Problem-Driven Learning at Georgia Tech

Jeanne L. Narum, Principal, PKAL LSC
An Interview with Wendy Newstetter, Director of Learning Sciences Research, Department of Biomedical Engineering

Jeanne L. Narum: *Wendy, your story is one of a cognitive scientist embedded in a program of biomedical engineering. Surely this is unusual?*

Wendy Newstetter: Well, the Whitaker Foundation "call for proposals" several years ago, in the realm of biomedical engineering (BME), required demonstration of innovation in both research and education. At that time, the fledgling Georgia Tech BME program was really nothing more than research collaborations between our campus and Emory, and when Tech's BME faculty decided to respond to the Whitaker call, they connected with our group of cognitive scientists on this campus to help them craft a vision for education that was innovative, and that would serve as a driver as they planned to expand the BME program.

Narum: *This seems to me to be wonderful example of bringing different voices to the table in the process of change. Was this the first time for you and your cognitive science colleagues to be asked to join discussions about pedagogical reform?*

Newstetter: Yes. With hind-sight, this was the logical next step for our campus, which had put most of its energy prior to that time in building innovation and excellence in research. More broadly, of course, the engineering community writ large had really lagged behind other disciplines in paying attention to the kinds of learning environments we are creating— and this may be one of the reasons we have been losing students.

Narum: *To be sure, fifteen or twenty years ago, few people were bringing insights on how people learn— much less inviting cognitive scientists to the table— in the process of shaping new programs and spaces.*

Newstetter: That's right, but the critically important thing to note about BME here is that this is a new discipline. When we now talk about biomedical engineers, we are not talking about someone who basically fixes machines in hospitals, but rather an engineer who takes the tools and understandings of engineering and applies them to the biosciences. The context is that within the last 8 - 10 years, there has been an evolution as we've moved from the 20th century being the century of physics to the 21st century being one of biology.

So BME is really a marriage between the biosciences, engineering, and clinical applications. When we started planning the new curriculum and the space, the engineers spearheading the effort made two things very clear: "we do not want to recreate ourselves in the students who come through the program; we are engineers who started working on biology problems late in our lives, without experience in crossing the boundaries between biology and engineering."

Thus, the goal we articulated was to prepare students who can be truly integrative thinkers, who can move seamlessly between these three worlds and develop the next generation of clinical applications— whether the applications be at the frontier or closer at hand. So our self-imposed charge was to create a curriculum that supported the development of truly innovative thinkers.

Another important piece of this story is that there are no text books for use in undergraduate BME. This is really quite wonderful, because we then had to create every single course from scratch, with no baggage, with no one able to say, "but we've always done it 'that' way before." If you think about it, textbooks fossilize a methodology of teaching.

> *If you had the option to start from scratch— no courses, curriculum, or spaces— yet with the vision of guiding students to become truly integrative thinkers, to be able to move seamlessly between the world of engineering and the world of biology, what kind of learning environment would you have in place today?*
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> *Based on their theory of learning, that it should be situated and collaborative, Georgia Tech's biomedical engineering faculty have achieved courses, program and space that engage students in authentic problem-solving, doing the kind of model-based reasoning that engineers do.*
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> *Their PBL rooms are designed for groups of eight students–with wall-to-wall white boards. Here students can "go public," externalize and display what they are learning, and identify through that display what they do not yet know.*
>
> *— Wendy Newstetter*

Narum: *The sage on the stage?*

Newstetter: Exactly. So we arrived at problem-based-learning (PBL) as the foundation for our program because our group became interested in research on something referred to as cognitive flexibility.

This describes, essentially, the capability of looking at problems from a variety of perspectives, and it was precisely what we were after; PBL is an educational approach that offers the possibility of having students be able to solve complex problems— to gain cognitive flexibility when (and this is the key point) when they are challenged with the right kind of problems.

