this revolution will be significantly accelerated by the Academy of Electronic Media, which specializes in the creation of interactive multimedia, the development of new pedagogy for how they should be most effectively utilized, and the discovery of new technology to aid in the development, deployment, and dissemination of these materials.

*This academy is like a combination of the ITC and the CCNMTL. The faculty involved have produced archetypal products, one of which I cite in the RPI examples (below). The "vision statement" of this center is impressive. For example, it refers to the cognitive underpinnings of the design criteria for its education products, presumably the results of cognitive science research. However, as is frequently evident in IT enterprises, vision usually far exceeds accomplishment. (See the results of my using one of the modules they developed, below.)*

---

#### The Anderson Center for Innovation in Undergraduate Education (CIUE)

Dedicated to improving undergraduate education through the deployment of new pedagogical methods and innovative uses of technology. <http://www.ciue.rpi.edu/>

An example of a Studio Course is Physics 1200:

<http://webct.rpi.edu:8900/public/78116009/>

*This is Jack Wilson's old organization. My recollection is that he was the founder and original director. Currently, Brad Lister is the director. The most notable product of this center was the "studio" metaphor for IT-based instruction. "The CUPLE Physics Studio" by Jack M. Wilson is a paper linked to this site, and gives the general concept of the studio metaphor, even if embedded in the subject matter of physics. (c.f. "Products" section below)*

*After looking through some of the links, I learned a few things about the RPI IT environment. From the workshop list, I see that they are an IBM/Windows shop. They must have a site license for WebCT, since they expect course content to be delivered in that environment.*

---

#### Center for Digital Video and Media

An NSF Industry/University Co-Operative Research Center

<http://www.rpi.edu/web/CDVMR/>

*This is yet another "center" headquartered at RPI but sponsoring research done at the locations of its other university and industrial partners. A "center" seems to be the predominant RPI model. The educational activities are limited to seminars - on their research topics - for partners and for the larger scientific community.*

#### The Center

The NSF Industry/University **Co-Operative Center for Digital Video and Media Research** (CDVMR) will share space with the existing Center for Image Processing Research (CIPR). to support research projects proposed by the investigators of the CDVMR, who would belong either to Rensselaer or its university partners, and the Industrial Advisory Board (IAB). The IAB consists of the one designated representative from each of the companies or agencies with full membership in the CDVMR.

#### Activities

Presentations of results and progress will be a part of the semi-annual IAB meetings. The CDVMR will also sponsor short courses and symposia on topics related to its mission.

*Here is a list of current research projects at one of the other university partners. I chose those of NJIT both because they are a Gateway partner of Columbia and because they are doing work related to two other project ideas that I am trying to develop here.*

#### At New Jersey Institute of Technology:

- XDSL Performance Simulator for Video Compression
- Video, Data and Voice Transmission in NII?SUPERNet (5 GHz Band)
  - Indoor propagation characteristics for wideband applications
  - R&D of miniaturized dielectric filters and VCO's in the 5 GHz band for PCMA cards.
  - Novel antenna development.

- Receiver design issues.
  - Scalable video compression for indoor channels.
  - Multimode Hypermedia Collaboration Environment.
    - New Media Center - WWW-based environment to support different modes of collaboration with seamless transition and support for individual information processing, group process, and meta-process.
    - Collaborations - same time / same place, same time / different place, different time / same place, different time / different place.
    - Hypertext / media - structuring, accessing, and communication interrelated information in multiple media.
    - Multimedia - fit between the nature of collaborative activity and multiple media.
  - Presentation and Publishing in Multimedia
    - Development of interactive multimedia based and research on educational enhancement tools
    - Development of courseware and generic design and educational process tools
    - Development of educational interactive simulation / animation tools and incorporation into Web pages
    - Development of interactive program management tools incorporating Web pages and cross functional databases
- 

### New Media Center

*Apparently they have so many centers that the centers themselves are forming centers. This is a center of centers! Note that they here combine their service **and** their development organizations.*

Promoting the effective use of multimedia instructional material.

