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Using Kolb's Cycle to Round Out Learning

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Abstract. We have assessed the learning styles of industrial engineering students over a ten-year period. Using Kolb's Cycle of Experiential Learning as a basis, we have identified that Industrial Engineering students tend to rely on abstract conceptualization and active experimentation as their preferred mode of processing information (or learning). This paper summarizes the findings of the research. The paper also offers recommendations for providing students with an opportunity to process information with concrete experience and reflective observation, thereby making them more well-rounded thinkers. Case studies from four undergraduate classes will demonstrate how this improves students' abilities and provide valuable insights to engineering educators.

Kolb's Cycle of Experiential Learning--A Theoretical Framework

David Kolb[2] proposed in 1976 that people learn by going through a four-step cycle. He suggested that people learn by first having some sort of concrete experience, followed by reflectively observing what happened, then developing an abstract conceptualization, and ending with an active experimentation to verify the concept. An alternative definition of these steps is doing, thinking, modeling, and checking. This cycle is shown in Figure 1. More total learning occurs when each of these four steps occurs[5, 6].

It can be argued that learning can begin with any step of the process. Engineering, for example, is often taught by introducing a concept or model and assigning homework to reinforce the concept. In a course that has a lab component, the students can sometimes put the concept into

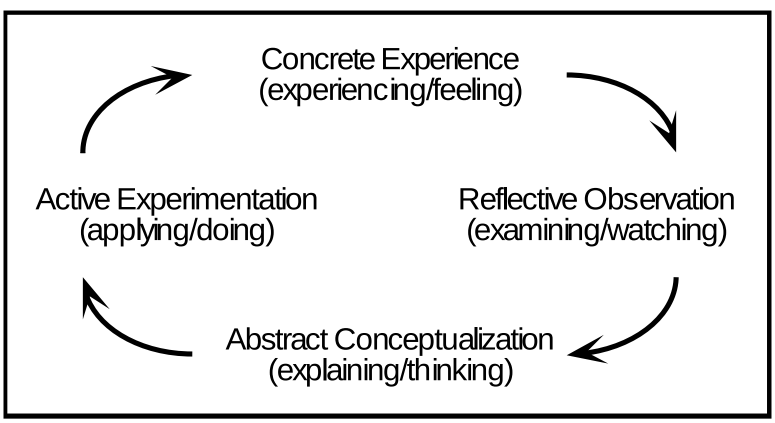

Figure 1. Kolb's Cycle of Experiential Learning

actual practice (concrete experience) with a lab report that requires a reflective observation. Since time, facilities, and resources are always limited, these well-coordinated lab activities are not so common in practice.

Additionally, most people have a preference for how they learn, or process information[1, 3, 7]. The few people who have no preference are called “hub learners,” and they can learn in practically any setting. Most people, however, will rely on two steps of the cycle. “Divergers” learn best by a combination of experience and observation; college students with this inclination are most at home in the performance fields like theater and art. “Assimilators” prefer a setting of reflective observation and model development; in college these students gravitate toward mathematics and the sciences. “Convergers” like a setting of abstract concepts and active experimentation; engineers and law students are examples. “Accommodators” enjoy combining experimentation with experience; business majors tend to be accommodators. This does not mean that all students in a given major are in that particular group, but the majority tends to be.

This preference toward a particular learning style can be assessed. The findings from our assessments over the past decade provide the basis for this paper.

Learning Style Assessments, 1991-2001

The present research began in 1991 when the first author requested the assistance of the second author to help maintain an active learning classroom. In previous sections of that particular class, Industrial Labor and Law, enrollments had been in the teens, but had mushroomed to 55. Through a series of consultations, the Kolb Cycle was decided as a framework for assessing the course and developing learning experiences.

The results of that initial assessment showed that the overwhelming majority of students (juniors and seniors in Industrial Engineering) were convergers, with a few accommodators and a few assimilators. Initial indications were that one student was a diverger, but he later proved to be a converger. The results from that first assessment were discussed in an earlier paper[7] and are shown as corrected in Figure 2. The pedagogical approach and remarks pertaining to learning in that course, and several others, will be discussed in a later section on case studies.

The authors have continued these assessments of industrial engineering students over the years. The latest data are from a junior level Industrial Engineering Course in Production and Operations Management. The results, shown graphically in Figure 3, indicate that there has been no change in student learning preferences in the last ten years. These data are typical results and the pattern remains the same.