That was our challenge, to come up with the right kind of problems. To foster the truly innovative and integrative thinkers that we aspired to achieve, problems were needed that demanded quantitative engineering skills, as well as biomedical understanding and the ability to see the implied clinical applications.

We had to drive students from the very beginning to see these three threads coming together (maybe I should say four, because chemistry is a part of this as well).

If you think about Thomas Kuhn's work, he talks about a disciplinary matrix. Essentially what biomedical engineering is trying to do is to create a new matrix, with ways of solving problems, ways of thinking about problems, methods and exemplars that are truly integrative across these fields.

Narum: *So part of your responsibility, as a cognitive scientist, was to use theories of learning to help design such problems?*

Newstetter: Yes. We started by developing a Ph.D. program, and here problem-development was easy—professors just took them out of their research labs. What we realized was happening was that students were trying to solve problems like doctors: they tried to diagnose—starting from inquiring about the symptoms and through a sequence of further questioning, testing and data gathering, they finally arrive at a diagnosis.

Indeed, this is standard in problem-based medical education. The "scaffolding" of the discussion of the problem is four quadrants on the white board: inquiry, hypothesis, ideas, and facts. This should have been a no-brainer for us; we were getting results related directly to the type of pedagogical approaches we were using.

So, we went back to "excavate" what it is about how engineers solve problems from how doctors do? We came back the following year with the same problems, but with a different scaffolding system through which we were really trying to support the kind of model-based reasoning which is what engineers do: they start with a very qualitative problem by going to the principles, then create an idealized model which is often a graphic that illustrates what they are interested in.

This model "scaffolds" the ability of the student to begin to do the mathematical modeling needed to solve the problem. In short, this is a model-based approach to problem-solving rather than an hypothesis-driven approach.

So, in this next year, using the same problems but a different scaffolding, we got very different answers back from the students, answers that were much more quantitative, which is what we were going after.

Narum: *Who are the "we?"*

Newstetter: The "we" was still the original group of five, all of whom recognized that old methods of teaching were not going to achieve the kind of learning outcomes we were aiming.

We all began to understand the value of experimenting with new kinds of "scaffolding" to get students to think and to solve problems in an integrative manner.

So, when we began to shape the program for undergraduates, we had learned some clear lessons about identifying and designing problems that really served our vision.

It turned out that identifying problems was very easy. BME is a frontier discipline, and we could just take problems out of the daily newspaper. Our first undergraduate problems dealt with mad-cow disease, which was all over the news at that time; we've dealt with 9/11, with agents to sense bioterrorist agents.

We initially thought that we'd arrive at a stable of ten problems that we would just run over and over. That has not happened.

Narum: *Link this back to your work as a cognitive scientist.*

Newstetter: Let me put it this way. Solving problems on the frontiers of science that other experts are trying to solve at the same time does two things: it motivates students tremendously, and has a very interesting impact on identity.

A major problem with students going into the sciences and being sustained is that they don't identify with the kind of activity they are being asked to do. They don't see their own personal identities or lives aligned with science.

Whereas, when you give them a complicated, multi-dimensional, interdisciplinary, problem out of the real-world, their imagination is sparked. They begin to say, "I can see myself doing this."

So problem-solving is about motivation and identity, about engaging students through the excitement and fantasy of trying to solve these real problems.

Narum: *So they learn a scientist or engineer is not someone cloistered alone in a closet, working without contact to others or the world beyond the lab?*

Newstetter: Absolutely. Here I can start talking about the kind of spaces that serve our program. My theory of learning is that robust, sustained, and intense learning is learning about solving problems, and that this PBL demands collaboration with people for varied expertise.

It demands social support systems and mentoring. It entails risk-taking and failure, and continuing to come back after failure. What drives strong learning is the desire to overcome failure and to solve complex problems.

