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Technology, Learning, and Schools: Comments on Articles by Tom Carroll & Gerald Bracey

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If I had more time, I'd have written a shorter book. ... Mark Twain

It is a pleasure to have this opportunity to comment on two highly interesting and provocative papers. The first is Tom Carroll's article on "If we didn't have the schools we have today, would we create the schools we have today?" The second is Gerald Bracey's comments on Tom Carroll's article.

Tom Carroll argued that new technologies can transform the nature of learning and schooling as we know it. Gerald Bracey noted that he has heard this kind of talk before. He acknowledged that technology can indeed be transformative for some people (e.g., "the kids get it"), but he questions some of Carroll's claims (e.g., that classrooms of today are no different from those of 100 years ago) and argues that, as a futurist, Carroll is long on analogies (e.g., putting steam engines into wooden sailing ships) and short on specifics. "Futurist articles are often long on schematic diagrams and analogies from other fields and short on concrete examples of the matter at hand" (Bracey). His overall assessment of Carroll's paper is that it "does not seem to advance us much toward solutions" (p. 3).

Both Carroll and Bracey made a number of important points, and we are thankful that we get to comment on their articles rather than vice versa. We organize our discussion into three parts.

1. First, we attempt to put Carroll's "futurist" comments in perspective by explaining why they are important and valuable, even if they are long on schematics and analogies and short on concrete examples. One reason is that Carroll's intended audience includes professors from over 200 schools of education who have recently received Federal Grants to better prepare future teachers to teach with technology. (This is known as the PT3 or Preparing Teachers to Teach with Technology initiative). Carroll was asking all the PT3 recipients—and everyone else involved in education—to do more than simply "bolt on" the new technologies to existing practices (analogous to simply adding steam engines to sailing ships without changing the ship's design or the roles of the crew). Carroll invited us to break free from old ways of thinking and explore new opportunities made possible by new technologies.

This is an important message, especially to recipients of new grants who may be wondering how bold they dare to be. Carroll's message is "be bold." Furthermore, Carroll frames issues in ways that can help us think more creatively about issues of technology, learning, and education. Later,

we show how his strategies fit nicely with the problem solving literature on ways to help people break free from old habits of thought. On the other hand, too much flexibility can get in the way of focus and cumulativeness of progress, a point we discuss in (3) below.

2. In the second part of our commentary we provide some concrete examples of "Networked Learning Communities" (NLCs)—one of the key concepts Carroll discusses. Carroll provided examples of NLCs. However Bracey's commentary is critical of these examples; he argued that the paper as a whole fails to advance the field toward solutions. The examples we discuss are not all full-blown NLCs, but they illustrate concrete examples of many of Carroll's ideas that we as educators can use to prepare future and present teachers to create and participate in NLCs.

3. The third and final part of our commentary analyzes Carroll's "we have launched a rocket" analogy. At the beginning of his article, Carroll noted that the amount of money currently devoted to technology infrastructure for K-12 schools is in the neighborhood of \$7 billion a year—an investment that is comparable to the space program. Carroll stated, "The process of building this infrastructure is similar to launching a rocket in education. Now that we have launched that rocket, we must learn to fly" (p. 1).

This is a thought-provoking vision; one of the thoughts it provokes is that there are major differences between the space program and our current educational situation. The space program has a much clearer set of missions than we do in education and it focuses its resources on achieving these missions. It also has clear criteria for knowing whether it is successful or not.

In education, it is not clear that we have launched a single rocket that is travelling toward a clearly defined destination. Instead, our efforts seem more analogous to launching a set of little model rockets that, when all added together, represent a significant investment of money. Nevertheless, they are all pointing in different directions, frequently collide with one another, and do not share a single, clear mission like landing on the moon or mars.

We know that Carroll is very aware of these differences and cares deeply about them. A major question for all of us is: Are there ways to begin to achieve more focus and cumulativeness in education without sacrificing creativity of thought? We think there are. Although we are far from having the answers, we provide a few examples of ways that technology might move us closer to achieving these goals.

1. Putting Carroll's "Futurist" Comments in Perspective

Our goal in this first section is to explain why Carroll's "futurist" visions about technology, learning, and education are important. We noted earlier that Bracey criticized Carroll's paper for being short on specifics. We agree about the shortage of specifics. But Carroll's vision and analogies are important, nonetheless.

As noted earlier, Carroll asked all the PT3 recipients—and everyone else involved in education—to "be bold." But he also went beyond being a cheerleader and couched his arguments in ways designed to help us "break out of the box." His approach fits very nicely with the problem solving literature.

1.1 Assumptions, Problem Spaces, and Problem Solving

Researchers in the area of problem solving note that, whenever we attempt to solve some problem (e.g., improving education by using new technologies), we invariably make a number of

assumptions that may or may not be conscious. Our assumptions constrain how we define problems, which in turn affect the problem spaces that we explore (Newell & Simon, 1972). Sometimes the assumptions we make are unnecessary, hence our problem solving is unnecessarily constrained. When we break free from these constraining assumptions, we frequently achieve a feeling of "aha" or insight.

As a simple example, consider the following problem: "Two men played five games of checkers and each won three games. How is this possible?" At first, most people have trouble generating a satisfying resolution to this problem. A common answer is "they tied," but a tie is not a win. The problem is difficult because most of us initially place ourselves in a cramped box by assuming that the men must be playing one another. Once we let go of the assumption, the problem is easy to solve.

Land, inventor of the Polaroid Land camera, suggested a wonderful, tongue-in-cheek definition of insight. He defined it as "the sudden cessation of stupidity." In the preceding problem, we cease our "stupidity" when we stop assuming that the men had to be playing one another. We find Land's definition of insight helpful, in part, because it adds a sense of humor to what can seem like a "grim" process of problem solving, and in part because it focuses attention on the importance of attempting to discover assumptions that may be constraining our thoughts.

1.2 Examples of Unnecessarily Constraining Assumptions That Affect Thinking about Technology, Learning, and Education

The "two men playing checkers" problem is simple and is usually solved successfully after a few minutes of thought. For most everyday situations, identifying assumptions that are limiting our problem solving is much more difficult, because they are tacit and taken for granted. For example, it is often claimed that railroad companies got into trouble when cars, trucks, and airplanes started to become common, because the railroad people defined themselves as being in the railroad business rather than the transportation business. This definition of who they were constrained the potential problem spaces they explored.

Carroll's focused on assumptions that unnecessarily constrain our thinking about learning, technology, and education. Are people really thinking "inside the box" about technology, or does Carroll simply think that they are? We did an experiment to test this idea and found that the answer is a clear "yes," they do tend to think inside the box when it comes to issues of technology and education. To read about this experiment, see [Appendix A](#), Knowledge and Problem Solving.

1.3 Alternative Problem Definitions

We noted earlier that Carroll did more than encourage readers to "be bold." He also framed the issues to invite new thinking. His strategies fit well with the literature on problem solving. For example, researchers argue that one way to make our tacit assumptions more explicit is to attempt to define any problem we face from at least two different perspectives (Bransford & Stein, 1993). Like any set of contrasting cases (e.g., see Garner, 1978; Gibson & Gibson, 1955; Schwartz & Bransford, 1998), contrasting definitions of a problem can help us make tacit features and assumptions explicit and see alternatives. To return to the railroad example, a problem solving consultant might ask executives to try to make their current definition of their problem specific, and then to look for at least one alternative definition. This might eventually lead to contrasting problem definitions, such as "How do we expand our railroad business in the

face of new competition?" versus "How do we expand our role as a transportation business?" The latter problem definition opens up new problem spaces for exploration

Carroll provided powerful contrasts for defining some key educational problems. Examples (which we paraphrase) include:

1. How can computers improve schools ? versus How can computers enhance learning ?

(The latter definition helps define a problem space, which acknowledges that a great deal of learning takes place outside of schools and that we need to capture some of this time)

2. How can computers improve schools as we know them? versus How can computers support new visions of schools?

3. How can *K-12 teachers (and teachers of teachers)* learn to be guides on the side rather than sages on the stage? versus How can teachers learn to be fellow learners along with their students?

(Carroll noted that the idea of teachers learning from their students is often not explicitly linked to being a "guide on the side").

4. How do we get students to master the existing (one-size fits all) curriculum? versus How do we support mass customization that fit particular sets of interests, strengths and needs?

5. How can we create communities of learners? versus How can we create learning communities? (in the latter everyone teaches as well as learns).

6. How can we motivate educators to use existing research to decide what works? versus How can we motivate educators to not only use research but become pioneers who themselves create new knowledge?

7. How can computers (as we are used to thinking about them— for example desktops) enhance learning? versus How can new versions of networked computers be used to enhance learning?

(Examples include inexpensive Web computers; palm-sized units that can include probes, toys with computer-embedded "smarts, etc.)

The issues highlighted by Carroll's contrasting definitions of problems are extremely important and fruitful to explore. Asking the right questions is a difficult art to master; Carroll does it extremely well. Each of the seven contrasts listed above is worth at least an entire paper. We explore some of these issues in the next section, where we provide examples that seem to fit Carroll's discussions of NCLs.

