

The Classroom

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Instructional Design COE 1361 – A Case Study

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In this issue of The Classroom, we look at Instructional Design. While many different researchers have different definitions of this term, the way I like to think of it is the purposeful planning that occurs before a course is offered for the first time (or before it is significantly revised). This planning should encompass the pedagogical approaches, the content, the learning objectives, the educational assessment, and the logistical issues that surround any new edition of a course. There are of course two key words in this interpretation – purposeful and before. Throughout these pages you will find articles about the design of specific courses, an interview with an award-winning faculty member who has experience in instructional design, and two book reviews on this topic. To start, I will tell you about a new course that is being developed in the College of Engineering. I first need to acknowledge Drs. John Leonard, Farrokh Mistree, and other members of the COE IT Council for loaning their words to this effort.

Background of the Initiative

Some background is needed before we leap into this course. Over the past few years, several educational activities at the Georgia Institute of Technology have been converging:

In 1998, computer ownership was required for all entering undergraduates. While this computer ownership policy assures that our undergraduates have equal and uniform access to various software tools, whether at an on-campus computer lab, or at home, unfortunately, a program of training students in the appropriate use for these computer tools was not created. Further, no procedures for comprehensive integration of these tools into the curricula were developed as part of the computer ownership initiative.

In 1999 the then Dean of the College of Engineering (Jean-Lou Chameau) initiated an effort to examine student retention rates

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within engineering. One complaint cited by students was the lack of “engineering” and contact with engineering faculty at the early levels of their undergraduate education.

In 1999 the Dean initiated an effort to infuse information technology concepts and skills throughout its undergraduate and graduate curricula. The Dean appointed an IT council with members drawn from across the college to explore opportunities to enhance undergraduate, graduate, and continuing/professional education.

In 2001 the Institute undertook a reexamination of their General Education Requirements for Undergraduates. As part of this initiative, a comprehensive list of computer literacy objectives and corresponding outcomes was identified.

One outcome of all of these events, was that in 2001, under the direction of the Dean’s IT council, a group of engineering faculty began development and initial deployment of a first course in computing, specifically for engineering first year students. This course is motivated by a need to address *engineering student retention, to introduce the students to engineering and the engineering faculty earlier in the students’ undergraduate careers, and to ensure adequate and efficient use of computing tools already owned by the students.*

The effort expended by these engineering faculty members was huge. They began with no assumptions and attempted to build a course from the ground up, beginning with a front end analysis of the learners, the content, and the learning context.

Analysis of Learners

In order to identify the needs of the students, the faculty group studied some of the literature on how first year college students learn, what is different about this cohort (as compared with more senior college students), and what approaches to teaching are best suited to this audience. With this information, they set out to design an interactive class and came up with the following list of “needs”:

- The students who enter this class will all have very different levels of expertise and understanding.

There is a need to get them all onto the same page before we can proceed to bring the material alive.

- The students will have only a high school level knowledge of physics and mathematics. There is a need to introduce many new concepts and terminology before students will be able to understand the principles and the associated mathematics.
- There is a need to scaffold the learning of these students so that they are able to relate different concepts into a systemic whole. In other words, they will need help to learn how they can create new knowledge on their own so that they can continue to learn on their own.
- There is a need to hold the attention of students using examples that students can relate to in their everyday lives.
- There is a need to figure out ways to keep students who have varying learning styles engaged and interested.
- There is a need to figure out policies that allow these students to make a slow start and yet succeed.
- There is a need to help students develop their note-taking skills.
- There is a need to check for understanding in different and engaging ways.
- There is a need to bridge the gap between how these students have been taught to think and solve problems in high school and how they will need to approach problems at GT.
- There is a need to reinforce the message again and again to let it sink in.
- There is a need to organize the material in small bits that are digestible and not overwhelming.

Strategies related to the Learners

As a consequence of this list, it was determined that the course should be offered in small sections (no more than 30 students per section) in computer-equipped classrooms with one computer per student. Further, the layout of the room is critical in that it must facilitate both a lecture/tutorial and an active learning environment. A lot of attention was paid to this learning environment, in particular to the fact that there

is much literature that indicate the benefits of a teaching style that encourages scaffolding to ensure long term retention of the material

Analysis of Content

While all of this attention was being paid to issues related to teaching and learning, the faculty group was also thinking about content. The primary computing philosophies that guided the curriculum were:

- The belief that it is important to demonstrate to students how to integrate computer programming within an overall engineering problem solving and design context.
- The belief that a computer program is more than just “C++” or Java code – a computer program can include VB scripts, MATLAB code, or any other scripting language built within the software tool at hand.
- The belief that it is important for the student to experience how small, “quick and dirty” computer programs can save time in their studies, and make more efficient use of their time on the problem-solving and design side of an engineering problem.

Analysis of Context

After a year of analysis and design, a new rationale for the course emerged: to provide a course for first year engineering students to:

- learn about computing in the context of the types of problems they will be challenged to solve during their educational and professional careers; and
- understand how they learn and to empower each individual with the fundamental skills and abilities for continued self-directed learning albeit in a group setting.

Strategies related to Content and Context

The pedagogical goals for the course were outlined. Students should:

- gain an understanding of how to use computers effectively in engineering problem solving and how to use computing technology as a means to support learning;
- have a foundation suitable for subsequent courses in numerical methods in engineering and computing offered by the College of Computing,
- acquire computing skills in the use of MATLAB to facilitate their subsequent engineering course work,

Microsoft Office suite to increase their productivity in all other course work, and cognitive skills to facilitate their easy transition to learning other computer languages and computing environments.

