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Preparing Faculty for Instructional Technology: From Education to Development to Creative Independence

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Abstract

Instructional technology can be imposed on existing courses, materials and approaches. Or faculty can learn to make appropriate choices in order to create new learning environments that apply research insights into memory functions, learning strategies, learner styles, personal interest, and motivation. This paper examines a training and support infrastructure that engages emerging instructional technology users in a recursive process of research, design, development, and assessment aimed at producing student-centered learning environments. Key to the success of this approach to faculty training has been providing teachers with skills and expert tools that lead to independence; facilitating access to equipment and support personnel; and establishing new evaluation and rewards procedures that recognize the value of instructional technology in the teaching process.

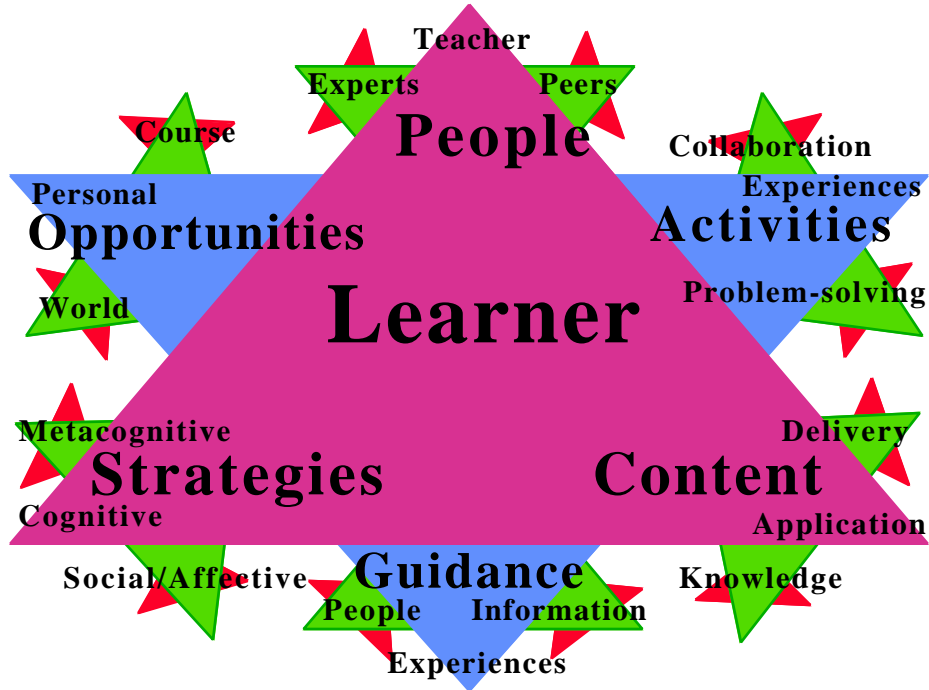
Research

As this millennium nears its end, higher education is faced with enormous challenges brought about by increased demands from corporations for employees who are skilled at working in teams, have *learned how to learn*, can effectively solve problems, are able to process and apply information, and who have a high level of expertise with a variety of technologies. The teacher as primary source of knowledge no longer suffices in a world where knowledge doubles every 7 years and 10,000 scientific articles are published every day. (Forman, 1995). An education process that pushes students to the center changes the teacher's role to one of facilitator, guide, and coach. It places emphasis on students as active participants in the process of finding, organizing, analyzing, and applying information in novel ways to solve problems. Students become part of a learning community where they collaborate to discover information from a variety of sources, including peers, teachers, experts, real world data, simulations and experiences. Ultimately, they apply that information in novel ways to solve problems, communicate ideas, and continuously add to their knowledge base.

In response to this external pressure, educators have recently jumped on a cooperative or active learning bandwagon. Based on research, this popular approach offers cooperative activities such as 'think-pair-share' and 'jig-saw' techniques as a means of placing students in the center of the learning process; however, this methodology ignores the needs of receptive, analytic, linear learners who may be disadvantaged by an active approach. This paper suggests that a single approach will not suffice and that teachers must be well versed in current research from cognition and learning theory in order to understand how learning occurs and to create their own, eclectic techniques. It falls upon the teacher to constantly recreate the instructional process and offer a variety of choices for approaching information and tasks in order to meet learners' ever-changing, individual needs. A firm theoretical foundation offers teachers a starting point from which they can build a series of learning opportunities, responding to all styles and encouraging a wide range of strategies in order to encourage successful learning. Innovative classroom approaches plus access to appropriate technologies will lead to the creation of new learning environments that are flexible and provide a custom education for each student, regardless of class size, time and distance constraints, previous preparation, and personal factors. Selection of 'appropriate technologies' is defined by desired learning outcomes and students' needs to tackle tasks according to their individual styles and strategies, not an imposition of technology because it offers a fun or flashy approach to learning.