2.0 Some Examples of Networked Learning Communities (and Steps Toward Getting There)

In this section, we will provide some concrete examples of NLCs—one of the key concepts Carroll discussed. Bracey was critical of Carroll's examples. For example, Bracey argued that the reference to Tanaskee, Washington, as an example of a learning community is questionable. Bracey noted that, at least as the example was presented, the activities in that town seemed more

like a top-down reaction to the problem of the kids leaving town, and the orchard growers were operating like traditional teachers. Bracey also pointed out the following:

As Carroll discussed learning communities, I kept wondering Who decided what they were going to study?" On the basis of what criteria? Why and how did these people come together? It seems to me that a genuine learning community and compulsory attendance laws are mutually exclusive. (p. 2)

We agree that Carroll did not discuss the issue of *what* should be taught and *who* gets to decide (although we know from previous conversations that these topics are extremely important to him). Some of the most important advances in education involves changes in what is taught and when. For example, powerful concepts relevant to calculus, statistics, scientific exploration and so forth are being taught in new ways, and they are being introduced at early ages (Bransford, Browning, & Cocking, 1999). Rather than have THE high school course on statistics, calculus, and so forth, (some) students are receiving opportunities to acquire an understanding of these disciplines throughout their K-12 careers. In many cases, attempts to teach this kind of knowledge—and introduce it at an earlier age—are greatly enhanced by effective uses of new technologies (e.g., see Dede, 1999; Bransford et al., 1999, chapter 9; Linn & His, 2000).

It also seems important to clarify Carroll's claim that the early pioneers of flight formed a learning community and discovered the principles of flight. They certainly did not do this alone. It took some major discoveries in the field of physics to blend with the engineering experiments of the early test pilots. So the questions of who constitutes useful learning communities is an important issue to be explored.

But assuming that we agree on the need for clear goals about what people need to learn, we agree that carefully chosen expertise is needed, and t we agree that we still need some form of schools in which some people in the NLC have more authority to set the content goals and standards than others. Are there important ideas from Carroll's discussions of NLCs? Our answer is yes. We begin by examining implications of Carroll's arguments about the need for changes in teachers' roles within relatively traditional classrooms. We then move to ways that technology can help transcend the confines of classrooms and schools in order to create more distributed NLCs.

2.1 NLCs and Changes in Teachers' Roles Within Classrooms

Let us begin where Bracey and Carroll agree:

Where I do agree with Carroll is that there is a press for change, because "the kids get it." I think we will see a great deal more of learning at home (not the same as home schooling), simply because it is possible and effective . . . With the onset of so much niche-knowledge so early in people's lives, it will simply not be possible for a single teacher to keep up with a class of 25 diverse students.

Here we reach a point where ideas from Carroll's NLC can provide a beacon for helping teachers teach more effectively. How *can* they keep up with the needs and desires of 25 diverse students who have multiple opportunities to learn things outside the school setting—including many things the teacher does not know?

The first step—and Carroll did an excellent job of emphasizing this point—is that we must help teachers rethink their roles as professionals (as "experts"). We need to help future teachers—as well as current teachers, researchers, parents, and others—realize that being a learner is the essence of being an expert. A good model for this is the concept of "adaptive expertise" (Hatano

& Inagaki, 1986; Lin, in press.) The idea of adopting the concept of adaptive expertise as a "gold standard" for education is discussed in Bransford et al., 1999; (see also Vye, 2000). Often, people who see themselves as "experts" are hampered from new learning because their tacit model of expertise is "one who already knows." If they are supposed to know already, it can be difficult to also visibly learn. (See [chapter 2](#); the section on adaptive expertise is near the end).

Carroll noted that it has become fashionable to define teachers' roles as being "guides on the side" rather than "sages on the stage." But he argued that this does not go far enough—teachers also need to explicitly see their roles as learners. It is easy to say "sure" to this idea because it seems obvious—does not everyone in the world need to be a learner? But the idea of teachers being learners is much deeper than it might appear to be at first glance. It has important implications for how teachers think about themselves as professionals (i.e., their professional identity), and for how teacher educators need to help them develop these identities.

2.11 Learning What Our Students Are Thinking: One aspect of the "teacher as learner" concept involves learning what our students are thinking about our courses and the content. We all do this to some extent, but the importance of making students' thinking visible is becoming increasingly clear from research.

The National Academy of Science Report, *How People Learn* (HPL; Bransford et al., 1999) uses Len Lionni's children's story *Fish is Fish* (Lionni, 1970) to show why making students' thinking visible is so important.

[Lionni's story involves] a fish who is keenly interested in learning about what happens on land, but the fish cannot explore land because it can only breathe in water. It befriends a tadpole who grows into a frog and eventually goes out onto the land. The frog returns to the pond a few weeks later and reports on what he has seen. The frog describes all kinds of things like a bird, cow and people. The book shows pictures of the fish's representations of each of these descriptions: each is a fish-like form that is slightly adapted to accommodate the frog's descriptions —people are imagined to be fish who walk on their tailfins, birds are fish with wings, cows are fish with udders. This tale illustrates both the creative opportunities and dangers inherent in the fact that people construct new knowledge based on their current knowledge. (p. 11)

Fish is Fish helps clarify what it is so important to make students' thinking visible. If we don't, what they understand may differ considerably from the messages that we intend (e.g., Schwartz & Bransford, 1998). Efforts to make students' thinking visible involve "formative" (rather than only summative) assessment. Carroll argued, and we agree, that technology can play a major role in providing opportunities for formative assessment that do not overwhelm teachers due to time constraints.

During the past several years, we have taken the *Fish is Fish* story seriously and introduced multiple opportunities for formative assessment in our own college classes. The results have convinced us that formative assessment is even more important than we had believed initially.

One example involves insights from a study by Bransford, Brophy, and Williams (2000) into what students thought they understood after reading the chapter on expertise ([Chapter 2](#)) in Bransford et al., 1999. Their interpretations were very different from what was expected; for example, they saw no connections between the chapter and their own lives because they felt that "we aren't experts in anything." At first these interpretations were surprising to the course instructors. How could the students fail to connect to the chapter? They had developed at least a moderate degree of expertise in a number of areas, including driving a car, typing, writing

papers, and so forth. In retrospect, the students' interpretations made perfect sense, given the structure of the chapter. Discovering this allowed the instructors to come up with new assignments that helped everyone learn (for more information, see [Appendix B](#), Lessons From Students Taking a Course on How People Learn).

A second example of the value of learning from one's students involves a course on "Cognition, Culture and Technology" that was taught by one of the authors (Lin) with the assistance of the other two authors (Bransford & Schwartz). It was a highly diverse course, where the diversity included graduate students plus undergraduate students (about 15 of each), students from a number of different countries, students from different ethnic groups within the US, students who were raised in the South and those who were raised in the North, and so forth. Each of these dimensions resulted in issues that were important to pursue but also highly emotional.

The course would have been a disaster without a firm commitment to a "teacher as learner" philosophy. And technology played a key role in this processes. The basic technology was extremely simple—it involved e-mail. However, the way it was used helped transform a major disaster into a success. During the class periods, the students all "put on a good face" and everything seem to be going relatively smoothly. The e-mail journals revealed great turmoil beneath the surface, and this helped us take action. To learn more about this example, see [Appendix C](#), The Course on Cognition, Culture, and Technology.

A third example of issues related to "teachers as learners" is designed to reminds us that students do not always appreciate the idea of teachers as learners—some prefer to view their teachers as authorities in their subject matter. This is illustrated in a study conducted by Candyce Williams Glaser (1998), who followed a group of college professors as they attempted to change their practices by using new technologies. One of the professors was a real pioneer and continually helped his students see his enthusiasm for learning. His course evaluations revealed that most of his students were not pleased. (See [Appendix D](#), Williams-Glaser Interview.)

2.12 Students as Teachers and Learners:The previous discussion focused on ways that teachers need to focus on students' interpretations of subject matter and classroom interactions. A next level of the "teacher as learner" concept involves creating a "distributed expertise" environment by explicitly asking students to teach things that teachers might not know. This requires a more difficult shift in professional identity than might be apparent at first glance.

In a radio interview for our Vanderbilt studio, Pam Burish an outstanding teacher whose awards include Tennessee Teacher of the Year and a Milken award, explained that many of her third graders often knew more about certain software programs than she did. How should she handle this? Should she keep it a secret so she could preserve her authority?

Burish asked her students with special technology skills to be teachers who taught others—including her. She noted that, at first, the thought of doing this made her very uncomfortable—what would the students and their parents think? She soon realized that the students loved to contribute, and they saw their teacher's enthusiasm as she learned. This idea of capitalizing on the distributed expertise of a community is extremely important and fits well with Carroll's message about building new kinds of learning communities. Teachers need to see models of other teachers who are respected because of their willingness to learn (Listen to [Audio 3](#), EdTalk interview with Pam Burish—approximately 1 min.)

Ann Brown and Joe Campione (1994, 1996) are excellent examples of researchers who have

designed innovative education programs that specifically ask students to be teachers as well as learners. It is interesting that Brown and Campione's program is called "Fostering a Community of Learners." Nevertheless, we think their environment qualifies as a learning community, as Carroll uses the term.

Like the example with Burish discussed earlier, Brown and Campione ask students to use their expertise to teach others—including their classmates, their teachers, and others in the community. And in fact, Brown and Campione's curricula are designed to explicitly promote distributed expertise in the classroom by letting different groups of students "major" in particular areas, conduct research in these areas, and then teach one another. The idea of learning in order to teach others is highly motivating, and leads to strategies and levels of understandings that are not necessarily reached when students simply study for tests (see TAG-V, in press).

The act of identifying particular knowledge and skills of our students and asking them to teach others (including us) appears to qualify as an example of Carroll's "Invention" level of learning communities, where young and old are learning collaboratively to construct the future. When done properly, it creates a win/win situation. Expertise becomes available that otherwise would be invisible. And students learn by teaching rather than only by being taught. Furthermore, the entire classroom learns to function as a community where everyone contributes something unique.

The idea of encouraging students to teach as well as learn suggests the need for software that could allow teachers to keep track of special interests and of areas of expertise of their students (plus the students' parents, etc.) Given a curriculum topic, teachers could access the database to see who might be able to lend a hand as a teacher. This would make it easier to maximize the benefits of the expertise available to a learning community.