In addition, there were supplemental goals:

- improve the educational experience of first year engineering students, and as an important subsequent result, increase their retention and graduation rates;
- create an environment in which faculty are excited about their participation in the course development and delivery, and that broadly encourages the Georgia Tech community to emulate in their instructional opportunities; and
- satisfy the Board of Regents’ computing requirements.

Current Status

The course has now been piloted for four terms in a total of 10 sections (including this semester). Unfortunately, it continues to be plagued by problems that put its future at risk. With an undertaking this large (the potential number of students who would have to take this course would necessitate at least 25 sections per year), it is critical that there is an efficient logistical structure for the course. Further, given the unique list of pedagogical concerns above, there must be adequate initial training and ongoing faculty development for the instructors. Equally importantly, there needs to be a structure for the creation of the technical and curricular materials that allows for parallel offerings of the same course while allowing faculty the professional freedom to teach “their own” class. Finally, there needs to be widespread agreement across the College about the actual curriculum – for when you get right down to it, a good course requires both good teaching AND good content. This is an unfinished story; only time will tell the conclusion. It has been an excellent adventure in good instructional design, but now we must wait to see if it can turn into an equally excellent journey of deployment. ■

Q & A:

An Interview With

Dr. Mark Guzdial

Associate Professor
College of Computing

Dr. Guzdial was awarded the Board of Regents' Research in Undergraduate Education Award in 2001.

Mark Guzdial, Associate Professor in the College of Computing at Georgia Institute of Technology, received his Ph.D. in education and computer science (a joint degree) at the University of Michigan in 1993, where he developed Emile, an environment for high school science learners programming multimedia demonstrations and physics simulations. He is also the designer of MediaText, a multimedia composition environment used in elementary and high school classrooms. His current research centers on facilitating student learning through student design, construction, and analysis of artifacts.

His goal is to provide to students similar kinds of opportunities that professional scientists and engineers have for learning and exploring through computation. He has developed simulation environments for learning science through construction, and is now exploring simulation, reflection, and collaboration environments to facilitate science and engineering learning. To evaluate the usability and learnability of the environments he creates, Mark is developing techniques for analysis of user event traces (log files).

A full description of Mark's current research projects can be found on his website at <http://www.cc.gatech.edu/gvu/people/Faculty/Mark.Guzdial.html>.

Q: When and where did you learn to design instruction? Was it through a formal process or by experience?

Dr. Guzdial: My Ph.D. is a joint Education and Computer Science & Engineering degree from the University of Michigan. Michigan's Rackham Graduate school offers the opportunity for an individual to define a joint degree program by taking at least 2/3 of the requirements of each department. So while I was taking my breadth requirements in Computer Science, I was also taking Instructional Design, Educational Philosophy, and Educational statistics.

The formal process that I was taught was based on older models of learning and teaching, but the general process remains the same: Figuring out where you want to get to, designing something to get you there, trying it, evaluating it to see if you got where you wanted to go, and then iterating. Nowadays, I tend to work from a more modern pedagogical model, like constructionism, and my "where I want to get to" includes getting students to be more active learners.

Q: From the point of view of someone who is familiar with the challenges of teaching students to be designers, how do you approach the design of your instruction (or of your courses)?

Dr. Guzdial: I design my software and my courses iteratively. When I try something new, I'll do a lot of

student surveys to get student attitudes, and I'll try to compare learning to previous semesters to get a sense whether there's any benefit. For example, I'll use a midterm question that's very similar to one that I've used a couple years before. That way, I can compare how students did that previous term to the current one where I'm trying out some new intervention or a new way to teach something.

Q: Where does evaluation fit into your design process?

Dr. Guzdial: I have a couple of different ways that I design depending on my audience and my role. As a teacher, when I design something new (e.g., a new way to teach something, a new activity to use in the CoWeb collaboration software we use), I work on the evaluation in parallel with the design. If I'm doing something new for my classes, I know what the impact is that I want or the problem I'm trying to address. While I'm figuring out what I'm going to do, I'm thinking about how I'm going to determine whether or not I got to where I want to go.

As a researcher in software for learning, I frankly do start out from the technology. There are so many

Q: The software you have developed for supporting collaborative learning is in use worldwide. What approach do you take to designing technological solutions for learning?

Dr. Guzdial: Jochen "Je77" Rick and I wrote a paper last year about our design approach in building the CoWeb, so we got a chance to reflect on what we did. We used very rapid iterations—we had new versions every two to three months for a couple years! We made changes and added features based on what our users were telling us, but filtered with our understanding of who the users were. We realized that teaching assistants (TAs), faculty, students, and external visitors all want to use the CoWeb in different ways. For example, TAs care about the overall functioning of the site, while visitors (say, in Architecture, reviewing student work) want to find the right pages for their activity and contribute with as little effort at learning the tool as possible. By identifying the *kinds* of users, we were better able to make sure that each of those kinds was well-supported.

Q: What role does a textbook play in the design of your courses?

Dr. Guzdial: Quite a bit, actually. Particularly in large, introductory courses, where students just can't get enough of the teachers' and TAs' time, the textbook plays an important role for providing information and guidance. I've tried teaching courses without texts and find that, at least, extensive course notes turn out to be necessary.