Rounding out the Learning Experience—Suggestions to Complete the Loop

As the data show, engineering students show a penchant for learning by the converger method of abstract conceptualization and active experimentation. Convergers love to design things, make decisions, and evaluate plans. They tend to be action oriented, but may come to a conclusion too fast or solve the wrong problem if they are excessive.

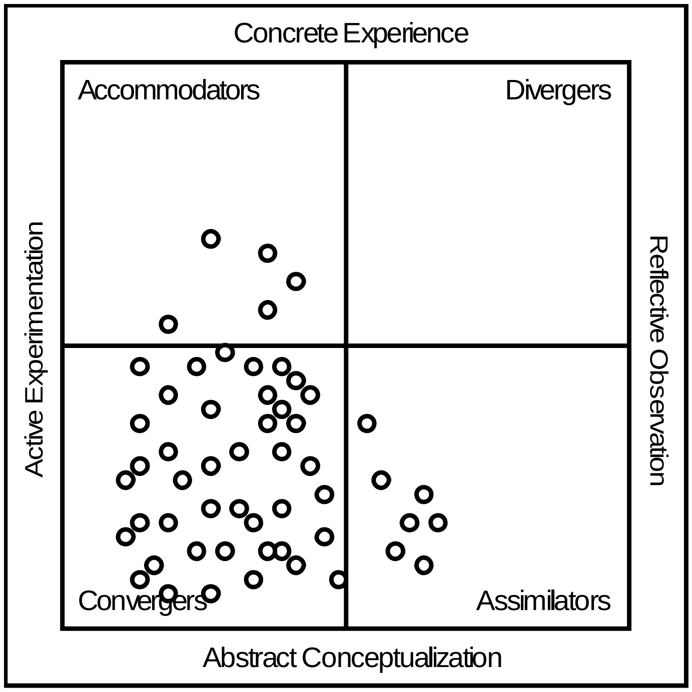

Figure 2. Student Learning Styles from Industrial Labor and Law, 1992.

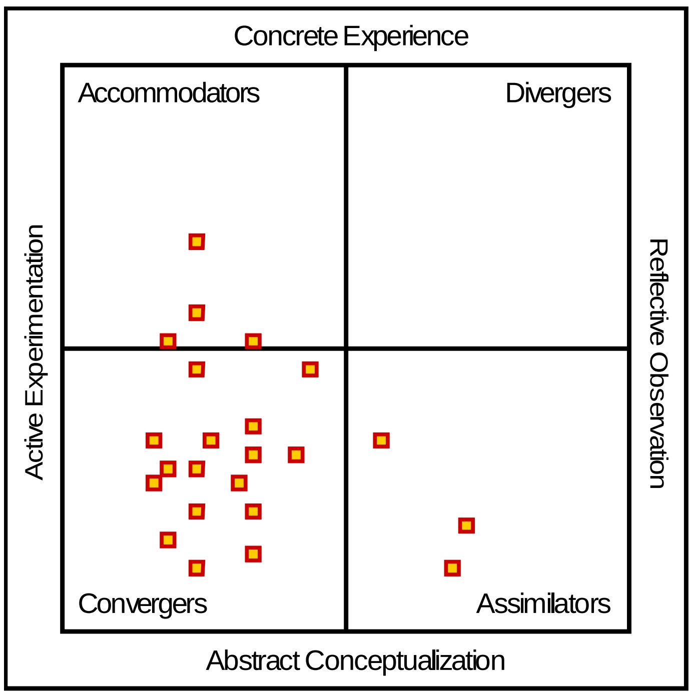

Figure 3. Student Learning Styles from Production and Operations Management, 2001.

Traditional engineering courses reinforce this convergent learning style. Granted, this may be extremely efficient for both the teacher and the learner. One of the key characteristics of a converger is the belief in a "single right answer"; as long as we get the answer in the back of the book, we must have learned the material! Figure 4 shows how the Kolb Cycle can be truncated to emphasize the learning style that most engineers tend to have.

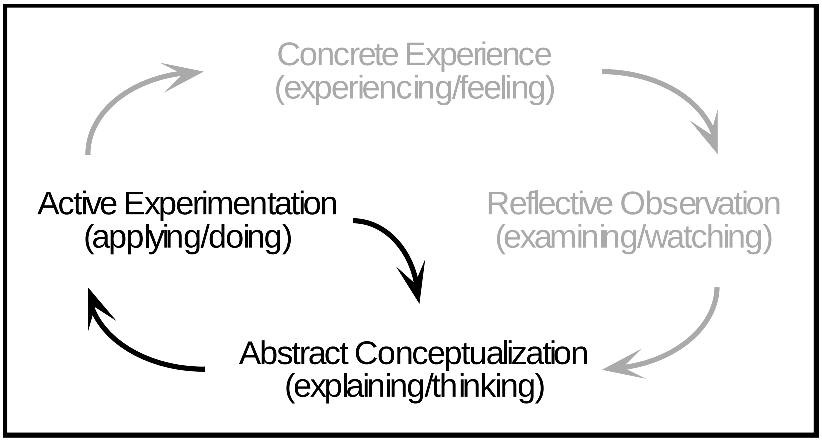

Figure 4. A short-circuited Kolb's Cycle that de-emphasizes experience and observation.