2.13 Teachers as Pioneers: Another level of "teachers as learners" is the idea of helping teachers see themselves as pioneers who are willing to take some chances—for example by trying some new technologies that might not work exactly as planned. One tension with being a technology pioneer is that teachers' lessons may be interrupted if the new technologies do not work perfectly. But teachers who create "pioneering" classrooms can help their students appreciate the value of taking risks and overcoming difficulties. One of our favorite examples comes from Myrna Cooney, a middle school teacher in Cedar Rapids, Iowa, whose teaching we have admired for years. Several years ago she explained to us how she helped her middle school students deal with the frustration of computer crashes. Basically, she taught them to think like pioneers. (See [Appendix E](#), Lessons from Myrna Cooney.)

2.2 NLCs That Move Beyond the Walls of Classrooms

The preceding examples all involved teachers and students whose roles changed within typical classroom settings. Carroll emphasized that this is important, but we also need to extend beyond the walls of traditional classrooms when we are thinking about NLCs. Indeed, this is where the possibilities of new technologies become particularly exciting.

2.21 Feedback Loops Between Teachers and Outside Environments: One example of Carroll's point is the need to keep up with what is happening outside the school and university. In the research world, it used to be the case (at least we have been told that this is true) that new ideas tended to be spawned within universities and were then "spread" to businesses and other places. But this situation is changing dramatically. Many new ideas now come from outside the

university and need to be incorporated into college classes so graduates can be better prepared for the worlds they will enter. And students come with sets of ideas and competencies that can be different from those familiar to teachers. If teachers do not stay connected to these changes, their courses can quickly become out-of-date. (To further explore this issue, see [Appendix F](#), Connections to Outside Groups.)

2.22 Virtual Challenges That Teachers and Students Can Explore Collaboratively: New uses of technology can also allow students and teachers to explore "virtual spaces" that connect them with other learners and environments. This kind of "distance learning" is very different from simply putting lectures on the web. For example, there are web-based environments where students and their teachers can work together to do real work in areas such as science and history (e.g., see HPL, chapter 9). Environments also exist in which teachers and students can participate in virtual "quests" or "challenges." These environments can be used as measures of assessment that provide information quite different from the kinds typically provided by standardized tests. For examples of web-based curricula that create learning challenges for teachers and students, see [Appendix G](#), The Challenge Zone.

2.23 Virtual Learning Spaces for Coteaching and Collaboration. Student achievement data consistently point toward the overriding importance of teacher quality. Teachers' impact on student learning is much greater than the impact of particular curricula, policies, or technologies. Much of the work on teacher quality is summarized very succinctly in a 1999 report from the American Council on Education entitled *To Touch the Future: Transforming the Way Teachers are Taught* (see also Darling-Hammond, 1998, 1999; Putnam & Borko, 2000; Shulman, 1987). The following is a summary of the major conclusions from that report:

- The success of students depends most of all on the quality of the teacher.
- The essential competencies of effective teaching include a command of the subject matter and preparation in effective pedagogical practice.
- Teachers are inadequately prepared to understand and apply technology to teaching.
- There is an opportunity to transform the quality of teachers in American schools with the hiring of at least 2.5 million teachers in the next decade.
- Demands for new teachers can be reduced significantly by reducing teacher attrition.
- The professional environment in which teachers work is inadequate to attract and retain enough high quality individuals to meet demand.

The HPL (Donovan, Bransford, & Pellegrino, 1999) argued that the majority of the kinds of learning experiences provided for both practicing teachers and pre-service teachers violate *multiple* principles known to enhance learning (see especially chapter 8). For example, HPL (chapter 6) emphasized that effective learning environments are learner centered, knowledge centered, assessment centered, and community centered. HPL argued that the majority of professional development programs miss each of these.

- They are not learner centered, because teachers rarely have a chance to explore issues that they care about—instead, teachers are often offered only a small selection of options that may not be directly relevant to them.
- They are not knowledge centered in the sense that many workshops for teachers are about general strategies for pedagogy but are very weak on helping teachers improve their content knowledge and integrating it with new pedagogy.

- They are not assessment centered in the sense of formative assessment that provides feedback that can lead to improvement. Teachers tend to teach in isolation and have no one else to help them see what they are doing well versus not so well.
- They are not community centered because teachers are not helped to form ongoing learning communities within and between schools that can lead to a sense of professionalism. For this to occur, teachers need to feel that they can contribute to the community, as well as learn from it (e.g., see Cognition Technology Group at Vanderbilt (CTGV), in press; Schwartz, 1999).

In recent years, a number of programs have been developed to provide teachers with innovative, sustained professional development activities. HPL discussed several of these (see chapter 8) and noted how, compared to typical approaches to professional development, they are much more compatible with our current knowledge of how people learn.

One of the key ideas for improving professional development is to situate it in classroom practice rather than primarily in lecture classes or workshops on general ideas (e.g., Bransford et al., 1999). One way to do this is to have teachers actually visit the classrooms of experienced teachers, try out ideas in their own classrooms, receive feedback from peers who visit their classrooms, and be helped to organize their experiences into a "user friendly" theory of learning. In our work in the Schools for Thought project (CTGV, in press), these were the types of experiences that teachers overwhelmingly found to be most valuable. However, there are many requirements for making this work on a broad scale—including access to outstanding classrooms, time to visit, people to provide feedback, and so forth (Shimahara, 1991). We, as well as others, have found that this is possible only to a limited extent.

Video cases of classroom practices can, to some extent, act as a substitute for classroom visits (see Hmelo & Spiro, 2000). But they are not interactive in the sense that teachers can actually work with students and see how they respond. New Web-based technologies now make this possible. An example involves the use of "virtual learning spaces" (VLS's) for collaboration among teachers who then coteach students. The VLS idea was recently piloted at Vanderbilt (by Xiaodong Lin, Dan Schwartz, John Bransford, Jeff Holmes).

The goal of the pilot was to begin a project that could help teachers increase their content knowledge, pedagogical skills, and abilities to appreciate and work with students and colleagues from diverse backgrounds. We especially wanted to help teachers view themselves as members of a worldwide community of professionals (see Aikenhead, 1997; Darling-Hammond & Bullmaster, 1997) and to view themselves as "adaptive experts" (Hatano & Inagaki, 1986), who take pride in learning throughout their lifetimes. We wanted them to experience the fact that they have colleagues throughout the world—all of whom are working to hone their individual and collective expertise.

The project used several different Internet-based technologies to connect teachers in the US with teachers from Hong Kong. The VLS was programmed in Active Worlds—a highly visual, 3-D, multi-user virtual environment (MUVE) that allows individuals to move about and see themselves and other participants as avatars. Participants can access Web resources while in the MUVE, and they can communicate with other participants by typing in a chat window; a special whisper mode allows users to communicate privately with one another.

In our pilot work, teachers from the US and Hong Kong collaborated to teach students about a "control-of-variables" experiment that was made available in a VLS. The results indicated that

teachers learned a great deal from one another. One of the most important findings was that opportunities for teachers to collaborate in the VLS context "humanized" their cultural differences and dramatically reduced cultural stereotyping (for example, when they watched and commented on videotapes of one another's classroom teaching). In contrast, teachers who had not participated in the VLS showed a great deal of evidence of stereotyping and a low willingness to borrow ideas from the other culture because "their students are too different from ours." For more information about this study, see [Appendix H](#), The VLS Study.

3.0 Exploring Carroll's "We have Launched a Rocket" Analogy

As noted in the introduction to this article, our goal in this third section is to analyze Carroll's "we have launched a rocket" analogy and show how this analysis highlights the need to explore issues of "focus" and "cumulativity" in education. At the beginning of his article, Carroll does a powerful job of capturing our attention by noting that the amount of money currently devoted to technology infrastructure for K-12 schools is in the neighborhood of \$7 billion a year—an investment that is comparable to the space program. Carroll stated, "The process of building this infrastructure is similar to launching a rocket in education. Now that we have launched that rocket, we must learn to fly" (p. 1).

There appear to be important differences between the space program and our current educational situation. A major difference is in the degree of focus and cumulativity. The space program has a much clearer set of missions than we do in education and it focuses its resources on achieving these missions. In education, we do not appear to have launched a single rocket that is flying toward a clearly defined destination. Instead, our efforts in education seem more like a set of little model rocket launches that, when all added together, represent a significant investment of money. Nevertheless, they are all pointing in different directions, frequently collide with one another, and do not share a single, clear mission like landing on the moon or mars.

The space program also has clear criteria for knowing when it is successful and when it is not. Sometimes this is not pleasant because failures are evident. But at least they can see the need to change. Carroll did not explicitly discuss these differences between education and the space program in his article. Nevertheless, we know he is aware of issues of alignment and cumulativity. In fact, he is actively engaged in attempting to change the scattered state of the educational field. So it seemed useful to analyze the alignment issue in a little more detail.

3.1 An Analysis of Alignment and Cumulativity in Education

The need for alignment and cumulativity in education is discussed in HPL (Donovan et al., 1999). The report emphasizes the lack of alignment among major elements that affect classroom practices and help them become more compatible with principles of how people learn. Elements that affect classroom practice include available curricula, preservice and inservice education, policy, and the public (including the media). Donovan et al., used two contrasting diagrams: one illustrated the current lack of alignment; the second illustrated what a more aligned system might look like and require. Central to the latter is the ability to accumulate knowledge that is both useful and usable. This knowledge needs to come not only from the current research community, but from additional sources such as teachers, principals, parents, business leaders, and the students themselves. (For more information, see [Appendix I](#), Needs for Alignment.)

3.2 Expanding Our Ideas About What It Means to Publish

Consistent with recommendations from Donovan et al., (1999), one approach we are trying at Vanderbilt is to use the Web as a new type of publication medium. The genre for our publications is a talk show where people discuss educationally relevant ideas and experiences with a host. The talk show format breaks the assumption that written articles are the only legitimate publication media (a legacy from the days of the printing press) and gives voice (literally and figuratively) to many people who are not accustomed to writing articles, or do not have the time to write them, or do not like to write them.