“ ‘Anchored Collaboration’ . . . is the idea that we can encourage collaboration for learning by linking the collaboration to something that the students want to talk about.”

opportunities to try interesting things around Georgia Tech that I can usually design the software around an *imagined* use. Once I have the software, I show it to people (typically, Georgia Tech faculty) that I think might be able to use it. Their questions, concerns, and potential applications lead to an iteration on the design of the software. It's at this point that we start thinking about evaluation—if we were to use this software in this way, what would we expect to see?

I co-taught a course with Jim Greenlee last semester on *Computer Music Implementation*. While there are great books on computer music and the underlying theory (like Tech's own *DSP First*), they're not really written with CS students in mind. For example, few have much in the way of executable code to explore, and many require

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more math than we could assume. We ended up writing essentially a mini-textbook online (<http://swiki.cc.gatech.edu:8080/compmusic/ActiveEssays>), which we felt was necessary to make the course work.

Q: According to Dr. Janet Kolodner, you have coined the phrase “anchored collaboration.” Can you tell us what you mean by anchored collaboration? In what way is this important?

Dr. Guzdial: I don’t think that I coined the term, but Jennifer Turns and I have probably written about it the most. The idea is that we can encourage collaboration for learning by linking the collaboration to something that the students want to talk about. The “something to talk about” is the anchor, like an assignment.

“ . . . the most common mistake that we faculty make is to teach the way that we learn . . . We’ve learned a lot about learning in the last couple decades. I would advise an instructor who’s designing or redesigning a course to learn how people learn, and then teach to make that happen effectively.”

Discussions in newsgroups, for example, tend to be short and scattered. In anchored collaboration, we make a place to talk about an assignment and link it to the assignment. The anchor serves to contextualize the discussion and to index the discussion. Jennifer and I showed that anchored collaborations tend to be significantly longer (more discussion, more give-and-take) than newsgroup discussions.

Q: Are there any personal experiences that have sparked your interest or encouraged you to continue working to improve student learning? Can you share any student success stories that have led you to better solutions, better learning environments?

Dr. Guzdial: I’m motivated by the students who come up to me and tell me how excited they are by something, and who ask to do an independent study or senior research project to dig deeper into the topic.

One of my research and teaching agenda items these days is to explore alternative ways of teaching programming. There’s a good bit of evidence that *no one* teaches programming very well. I was part of a three nation study this last summer where we developed some surprising evidence that we’re doing a pretty bad job of teaching programming in all the institutions we studied. It seems that a fairly small percentage of the students in introductory programming

courses are *really* getting it. Could we teach the same topics in a different way or in a different structure and perhaps interest more of those students? We’ll probably want to keep the current path for the students who find that appealing, but I think that multiple paths is a good idea—one that Donna Lewellyn first suggested to

me, by the way.

I try to teach my courses in a “different” way than many programming and design classes. I have students building computer music, personalized web newspapers, 3-D adventure games, and so on. It’s particularly rewarding for me when I get a student telling me, “You know, I was about ready to quit computer science, until I realized that *this stuff* is

computer science, too!” That’s what makes me interested in exploring some different ways of teaching programming.

Q: According to one of your graduate students, you are “never satisfied with the improvements of a previous offering” and are constantly working to improve your course. How do you go about improving a course?

Dr. Guzdial: That’s pretty easy—I look for the parts that students still aren’t getting. There is a research literature in computer science education that goes back some 20 years. While it’s not a huge literature, it does identify a set of known problems that students encounter. When I see those problems in my students, I start the design process we discussed earlier to resolve them. For example, there’s a particular technique in building user interfaces called the *MVC paradigm* that was identified some ten years ago as tough for students to understand. When I first started teaching MVC, I found that student averages on the midterm on MVC-based problems were 40-50%. I started exploring new ways of teaching MVC, and found an approach that has been leading to averages above 80% pretty reliably.

Q: What are the reactions of Tech undergraduate students to courses that you have designed? How about to the tools that you have developed? You have written, with other Tech faculty, about how these reactions differ across disciplines. Can you briefly tell our readers about these findings?

Dr. Guzdial: We’ve tried using the CoWeb in well over 100 classes on campus now, from Architecture to Chemical Engineering to Computer Science to LCC. In many cases, it’s been quite successful—more successful than we realized, because faculty have adopted it and invented specialized uses for their own classes. Lissa Holloway-Attaway has invented a “close reading” activity that she uses in her composition classes that’s been very effective. We’ve

studied her classes, with and without her CoWeb activity, and found that her CoWeb classes are learning more while spending less time on the course outside of lecture—and they *like* the CoWeb!

But the CoWeb has not been successful in a bunch of classes, typically math, engineering, and some computer science classes. Working with my colleagues Tom Morley, Matthew Realff, Pete Ludovice, and Karen Carroll, we’ve found that students in these classes find them to be highly competitive and graded on a curve (sometimes, even when they’re told that it won’t be), so it’s simply not rational for them to collaborate and give up any edge they have. Other students in these classes seem to have “learned helplessness.” One told us, “I already know that I’m wrong. Why should I post on the CoWeb?” High degrees of competition seem to inhibit collaboration.

Q: What role should CETL play in helping faculty with instructional design issues? What resources should be centrally provided? What would make your job in this area easier?

Dr. Guzdial: CETL plays a vital role on this campus. The Education school at the University of Georgia is one of the best in the country. Unfortunately, it’s annoyingly far away. This makes it hard for the engineers and computer scientists at Tech to help build tools with the education experts there, and it makes it hard to get those experts to help us to improve our engineering education. CETL has to play that role: To be the voice encouraging us, cajoling us, and sometimes nagging at us to keep trying to make our classes better. Offering mini-courses is a great idea, and there are definitely central resources that CETL

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an interview with Dr. Guzdial, continued . . .

could provide. But the primary job should be to keep improvement of our educational practices as a visible, high-priority task for Georgia Tech faculty.