While modifications to the face to face environment create additional opportunities for interaction at a single place in a single time-frame, the addition of technology-supports places the learner at the center of a process that removes the confines of the traditional classroom through access to information, interactions with peers and experts, and opportunities for simulated and real experiences. **Figure 1** employs a fractile model informed by Chaos Theory to demonstrate that within a learner-centered process, students can create infinite combinations of people, opportunities, information within the confines of finite resources.

Figure 1



Rather than depending on a single set of materials and activities within a content area, all learning becomes interdisciplinary as students expand on prior knowledge, pursue interests, combine information in new ways to solve problems and reach new understanding of old knowledge. Learning becomes a dynamic, customized pursuit of new solutions rather than the acquisition of a preconceived package of facts. It becomes possible for learners to discover what even experts do not know. Thus learners become teachers even as experts remain perpetual learners within the new recursive cycle of exploration and discovery.

Technology adds the tools that facilitate access to the people, content, strategies, activities, guidance, and opportunities to apply new information that make learning a personal process. Technology adds the ability for students to choose how, when, and where they participate in the learning experience and to bring together a vast wealth of learning resources, including people, places, and things to which they might otherwise never have access.

Learning Styles and Strategies

Table 1 summarizes possible learning styles that students bring to the common learning experience. However, not all learners are equally proficient with all styles. Guidance, opportunity, and practice can help them acquire new ones and expand their potential for success in a variety of situations. Since multiple styles are dominant in learners to varying degrees, "teaching to styles" is a daunting task in a traditional, teacher-centered face-to-face classroom. Teachers, as the sole information source available to students, would be forced to bring in materials and approaches that simultaneously present information from the global perspective as well as the detailed perspective, offer concrete experiences as well as discovery options, and present facts in a non-linear as well as linear fashion. Preparation for a single class would require teachers to create multiple lesson plans and to accumulate a library of material on each topic. Clearly, this is impossible for one person to accomplish for even one class let alone for an entire course or curriculum.

Table 1
Contrasts of Learning Styles

∑ Field Dependent: global, external motivation & rewards	∑ Field Independent: details, internal motivation and rewards
∑ Analytic Reasoning	∑ Innovative Reasoning
∑ Dynamic: discovery, intuition	∑ Common Sense: concrete, experiential
∑ Visual/auditory: reception	∑ Tactile/kinesthetic: hands on participation
∑ "Right-brained": non-linear processing	∑ "Left-brained": linear processing
∑ Serialist: sequential	∑ Holist: hierarchical
∑ Abstract Perceiver: analysis	∑ Concrete Perceiver: experiences
∑ Reflective Processors: reflection	∑ Active Processors: application

Traditional, lecture-based approaches to education emphasize receptive, reflective, abstract, analytic, and linear learning styles. A collaborative, learner-centered approach offers opportunities for all learning styles to succeed, provided adequate information delivery, analysis, and application opportunities are made available to students. Adding technology-supported learning options improves and greatly expands the ability to accommodate style variations. **Table 2** suggests a few technology-supports that accommodate different styles, offering students the opportunity to benefit from dominant ones while learning to use new ones.

Table 2
Sample Technology-Supports for Learning Styles

Style	Technology-Support
∑ Field Dependent/Independent	∑ Presentation software ∑ tutorials ∑ web searches
∑ Analytic/Innovative Reasoning	∑ simulations ∑ tutorials
∑ Dynamic/Common Sense Reasoning	∑ collaborative discussions ∑ simulations ∑ models
∑ Visual-auditory/ Tactile/kinesthetic	∑ multimedia supports
∑ "Right-brained"/"Left-brained"	∑ tutorials ∑ organization software (outline, flow charts, spreadsheets, etc.) ∑ decision software ∑ collaborative discussions
∑ Serialist/Holist	∑ tutorials ∑ organization software (outline, flow chart, spreadsheets, etc.) ∑ decision software ∑ collaborative discussions
∑ Abstract/Concrete Perceivers	∑ presentation software ∑ simulations ∑ models ∑ experiences, role playing
∑ Reflective/ Active Processors	∑ presentation software ∑ simulations ∑ models ∑ experiences, role playing

Research has shown that, in addition to the individual styles, successful learning, task completion, and problem solving depend on the implementation of a variety of strategies. O'Malley and Chamot (1990) suggest three different types of strategies through which learners tackle knowledge acquisition opportunities: metacognitive (thinking about and planning for learning), cognitive (active participation in the learning process) and social/affective strategies (interaction with others and control of affective factors). While this research emphasizes foreign language learning, the strategies are global ones that apply to all learning environments. Awareness of the need to enable a variety of strategies creates a new dimension of complexity for teachers in traditional classrooms, especially when faced with providing opportunities for students to plan for learning.