The talk show format allows us to easily gather ideas from teachers, current and previous students, parents, business experts, and a host of others whose wisdom is often invisible to most of the world because it is not captured (published). This is especially important as teacher begin to think of themselves as learners whose role is to contribute to a growing knowing base. Furthermore, the talk show format helps make the ideas of researchers more assessable, because they are more likely to talk "in plain English" when they are interviewed than when they write articles. In our talk shows, we also try to capture some of the backgrounds and motivations of the people being interviewed. This information, coupled with tones of voice, pauses, etc., add a human quality to publishing that is often absent when one simply reads a text. (See [Appendix J](#), New Publication Media.)

3.3 The Challenge of Organizing Resources

Having resources on a Web site can be valuable, but they need to be indexed and organized in ways that are useful. We are working on a number of ways to achieve this goal. One is to create useful search engines for our databases. Another is to announce new resources as part of LT Seek—a outstanding daily Internet news service written by John Rakestraw that highlights issues in technology and education (send a note to ltseek@cilt.org—the service is free). Yet another way to use the resources is to augment articles as we have tried to do in this one. (If you find these audio additions valuable, or not valuable, we would very much like to know your thoughts).

Still another way we are using audio (and video) resources is to create modules that can be used for Web-based courses. For example, last semester Bransford taught a course on How People Learn that was all module based. About 70% of the activities took place over the Web (outside of class) and 30% took place in class. Each module was in the form of a challenge that students first answered based on their intuitions. Students then got access to resources about the challenge and wrote a response again. Class discussions were extremely lively, because students posted their thoughts about challenges (on the web) prior to coming to class. In addition, by making the course modular, it is easy to change it by eliminating weak modules and adding better ones. (For more information about modular design, see [Appendix K](#), Web-Based Modular Design).

3.4 Adding Modules

One of the exciting features of modular designs is that different members of any community (NLC) can create modules and share them. For example, students in the How People Learn class created some modules of their own as a final project—they were extremely creative and useful. Over time, we can collect the "best of the best" modules that people can then organize in ways that fit their particular needs and goals. And as mentioned earlier, resources for the modules can augment typical forms of text publication and simulations, interviews, and other examples that capture wisdom otherwise invisible to most of the world.

At Vanderbilt, we are currently in the process of creating a Web-based infrastructure, plus a set of templates and design principles for creating modules. These can play a significant role in filling in the central portion of the "alignment" figure discussed by Donovan et al. (see section 3.1).

3.5 Re-Thinking Assessment

Central to efforts to develop some sort of focus and alignment in education are issues of assessment. In the space program that Carroll discussed, we have a pretty good idea of what counts as successful. Sometimes this is not pleasant, because failures become evident. But at least people know we need to improve (and sometimes *how*).

We think it is especially important for teacher educators to create a set of assessment environments that provide information about specific competencies. This is very different from more generic assessments such as standardized tests, which frequently are very insensitive to curricular changes (e.g., see Pellegrino et al., 1999) or international comparisons such as the Third International Mathematics and Science Study. These more general forms of assessment are important, but they also often mislead us into thinking that less progress is being made than is actually the case.

Consider the following example. Carroll noted that medical research is usually held up as a model of success—especially when compared to educational research. But it is useful to ask why we believe that medical research has been productive. Is it because our country is the healthiest in the world? We think the answer is a clear no. Americans tend to be overweight, we rank below many other nations on indices such as percentage of healthy births, and so forth. These are not the metrics we use to judge the success of research in medicine. Instead, we judge success by the degree to which we are improving our abilities to solve specific problems, such as heart disease, diabetes, prostate cancer, and so forth.

Educational researchers need to focus on similar metrics. And, in fact, there is mounting evidence that technology—when used appropriately—can help us vastly improve students' abilities to learn about specific topics in areas such as algebra, physics, biology, reading, complex problem solving, and so forth. Chapter 9 in Donovan, Bransford, and Pellegrino (1999) provided a number of examples. Obviously, we have a long way to go. But looking at specific areas gives us a different picture of the state of the art—in both medicine and education—than looking at generic measures, such as some overall "health survey" or our overall ranking in the world.

We noted in section 2 that new technologies can help us move beyond the limitations of relying primarily on standardized testing. As an example, imagine that all of us as a research and practice community began to develop a set of Web-based challenges that were consistent with agreed-upon standards and let groups of students and teachers "test their mettle" and learn to work smart in various areas. The kinds of challenges we have in mind are "PFL" (preparation for future learning) challenges, not typical "drop in from the sky tests," where people know little about what to expect and are given no opportunities to learn once the test questions are presented to them. The tests we use now are tests of "sequestered problem solving"—students have no access to resources in order to learn to deal with new challenges. But as Carroll noted, the future is about learning, not about performing in a sterile, sequestered environment. Underlying the idea of traditional tests versus PFL assessments are very different theories of the nature of transfer (e.g., Bransford & Schwartz, 1999). New technologies make it possible to use these ideas to

change what and how we teach, and how we assess peoples' competencies.

APPENDIX A

Knowledge and Problem Solving

About one year ago, John Bransford had a chance to hear Carroll talk about some of his ideas at a conference, and this motivated us to test some of his claims about "unnecessarily constraining assumptions". The test took place in an undergraduate course on "How People Learn" that Bransford taught this past semester. Here is Bransford's description of what he did.

The class was working on a unit on Knowledge and Problem Solving. As part of this unit, I asked the students—extremely bright and eager students—to write down what they viewed to be the biggest obstacles to using technology to improve learning. Answers included "many schools cannot afford computers"; "teachers may be afraid of the technology"; "computers often break and there is no one to fix them," "much of the existing software is poor," "kids may waste time on the Internet."

As students shared what they had written, it gradually became clear that each of their answers assumed that the learning they were imagining was taking place in schools, and that the structure of the schools was like the ones the students had experienced. Over time, they realized that I had asked them about computers and *learning*—not about *computers in schools* nor about *computers in schools as they currently exist*. Until it was made explicit to the students, they were unaware that their thinking was constrained by their school-centric assumptions. These are exactly the kinds of assumptions to which Carroll referred. And he uses some excellent strategies for achieving this goal. ([Click here to listen to Audio 1, containing parts of an audio interview with Tom Carroll in which he discussed obstacles to effective uses of technology in education](#)).

APPENDIX B

Lessons From Students Taking a Course on How People Learn

One example of what Bransford, Brophy, and Williams learned from students in the How People Learn course emerged from an assignment in which they asked students to bring to class (or send electronically) a thought paper commenting on Chapter 2 in HPL—the chapter on expertise. They were asked to briefly answer questions such as (a) what do you see as the main point of the reading? (b) what especially "connects" to your experiences and what doesn't? (c) what do you find confusing or want to learn more about?

A number of points were extremely informative to them. (See Bransford, Brophy, & Williams, 2000, for a full discussion.) For present purposes, we focus on one point that was learned from the students' thought papers. Reading the papers created one of those "aha's" that fit Land's definition of insight as "a sudden cessation of stupidity."

Bransford, Brophy, & Williams stated the following:

One of the questions we had asked the students was how the chapter on expertise connected to their personal experiences. The vast majority noted that it didn't connect because "we aren't experts in anything." Once we saw these comments, we realized that the chapter set the students up for this assumption. Nearly every example involved

experts who were much more senior and accomplished than the students in the class (the studies discussed world-class chess masters, professional historians, physicists, etc.).

Thanks to their thought papers, we were able to rethink our own teaching strategies and work to help students understand that there were many levels of expertise and that they indeed had developed at least mid-level expertise in a number of areas—including everyday language, the ability to drive a car (and carry on a conversation at the same time), keyboarding (for most of them) and so forth.

After reading the thought papers we encouraged students to identify areas where they had acquired at least mid-level ranges of expertise. Examples included football (complete with outstanding pattern recognition and memory for what happened in the games), soccer, waitressing, dance, public speaking and other activities. Students wrote about their particular areas of expertise and ended up relating them to the literature on expertise. For example, if experiments like those discussed in Chapter 2 were conducted in their areas of expertise, how would their understanding and memory for events differ from novices? Did they feel like they were on the road to become "adaptive experts," or were they becoming only "routine experts" (Hatano & Inagaki, 1987). Thanks to insights into what the students were thinking, we were able to learn a great deal about our initial attempts to communicate and where and how we had failed. And their essays taught us a great deal about areas of expertise that we had not known about before.

APPENDIX C

The Cognition, Culture, and Technology Example

Each student in this course was required to write an e-mail note to Lin on a weekly basis. The purpose of the note was to inform her about the students' struggles and triumphs in the class.

A great deal of effort went into gaining the students' trust so that they would be honest about any feelings and problems and share them with us via e-mail. And as soon as they mentioned any problems, we responded positively and thanked them for their honesty. We predicted, and the students later agreed, that the e-mail format made it easier to discuss emotional issues than would have been the case in face-to-face meetings. The e-mail provided students with a safe distance and a chance to carefully craft their messages. Many noted that, if they had met with us face-to-face, they would have held back their concerns for fear they might cry.

About several weeks into the course, it became apparent that there were a number of underlying tensions in the course—tensions that were only slightly visible to us during the face-to-face class meetings. Students were all polite in class and "put on a good face." But beneath the surface, the e-mails revealed a number of problems that desperately needed solving.

One problem involved class discussions focusing on issues of race and nationality. A number of students felt they were being accused of being prejudiced by some of the other students, but felt powerless to respond. Another issue revolved around the fact that the course was project oriented, which meant that students would eventually create some kind of product for subsequent students. But at the beginning of the course, the nature of the projects were not defined completely—the goal was to have ideas for projects emerge over time. A number of students—especially the undergraduates—complained that they wanted more structure. Many wrote in their e-mails, "Just tell us what we need to know."

