The Stanford University Learning Laboratory: A Prospectus

Larry Leifer
Stanford University, USA

Why a Learning Laboratory at Stanford

The Stanford University Learning Laboratory was established in May 1997 by our President, Gerhard Casper. His decision was based on a three year study and recommendation by his Commission on Technology in Teaching and Learning. Their deliberations engaged hundreds of faculty, staff, students and outsiders. It is the centerpiece of Stanford's response to the revolutionary changes now facing education. Its aim is to achieve a substantial impact on the quality of education at Stanford and elsewhere through the use of innovative pedagogy and technology.

The Laboratory was established in order to develop powerful new theoretical and experimental methods for the improvement of learning in all areas of education, inside and outside the university. Though based at Stanford, and firmly committed to the bettering of education at this university, the Lab will extend its efforts and interests without regard to geographical or cultural distance, entering into creative partnerships with educational, industrial, corporate, and research groups throughout the world.

The Lab will sponsor research in learning itself, and in the technologies and curricular structures that best support that learning. It will work closely with faculty and students to deploy the methodologies it develops in the classroom and in many other learning arenas, such as corporate training programs, long-distance education and in residential settings. These deployment efforts reflect the Lab's belief that learning does not exist in isolation, but that students, faculty, alumni, outsiders and institutions all interact in a finely balanced ecological system.

The Lab will focus on the judicious application of pedagogically informed learning technology in order to 1) create carefully balanced and challenging learning experiences for faculty, students, and staff that enhance both scholastic performance and future career performance; 2) develop and deploy learning strategies that significantly improve cost-performance ratios, re-use and adoption rates: 3) rigorously apply nuanced assessment techniques to evaluate the efficacy of these pedagogic and technological strategies; and 4) develop methods to increase their efficiency and usefulness.

The Lab will strive to ensure that students gain the cognitive, social and manual skills required for life-long continuous, learning --- at school, on the job, in the family, and within the community at large. By improving learning performance, students will acquire knowledge more deeply and swiftly, enabling some, for example, to complete joint BS/MS or BA/MA degree programs in 4 years or include a full year of overseas study.

The Lab will work closely with the varied communities at Stanford to assess and formally review the pedagogy and learning technology of all Stanford Schools once each decade, and will partner with others to provide learning technology deployment leadership in the K14 community. Finally, the Lab will act as a center for information and for the dissemination of new methods, enabling students, alumni, corporate partners and researchers to form an extended and mutually beneficial family of learning and learners.

An Example of Global Collaborative Learning

Learning Lab leaders have been influenced by recent "success" in the field of product design-development team management research. Design Research protocols that call for detailed examination of what "designers really do when they do design" have lead to important insights that dramatically changed the way technology is being allocated in graduate design education at Stanford. These lessons and demonstrable proof that they make a difference are the result of integrated teaching and research, the classroom as laboratory, the curriculum as content. The center piece of these studies over the past 8 years (Leifer, 1997) is a Product-Based-Learning course at the graduate level, ME210.