Passively hoping that learners will be able to activate appropriate strategies without guidance is insufficient to ensure successful learning and development of the ability to trigger the strategies as part of lifelong learning skills. Instead, strategy development and application can be actively included in learning opportunities. Appropriate technologies can enable teachers to create choices that allow students to apply a variety of strategies that help organize and advance the learning event. **Table 3** describes selected strategies and techniques students can use for employing them in face-to-face as well as on-line learning environments.

Table 3
Sample Learning Strategies

Metacognitive Strategies		
Strategy	Traditional/In-class techniques	On-line techniques
Self-monitoring: check own understanding	<ul style="list-style-type: none"> Σ Ask teacher questions; Σ Check work against a model Σ Keep learning log 	<ul style="list-style-type: none"> Σ consult peers, experts through conferencing, e-mail, etc.; Σ participate in learning dialogues; Σ compare work to simulated & real world models; Σ interact with tutorials
Directed attention: decide in advance to focus on particular tasks and ignore distractions	<ul style="list-style-type: none"> Σ choose to complete assignment before engaging in diversions; Σ establish a plan to complete exercise, experiment, etc. 	<ul style="list-style-type: none"> Σ follow steps in a software lesson; Σ outline search process for web; Σ avoid surfing; Σ outline search process for on-line encyclopedia, electronic library
Self-management: decide in advance to focus on specific information	<ul style="list-style-type: none"> Σ work with teacher to choose activities, approaches Σ work in small groups or with partners 	<ul style="list-style-type: none"> Σ explore web and make selections Σ consult peers and experts; Σ engage in new simulation, modeling, problems-solving, role-playing activities
Metacognitive planning: develop personal objectives and select appropriate strategies	<ul style="list-style-type: none"> Σ list personal goals Σ match goals and activities; Σ keep checklists to determine effectiveness of strategies; Σ use teacher feedback to assess effectiveness of strategies 	<ul style="list-style-type: none"> Σ share personal goals with peers and experts; Σ seek advice on selecting appropriate strategies; Σ search web for guidelines

Cognitive Strategies		
Strategy	Traditional/In-class techniques	On-line techniques
Deductive: Applying rules	<ul style="list-style-type: none"> Σ solve problems Σ complete experiments 	<ul style="list-style-type: none"> Σ consult peers, experts through conferencing, e-mail, etc.; Σ participate in learning dialogues; Σ compare work to simulated & real world models; Σ interact with tutorials

Resourcing: Use reference materials	<ul style="list-style-type: none"> Σ refer to textbooks and handouts; Σ teacher-supplied data; Σ materials in library; 	<ul style="list-style-type: none"> Σ electronic libraries; Σ listservs; Σ on-line tutorials; Σ databases on web; Σ peers and experts; Σ authentic materials on web
Note-taking: write down key words and ideas	<ul style="list-style-type: none"> Σ write in notebook Σ create tables Σ draw diagrams 	<ul style="list-style-type: none"> Σ collect examples Σ bookmark sites Σ create webpage summaries of findings Σ information organization software (outline, flowchart, spreadsheet, etc.)

Social/Affective Strategies

Strategy	Traditional/In-class techniques	On-line techniques
Collaboration/Cooperation: Work with classmates to solve problems, help build confidence	<ul style="list-style-type: none"> Σ pair activities Σ small group activities Σ team experiments, experiences; Σ build learning communities with peers 	<ul style="list-style-type: none"> Σ collaborate with peers, experts through conferencing, e-mail, etc.; Σ engage in role-playing, simulations; Σ share work with peers and experts in real-time chat sessions; Σ build extensive learning communities with peers and experts to gather interdisciplinary perspectives

Choices

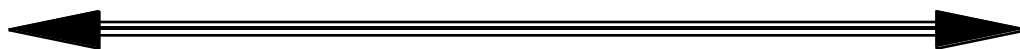
Technology adds choices as to how, when, and where students access learning opportunities. Thus, technology can reduce barriers imposed by affective factors (I'm tired, I'm hungry, I'm distracted by personal problems) on a single time, place, and mode of learning. Learners gain access to people, information, and experiences as they choose to come to class and enjoy a traditional social experience or select on-line learning options. Learning becomes a personal experience combining personal interactions with media supports and on-line learning and communication activities. Illness and personal crises no longer remove learners from the education experience. Instead, they remain connected to peers, experts, information, and experiences through threaded conference discussions, video records, and real world data simulations in an anywhere, any time frame of access.