Q: What advice would you give to an instructor who wants to design, redesign or improve upon a course?

Dr. Guzdial: I think that the most common mistake that we faculty make is to teach the way that we learn. However, very few of our students are going to go on to earn their doctorates and become faculty at a prestigious research institution! Most students are going to need a bit more explanation, a bit more demonstration, and a whole lot more motivation to learn the hard things that the teachers around here find easy. We've learned a lot about learning in the last couple of decades. I would advise an instructor who's designing or redesigning a course to learn how people learn, and then teach to make that happen effectively. The National Research Council came out with a report a couple years ago now, *How People Learn*. It's a nice book that summarizes many of the most recent findings about learning. It's a good place to start to get some ideas about how to help your students learn.

Q: What kinds of initiatives would help enhance undergraduate learning at Georgia Tech?

Dr. Guzdial: Wow — that's a big question! There are so many things that we could do to make undergraduate learning better around here.

I'd like to see a special initiative to sustain the co-op program, despite the switch to semesters. I think the co-op program is a great way for students to see the value of their studies and to become better learners through improved motivation.

I'd like to see more undergraduates involved in research, by helping faculty to find value in involving students in their research. I look for ways to talk about my research in my classes, and I try to save some time in "Dead Week" to explain what I do. Students choose to come to Georgia Tech often *because* of the kind of research that's going on here, and we have really bright students who can make contributions. It's a win-win situation to tell them about our work and to invite them to help.

Finally, I would like to see an initiative to encourage faculty to do research on their own teaching and their students' learning. Some disciplines take research on their own educational practices very seriously—physics and math, especially. But so much more can be done. The things we teach at Georgia Tech are hard. By figuring *why* they are hard, and using that knowledge to design better teaching, we do our students a service, make it possible for more students to be successful, and make an important research contribution to our disciplines. ■

Q&A

The Educational Epicenter

Georgia Tech Library plans to shake things up with an innovative learning center.

By Richard W. Meyer
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In today's ever-evolving academic environment, students are becoming more reliant on expansive resources and alternative media. It is becoming essential for higher learning to not only provide state-of-the-art equipment and software, but also the supplemental support that research, technical and multi-media-based assistance can provide. In response to such demands and in keeping with an ongoing pursuit of excellence, the Georgia Tech Library and Information Center, along with the Office of Information Technology (OIT), have devised a plan to infuse traditional academia with new educational technologies.

The Library West-Commons (LWC) section of the building has been designated as a veritable epicenter, where library, OIT and educational technology staff converge in one common service point. This innovative, highly-enriched, one-hundred-seat learning environment will enhance students' individual and collaborative academic experience by combining comprehensive information resources with cutting-edge technology. Additionally, through the collaborative efforts of the Library and OIT, the LWC will expand existing support services, improve informational resources and technologies and leverage developing educational services. The support model has been well-received by many Georgia Tech faculty and will be an essential test bed, providing valuable insight as Georgia Tech embarks on the detailed design and construction of an even more extensive Innovative Learning Resource Center (ILRC).

The Magnitude...

The LWC will consist of approximately 80 general-purpose, single-platform computers (Intel-based) and 20 high-end mixed-platform multi-media systems

(Apple and Intel) for a total of 100 computers. Each system will have high-speed networking capability. This space will include a consolidated print cluster that will include presentation and photo quality options. The printing model will also allow for cost-recovery using a pay-for-print solution currently being reviewed by OIT.

The LWC will also house a multi-media workshop which will provide high-end computers with specialized multimedia devices, such as scanners, video capturing and editing tools, audio capturing and mixing tools, web development tools, and more. Additionally, the area will be sectioned off in order to comply with classroom and lab standards and will receive full A/V presentation capabilities as dictated by campus standards.

The design of the infrastructure will provide for flexibility to adapt to changing teaching and learning technology requirements. There will be large work surfaces and extra chairs provided for workstations to encourage collaboration and group activities. Flat panel displays are also proposed to maximize available space and to reduce heat and noise. Some of the multi-media systems will have multiple high-resolution monitors in order to augment multimedia development. This lab will maintain compliance with the SCO requirements in addition to offering multi-media authoring tools. As with the current labs, central file storage and retrieval will be provided to allow students to work with their files on any machine.

An enhanced infrastructure will be implemented to take advantage of high-end networking, both tethered and wireless. Connectivity will be provided using existing and forth-coming standards for cabling and

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network electronics. (Note: It is expected that the demand for wireless access will increase significantly over the next three years, however, cable and fiber will act as the primary conduit for connectivity to ensure bandwidth capacity). Campus standards will also be used for infrastructure assessment and planning. Restroom capacity, fire and security evaluation are being considered and incorporated as part of the plan.

A functional support model will be introduced which will include Library and OIT personnel. This combined support effort will provide technical, instructional and research support in one centralized location. It will also provide 24-hour access to instructional technology and computer support in a secure, staffed environment.

The support area will feature a central technical and library reference counter immediately adjacent to the entire Commons area with three to five support staff. Additionally, roving full-time staff and student assistants will focus on the main floor to assist with any of the student operational and application needs. Support will be available from 8am to midnight each day, with possible extended coverage when necessary.

The Impact...