"Efficient" learning is not necessarily the same thing as "effective" learning. "Efficiency" can be considered to be able to do things right; that is, quickly and with a minimum of effort. "Effectiveness" can be considered to be doing the right thing. When teaching engineers, the ability to provide learning situations that require experience and observation can have profound on their abilities to actually apply what they have learned to the "real world."

The authors have put engineering students into the position of having to learn through concrete experience and reflective observation. The typical response is that the students first do not understand why they are asked to learn that way, even after the learning cycle has been explained. They ask, "What am I supposed to do?" and follow up with, "What is the answer I'm supposed to get?" The students can be brutal on course evaluations because they do not like a learning process that does not play to their natural strengths as highlighted in Figure 4. Before passing out the student evaluations, the instructor may tell the students that they have had an alternative learning experience that has used Kolb's Cycle and the course emphasized learning rather than teaching. Even so, ratings can be lower for several key student evaluation questions, including:

- The instructor was an effective speaker.
- The instructor gave helpful feedback on my performance.
- The instructor made clear how my work was to be evaluated.
- The instructor explained what is expected from students.
- Overall, the instructor presented the subject effectively.
- Overall, I learned a lot in this course.

These questions tend to reflect how an instructor comes across as a performer and how the students perceive open-ended learning as busywork. The authors recommend that when submitting the results of the student evaluations into the academic record file, a written analysis of the results be included to mitigate the negative impression of "low" scores. By redefining a desirable target level for scores, the view of the instructor's performance in the classroom can be held in a better light.

The advantage of using Kolb's Cycle is to develop engineers who can work well in settings where they have no clear problem statement and required cookbook solution; in other words, we do it because they will be more effective engineers as a result of our approach. It would certainly be more efficient to use the traditional lecture and homework paradigm, but including the messy, "touchy-feely" aspects associated with actually doing the work and thinking about what we observe will make for a much deeper, longer-lasting educational experience. We, as engineering educators, become "facilitators of learning" rather than "teachers."

Teaching tools that can be used to facilitate total learning using Kolb's Cycle recommended by Wyrick and Hilsen[7] are shown in Figure 5. The tools that are more teacher active are toward the center and the tools that are more student active are toward the edge. A simple example may be that a Statics instructor point out the ice and snow sitting on top of a lamp post outside the classroom (a visual experience) and ask the students how the post stays upright (reflective observation); the students should identify the concepts of sum of forces and sum of moments equal zero (abstract conceptualization), and a homework problem or in-class exercise can be assigned to solve the problem (active experimentation). By pointing out a physical example, the class becomes more germane and the students hopefully will begin to visualize more applications of the theory.

An example of using Figure 5 to develop a more student active learning experience comes from the area of supply chain management. Students participate in a supply chain management simulation developed at MIT and commonly referred to as "The Beer Game."[4] In this simulation, students try to manage their ability to meet customer demand at the level of either a retailer, wholesaler, distributor, or brewery. Typically they experience wide swings in inventory level and ability to meet demand (concrete experience of simulation). They are asked to think about the results and what happened, and they usually reply that their customers and suppliers were all messed up (reflective observation of brainstorming and discussion). The concept of the "bullwhip effect" is then presented (abstract conceptualization of model building), and the student teams plot their ordering, inventory, and sales data over time to find that the bullwhip applied to their case as well (active experimentation of plotting data). In the cases where the game is repeated with slightly different conditions (thus providing another cycle of learning), the students will tend to reflect more on their own decisions rather than point fingers at other players, which typically yields a smaller bullwhip curve.

Hopefully these suggestions for rounding out the learning experience will help the reader develop good learning situations for the students, shift the focus from teaching to learning, and mitigate any changes in student evaluations.

Case Studies

The following case studies provide some examples of approaches used in different courses and some of the key findings. Cases from four different courses in Industrial Engineering spanning a decade are presented. Ideas from these cases can be applied to other disciplines.