Administrators and faculty often fear that addition of technology-supports can spell the end to on-campus, residential learning experiences. However, **Table 4** suggests that availability of traditional plus virtual learning options will create new environments in which students make choices to customize the learning experience to suit their personal and changing needs. Thus, this technology-supported, choice-based model of education can increase access to education and experts. It can blur distinctions between courses, rendering separate remedial or advanced courses unnecessary. Through choices offered as extensions to traditional, face-to-face classes, high school students can join college students as well as lifelong learners in corporations in an on-going process that offers access to learning modules, courses, and entire programs.

Within the face to face classroom, choices enhance collaboration, decision-making, and problem-solving activities by removing the need for turn-taking and giving everyone equal chances to perform. Teachers as guides, facilitators, and coaches interact more fully with students as the technology takes on repetitive tasks. Teachers participate in collaboration sessions, guide experiences, provide feedback, and mentor individuals while technology-supports present key concepts and basic information, link students for recorded discussions, bring experts to the students, and offer opportunities to explore databases and real world information archives. In the 'smart' classroom, presentation software, networked computers, simulations, models, decision-making

programs actively engage the students in a variety of activities or simply allow them to passively explore a 'canned' presentation at their own pace.

Table 4
Choices in an Introductory Course
Traditions + technology = customization of educational experiences



Class Structure	Traditional Choices	Virtual Choices
syllabus	hard copy	web-based
three 50-minute lectures per week, guest lectures	face-to-face	video delivery; web-based copy; audio version; computer conferencing
discussions	in-class; small group; guidance from professor/gat	computer conferencing; virtual environments
small group activities	in-class; outside of class	e-mail/computer conferencing; 2-way video; audio conferences; virtual environments
films, music, interviews	group screening in class; individual screening out of class	individual screenings; on-line delivery of clips; cable
labs/experiments/simulations	guidance from GATs; individual practice; team projects; workbook answer sheets	e-mail/computer conferencing; 2-way video; audio conferences; virtual environments
office hours	face-to-face	on-line consultations (chat); virtual environments; e-mail
presentations	individual; group to class	computer conferencing; student home page; multimedia presentation - individual/group; student generated simulations, models; role playing in virtual environments for problem solving
papers/reports/daily assignments	hard copy to instructor; peer revision of hard copy	computer conferencing; student home page; multimedia presentation - individual/group virtual environments; on-line consultations (chat)
interviews/surveys/experiences	out-of-class; individual; teams	computer conferencing; 2-way video; e-mail; audio conferences; virtual environments
library searches	on site; individual; card catalogue, SABIO; guidance from librarians	on-line direct access; customized searches of databases
reading assignments	home, library; text-based	virtual libraries; web sites; hypertexts
exams	in class/take-home; single time; hard copy; oral responses; individual	performance; creation of simulation/models; on-going evaluation; collaborative efforts
feedback options	face-to-face; written responses	e-mail; chat; collaboration in virtual environments

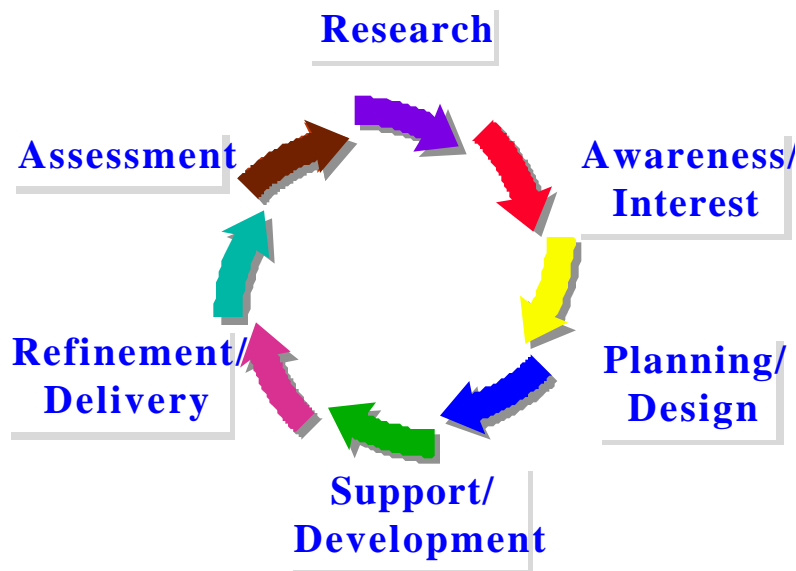
Of course, addition of technology choices does not tend to save teachers any time. In most cases, development of a technology rich learning environment involves far more time that does