<http://www.rpi.edu/dept/new-media-ctr/index.html>

**Rensselaer New Media Center** is composed of separate facilities working together as a *virtual center*. Its aim is to promote the effective use of multimedia instructional material throughout the Rensselaer campus.. Its members are:

- **Academic Computing Services**, which supports the public access multimedia classroom/labs for teaching courses;
- **The Anderson Center for Innovation in Undergraduate Education**, which supports faculty development for creating curricular materials;
- **Academic Support and Media Services**, which supports a professional video studio and the equipment necessary for using new media technology for teaching in classrooms around the campus;
- **Rensselaer Satellite Video Program**, which is a distance education program providing continuing engineering, science, communication, and management education to learners everywhere;
- **Integrated Electronic Arts at Rensselaer**, which are state-of-the-art electronic media facilities devoted to art in the fast lane;
- **Electronic Media Arts and Communication**, which is a new undergraduate degree program with state-of-the-art electronic media facilities devoted to communication;
- **The Academy of Electronic Media**: engaged in the development and use of engaging interactive electronic media which simultaneously stimulate multiple senses will revolutionize the way in which knowledge is garnered and technology is utilized at all levels - from young child to life-long learner;
- **Core Engineering**: the program which provides a broad scientific and technical foundation to Engineering students.

---

The following are a number of **sample products** that were produced, and are being used, at **RPI**.

An IT module from the Academy of Electronic Media

*This is a Web module developed with Director and execute on a WWW Browser equipped with a Shockwave plug-in. It did not function correctly when I tried it.*

**The Hidden Curve Module** can be used to explore some of the "Big Ideas" in the calculus in an inquiry learning and teaching setting. The student is provided with an assortment of virtual tools to assist investigating of topics such as tangency, extrema, curve-sketching, and motion.

---

Professional and Distance Education - Presentation at EDUCAUSE '99

*This paper describes the genesis, conception, development, and delivery experience of a sequence of four courses that implemented a graduate certification program in human-computer interfaces.*

"The Distance Learning Experience: Developing, Transmitting and Participating in Courses Delivered at a Distance" - [stc\\_99\\_paper.pdf](#)

---

Professional and Distance Education - Non-Credit Courses

*This paper describes the genesis, conception, development, and delivery experience of a sequence of four courses that implemented a graduate certification program in HCI (human-computer interfaces).*

**Professionals who are interested in acquiring advanced and updated knowledge for professional or personal advancement but who are not seeking degrees or graduate credit can participate in credit courses at a distance on a non-matriculated basis and can also attend a number of non-credit activities, many of which are offered at a distance.**

**Current Offerings:**

- Colloid Chemistry Applied to Industrial R&D: Nov 17-19
- Modern Developments in Multiphase Flow and Heat Transfer: Nov 8-11

---

## **2. Pew Learning and Technology Program - RPI**

*This is actually one of the academic "centers" based at RPI. The funding from Pew pays for grants to other institutions for IT integration into curricula. This is the Course Redesign Program. It supports the strategic implementation of IT in a single large target course for the purpose of increasing faculty productivity. These issues are not likely to be popular here on this campus.*

*Nonetheless, the program they have laid out for course redesign provides perspectives that may be appreciated here in terms of their value in learning how to rethink curricula in a systematic way. These perspectives were formulated in a symposium held last summer, which brought together a number of administrators and some faculty from "key" institutions that have had a hand in shaping or experiencing IT-based course reform. The report from this symposium is summarized by its conclusions below, and may be access in its entirety on the Web.*

---

**Entire report:** <http://www.center.rpi.edu/PewSym1.html>

**Improving Learning & Reducing Costs: Redesigning Large-Enrollment Courses**

By Carol A. Twigg

## **CONCLUSION**

At the symposium's end, participants reconsidered assumptions listed at the beginning of this paper

- Improving quality means increasing cost.
- Adding information technology to the mix only increases higher education's cost.
- The use of IT in higher education may even threaten quality.

They were asked, does anyone still believe that improving quality has to mean increasing costs? No, they said. By employing well-thought-out redesigns, it is possible to improve quality without adding costs. Does anyone believe that adding information technology always adds cost? Again, the answer was the same. And finally they were asked, does anyone still believe that using information technology threatens the quality of higher education? Again, the answer was the same. It depends on the design of the course.

The participants agreed strongly that the concept of readiness criteria is an essential one. Large-scale redesign is not a trivial process. It requires a high degree of preparedness in order to be successful. Participants noted, however, that as more institutions go through the process of redesign, those that follow will be the beneficiaries of what the early pioneers have learned.