The e-mail feedback provided us with multiple opportunities to respond to individual students plus the class as a whole. One particularly important response occurred just before mid-semester. We summarized to the class some of the concerns that had surfaced in the e-mails. Then we presented the diagram shown in Figure 1. On the horizontal dimension we listed a continuum of courses from "sit at the foot of a mentor" to "working at the edge of one's knowledge."

On the vertical dimensions, we listed the degree to which the issues discussed in courses involved "hot" versus "cold" cognition. We then asked the class to say where our course fit in the framework. All agreed—it fit at the far bottom and the far right (i.e., very "hot" cognition that involved "working at the edge").

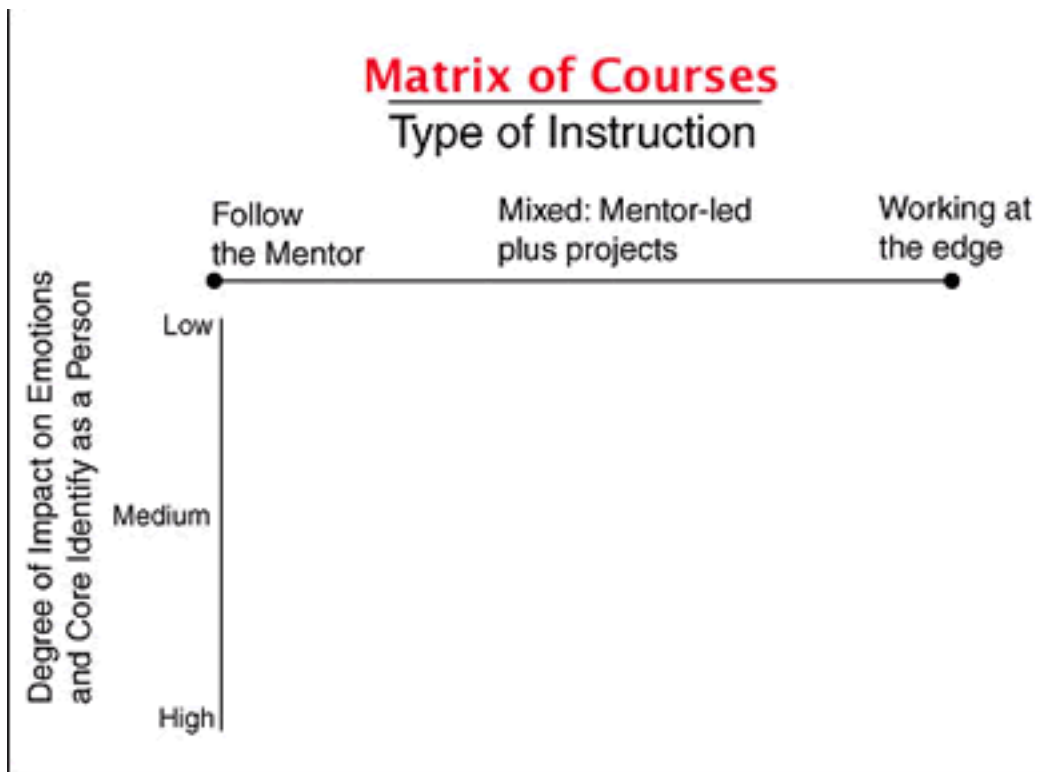


Figure 1. Matrix of Courses

Next we began a discussion of why it might be valuable for at least some of one's college classes to fit the profile of our course. Ideas that eventually emerged included that fact that life was filled with "hot cognition" issues and that it was important to develop a safe place to explore them. If we could not do that here, where could we do them elsewhere in life? In addition, since the world was changing so rapidly, it was not possible to always learn by "sitting at the feet of a mentor." If one ever wanted to be a pioneer, that meant working "at the edge" of existing knowledge. And "at the edge," there were no mentors who knew all the answers. In this context, it was helpful for students to listen to a radio interview with Dr. Peter Vaill, a management expert and distinguished professor who had visited hundreds of companies and noticed how they all required "on-the-edge, whitewater learning." (Listen to [Audio 2](#), Excerpts from the interview with Dr. Vaill.)

Figure 1, plus some additional materials we used, helped break the ice and create a community in which we all learned from one another. Students began to share their stories of how they grew up, their beliefs, their assumptions about other cultures and races, their insecurities, and so forth. The information shared was profound and unforgettable.

Overall, the course turned out to be one of the most rewarding we had experienced. But it would have been a disaster if we had not had the opportunity to learn from the students. They not only helped us identify problems occurring below the surface, they also contributed by sharing stories, experiences and articles that make the experience, much richer than it would had been if we had controlled most of the discussions. Hopefully, these students got a taste of what it is like to be the kind of pioneer that Carroll called for in his article.

APPENDIX D

Williams-Glaser Interview

In one interview conducted by Williams Glaser, a professor discussed how his department begged him to not only use new technologies, but to also teach a course in a field that was outside his direct area of expertise. He explained to his students that the technology and the content were new to him and all of them needed to learn together. So if a student asked a question he could not answer, he said "I'm not sure, but I'll find out by the next class." And he always found out.

On the course evaluations, many students rated the professor as poor because "he doesn't know his field." They failed to appreciate his willingness to be a pioneer by exploring an area that was new to him; his openness about explaining what he did and did not know; the fact that he shared with them his learning strategies for finding answers to their questions.

The lesson we take from this example, and we are sure that Carroll would agree, is that students also need to understand and appreciate new roles for teachers as learners. The longer students have been in school the more challenging it may be to do this. But we are convinced that it can be done. In fact, to be successful it must be done. The students need to understand the value of being pioneers, and the value of developing "adaptive expertise."

APPENDIX E

Lessons From Myrna Cooney

Myrna Cooney's class was testing the first generation of Knowledge Forum, an innovative computer program that allowed students to build knowledge collaboratively (e.g., see Scardamalia & Bereiter, 1993). Like many first generation programs, it crashed a lot. Before long, many of the students became discouraged and wanted to abandon their attempts to use Knowledge Forum. It was too frustrating.

Cooney worried about the mounting frustration and thought about ways to deal with the problem. She finally decided to show her class a videotape of some of the early attempts at flight. (You probably remember seeing old movies of strange contraptions that usually ended in crashes—but non-lethal crashes because the "planes" did not fly very high.)

Cooney showed her class the videos and then said (paraphrase), "These are some of the pioneers who helped develop airplanes as we know them." She then explained, "We are also pioneers. If

we can remain patient, be observant, and communicate to the developers what went wrong with our software, we can help make things better for others who will follow us."

Cooney helped her students view themselves as pioneers who were trying to make things better for others. This was not just a cover story; they were indeed pioneers. Their initial frustration at computer crashes turned into enthusiasm for documenting problems that could help the computer company eliminate bugs.

The point here is not that we should introduce bug-filled software into schools so that students can help fix it. The point is that there are ways to frame problems that can help people see them as challenges and opportunities rather than simply as nuisances or failures. Cooney did a brilliant job of helping her students re-conceptualize their "frustrations" as "challenge and opportunities." One of Carroll's many important messages was that we need to help teachers develop this kind of mindset. We need to prepare them to cope with the inevitable difficulties they will encounter whenever they try something new. The teachers, in turn, can help their students develop similar attitudes.

APPENDIX F

Connections to Outside Groups

Technology provides tools that can help all of us stay more connected. One example involves the use of collaboration technologies to co-develop curricula with people in industry. Like many other groups across the country, members of our Learning Technology Center are currently doing this as part of our bioengineering project (see <http://www.VANTH.org>) and part of a project with professors in community colleges (<http://www.nsti.tec.tn.us/seatec/>) In addition to co-developing curricula, we are recording interviews with people in industry about the nature of their environments and the kinds of skills, knowledge, and attitudes needed to do well in them. These interviews can be text, audio or video and reside on the Web.

Carroll also emphasized the importance of learning from our students once they graduate. What did they find most useful from courses and internships. What could we do better to prepare them for the worlds they will meet? As part of a US Department of Education Catalyst grant, we are conducting audio interviews with young graduates who have been teaching in the schools for several years. The information they are providing is extremely informative. For example, a number have discussed how different aspects of their technology training prepared them not simply to use existing technologies, but how to be leaders who can help others learn, help write grants for technology and teaching, and so forth. We also have interviews with three outstanding graduates who gave up on the teaching profession after several years and did something else like go to graduate school or a professional school. What was missing for them in the teaching environments? Carroll noted that information such as this is crucial for us to know and document.

Peter Vaill, A Distinguished Professor of Management, commented on the need for better feedback loops for faculty. (See [Audio 4](#), Excerpts from Vaill interview.)

APPENDIX G

The Challenge Zone

The following examples are from our Challenge Zone work at Vanderbilt. We use these examples not because they are the best out there, but simply because we are most familiar with them.

Our work on the Challenge Zone concept has been developed in conjunction with Nancy Vye, Linda Zech, Jay Pfaffman, Taylor Martin, and others in the LTC. Through this project, we have had opportunities to study the benefits of web-based challenges that let students and their teachers engage in a set of activities such as (a) plan for an upcoming challenge; (b) adopt, adapt and invent tools for "working smart" in order to meet these challenges; (c) receive chances to "test their mettle" and revise their strategies and tools as they work towards "The Big Challenge," and (d) participate in "The Big Challenge" and see how they do compared to benchmark performances from around the country and the world.

As an illustration of a challenge, imagine allowing groups of students and teachers several weeks to prepare to help a person named Emily, who is starting an ultralight-based rescue and delivery service. She needs to quickly respond to customers who want to know travel times and fuel costs depending on how far they need to travel and the amount of equipment they wish to take (the latter information will affect payload requirements and eventually the choice of plane to use).