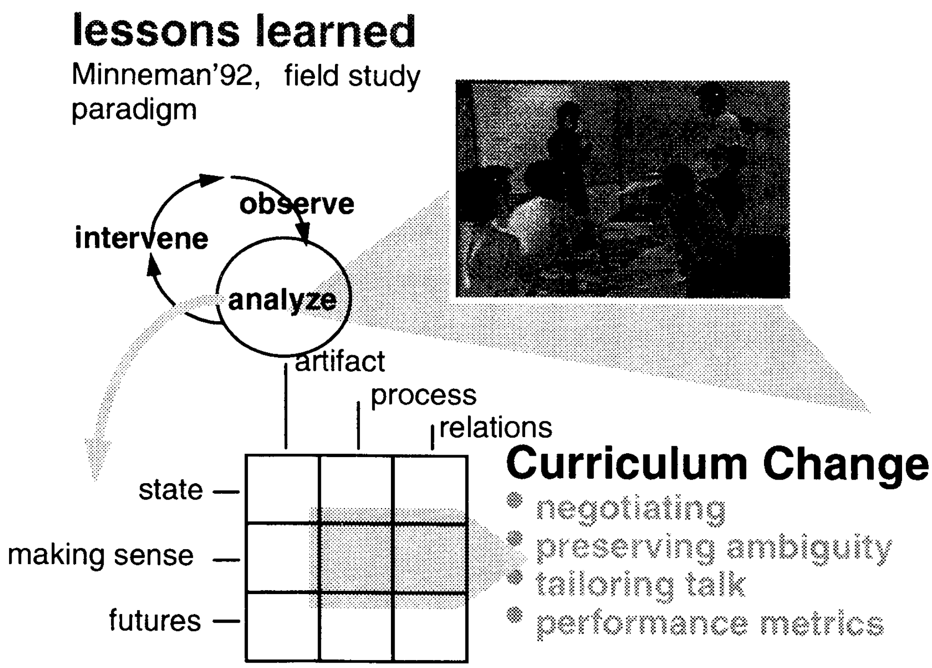

Figure-1: The key innovation leading to ME210's systematic improvement has been the integration of research, teaching and learning. Research methodology from the world of "Design Studies," teaching a 9 month-long design-development course at the master's level as though it were taking place under a microscope; and focusing on student performance as measured internally with grades and externally with anonymous peer-review. The circle of improvement begins on the upper right side with the direct observation of design-team activity using video interaction analysis (Tang et al, 1996). Through an iterative process of observation, analysis and intervention, we converge on the factors that seem most relevant to the performance of these designers. The resulting activity characterization framework (the matrix in this figure) guides further data review (after Minneman, 1991). Curriculum change follows on these observations. The impact of change is measured in the next external peer reviewed design competition.

It is hypothesized that Product-Based-Learning (PBL) methodology and technology have evolved in a manner that will make widespread PBL adoption and assessment financially feasible for undergraduate, graduate and continuing education. PBL is defined as problem oriented, project organized learning activity that produces a product for an outsider. Unlike other versions of "PBL" that focus only on the project or problem, the product focuses our attention on delivering something of value beyond a "training exercise", something suitable for evaluation by outsiders. The objectives of PBL curricula may be stated briefly as follows (after Bridges & Hallinger, 1995):

- Familiarize students with problems inherent in their future work;
- Assure content and process knowledge relevant to these problems;
- Assure competence in applying this knowledge;
- Develop problem formulation and problem solving skills;
- Develop implementation (how to) skills;
- Develop skills to lead and facilitate collaborative problem solving;
- Develop skills to manage emotional aspects of leadership;
- Develop and demonstrate proficiency in self-directed learning skills.

The Stanford University School of Engineering course, "ME210: Global Team-Based Design-Development with Corporate Partners," has served as a model for exploring this approach. The seeds of our PBL understanding have emerged from this design-development laboratory where twenty years of cumulative evidence is making soft factors like "team personality" ring true statistically (Wilde, 1995) as well as intuitively. Objective metrics (Leifer, 1997; Baya et al, 1996; and Mabogunje et al, 1997) are being derived from detailed examination of the formal written records produced by design teams in the natural course of doing their job. Highlights from ME210's 1996-1997 academic season include the following:

- Students won 6 of 7 medal awards and 2 of 5 merit awards in the national Lincoln Arc Welding Foundation's 51st Graduate Design Competition'97 (double blind faculty peer review protocol).

- Instructors won the ASME 1997 Curriculum Innovation Award, to be presented at the ASME 1997 International Mechanical Engineering Congress and Exhibition, Nov.18.1997, Dallas, TX.

Our curriculum technology focus is Mechatronic systems design-development (smart products). Mechatronics is frequently defined as the integration of real-time software, electronics, and mechanical elements for imbedded systems. In our definition, we include human-computer-interaction and materials selection. Typical products in this domain include: disk drives, camcorders, flexible automation-systems, process-controllers, avionics, engine controls, appliances and smart weapons. Mechatronics is a particularly good medium for introducing PBL because the need for interdisciplinary collaboration is almost self-evident.