The group also agreed with placing primary emphasis on improving learning when thinking about redesign. Some went so far as to argue that if these new environments provide a better way to deliver education, why base the argument for a cultural change within our college and universities on the fact that it will save money? Others countered that there can be no quality improvements without controlling costs because innovations cannot be sustained without doing so. A wealth of experience shows that attempts to add on innovations with external support, and without internal structural change-especially the commitment of resources in the institution's core budget-have been almost totally unsuccessful. In order to be sustained, changes in instructional practice must be affordable by institutions and integrated into their base funding practices.

Since the participants became convinced that it is possible to enhance learning while reducing costs, at the end of the day the discussion returned to one of our starting points: the different views of higher education's stakeholders as to who should harvest the savings. Is it the department or the instructor, the institution or the students? Legislators would prefer to see some, if not all, of the savings passed on to the public or to the consumer in some way, by reducing tuition, for example. If some or all of the savings are retained by the institution, what should be done with them?

Should the extra resources be reinvested in the course's ongoing development? Perhaps the academic unit should capture the savings. Or should the savings be returned to the institution to be reallocated for other uses? If the savings are captured by the department or by the institution, there is little incentive for faculty members to improve productivity by increasing enrollment or improving retention.

Some believe that the faculty members involved in the redesign should benefit directly as an incentive or a reward for increasing productivity. If the individual instructor captures the savings (faculty time), it may mean more time to do research or it could mean more time to pursue personal interests. How we reward faculty and staff for increased productivity is an important consideration.

Once it is possible for institutions to create a surplus of instructional resources rather than simply consuming them, we will be forced to rethink many of our assumptions about planning and budgeting. A whole host of institutional policy issues will be involved as well as numerous practical matters having to do with supporting innovation.

---

### **3. Dartmouth College**

Major focus of their IT innovation has been their five year NSF project for

#### ***Mathematics Across the Curriculum***

This is a comprehensive attempt to raise the quantitative level of the college curricula as a whole by preparing materials that will permit instructors in non-math courses to supplement their instruction with mathematical insights motivated by the course content. This notion of "learning in context" has been popular in the wake of recent results of research in teaching and learning which indicate a strong context dependence of learning. So there are both affective and cognitive reasons behind such a project.

The technological justification derives from the ease with which materials can be published on the WWW. Ironically, when this project started in 1995 the organizers envisioned packaging its course material as paperback books supplementing the standard text in a course or, in a collection by themselves, comprising an entire interdisciplinary course. From their proposal summary:

We will work to target materials suitable for dissemination, especially in a modular form. We envision a shelf of 20 to 30 inexpensive, self-contained, application-driven paper back books designed to be used in conjunction with standard textbooks, as independent reference material for students, or several put together as the basis for a complete interdisciplinary course. In addition we will provide support materials for teachers in the form of ideas for classroom work, documented software, on-line materials and videotapes

Now, it appears that the supplementary materials have replaced the primary ones in the sense that all of the materials are available on-line. Many of the modules incorporate Java applets to reify the applications that drive the content by allowing students to calculate, simulate, and explore.

URL for the Math project site:

<http://www.dartmouth.edu/~matc/>

The following is a list of the **MATC Courses** arranged by topical category:

#### **Mathematics and the Humanities**

- **Pattern**
- **Chaos**
- **Late Renaissance Thought and the New Universe**
- **Renaissance Math in Fiction and Drama**
- **Math and Science Fiction**
- **A Matter of Time**
- **Geometry in Art & Architecture (under construction)**
- **Music & Math**
- **As the World Turned - A Reader on the Progress of the Heliocentric Argument from Copernicus to Galileo**

#### **First Year Mathematics and Sciences**

- **Interdisciplinary Mathematics and Physics**
- **Math 15.2**
- **Calculus 1998    Calculus 1997**
- **Introduction to the Calculus of Medicine & Biology**
- **EARS 5 Natural Disasters and Catastrophes**
- **Short Written Problems**

#### **Upper Division Mathematics and Sciences**

- **Partial Differential Equations with Applications to Quantum Mechanics (Math 15.3)**
- **Discrete Mathematics II Project (Math 19 / CS 21)**

#### **Statistics Across The Curriculum (SATC)**

- **Teaching Introductory Statistics in the Social Sciences and Engineering (X10)**
- **Introduction to Linear Models (Math 30)**
- **Exercises in Data Analysis**
- **Dartmouth College Mathematical Social Sciences (MSS)**
- **Probability and Statistical Inference (Math 50)**
- **Instructional Applets**
- **Chance**