We asked college students to try this challenge (without any prior instruction from us) in order to establish a benchmark for performance that K-12 students could try to beat. After hearing about the overall challenge, college students tended to prepare by writing down relevant formulas (e.g., $D = RT$), getting out their calculators, and solving each problem that was presented (they were presented over the Internet as if they were queries coming from potential customers) by calculating answers. This is not a bad strategy, but it is relatively slow and inefficient and falls short of "working smart." (For more information on working smart, see Bransford et al., 2000).

We wanted to help K-12 students and their teachers learn to "work smart" and, in the process, exceed the performance of the college students. Working smart involved developing a set of problem-relevant smart tools (some involved computer-generated graphs that allow students to easily determine travel times as a function of speed of planes and distances; some were specially designed spreadsheets that automatically calculate answers; and so forth). Furthermore, we wanted to help the K-12 students learn to work as a team. Under these conditions, the students outperform others who simply use calculators to calculate each problem from scratch.

Another challenge might be to take a week or so of class time to evaluate the idea that creating a one-acre pond for raising lobsters can be as economically viable for farmers as raising tobacco (this is a project that is actually being tried in Kentucky and Tennessee).

It is clear from our experiences that challenge-type environments are motivating, help students and teachers see their roles as inventors (of tools, concepts, strategies) for solving problems, and help them understand ideas at a deeper level than they would traditionally. Central to these environments are opportunities for students to "test their mettle," revise, and try again. These are examples of the kinds of formative assessment environments that Carroll argues are extremely important. (For experimental support see Bransford et al, 2000; Legacy et al., 1998).

Challenging environments such as these can also be used to assess the value of helping students and teachers form networked learning communities that make effective uses of technology. Imagine, for example, that some students and their teachers have access to technology to prepare

for challenges like Emily's rescue and delivery service or lobster farming—plus have had the opportunity to develop skills like working collaboratively by acquiring different areas of expertise and then teaching one another (see the discussion in section 2.2 of Brown and Campione's *Fostering a Community of Learning*). Other groups have neither the technology nor the skills for learning and teaching one another. Is there any question which group is going to better meet the challenges that are eventually presented to them?

The key to these environments is their emphasis on assessing how well students are able to learn in order to prepare for a specific challenge. If we have prepared students for new learning (by providing them with powerful concepts, skills and tools), they will do well in the challenges. This emphasis on assessing "preparation for future learning" represents a new way of thinking about transfer and assessment that is quite different from ways of thinking that have been prevalent in the past (e.g., Bransford & Schwartz, 2000; Schwartz & Bransford, 1998).

Using this kind of model could dramatically change the nature of education as we know it. For example, students could still work in classrooms with a lead teacher (fellow learner). But the teacher would not necessarily know all the knowledge and skills necessary to solve particular challenges. Instead, she and her class would work together to prepare for the challenges—including self-assessing their functioning prior to the "big event." Over time, a great deal of expertise could reside in Web-based challenge environments and resources for preparing for them. And teachers could become learners who learn alongside the students in their class.

APPENDIX H

The VLS Study

The VLS study involved US and Hong Kong teachers who mutually explored a VLS in order to prepare to teach students (one from the US, two from Hong Kong) a "control of variables" science lesson. Then students visited the space, and the teachers taught. Figure 2 outlines the professional development model that was piloted.

Professional Development Learning Cycle

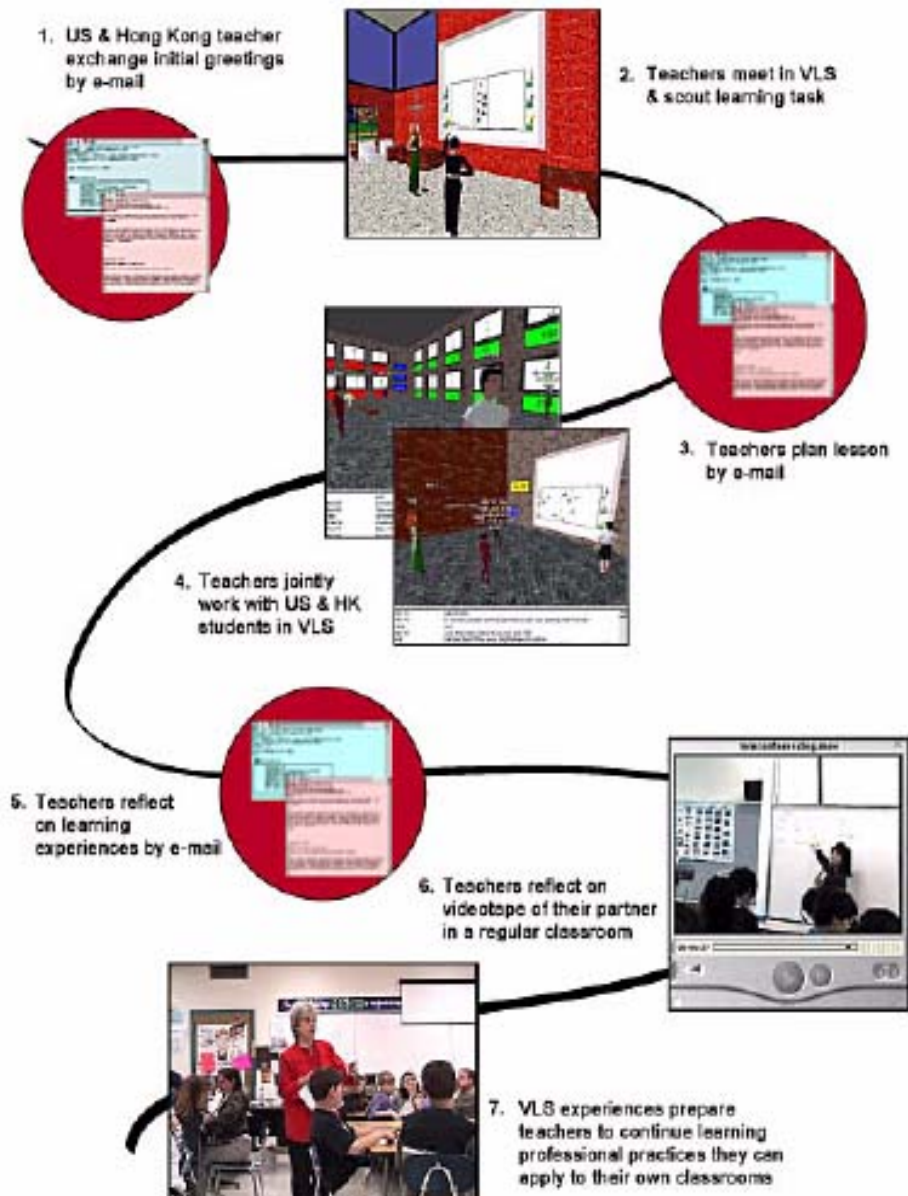


Figure 2. Professional development learning cycle

1. In the first step of the collaboration, a middle-school science teacher from the US (Sally) and a comparable teacher from Hong Kong (Hui Ying) exchanged initial e-mail greetings describing their teaching goals and training.

2. A few days later, the teachers met synchronously for the first time in the VLS and became better acquainted. After jointly exploring the features of Active World, their task was to scout the activity we prepared (experiments on cockroach habitats that varied one to three variables simultaneously), so they could develop learning goals and plan lessons for the students.

3. The teachers planned their collaborative lesson through e-mail. This generated many

discussions. For example, Sally and Hui Ying discussed one another's strengths (e.g, content expertise, classroom management) so they could partition their teaching roles.

4. The teachers instructed students they had not met, in this case, two students from Hong Kong and one from the US. The students quickly learned the whisper mode to exchange their own solutions, and this led to breakdowns in the lesson plans. The teachers bonded as they struggled in whisper mode to determine how to ensure the students would still learn about systematically conducting experiments. Eventually the students learned. Examples of these teaching interactions are illustrated in Figure 3.

Overview of VLS Interaction & Samples of Teacher and Student Dialog

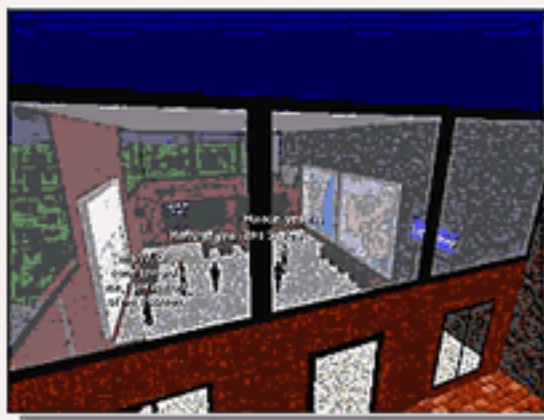
Teachers Greet Students Outside Virtual Classroom

To this point, the teachers have never met these students nor have the students from Hong Kong and the U.S. met each other.



Teachers Help Students Navigate into Classroom

The teachers have students practice Active World features, and they ask them to gather in front of the board showing the experimental setup.



Teachers Explain Experimental Setup

The left side of the cockroach tray is fixed at medium heat, humidity, & light. Students set

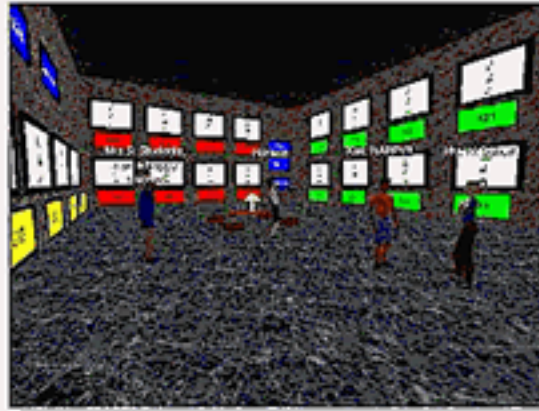


values on the right side. (The number of bars corresponds to strength of the variable.) Students will look at results to see which side cockroaches prefer.