preparation of a traditional lecture. Emphasis shifts to design and development and away from lecturing, correction, and feedback as peers and the students themselves become more involved in exploration, discovery, and performance-based modes of evaluation and assessment. Students may also find that the technology-rich classes requires more time as they become involved in information searches, on-line discussions and interactions, simulations, and experiential learning opportunities.

On-line classes can be fun, personal, customized experiences that help students successfully process information and expand their knowledge bases. This claim is now supported by anecdotal evidence rather than extensive research. The University of Arizona proposes to fill the current instructional research void by engaging in systematic evaluation and assessment of how new learning environments impact a variety of learning outcomes.

From Research to Development to Independence

Instructional technology can be imposed on existing courses, materials and approaches. Or faculty can learn to make appropriate choices in order to create new learning environments that apply research insights into memory functions, learning strategies, learner styles, personal interest and motivation. The University of Arizona has created a model faculty education program and support infrastructure that engages faculty in a recursive process of research, design, development, and assessment that leads to research-based, technology-supported student-centered learning environments. **Figure 2** provides an illustration of the cycle of progress from application of current research through the creation of new knowledge that contributes to the growing body of research, thereby helping faculty design these new learning environments. Thus, the process moves to a higher level as assessment projects yield new knowledge.



Key to the success of this approach to faculty education has been providing teachers with skills and expert tools that ultimately lead to their independence as learner-centered curriculum designers. The faculty education paradigm progresses from awareness of our current understanding of learning and assessment, curriculum design, and instructional techniques to providing access to equipment and support personnel as part of a curriculum design and development process. Finally, it provides information on learning outcomes that advance campus-wide efforts to establish new evaluation and rewards procedures recognizing the value of instructional technology in the teaching process. The education cycle in **Figure 2** is manifested in the physical design of the University of Arizona's new Faculty Development Center. There, faculty are immersed in education and support opportunities

for the purpose of completing a curriculum innovation process that applies learning theories and innovative instructional techniques in a technology enhanced environment.

The University of Arizona's faculty education process begins in current research. Its purpose is to apply this existing body of knowledge to the creation of new teaching/learning approaches in order to increase our understanding of how learners reach desired outcomes. This means that the process will never end: as we gain more knowledge of how students learn and how we can support and encourage that process, faculty will repeatedly return to acquire new knowledge and new skills.

Through symposia, workshops, focus groups, and individual counseling efforts, faculty become aware of our current state of understanding of learning, assessment, and teaching processes. Collaborative learning and other hands-on activities encourage faculty to begin to modify segments of their lessons, classes, and curricula as part of these training sessions. Introductions to technology-supports and their applications to the learning process motivate some to seek means of expanding their instructional opportunities so as to remove traditional barriers to learning.

Awareness/Interest raising occurs across campus as well as within the Faculty Development Center itself. Each awareness session inspires faculty to express a desire to incorporate technology-supports into existing or new courses. In order to initiate the curriculum innovation process, these interested faculty are invited to enter a Planning/Design process within the Center. There, support personnel teams of faculty and support specialists in learning and assessment theory, instructional techniques and procedures, and curriculum design, visualization, knowledge management, programming, and video distribution meet with the faculty to show them existing models and to help them combine content with learning objects and desired performance outcomes. Together these experts create a course that is based in learning theory and incorporates innovative methods and appropriate technologies. Each project design phase also includes a research design component which outlines procedures for collecting baseline data as well as experimental data in order to determine the impact of the new learning environment on factors such as student learning outcomes, time-on-task, student retention in the course, and student satisfaction.