The MATC project expresses the belief that there is added value in creating a set of educational materials of common ilk and "feel" during a certain window of time and archiving them in one place. Presumably this is true with respect to common, thematic content - here, applied mathematics. In this sense, the collection makes the statement that one application may inspire others, and thinking outside of the mathematical box breaks a mode of thinking about the role of mathematics in the curriculum that has led to the need for this type of reform. Less obvious may be the fact that a supportive infrastructure grows up around a "critical mass" and lowers the threshold of effort needed for an instructor to attempt to creating new curricula. This has been our experience at Columbia in the context of our Faculty Cluster for Instructional Technology and the consequent funding of our Student Technology Assistant (STA) program.

There are questions about this project important to a critical review that the Web site does not resolve. The details of the infrastructure that I infer are not here. Nor does the site reveal the level of participation of the Dartmouth mathematicians, except in those cases where they partnered the course authorship and hence were credited. One of the most serious impediments to collaborative development of curricula in my experience is the manner in which colleges are "balkanized" by their departments. Another is how credit for curricular development work is, or is not, rewarded in such a political culture.

---

#### 4. University of Oklahoma

Their School of Pharmacy has some on-line course syllabi with exercises that resemble in spirit those of the Dartmouth program.

<http://www.cpb.uokhsc.edu/>

In fact I'm fairly certain that I linked to one of their on-line courses from the Dartmouth site. The home page for the course is [ <http://gaps.cpb.uokhsc.edu/boomer/course/phar7633/> ], *Pharmacokinetics*, and the course material itself starts at:

<http://gaps.cpb.uokhsc.edu/gaps/pkbio/>

This course has case-based studies which introduce data and pose a problem to be solved by the students using those data. Depending on the evolving aptitude of the students to frame good questions on their own, the presentation can omit questions, or suggest questions. They can also make the solution of the case require that students realize the need for additional data.

More generally, the School of Pharmacy home page gives a clue to the scope and character of all their curricular work. They have six on-line courses listed as links. They also have a link to a *WebCT course* site at which twenty (supposedly WebCT-based) courses are listed. The course titles reflect a wide range of course types, and course subject matter within the scope of pharmacy. These range from math (Pharmaceutical Math), probably remedial, to a pharmacy practicum. I tried several of these links. All but one gave me a "log-in" pop-up, expecting that I was a student already "registered" for the course. So for those I could go no further. But one, *The Infectious Disease Practicum* at -

[http://157.142.72.188:8900/SCRIPT/http://157.142.72.188:8900/SCRIPT/PHAR7094/scripts/serve\\_home.pl/scripts/serve\\_home.pl](http://157.142.72.188:8900/SCRIPT/http://157.142.72.188:8900/SCRIPT/PHAR7094/scripts/serve_home.pl/scripts/serve_home.pl) (no longer active)

- gave me the opportunity to log on as a "guest". When I did so, I got the sense that I was in the WebCT course construction environment, and not in the PHAR7094 course material itself. So maybe this site is intended for access (with someone's permission) to exemplary courses that demonstrate the WebCT tools to faculty prospects, so they may thoughtfully consider putting their course on-line.

In addition to the on-line courses, the SOP home page lists a number of ...

##### *Other Resources:*

- Electronic-Based Instructional Resources SIG of the AACP. AACP WebSite.
- Pharmacokinetic Resources.
- MultiMedia and CAI Resources of interest to Pharmacy.
- Pharmaceutical Chemistry/Pharmaceutics Resources.
- A list of Computer Tutorials and other resources.
- The Virtual Library: Pharmacy Page (includes other Pharmacy WWW servers)
- Links to Information about Pharmacy and Related Jobs and those looking for such jobs.
- Symposia, Seminars and Grand Rounds, on Campus, the OUHSC Oklahoma City campus.
- Panoramic Scenes of the Campus.
- Pharmacy related Periodicals and Conferences.
- World List of Schools of Pharmacy, maintained by David Temple, Ph.D.

One of these *A list of Computer Tutorials and other resources*, gives an example of what kind of material these resources contain.