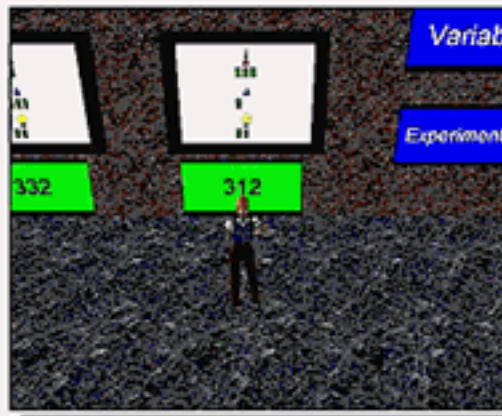
Teachers Lead Students into Laboratory of Experimental Designs

Each "billboard" shows a specific setting for the heat, humidity, and light on the right side of the cockroach tray. The walls correspond to experiments that change 1, 2, or all 3 variables simultaneously.



Students Choose which Experiment to Run

This student is about to choose an experiment that increases the heat, decreases the humidity, and keeps the light the same as on the left side of the tray. The numbers, 312, correspond to the level of each of the variables. The left side of the tray is always 222.



Students Transport to Rooms Holding Results for the Chosen Experiment

The distribution of the cockroaches shows that they do not exhibit a strong preference for 312. Students record data, and they return to Lab to choose additional experiments as needed.

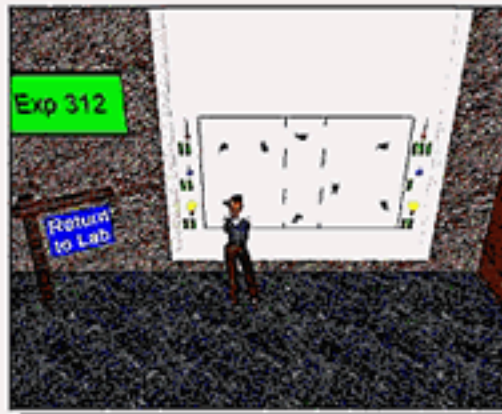


Figure 3. Overview of VLS interaction

5. After teaching, the teachers reflected on their experience. Sally and Hui Ying decided to control the structure of the reflection experience by first writing their separate impressions and then commenting on one another's observations. They then discussed many ways to improve the lesson and how they might map what they learned into their own classrooms.
6. The two teachers watched videotapes of one another teaching in their regular classrooms in their normal cultural context. As we discuss below, the teachers were attentive to one another's strengths and considered what they could learn from those strengths (e.g., maintain high expectations of students). In contrast, comparison teachers who had not participated in a VLS engaged in a great deal of stereotyping when they viewed the videotapes (we discuss this in more detail later)
7. Teachers attempted to leverage their experiences to continue learning, for example, by watching TIMMS videotapes that present other models of practice, by attempting to apply lessons in their own classrooms, by revising or developing their own VLS activities, and by taking leadership roles in the VLS community.

Several findings from this study suggest the potential of this kind of environment for developing the kinds of NLCs that Carroll envisioned

1. The teachers and students very much liked the VLS environment. For example, both teachers made comments, such as, "This environment is so cool! My students will be more motivated to learn about technologies ..." Several of the students also noted that the VLS -based science experiment was more fun than the ones she usually did in class.
2. The teachers learned a great deal about one another's strengths and about their own weaknesses. The e-mails between the two teachers suggested a strong and open bond. They decided to take particular roles that built on one another's experiences and strengths. We believe that this bond was created, in part, by the fact that the teachers had shared a mutual, challenging experience (to explore the VLS and "solve the problem"). Even more important is the fact that the teachers knew their ultimate goal was to teach others. In research we have conducted on learning by teaching (see TAG-V, in press), we have found that people study differently when they prepare for teaching (versus tests), and that they are more motivated to make sure they understand rather than simply memorize.

The challenge of having to teach was made more salient because our VLS environment lacked many of the normal supports available in classrooms. For example, the VLS for our pilot work involved a number of different "experiment" rooms that students could explore in order to conduct variable control experiments. This design meant that teachers had no guarantee that students would sit quietly at desks (there were no desks) and await instruction. This prompted a great deal of excited planning by the teachers. They focused on issues of engaging the students with respect to the core content to be learned and on ways to deal with the diversity of backgrounds and expectations that their class of international students was likely to have. Sally and Hui Ying exchanged 24 e-mails as they planned their teaching. Examples of their interchanges are as follows:

Sally: "My concern is that we be very careful to avoid having students just click all the boxes until they find the solution."

Hui Ying: I suggest to teach the student by letting them to explore first, Allow them some time to think and then ask them the plan of investigation instead of allowing them to do whatever they like."

These interchanges led to reflective and invigorating exchanges during the planning stages. For example:

Sally: Honestly, I have not sat down to "think" of teaching for quite a long time, and everyday I feel like I'm teaching and reacting in a "reflex" manner. It is indeed my pleasure to discuss this lesson with you. Fondly, Sally.

Hui Ying): I have prepared a draft for the teaching plan....I have to state very clearly that the draft is not a must, I just typed in so that you can save time and just modify.

At one point in the interchange Sally said the following:

I am so impressed with you! You have such a command of the science experiment design that I think you ought to be teacher A who teaches content and I can be teacher B (the social one) and whisper with you and encourage talk among the students. Fondly, Sally

3. The teachers learned a great deal by attempting to teach their three students. Much of their learning came from things they had neither expected nor planned for. Examples of interchanges between the teachers (sometimes in "whisper" mode—shown in italics—so the students could not hear) are as follows:

Hui Ying: Horace suggest that cockroaches like lower temperature.

Hui Ying: Do you agree?

Nina: No.

Kait: Absolutely not.

Horace: They like higher temperature

Hui Ying: Horace, can you explain a bit on your answer then?

Kait: [whispering to Hui Ying] I think that the answer is number 321.

Kait discovered the solution earlier than the teachers expected, and the teachers start whispering to figure out what to do

Hui Ying: Sally, what should we do? They got the answer TOO Soon!!!

Hui Ying: Kait, you need not draw a conclusion so quickly. Check more.

Hui Ying: [to Mrs S] After the 5 minutes, what should we do?

Hui Ying: Sally??

Hui Ying: Kait, good. I think 321 is some hint but it is not good to draw conclusion that quickly. We need to check clearly first. OK?

The teachers eventually gathered all the students together (they were in different experimental rooms) to see what each had concluded and whether the conclusions were solid or premature. In

the process, one student got lost for awhile in the VLS. So there were numerous unplanned events that challenged teachers to work collaboratively.

4. The teachers' reflections on their collaborative teaching efforts were instructive both to them and to us. For example, they generated important ideas about how the structure of new VLS's might be designed. After this experience, we suspect that they will be very interested in the ideas that Carroll presented.

5. A fifth finding from the study was especially important: The experience of the teachers working together in the VLS helped "humanize culture" and break down stereotypes. The part of our pilot study that most directly addresses this issues involved asking VLS teachers, plus other teachers who had not participated in the VLS, to view videotapes of Sally and Hui Ying. The purpose of the videotapes was to help the teachers see how their colleague's virtual behaviors appear as practices in a regular setting.

Data indicate that the VLS teachers were much more receptive and reflective of the practices in the videotape compared to those teachers who had not shared experiences in the VLS. For example, the US "baseline" teachers who had not had interactive experiences tended to notice many more negative aspect of the Hong Kong teacher's teaching, and they attributed differences in teaching behaviors to culture. As a consequence, they did not consider the differences in practice relevant to themselves as teachers. Here are comments from one baseline teacher after viewing Hui Ying's teaching tape:

My initial reaction is that she is going over so much and not giving time for questions for the students. She was just going, zip, zip, did not give students time to respond. I could never give that many directions. You know. She was going through it so fast with what she wanted to do without giving students time or chance to develop their own ideas. They may just teach that way over there. The difference between Hong Kong and here is partially that they tell students what to do instead of asking them what they need to do...and ...it seems to me that all the instruction is teacher-led instead of students-led... it seems that there is no warmth in her and her class either...everything is so business like...

Most interestingly, when asked if they would be willing to adapt some of the Hong Kong teacher's teaching practice, one of our baseline teachers said,

Her classroom is quite different from ours. The US has a lot more diversity than her country. The big thing American schools have to deal with is off-task behaviors. Chinese students listen to their teachers. We have very different cultures. It is hard to teach like she did in the US.

We saw little willingness in baseline teachers to adapt or learn from other teachers' practice. In contrast, our interviews of a US VLS teacher showed a great deal of respect and interest in learning from the Asian teacher. For example, Sally said,

I really like her straightforward teaching style....She commanded her students attention, she was organized, she knew her lesson and content very well, that is not a surprise to me because of our interaction. She has a very good command of the content knowledge, from which I can learn from. She has very high expectations towards her students and I would like to learn that. I know a lot more about her from my communication with her. She is highly professional...

The two teachers who had shared experiences tended to look at the videos of one another and consider ways to adapt them to their own classroom; they did not look at culture as an excuse for

why they could not do it in their own rooms.

Overall, the pilot study created a strong bond between the teachers and motivated them to continue to want to learn from one another. The study needs to be replicated, of course. But it appears to provide a good example of the kind of technology-enhanced Networked Learning Communities that Carroll had in mind.