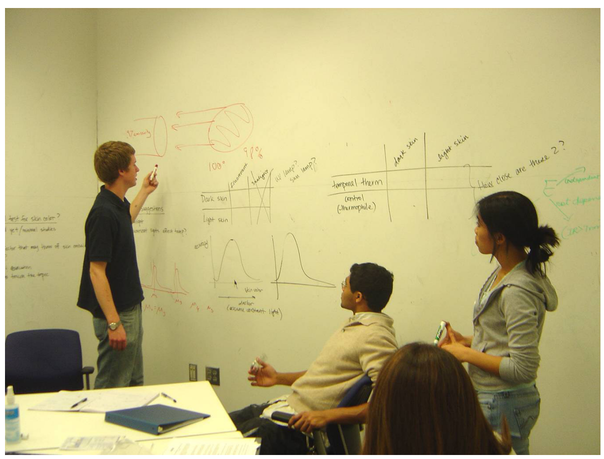
This theory is instantiated in the PBL learning spaces we've designed at Georgia Tech, and we now have a building that accommodates communities of problem-solvers, space for them to get together and to do the model-based approach to reasoning that engineers do.

There are spaces— lots and lots of spaces [but increasingly not enough spaces]— where students can externalize their current understanding of the problem in visual models that articulate and instantiate the problem-solving process.

Narum: *Your infamous white-board walled rooms?*

Newstetter: Yes. In contrast to most classrooms where there is one white board that only the professor uses because all that is happening is that s/he is displaying his or her knowledge, our classrooms are designed for students to display what they are learning to their colleagues (teams of eight students with facilitator).

As they display what they are beginning to know, they realize— when they cannot visualize it— what they do not yet know. Then they are pushed to figure out the next best question to ask— again and again pushing them to reach the limits of what they know on the way to understanding what the next round of inquiry should be.



Narum: *If someone walked into one of your PBL rooms, what would they see?*

Newstetter: They would see eight students working on a problem, with a facilitator who continues to press them with questions. Students writing on one or all of the four walls with white-boards, drawing pictures and arguing. They would see some students being very active, others more reticent, trying to figure out how to participate.

In fact, if they walked into each of the six PBL rooms running at the same time, they would see, very possibly, six kinds of interactions between team members, because every team is different.

Narum: *How do you know they are learning?*

Newstetter: That is an interesting question. Because each group has a facilitator, we get to observe what students are doing, up close and personal, for three hours every week.

We can see how each student is performing, how well they move, by the end of every four or five-week cycle, from an initial lack of knowledge with a particular problem to being able to present a polished 10-minute presentation in which they explain and defend a problem solution.

Following hard questions from colleagues, then they have to transform their original document, from that feedback, into a technical report— which is another problem to solve.

Narum: *When you started seven years ago, could you have imagined where you are today?*

Newstetter: No, and I think the very interesting part of this story is that all our BME faculty facilitate Problem-driven Learning (PDL) at one time or another, and this is having a fascinating percolation effect across the program.

Right now there are many points in the curriculum where students will engage in PDL, some sanctioned within the department (earlier identified as PBL) and others that have evolved spontaneously as professors come to experience the value of this approach.

When there is failure in PDL it is often because it is not infused into the whole curriculum, so if a faculty member tries it in upper level courses, it bombs because students have no preparation for this approach.

One important take-away message if that if you want to work with innovative approaches such as this, they really have to be integrated across the years and across the levels.

Narum: *Let me end by asking, knowing what you now know, if you were going to start from scratch in designing spaces for the problem-based learning that is the hallmark of the Georgia Tech Biomedical Engineering Program, what would you do differently?*

Newstetter: I would have more PDL rooms. We are already out of them and the ones we have are used 24/7. None of us anticipated that the students would appropriate these rooms, day and night, beyond their use for PDL.

It is very common to come in in the morning and see evidence that the rooms have been used all night, for a wide range of courses. That is the only thing I can say about limitations of our space. The students have embraced these spaces in ways that we hoped. What more could we ask for? ■