##### *Computer Tutorials:*

###### Tutorial: ONE

Title: Setting up MacMosaic v1.0.3 for 'New' Applications

Keyword: MacMosaic, Helper Applications, WWW

###### Tutorial: TWO

Title: Setting up NCSA Telnet for use with MacMosaic and CDPlus Medline (at OUHSC)

Keyword: NCSA Telnet, MacMosaic, CDPlus

###### Tutorial: THREE

Title: Setting up MacPPP and MacTCP (for use at OUHSC)

Keyword: MacTCP, MacPPP

Tutorial: FOUR

Title: Setting up the projector for classroom use (OUHSC only)

Keyword: Classroom

Tutorial: FIVE

Title: Changing Passwords on the OUHSC NT Server (Using a Macintosh Computer)

Keyword: NT, Password, Chooser, Macintosh

Tutorial: SIX

Title: Setting up OT/PPP for the OUHSC PPP Server (Using a Macintosh Computer)

Keyword: PPP, OUHSC, Internet, TCP/IP

Tutorial: SEVEN

Title: Instructions for using shared-cart and InFocus Projector

Keyword: Projector, VCR, Computer, Multimedia

Tutorial: EIGHT

Title: Creating a Poster Presentation in Power Point on the Banner Printer Step-By-Step Tips by Josephine Li

Keyword: Poster, Wide Color Printer

What is clear from all of this is that the school supports the systematic migration of their courses to Web-based versions, and that they provide tools for faculty to do so.

---

## 5. Rice University

From Rice comes their on-line *Statistics* learning materials. These are based at the site:

<http://www.ruf.rice.edu/~lane/rvls.html>

### *Rice Virtual Lab in Statistics*

#### HyperStat Online

An online statistics book with links to other statistics resources on the web.

#### Simulations/Demonstrations

Java applets that demonstrate various statistical concepts.

#### Case Studies

Examples of real data with analyses and interpretation

#### Analysis Lab

Some basic statistical analysis tools.

Clearly, the emphases here are on programmed simulations and supporting calculations. Case studies supply context for the core material. There is no direct indication of how these exercises were prepared, nor how they relate, if at all, to other Web resources. However, there are some indirect clues. This site is based in the section of a Rice WWW-server "owned" by David Lane and was developed with support of an NSF-DUE grant. The fact that it resides in the project director's account suggests that this kind of educational activity is left to individual faculty. The other clue I found was that the Web server was the Rice Unix Facility, suggesting that this is part of their research infrastructure. Again, this is suggestive, but would not be surprising in a traditional science/engineering school. This contrasts strongly with RPI where the educational support by the university was clearly apparent.

Statistics, the content of this package, is one of those subjects having currency across a wide range of disciplines. But unlike mathematics in general, which is either practiced competently or not practiced at all, statistics has a robust reputation for being misused and improperly applied by a wide variety of professionals. This epidemic problem increases the attractiveness of having tutorial material that has wide accessibility both intellectually and logistically. The use of case studies in this lab is one of its strong points. IT makes the publication of such case studies practical and the coupling of the cases to quantitative tools an easy step.

---

## 6. University of Michigan

Michigan has an especially strong effort at introducing multidisciplinary study of the environment called *Introduction to Global Change*.

<http://www.sprl.umich.edu/GCL/>

Every day, millions of human and natural activities are altering the planet on which we live. Over the past century, through our ever-increasing population and mastery of technology, we have been changing the global environment at a pace unknown to natural history. The University of Michigan offers a two semester introductory course sequence which investigates the causes and potential impacts of the changes we are just beginning to understand.

The first semester deals with issues relating to the physical nature of global change, while the second semester covers the human impacts involved. The course methodology includes laboratory and group/project work components, in addition to traditional lectures. The lab and project work is heavily supported by Web-based information technology.

One of the especially significant characteristics of this course is its emphasis on global change as an *on-going process*. The Web site's facilities accordingly reinforce the notion that global change issues are open questions. We do not know precisely either the full set of correct questions to ask or the answers to those that we do. As an example, links to outside resources unfold stories of global change phenomena. Among these are:

- Discovery On-line - Earth Alert
- Committee for the National Institute for the Environment
- American Geophysical Union's scientific analysis on global warming

These sources offer information about natural disasters, population, and global climate. They collectively point out that learning about global change must be a continuing project for concerned citizens. Inclusion of timely and contemporary information as bases for questions or for case studies is a powerful capability of information technology. This site uses it well.