APPENDIX I

Needs for Alignment

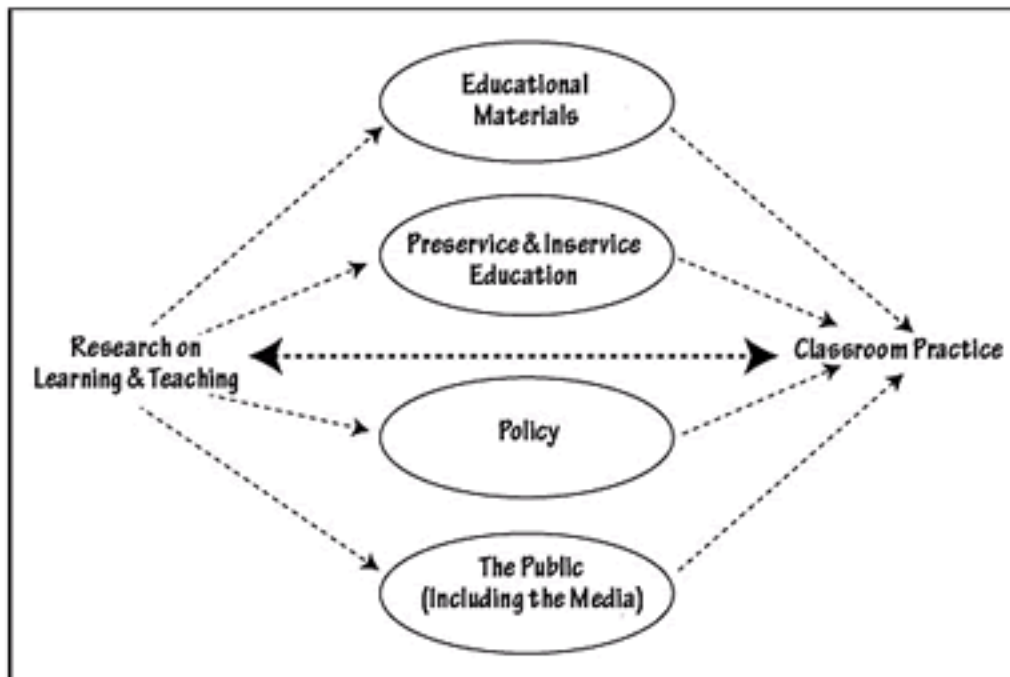


Figure 4. Key components impacting our educational system

Donovan et al., (1999) used the diagram in Figure 4 to illustrate the lack of alignment among key components that impact our educational system.

The authors of the report interpret Figure 4 as follows:

To a limited extent, research directly influences classroom practice when teachers and researchers collaborate in design experiments, or when interested teachers incorporate ideas from research into their classroom practice. This appears as the only line directly linking research and practice in Figure [2.0]. More typically, ideas from research are filtered through the development of education materials, through pre-service and in-service teacher and administrator education programs, through public policies at the national, state, and school district level, and through the public's beliefs about learning and teaching, often gleaned from the popular media and from their own experiences in school. These are the four arenas that mediate the link between research and practice in Figure 2.0. The public includes teachers, whose beliefs may be influenced by popular presentations of research, and parents, whose beliefs about learning and teaching affect classroom practice as well.

But change at the classroom level can be supported or thwarted by public policy. For the principles in *How People Learn* to affect practice, district-level school boards and administrators must be persuaded of the value of that change, and must lend it legitimacy and support. Policy makers at the national and state levels will also need to understand those principles and to set policies that are consistent with them. Otherwise, teacher efforts can be undermined by standards, assessments, and teaching and textbook requirements. Moreover, the level of funding allocated to activities required for change can facilitate or debilitate the effort. (pp.6-7)

Donovan et al. noted that the diagram in Figure 4 was purposely drawn to depict a lack of alignment among elements

: ... broken rather than solid lines are used to connect research on learning to the four mediating arenas; they illustrate weak lines of influence. Because they are weak, there is often a lack of alignment among them. Consequently, teachers frequently struggle to adapt to competing demands. Strategies for change are often short-lived and responsive to fads rather than to sound research and theory. (p. 8)

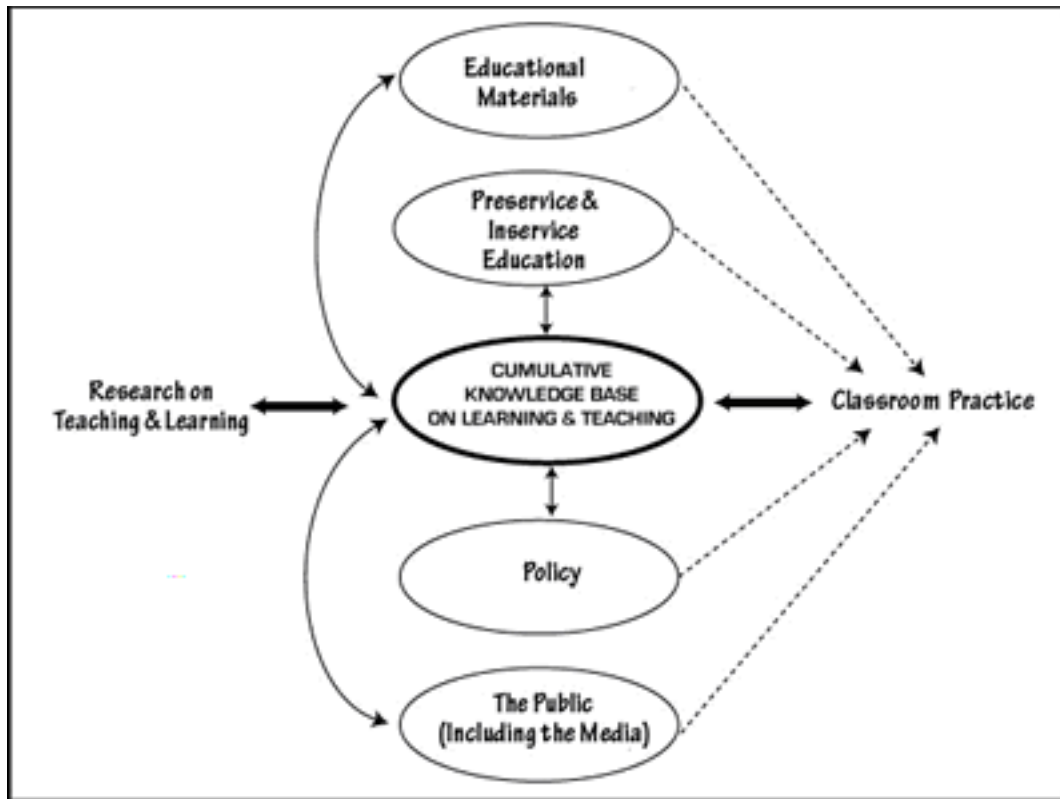


Figure 5. An alternative diagram

An alternative to the lack of alignment shown in Figure 4 is the diagram illustrated in Figure 5 (from Donovan et. al., 1999). The authors note the following about the diagram: An effective bridge between research and practice will require a consolidated knowledge base on learning and teaching that builds, or is cumulative, over time. Elaborating on the committee’s conceptualization in Figure 4, this knowledge base appears at the center of Figure 5. Fed by research, it organizes, synthesizes, interprets, and communicates research findings in a manner that allows easy access and effective learning for those in each of the mediating arenas. Attending to the communication and information links between the knowledge base and each of the components of the model simultaneously enhances the prospect for the alignment of research ideas and practice. (p. 33)

APPENDIX J

New Publication Media

One set of interviews we find extremely valuable was gathered from researchers who participated in a series on Issues of Cultural Diversity and Equity in Education that was held at Vanderbilt University last semester. Paul Cobb and Lynn Hodge were PI’s on an National Science Foundation grant that funded this series. The series lasted the entire semester. Each week, a different scholar visited Vanderbilt and presented a talk. After the talk, we were able to capture the speakers for a short radio interview in our studio. The interviews are available on the Web at (<http://extend.ltc.vanderbilt.edu/lsndiversity/>). We find them to be a treasure house of ideas, wisdom, and inspiration.

Having these interviews provides a number of advantages. One is that, like many of our

colleagues, we had to miss a number of the talks due to conflicting engagements. The talks were videotaped, but each video is about an hour and the tapes are not that good due to issues of lighting, etc. The radio interviews do an excellent job of capturing the essence of the talks. And they can be played on tape, CD, MP3, and so forth.

As noted earlier, our interviews also bring in more information about the personal background of the participants than is typically found in formal presentations. This information provides a context for interpreting their written articles. Students who have had the opportunity to hear some of the interviews have stated that they love to meet the voiceless and faceless people who author the articles they read.

The diversity project is just one of a number of "Knowledge Capture" projects that we are undertaking. Many of the interviews that accompany this article were captured as part of our knowledge capture work.

APPENDIX K

Web-Based Modular Design

Components for Modular Design

- Overall Course



- Mosaics (units)



- Modules



- Resources (text, video, audio, simulations, etc.)

Figure 6. Components for modular design

Figure 6 shows the current design for our Web-based modules. At the base of the system are resources such as audio and video clips, simulations, assessment shells, and so forth. These can then be put into modules that are challenge based. Modules can in turn be organized into larger units, called Mosaics. And Mosaics can be organized into a course.

Time does not permit a full explanation of our work on modular design. But we will soon (i.e., by the end of the summer) have a modular "How People Learn" challenge that can be visited on the Web. For present purposes we provide two examples of simple challenge-based modules. They may not make a great deal of sense without more information about the overall Mosaic and course organization. But we hope they will make some sense. Examples of Challenges, and resources relevant to the challenges, are provided in Figures 7, 8, and 9.

A Challenge-Based Module for the
"Knowledge and Problem Solving" Challenge
(Click Here)



Figure 7. A challenged-based module for the "Knowledge and Problem Solving" Challenge



Figure 8. A challenged-based module for the "Anyone, Anyone" Challenge



Figure 9. A challenged-based module for the "American History" Challenge

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Notes

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