Library staff and faculty expect the Library West Commons to impact the campus in a number of ways. The intention of the project is to ...

- Improve existing technology offerings to the students by providing a multi-faceted teaching and learning resource;
- Improve the provision of resources and technologies to enhance student learning by increasing the student's ability to develop and present technologically enhanced projects;
- Provide on-site, direct technical and application support to faculty and students that are requiring technology for the teaching and learning mission of the institute;
- Provide a centralized support organization and support structure to ensure the continuity, consistency and reliability of campus high-technology investments;
- Maintain a response team that would effectively coordinate information resources and pedagogical technology requirements with advanced computing and networking;
- Provide more cost-effective support to campus users of the laboratory technologies;
- Provide a location and support structure that encourages the appropriate use and practice of multi-media development;
- Establish a centrally located printing and "pay for print" paradigm.

In a few years, Georgia Tech will embark on the detailed design and construction of an Innovative Learning Resource Center, which embodies Georgia Tech's commitment to the improvement of the overall undergraduate teaching and learning experience. The success of this endeavor requires cultural changes that effectively merge leading-edge library, information technology and educational services. The proposed LWC project will not only benefit Georgia Tech students and the entire community, but will result in valuable lessons and insights that will directly impact the design of the ILRC. ■

Lessons Learned in Developing a Graduate Level Internet Course

by David L. McDowell

Regents' Professor and Carter N. Paden, Jr., Distinguished
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When the “electronic request” came in spring semester 2000 for me to consider offering Principles of Continuum Mechanics (ME 6201) as an internet course to support the Mechanical Engineering internet MS program, my reactions were mixed. Historically, I have not been an outspoken proponent of internet courses, viewing Georgia Tech’s chief advantages as excellent laboratories and high quality students and faculty. These resources add immeasurable quality. I was surprised to find that one advantage of the internet format is to add value to the educational experience of on-campus students, if used properly as a “backbone” to existing courses. I am still unsettled regarding my views of the experience for off-campus students, having just concluded my first offering in Fall 2001 to 11 remote students, a statistically insignificant sample.

Continuum mechanics is a mathematically precise and conceptually demanding subject. It invokes essential physical interpretations of almost all of its concepts. When taught well, it can serve as a valuable foundation for subsequent courses in mechanics and, perhaps most importantly, as a linguistic basis for assimilating the vast and diverse literature in various branches of mechanics. In other words, it has the requisite characteristics of a core course for graduate study. So there is no question that it begs for inclusion in the course offering of an MS internet program.

Some very basic lessons were learned in the process:

- It is not an easy matter to translate conventional classroom teaching styles and presentation formats to an internet format for a course that involves literally thousands of equations.
- Plan on 8-10 hours of preparation of internet course modules per credit hour of an existing, “well-oiled”, previously taught course. This does not include development of any new course materials per se. This means nominally 400-450 hours for a new course offering. I spent this much time even with my notes already largely typed into MS Word format at the outset, except for example problems and careful proofreading and successive corrections of typographical errors in equations. The latter cannot be underestimated, as the details involved in guaranteeing precision and accuracy are overwhelming and the internet course format is pseudo-archival – notes are posted clearly and unambiguously and they must be correct and consistent throughout.
- A visually appealing format for presentation requires at least 20-point font. Cramping too many equations on each internet page is to be

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avoided to retain clarity and to guard against demoralization of students seeing this material for the first time. This makes it especially challenging when a number of equations are necessary in each derivation or example presented, since bouncing back and forth through slides results in a disjointed, staccato-like presentation. This problem does not typically exist in the conventional blackboard presentation, as the instructor intentionally leaves key equations on the board. Instead, careful thought must be given to reorganization of derivations and re-presentation of pertinent equations.

- The burden of course preparation invariably falls upon the seasoned instructor, as it is difficult to imagine advanced assistants (support personnel or graduate students, for example) with appropriate experience and background to ensure accuracy and make the proper decisions on format and presentation. I conclude that there is little merit to the notion of increasing support for additional personnel in the preparation of course materials (except perhaps graphics and visualization). It appears that investment in realistic faculty release time to develop these courses is the only viable approach. I did note, however, that the limited availability for taping course modules in distance learning might be improved by investment of additional resources there.
- It is highly desirable for the instructor to develop and maintain his/her own WEBCT page for the course, rather than relying on others.
- It is necessary to use colored backgrounds for the slides for internet presentation. However, downloadable PDF files of lectures slides

should have white backgrounds to enable efficient printing by students, with minimum usage of toner.

- It is a good idea to take advantage of the technology and mix the length of modules to change pace, ranging for example from 10 minutes to 50 minutes. Avoid tacking more than one major concept in each module.

One of my most pleasant surprises arose from the incorporation of internet lecture and slide in my on-campus offering of the course. I made a strategic decision to explore an alternative approach in my class periods with the 40 on-campus students. Instead of the pursuing the traditional lecture format, I instructed them to use the Monday class period as a time to organize their viewing of internet modules, and the remaining Wednesday and Friday class periods were used in class to cover more challenging concepts within modules as necessary to execute the next homework assignment. Students were instructed to view pertinent modules prior to coming to class and to engage in a discussion of concepts/questions. This worked reasonably well, although some of the students appeared to lag rather consistently in viewing of modules and were therefore somewhat less interactive in class. I believe this aspect of the course will be greatly improved in future offerings for which all lectures will be posted at the beginning of the course; milestones in the course will be more apparent when it is all clearly laid out in advance. Aside from such inevitable glitches associated with offering a new course, it appeared that properly motivated students were excelling in this format to a greater degree than I had observed in the traditional setting. They seemed to love the freedom afforded by giving them responsibility to digest information at their own pace. Several international students commented that this format offered them substantial benefit by giving them unlimited access to difficult lectures, upon command, overcoming language barriers as a precursor to a proper number of example problems to support learning in the traditional lecture format.