Implementation of this curriculum builds, in part, on recently developed Internet tools and services for distributed product-development teams (virtual design teams)(Hong et al 1995). Such teams are increasingly common in the mechatronics field. Using the World-Wide-Web (WWW) as an informal, work-in-progress document archive and retrieval environment, we electronically instrument design-team activity and knowledge sharing for project management and learning assessment purposes. Examples include:

- **Share**: MadeFast, (http://www.madefast.org/), 6 universities, 6 corporations, formed a virtual company, delivered a product in 6 months and documented it all on the WWW (Toye et al. 1994);

- **ME210**: a graduate curriculum in cross-functional-team mechatronic systems design at Stanford (http://me210.stanford.edu), 12 to 15 companies, 45 students, 15 off-campus, build and document Mechatronic products each year;

- **NSF Synthesis Mechatronics**: a multi-university (8) co-curriculum development project focused on undergraduate mechatronics (NSF Synthesis Coalition web (http://www.synthesis.org).

Lessons Learned about the Role of Technology in Hi-Tech Education

There are many popular hypotheses regarding the promise of Hi-Technology in Education. Surprisingly few have been demonstrably effective at changing the quality of the learning experience. Without claiming definitive results, the following examples demonstrate important elements learned from a 20 year curriculum experiment whose most recent 8-year phase shows the power of an integrated research-teaching-learning performance evaluation paradigm.

creating knowledge in the world, people, teams & their "stuff"

Figure-2: We have observed that one of the key technologies in collaborative team learning is the physical space within which they work (Tang, 1989; Brereton et al, 1996), including the capture, preservation and re-use of their collective project knowledge. Physical collaboration space, "lofts" in the architectural tradition, are technology. In the future they may be physical and/or virtual. In either case, their primary function is to host and support a community of practitioners, designers, learners and leaders.

sharing knowledge through communication technology

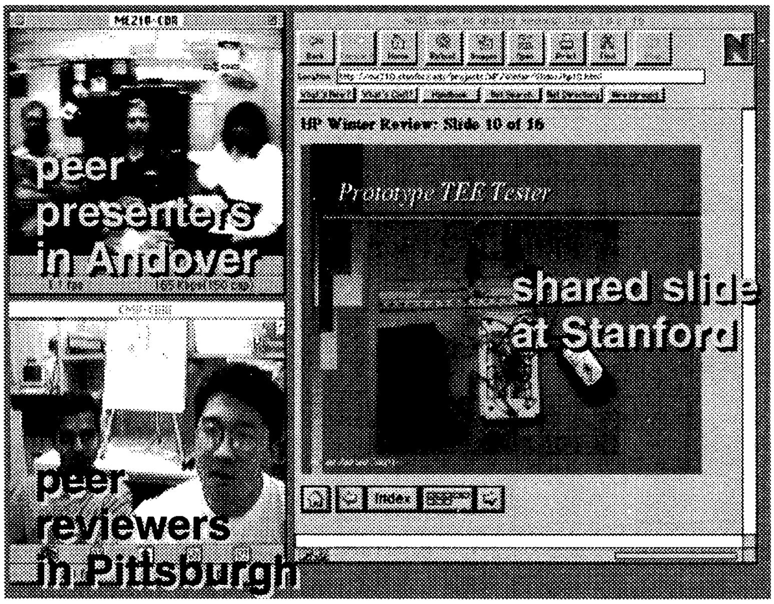

Figure-3: Virtual collaboration space has two distinct flavors. One is shared access to common physical space (as referenced in Figure-2) using wed based robot-cameras (Leifer et al, 1996), the other is shared virtual communication space as seen in this figure. A design-briefing is taking place in the lower right quadrant as viewed by students and faculty at Stanford. The briefing team, in the upper left quadrant, is in Andover, Massachusetts (a team of on-the-job engineers engaged in continuing studies). The peer-reviewing team, lower left quadrant, is a at Carnegie Mellon University in Pittsburgh.