---

## 7. Georgia Tech

For the past four years Georgia Tech has been experimenting with IT hardware to change the teaching and learning environments in their classrooms. This effort is known as *Classrooms 2000*. Its URL is:

<http://www.cc.gatech.edu/fce/c2000/>

### What Is Classroom 2000?

On the software side, Classroom 2000 is a collection of Java programs, Perl scripts, and C programs that captures and presents a classroom experience. On the hardware side, it is a collection of electronic whiteboards, projectors, computers, and audio/video recorders.

### How does it work?

At the start of class, the instructor walks up to an electronic whiteboard and finds either a blank screen or, if present, prepared slides. Everything the instructor writes is captured and saved. There are also additional screens present which give the illusion that the whiteboard extends across the entire room. If the instructor wishes, they may show Web pages as a part of their lecture. The pages visited will also be captured and logged.

Ceiling-mounted microphones record the instructor and students, and ceiling-mounted cameras capture the video. A PC in the corner silently encodes the audio/video into Real's streaming format and simultaneously broadcasts this data out in real time.

After class, students visit the class home page and see all of the notes and Web pages visited. Clicking on an ink stroke will let the student see/hear the video/audio that was recorded during the time the stroke was written. If they wish, students can then print out the notes or do a keyword search on the audio of the lecture.

All of the content generation and presentation is done automatically with minimal human effort.

In sum, this product is an elaborate and automated system for capturing the classroom process, indexing it, and making it available via the WWW for later use by anyone.

I heard this described from the end-users' point of view in a talk at the CSCL conference. This talk, entitled "Anchoring Discussions in Lecture: An approach to collaboratively extending classroom digital media". The idea was to use the archived classroom material - most of it lectures - as a framework for BB-based subsequent discussions by students in between class sessions. The logic was that, if the lectures are going to be considered the most important part of the course - as they are by many lecturers - then the students are going to want to invest time in studying them more closely.

---

## 8. UCLA

They have an entire Web site entitled *Humanities e-Campus* located at:

<http://ecampus.humnet.ucla.edu/>

This page offers humanities instructors both resources to produce and publish standard items for the Web (e.g. course syllabi) but also a place to store links to those curricular items, in a searchable database. There was a great deal of controversy a few years ago when the UCLA academic administration gave an "order from the top" requiring that every course have a Web page. Each is to contain a syllabus, administrative details and, if possible, links to Web resources for the course. *E-Campus* was evidently an implementation facility for this executive order, and offers resources to faculty for preparing such course Web pages.

There is much interesting and excellent research work on educational IT being done here. However when I visited the Web site above - the hub for IT course materials - I was not able to access from outside campus any of the course materials in the database. I then asked for permission to access course(s) that dealt with large enrollments. I was told that no existing courses fit the "large class" category!

The manner in which *e-Campus* Web site is constructed is notable. Its technological architecture is that a database whose access by a client's browser is mediated by the Web server. This structure is often referred to as a Web site "built on top of a database". Instead of the Web site containing html documents (i.e. pages) that are sent out to client browsers by the server, the server creates each Web page anew at the time of a client's request using information it draws from the database.

---

## 9. Harvard University

Ed Mazur has developed a comprehensive, active learning course format for the beginning physics course at Harvard. It combines collaborative peer learning with just-in-time feedback from students who prepare for class by doing the readings and/or answering key questions. The classroom collaborative activity is centered around "concept questions" embedded in the lecture/demonstration format. There are also other resources, all coordinated by means of the course Web-site located at:

<http://physics1.harvard.edu>

I used this site to create case studies for several of the special workshops that I developed this year.

Mazur's course structure and facilities are a moment to the effort and attention he and his colleagues have devoted to this project. There are a number of lessons to learn here. For one thing, they have kept in touch with the literature of research in teaching and learning. He is an active voice in that community's dialogues. For another, his course development work has followed a strategy of continuous quality improvement. They have tried, then abandoned or modified, several tactics that did not serve their educational objectives. He is not afraid to make mistakes, nor reluctant to correct them.

Among other features, his current course Web-site includes:

- syllabus
- problem exercises
- forms for responding to the readings
- threaded discussion facilities for students to discuss questions and share inspirations with one another and with the course instructor and TAs
- a streaming video archive of all the lecture sessions

Mazur's use of the Web for implementing his active learning strategies in a large class setting is an excellent example of how the Web can be used to facilitate small group learning communities in large class settings.