Instructional Technology

I received virtually no complaints from either on-campus or off-campus students regarding the visual or audio quality of the internet lectures, and I must say that they were delivered with a greater sense of content organization and compactness than previous traditional lectures.

From a pedantic viewpoint, I found the use of topic-oriented modules rather than fixed 50-minute lectures as highly desirable. In a course like continuum mechanics, it is quite desirable to focus on concepts in building-block fashion. I would also suggest that use of modules of different length allows the students to organize their time more wisely in viewing modules.

Undoubtedly, there are negative aspects of an internet course of this type. A few of the on-campus students commented that they just didn't assimilate material well from the internet delivery format. Of course, in my experience even in the traditional setting there are students who find it difficult to keep pace and digest material. On-campus students reported spending considerably more time attending/viewing lectures than in traditional courses, perhaps twice as much time for these activities. A difficult issue is that the off-campus students did not enjoy the same access as on-campus students to the instructor or, perhaps more importantly, to other students at a similar stage of development. Camaraderie is a very important aspect of the graduate student experience, particularly at the early stage of the program. I also found that the WEBCT e-mail and chat boards were dramatically underutilized in this course, both by on-campus and remote students, in spite of several reminders of this mode of communication and sharing. Personal e-mail communications and telephone appeared to be the preferred mode for remote students to ask questions. However, I did notice that the remote students seemed to have spent a great deal more time framing their questions and sorting out the issues than on-campus students.

To summarize, there are two primary messages beyond all the technical minutiae. First, the investment of time and effort necessary to convert an existing course to the internet must not be underestimated; it is roughly twice the effort required to develop a conventional course from scratch. This can be understood by anyone who has finalized an archival journal article or thesis in contrast to simply producing a rough draft. Second, internet course delivery, at least at the graduate level, offers the potential for unexpected positive benefits via alternative modes of on-campus instruction that may add considerable value to existing courses. ■

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In the CETL Library:

The Scholarship of Instructional Design

by Melissa Bachman
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Designing Environments for Constructive Learning
Edited by Thomas M. Duffy, Joost Lowyck, and David H. Jonassen
Springer-Verlag (1993)
ISBN 3-540-56452-7

Designing Environments for Constructive Learning serves as the proceedings of the NATO Advanced Research Workshop on the Design of Constructivist Learning Environments: Implications for Instructional Design and the Use of Technology, held at the Catholic University Leuven, Belgium, May 14-18, 1991. The chapters are provided by numerous different authors, and the viewpoints provided on constructivism are not always unified. Authors do agree on points regarding the need for collaboration and the importance of the authenticity and the context of the learning task.

Authors of part one describe learning environments that they have designed and use their description as a reference point for discussing the implications of constructivist theory for creating learning environments.

Part two is entitled “Design Issues”. Authors contributing to the second part of the book focus on how constructivism affects the way a learning environment should be designed. A “learning environment” might be a semester course, a workshop, a computer-based learning activity, or an assignment or group project. They discuss how constructivism affects the way these activities or modes of instruction are designed. The theory calls for a change in the approach taken to designing learning environments.

In the eleventh chapter entitled “A Manifesto for a Constructivist Approach to Uses of Technology in Higher Education,” authors David Jonassen, Terry Mayes, and Ray McAlesse offer a conception of why and how constructivist learning environments should be used in higher education. They suggest that complex and constructivistic learning environments are more suited for advance learners. It is also suggested that these types of learning environments are best for supporting “the advanced knowledge acquisition phase,” referring to the learning that relies on transferring and applying previous knowledge. The authors suggest that technology-based learning environments should possess certain characteristics. The article describes these characteristic and provides a rationale and example for each.

In summary, this book provides a wealth of information regarding the development, implications, and benefits of constructivist learning environments. The authors provide multiple perspectives. If you are the least bit curious about “constructivist learning environments,” you will find this book beneficial. If you are actively involved in developing or teaching within a constructivist environment that is supported by the use of technology, I highly recommend reading chapter eleven, “A Manifesto for a Constructivist Approach to Uses of Technology in Higher Education,” by David Jonassen, Terry Mayes, and Ray McAlesse. ■

Book Reviews

The Practice of Instructional Design

by Teshia Young Roby
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Building Learning Communities in Cyberspace: Effective Strategies for the Online Classroom

Palloff, Rena M. and Pratt, Keith
Jossey-Bass Publishers (1999)
ISBN 0-7879-4460-2
www.josseybass.com

Palloff and Pratt define this book as a sharing of their derived framework, successes, and difficulties with delivering distance learning programs. The authors offer the book as a tool “to be useful to anyone engaged in the process of online work,” (p. xvii).

The book is divided into two parts. Part one, *The Learning Community in Cyberspace*, consists of five sections that deal mainly with current research and theory, and is designed to provide a foundation for the authors’ distance education framework. In part one, Palloff and Pratt offer a definition of computer mediated distance education; a profile of the online student; concerns and issues faced by students and instructors in the online environment; a definition and re-definition of the concept of community, particularly in cyberspace; a literature review about electronic learning; and suggestions for difficulties related to time, and groups sizes in the online environment.