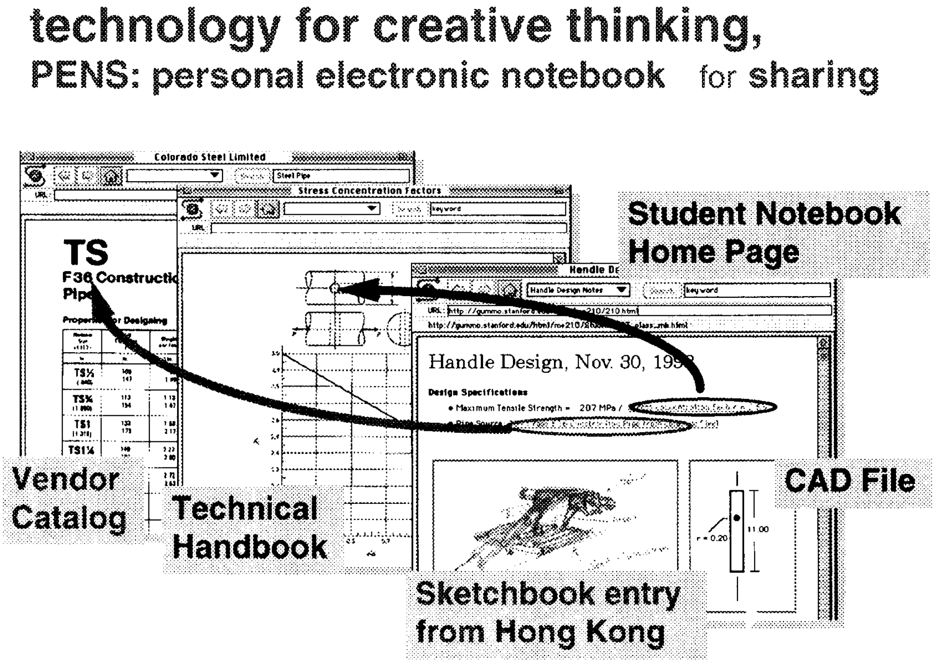

Figure-4: We have observed that most creative activity, one might call it learning, takes place in notebooks, on the backs of envelops and generally in informal media and situations. After 15 years of trying, we have not come close to emulating the flexibility, ubiquity and expressiveness of paper and pencil. We have, however, added a new dimension, the ability to share electronic notes, conjectures and knowledge with team mates, colleagues, editors, and even professors, almost instantly (Hong, et al 1995). When students share informal notes with their professors, we see that both gain immensely. Intellectual explorations are shared rather than judged. In this figure, we see one example of a shared notebook page, lower right, that includes a sketch imported from a partner in Hong Kong, a CAD file element built by the note owner, a paged scanned from a technical handbook and a similarly scanned page from a vendor catalogue. In fact, this assemblage was built in minutes, as a routine part of project work and then posted to the web with a single key-stroke.

Where Will the Learning Lab Go with these Results ?

The Stanford Learning Laboratory benefits from several lines of instructional research and technology development that set the stage for deep examination of "learning in our own shop," its quality, its cost. We have only begun. We aspire to review and catalyze change across the university within a decade. We know that the task of widely deploying learning-technology and new pedagogic models for using it will present expected challenges. Because the barriers to deployment are poorly understood, we must also perform research on the deployment process itself. In responding to this challenge we see an opportunity to formulate the requirements for an academic discipline and industry. The following are amongst our early plans and activities.

- we are instrumenting a number of Stanford classrooms and alternative learning spaces to enable direct observation of learning activity and to quantitatively measure the impact of pedagogic and technical alternatives deployed in those spaces and courses;

- we have focused on the role of traditional large lecture classes in residential undergraduate curricula, including experimentation with alternative pedagogic roles for the faculty;

- we are establishing a network of off-campus "Learning Labs in the Real World" which enrich the learning experience of students locally and remotely while informing our understanding of the learning requirements of those "situations";

- we endeavor to improve learning performance to the point that qualified individuals can choose to complete a degree program in fewer than 4 years using off--campus activities as PBL projects.

- we plan to formally review and experiment with the pedagogy and learning technology of all Stanford schools, at least once per decade;

- learning performance assessment is our highest priority;

- multi-media content development is our lowest priority.

To accomplish these tasks we are seeking and engaging in a wide range of academic and corporate partnerships. Partnership criteria are based largely on a shared perception of the problems and requirements for addressing shortcomings in the learning enterprise.