Once the design phase is complete, faculty are assigned a mentor who assesses their support needs, assigning personnel and high end development technology to their project. The mentor also reviews existing projects to determine how new and existing teams can collaborate in order to avoid duplication of effort and maximize resources. Once the development team is formed, the group works with the faculty to create a workplan designed to complete the project in a timely manner in order to avoid content obsolescence. (The creation of these technology-supported modules allows for continual updating and renewal of content materials, thereby providing more flexibility than traditional information delivery modes.) Throughout the development process, experts in learning theory, methodology, curriculum design, and assessment/evaluation work with the team to help ensure that the emerging courseware will produce the desired learning outcomes.

As the project nears completion it moves to a Refinement/Delivery area within the Faculty Development Center. There faculty work with visual communication experts to refine the visual impact the product will have. High end graphics workstations allow faculty to develop animations and even virtual reality modules for incorporation into their courseware. In addition, the faculty and their students use a 'Collaboratory', a cluster of five networked workstations, to test the courseware before offering it to a larger student population. Faculty also use the Center's Presentation Theater to share their project with more general audiences of peers, students, and support personnel in order to receive constructive critiques. Their support team helps them incorporate all pertinent suggestions in order to ensure that the final courseware product is as polished as possible.

Once the new learning environment is available to the students, an assessment team launches a formal research project to assess its impact. We anticipate that results of these investigations will yield new understanding as to how the new learning environments can enable learning, thus adding to the general understanding of how learning occurs.

Challenges

Although the project process is well defined, a number of challenges exist that impede its smooth implementation: time, access to technology, and tangible rewards.

Increasing demands on faculty time make it difficult for professors to commit the effort necessary to participate in the development of new learning environments. Reluctance on the part of regents and legislators to recognize the intensive time commitment required to research, design, and implement a course change has led to reduced access to release time for curriculum innovation. Understandably, these groups protest the need to remove faculty from the classroom in order to create a new course. This has led to a heavy dependence on graduate students and computer experts for the programming phases of curriculum innovation project design. The role of faculty as director rather than participant in the design and development process can have at least two negative consequences: 1) a gap occurs between the vision and the final product; and 2) new courses become so dependent upon graduate students and computer experts that when the support personnel is no longer available, the project dies. For this reason, as a first stage in the instructional innovation process, the support personnel for the Faculty Development Center have sought projects that can become replicable tools. The first projects facilitate theory-based course design and provide easy means for faculty to integrate unique content into a template that promotes collaboration, problem-solving, and other learning activities. For more information on our first projects, please visit our web-site at <http://u.arizona.edu/ic/facdev/fdc.html>.

Limited access to technology, both to workstations and the Internet, is a barrier that impedes the implementation of a wide variety of technology supported choices for courses. While we have taken a centralized support approach as well as offering grants to help faculty purchase labs and individual development equipment, the gap between the "haves" and the "have-nots" is still great and threatens to impede our progress.

Finally, the lack of a widely accepted promotion and tenure/continuing review system that recognizes and rewards both teaching excellence and teaching innovation has prevented junior faculty, those who tend to possess the highest level of technology skill, from becoming part of the transformation effort. We must provide valid and reliable researched-based evidence as to the impact of new learning environments on student outcomes before department heads and deans will be willing to encourage their faculty to participate in on-going innovation efforts.. Ultimately, such evidence must inform substantive changes to existing policies in order to acknowledge and reward teaching innovation.

Moreover, the catalyst for instructional innovation extends beyond the confines of academia. Development and design of new courses no longer rests in the hands of academic institutions alone. Response to corporate pressure for new learners requires that higher education partner with corporations, not only to create new learning experiences but to create new tools that help transform the way we conduct research and organize the learning experience. The University of Arizona/Lucent Technologies Alliance for Learning is one example of a unique collaboration for educational transformation. Content experts from the U of A together with communication and programming specialists from the Bell Laboratories have teamed to design on-line integrated learning environments based on Lucent's Persyst software. The Alliance plans to research actively the effects of Persyst as an instructional management environment and to build new spatial modeling/virtual reality tools, while allowing Persyst to evolve into an environment that successfully mimics face-to-face learning opportunities. You can follow the progress of these projects by visiting the Alliance website at <http://u.arizona.edu/ic/facdev/lucent.html>.

As faculty across colleges and even across universities begin to collaborate to develop theory-based learning environments, the body of research will grow, validating the need to transform the way we deliver higher education. Together we can employ the U of A's model of a recursive research/development process to evolve beyond the lecture paradigm, meet individual needs, and create a dynamic new education system for the coming century.

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