Part two of the book, *Building an Electronic Learning Community*, is more experiential in nature. It includes six sections that focus on making the conversion from the classroom to cyberspace; building the online course site and course components; suggestions for promoting collaborative learning; the experience of transformative learning - the process of experiencing personal growth

as a result of participating in an online course; suggestions for good course evaluation in the online environment; and lessons learned from involvement in distance learning.

The book concludes with examples of course syllabi from instructors who have taught online courses, and a short glossary of terms used in the book in reference to computer-mediated distance education.

Palloff and Pratt provide a vivid illustration of portions of community life within educational cyberspace. The authors focus on examples from their years as online instructors in the field of sociology by providing screenshots of course websites, student discussion excerpts, and instructor evaluation feedback. The duo also supplies a logical theoretical framework for delivering their own brand of distance learning programs. Unfortunately, the entire framework is presented in merely three pages at the end of the book, and detailed examples of each framework component are conspicuously absent from the text. Likewise, researchers in the field with similar frameworks (see Johnson, Johnson and, Smith, 1991a, 199b; Slavin, 1990) are obvious omissions as references.

Though the final chapter of the book is entitled “Lessons Learned and a Look Ahead,” the book concludes without revisiting the authors’ suggestions in heuristic format, making this text an unlikely choice for the reader who is in search of delineated and brief examples, or quick-reference answers to an existing question.

All in all, *Building Learning Communities in Cyberspace* is a worthwhile starting point for anyone with the interest and time to investigate effective strategies for the online academic community. ■

Problem-based Learning in Biomedical Engineering

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A rationale

The rapidly changing field of Biomedical Engineering poses particular challenges for engineering education. On the educator front, medical technology changes at such a rapid pace that it is hard to keep up with all the advancements in the related fields of molecular biology, computer science, tissue engineering, genetic engineering, etc. And yet, BME educators must stay current to provide an up-to-date, relevant educational experience. On the student front, the learning challenges are just as immense. The field demands that students develop multidisciplinary skills and knowledge in biology, chemistry, several engineering sub-disciplines and computer science. Students need the modeling and quantitative skills of traditional engineers, but also the qualitative understanding representative of a more biological approach. In short, they need to be fully conversant in two intellectual traditions, which are perhaps at odds with one another. While engineering seeks to analyze phenomena in order to abstract away from the real towards quantitative, idealized models, the life sciences work from hypotheses towards complex explanatory and descriptive accounts of real-world phenomena. Reconciling these two disparate practices requires cognitive flexibility and true interdisciplinary thinking—appropriate learning goals for a BME curriculum.

In an attempt to reconcile these worlds and foster interdisciplinary thinking among our undergraduate and graduate students, the BME Department at Georgia Tech has adopted a model of learning and a set of educational practices that have been used in medical education for more than three decades. Referred to as Problem-based Learning or PBL, this approach draws on constructivist pedagogy, which assumes that learning is the product of both cognitive and social interaction arrived at through authentic problem

solving. As an environment for learning, the PBL classroom has five goals: (1) the construction of useful disciplinary knowledge, (2) the development of disciplinary-specific reasoning strategies, (3) the development of effective self-directed learning strategies, (4) increased motivation for learning and (5) improved collaboration skills. The classic PBL version used in medical education utilizes rich medical problems, which support free inquiry. This freedom encourages student-directed learning and increased learning motivation (Barrows, 1985).

The Department of Biomedical Engineering has adapted this approach to the specialized needs of our undergraduate and graduate engineering students. Our four PBL classes, BMED 1300/2300 and BMED 8105/8106 have five objectives:

- The construction of knowledge useful in BME research
- The development of reasoning strategies which bridge the gap between engineering and the life sciences
- The development of effective self-directed inquiry strategies
- An understanding of the breadth of Biomedical engineering research
- Growth in effective cross-disciplinary collaboration and communication skills.

For two semesters, students tackle complex real world problems in teams of eight or nine guided by a faculty tutor. What gets learned, the routes the team takes to solve the problem, and the problem solutions they arrive at are determined by the group, not the facilitator. His/her role is to question, prod, and help students develop skills at the process level. To support this, the group utilizes what are referred to as “white

boards” to frame the problem-solving process. More specifically, the in-class white board is divided into specific sections used to record information, generate models and hypotheses, identify assumptions and issues for inquiry. The divisions are designed to mimic the reasoning strategies used by biomedical engineers. These four courses serving as the cornerstone of the BME educational program aim to provide students with valuable real-world experiences (clinical and research) which help them develop true interdisciplinarity.

The methodology

Problems are formulated to present minimal information about a situation (Barrows, 1985). A sample problem from BMED 1300 reads:

“The U.S. Government has requested preliminary proposals for the design of a device that can detect the Ebola virus. The device should be designed so that it is able to respond to the presence of the Ebola virus as rapidly and with as much sensitivity as is possible and is capable of remaining functional for two weeks or more in the field. The

Problem-based Learning . . . assumes that learning is the product of both cognitive and social interaction arrived at through authentic problem solving.

design that best meets these criteria will be fully funded to complete the design of the device. The large biomedical engineering company that you work for has decided to compete for funding for this project. The company’s strategy is to construct a mammalian-cell based device that is capable of detecting the Ebola virus. Your team is responsible for developing the detection assay. Other

teams will be responsible for implementing this assay in the field. You know that dying cells often lose their membrane integrity and release enzymes into the extracellular environment. Your team believes it should be possible to correlate the level of enzyme activity released by the cells with the concentration of Ebola virus that the cells are exposed to.