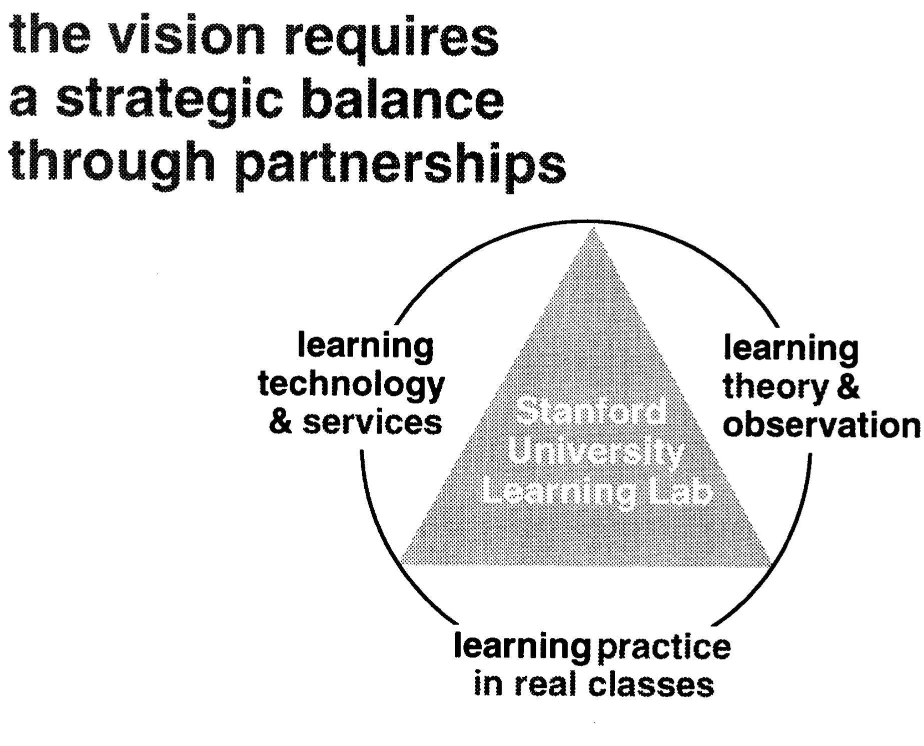

Figure-5: We perceive a need for dynamic balance between competing resource requirements of the research, teaching and technology development communities. We require partners to achieve this balance. For example, Stanford recognizes its need to improve learning practices in our own courses and we expect partners to perceive related needs in their organizations. We have a highly developed research community that can, with encouragement, focus attention on learning practice issues. They can also focus on complimentary issues experienced by outsiders. Few corporations will have this resource. However, we academics are infamously incapable of producing "commercial code", robust applications that can readily be supported in widespread deployment. In this context, industry has the stronger hand. By joining hands across industry, government, academic and cultural lines, we can expect achieve a dynamic balance unavailable to any one group alone.

In Summary, the Vision, Approach and Mission

We foresee that all residential learning experiences at Stanford can be personal, relevant and creative through pedagogically informed learning-technology. To accomplish this, the Learning Lab is a collaborative venture between Stanford University, the Silicon Valley community, global industry and international academic partners. Our mission is to catalyze Stanford's development as a global learning community.

References

Baya, V., Givins, J., Baudin, C., Mabogunje, A., Toye, G., & Leifer, L. (1992). An experimental study of design information reuse. Proceedings of the 4th International Conference on Design Theory and Methodology (pp. 141-147). Scottsdale, AZ: ASME.

Brereton, M.F., Cannon, D.M., Mabogunje, A., and Leifer, L. (1996). Characteristics of Collaboration in Engineering Design Teams: Mediating Design Progress through Social Interaction. In Dorst, K., H.Christiaans and N. Cross (Eds.), Analyzing Design Activity, Wiley, Chichester, UK.

Bridges, E.M., Hallinger, P. (1995). Problem Based Learning: in leadership development. (ERIC Clearinghouse on Education Management) Eugene, OR.

Hong, J., Toye, G., & Leifer, L. (1995). Personal electronic notebook with sharing. Proceedings of the IEEE Fourth Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises (WET ICE), Berkeley Springs, WV.

Leifer L.J., Stepper S., Schaefer M., Van der Loos HFM. (1997). VIPRR: A virtually in person rehabilitation robot, Proceedings of the International Conference on Rehabiliation Robotics, Bath, UK.

Leifer, L.J. (1997). Design Team Performance: Metrics and the impact of Technology, forthcoming in Evaluating Organizational Training, Brown, S.M., and Seidner, C., editors, Kluwer Academic Publishers, Mabogunje, A. (1997). Measuring Mechanical Design Process Performance: A Question Based Approach. Unpublished doctoral dissertation, Stanford University.