---

## 10. Tufts University

There are many instructional technology projects at Tufts, but the two that I wish to note here are *Project Perseus* and the work of the *Center for Science and Mathematics Teaching*. The are notable in college educational circles for quite different reasons. The first is a long-standing effort to bring integration to the study of classical culture and languages. It is now a foundation supported resource for teaching and learning in these areas. The main vehicle for dissemination of their products has evolved over the years from CD-ROM/video discs to the WWW. Their current Web portal is:

<http://www.perseus.tufts.edu/>

The resources of *Perseus* include classical texts and translations, images of art objects, commentaries and histories, maps, *etc.*, all cross-referenced through hyper-links and accessible through several searching tools. It is quite breathtaking in its scope and quality of its learning tools. One of special interest is the manner in which the databases containing all this information and documents were organized and indexed. Not listed in this site, but know to me from professional acquaintance with its early developers, I learned that *Perseus* materials were first annotated using an SGML created especially for the project.

The second is a research and development effort which has worked collaboratively with faculty from other universities and created a number of pioneering applications of laboratory instrumentation to "hands-on" science education, principally physics. Most notably, the exemplary curricula produced here are based on constructivist principles emerging from systematic research on teaching and learning conducted by many principals over the past 20 years. Many faculty have tested these curricula in variety of colleges and universities, and in a variety of contexts, over the years. The home page for this Center is:

<http://ase.tufts.edu/csmt/>

The principle "products" that this Center has participated in developing are:

- Microcomputer-based Laboratory tools (MBL) with the Technical Education Research Center
- Workshop physics curricula with Dickinson College
- Real-time physics curricula with the University of Oregon

---

## 11. The Evergreen State College

The threaded discussion list is the contribution of this example to the body of technology applications reported here. I have chosen Evergreen to represent this somewhat common practice for three reasons. First, the core values of this institution state that the main purpose of a college is to promote student learning by which students develop their capacities to "judge, speak, and act on the basis of their own reasoned beliefs".

[\[http://www.evergreen.edu/\]](http://www.evergreen.edu/)

Second, the college has pioneered the development of *learning communities* as a basis for personalizing learning and enabling learning to be an active process based on critical thinking. Third, the college Web site offers outside access to the threaded messaging records of recently conducted courses that used threaded conferencing. [<http://192.211.16.9/webx?>] Such openness is rare among institutions but is characteristic of this one. Here is a body of data from which one may realistically draw conclusions about how well the Web-based learning process works, or doesn't work. It includes an unedited collection of threaded mail lists that were set up for over forty TESC courses.

---

## 12. University of California - Berkeley

The Department of Statistics has designed a set of on-line instructional modules called: *Tools for an Interactive Learning Environment (TILE)*. This project was a collaborative effort between members of the Statistics Department at the University of California at Berkeley and Duncan Temple Lang at Lucent Technologies, Bell Labs Innovations. It is a vivid example of collaboration between university and corporate partners.

The TILE project is an effort to use many of these tools developed at Bell Labs, and elsewhere, especially those in *Omega* environment, to provide an extensible and customizable toolkit and labs for teaching statistics. On-line lab and tutorials illustrating use of the TILE toolkit are at the TILE project Web site:

<http://www.stat.Berkeley.EDU/~nolan/TILE/>

Another information technology facility, **NEEDS: National Engineering Education Delivery System**, is a digital library of learning resources for engineering education. NEEDS provides web-based access to a database of learning resources where users (be they learners or instructors) can search for, locate, download, and comment on resources to aid their learning or teaching process. The Web portal to NEEDS materials is at:

<http://www.needs.org/>

This facility illustrates the use of digital library technology providing access to multi-media information, documents, and software. This technology is a Web interface to a database containing these resources. It is a particular realization of the general concept of a Web site built upon a database, where the Web server dynamically generates Web pages as they are needed in response to specific, client requests.

NEEDS was developed by an engineering coalition. Their site is very well designed. Their project has had national exposure (*e.g.* they did a presentation at the NSF SMETE Workshop on Digital Libraries for Undergraduate Education <http://www.dlib.org/smete/public/report.html>). **Gateway Coalition** should consider publishing appropriate materials which it develops on the NEEDS site, as well as their own.

---