Your proposal (< 2 pages, excluding figures) must include a description of the following:

- (1) the cell type(s) used
- (2) the enzyme(s) to be detected
- (3) how the level of enzyme activity will be quantitatively measured
- (4) a mathematical model that allows one to correlate the level of enzyme activity to the concentration Ebola virus.”

This text is the **problem statement**, which may be issued with a short list of suggested resource persons (this list is not always given to more experienced students). When the student team first tackles the problem, they identify and articulate knowledge they already possess that is relevant to the case. In cognitive science terms, they activate their prior knowledge and preconceptions of a domain as a first foray into the problem space. They do this in a period of initial “brainstorming” of possible solutions which involves the generation of **hypotheses**. These solutions may or may not be feasible and may be eliminated as the session proceeds. The purpose is for the students to initially examine the problem qualitatively (as would an expert) and to identify **inquiry material** needed and **learning issues** to be explored (i.e. what information is missing in order to solve the problem). Some of this inquiry material can be provided to the students on an “as asked” basis if the facilitator has it (e.g. the results of a medical test, the original design of structure).

continued on next page

By the end of this first problem session, the students have narrowed down the viable hypotheses and identified the critical learning issues as a team. They individually choose research topics from the learning issues and consult with appropriate individuals and resources before returning to the group. Students then report on their work to the group and teach others what they have learned. They keep a log of their activities, and discuss the various solutions. Finally after three weeks, the **student outcome** is presented as requested by the problem definition (e.g. design of a new device, conclusion of how a structure failed and could have been prevented). The resultant learning is often presented as a **concept map**, a depiction of the processes and mechanisms learned in solving the problem. We also have the students present their solutions to the other groups and the faculty tutors. The focus in the final product is more on the underlying science or engineering fundamentals, rather than the “correct answer”.

A major learning goal in PBL is develop effective and efficient inquiry skills to solve the problem under consideration. During the PBL session, students should be brought to the level of knowing *what they do not know* but need to know to solve the problem. The assumption that follows from this cycle is that students will be more motivated to learn because they have identified their own learning issues rather than responding to those identified by the instructor. Further, since they are responsible to the

group for learning the material well enough to move forward in the problem, they are motivated to do the best job possible. It is the responsibility of the facilitator to ask questions that probe the students’ knowledge until they do not know the next step or process (Barrow, 1988). An experienced PBL team will do this in-depth probing on their own—peer to peer. Studies have shown that PBL students learn considerably more than their peers do in traditional learning environments about how to solve problems, how to manage their own learning, and how to work with others (Hmelo, 1998; Patel, Groen, & Norman, 1991; Patel, Groen, & Norman, 1993). PBL provides methodology, to which the students return every time they face a new problem.

During the PBL session, students should be brought to the level of knowing what they do not know but need to know to solve the problem.

As should be clear, good team skills are essential to this process. Learning how to collaborate is critical to solving the problems. Since they are too complex for an individual to even begin to solve it is critical that each member develop collaboration skills that will allow her to drive the problem solution forward.

PBL as distinct from project-based classes

PBL is well suited for learning in engineering but is not meant to replace project, design, and case study. PBL is a different methodology in that the students

eventually become entirely responsible for their own learning and independent of the instructor. Project and design classes are important components of engineering education, particularly at the undergraduate level, but the classes typically involve *application* of material learned in more traditional classes to a problem. It encourages creativity and independent thinking, but the instructor usually will indicate if the design is “correct”, offer suggestions, and therefore serves as an “regulator” more than a “facilitator”. Case study instructors often offer new information as needed, counter students’ hypotheses with alternative options, and compare and contrast the resulting solutions. The instructor provides feedback, indicating whether or not the student is right, whereas the PBL approach requires that students come to their own conclusions. The problem solving process is actual learning, not merely application of knowledge. For example, a senior *design* class might present a problem as *Design and optimize bi-directional interfaces between excitable cells and electrodes*. A design statement such as this might be divided among several teams in a competition format and is open-ended, in that, teams would likely generate different designs. A **PBL problem** that was formulated to have students get to the same design stage while learning the curricular components associated with it might be stated as: *You are a BME researcher for a private start-up company who had some initial success in the implantation of bi-directional electrodes in damaged neural tissue. The last three implantations have failed and the company president wants to know why.* The problem stated this way encourages the students to learn curricular components (e.g. cell biology, physiology, bioelectronics, signal processing) and elements of design.

Conclusion

The PBL approach forces students to tackle complex, open-ended problems with a team of students from both the biological sciences and from the various fields of engineering. The types of knowledge and the skills across the team are sufficient to solve the problems while individually they would be at a loss. From this kind of team experience the students can develop skills that help build an interdisciplinary perspective that is critical to biomedical engineering work. ■

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Spring Events

Faculty Development Seminars

January 9	Expectations, presented by Donna Llewellyn
January 17	Student Showcase of Educational Technology, presented by Damon Williams
February 21	Editing Academic Writing, presented by Lisa Rosenstein
March 13	Recent Developments in Family Friendly Policies for GT Faculty, presented by Mary Hunt
March 21	Gender Equity in and out of the Classroom, presented by Donna Llewellyn and Marion Usselman

Other Events:

March 20	Celebrating Teaching Day
March 26	TA Awards Luncheon
April 10	Faculty/Staff Honors Luncheon
April 16	Student Honors Luncheon

For more information on these events, visit the CETL website or call us at 404-894-4474.

The Classroom

CETL

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