Minneman , S. (1991). The Social Construction of a Technical Reality: empirical studies of group engineering design practice. (Xerox PARC Technical Report SSL-91-22) Doctoral dissertation, Stanford University.

Tang, J.C. (1989). Listing, Drawing and Gesturing in Design: a study of the use of shared workspaces by design teams. (Xerox PARC Technical Report SSL-89-3) Doctoral dissertation, Stanford University.

Tang, J. C. and Leifer, L. J. (1996). An Observational Methodology for Studying Group Design Activity. Mechanical Design: Theory and Methodology, edited by Waldron and Waldron, Springer-Verlag, Chapter 5, pp. 52-70.

Toye, G., Cutkosky, M., Leifer, L., Tenenbaum, M., & Glicksman, J. (1994). SHARE: A methodology and environment for collaborative product development. International Journal of Intelligent and Cooperative Information Systems, 3 (2), pp.129-153.

Wilde, D. J., & J. Barberet (1995). A Jungian theory for constructing creative design teams. Proceedings of the 1995 Design Engineering Technical Conferences, 2, (DE-Vol. 83), pp.525-30.

Appendix-A: Product Based Learning Video

Thank you for your interest in "Product-Based Learning (PBL)" and Global Team-Based Design-Development Education. Please consider reviewing Professor Leifer's paper, "Design Team Performance: metrics and the impact of technology," to appear shortly in Kluwer's "Evaluating Corporate Training: Models & Issues." In addition, two video tapes are available for your consideration. I recommend that whenever possible that you watch them in a small group discussion setting where everyone is strongly encouraged to stop the tape regularly and talk about the issues presented. Active discussion and the support of a facilitator can really bring this material to life. The viewing protocol is called Tutored Video Instruction (TVI), a proven "high-tech" learning method.

ME210: Global Product Development Teams (9 minutes)
Main Audience: Corporate partners, Global partners and incoming Students
Primary Focus: promotional, "Shows What ME210 Delivers"
ME210: An Experience in Product-Based Learning (52 minutes)
Main Audience: Students & Faculty considering PBL, Corporate Training
Primary Focus: instructive, "Shows How & Why We Do It"

The shorter, 9-minute video, shown at the NIME'97 conference, is a marketing tool that focuses on what is accomplished in ME210. It was developed to solicit corporate partnerships and interest students in this design curriculum opportunity. It has been well received by the corporate community. Now, I would like to extend its purpose to invite you, your colleagues, and top students to partner with us in the delivery of "global" design team experiences. To date, collaborating institutions include:

Carnegie Mellon University, Pittsburgh
University of Washington, Seattle
University of Massachusetts, Amherst
The Swiss Federal Institute of Technology, Zurich
University of Aalborg, Denmark
The Royal Swedish Institute of Technology, Stockholm, Sweden
University of Tokyo, Japan
University of Osaka, Japan (pending)
University of Queensland, Brisbane, Australia
University of Dundee, Scotland, U.K.
Norwegian Institute of Technology, Trodheim, Norway

The longer, documentary, video traces the experience of 4 design teams through the 9-month long ME210 product design-development cycle. It informs the viewer regarding the strategic thinking, events, emotions and management issues that inevitably confront a global development team. The video was produced to give incoming students a "real feeling" for the experience they are about to encounter.

Early experience with these materials is encouraging. We have seen that excerpts from the documentary can be used effectively to seed discussion of particular issues and problems in team-based design-development. We have used the video to give our colleagues a better understanding of PBL methods, objectives, and reality. We have used it to encourage PBL pedagogy in other disciplines. Adoption in civil engineering, aeronautics and astronautics, computer science, and industrial engineering is now taking place on our campus. We are eager to share our experiences with you and are equally eager to learn from your experience.

To order both videos please contact (there is a nominal fee):

Anne Flatte < flatte@Leland.Stanford.EDU>,
Producer/Director Digital Video Production
Stanford Center for Professional Development, Stanford, CA 94305
401 Durand, Stanford, CA 94305-4036
phone: 650-725-8454; fax: 650-725-2868; http://scpd.stanford.edu