Industrial Labor and Law, Winter Quarter 1991-92. This course covered basic business law, contracts, products liability, intellectual property, and ethics. It was a required course for IE students, taken as juniors and seniors. This was the course that began learning style assessment on a systematic basis at UMD.

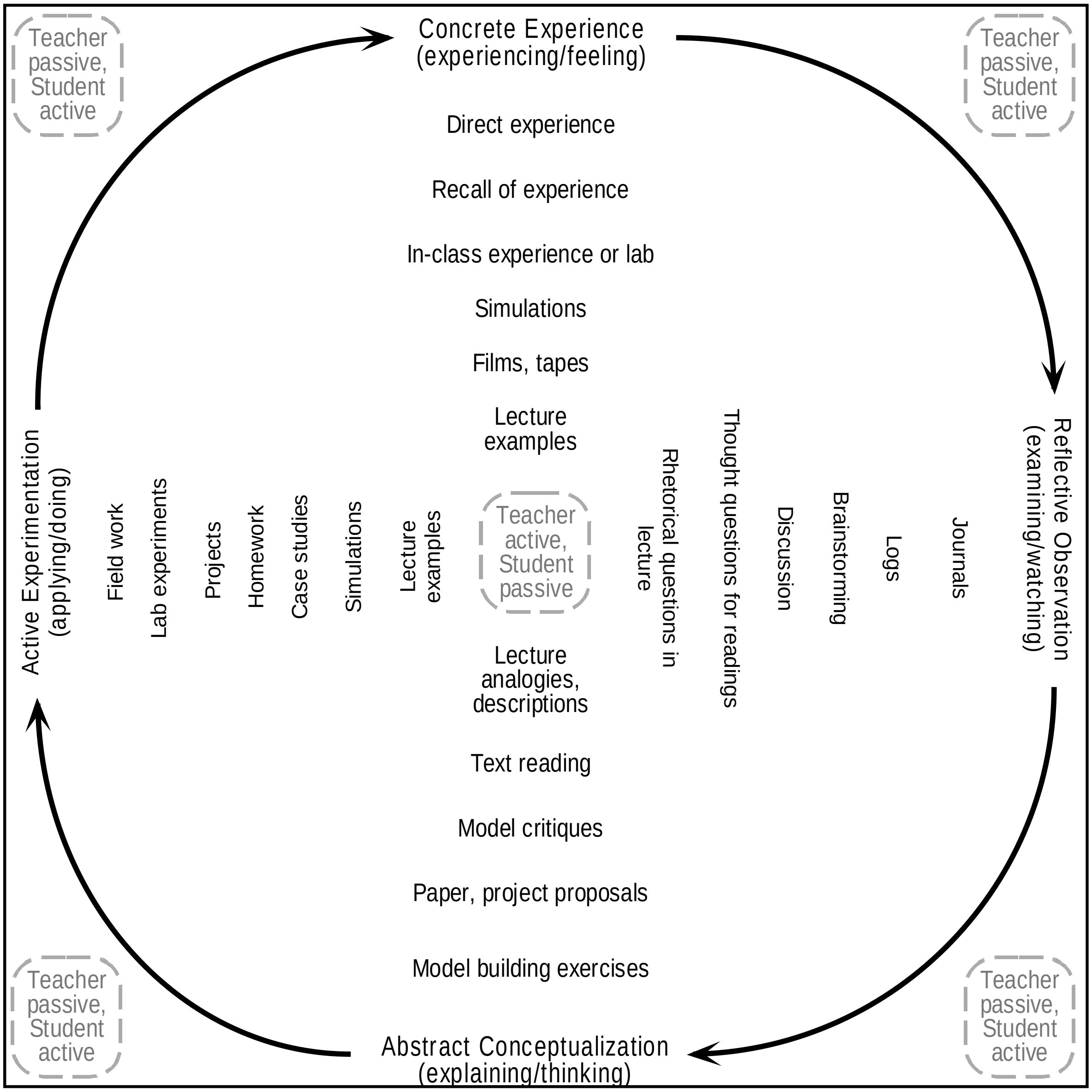

Figure 5. Teaching tools to use with Kolb's Cycle.

The course was taught as an initial 3-week block as a traditional lecture setting, followed by a 2-week break for the Christmas and New Year's holidays, and completed as a second 7-week session. A student course evaluation given right before the break indicated that the students really enjoyed the material. For the second session, students were required to take the lead on preparing for lectures and given several experiential exercises, including consumer products for products liability analyses. These exercises were designed to emphasize the experiential and observation elements.

One example was the issue of product liability. The class period began as students were asked to visualize the car they would buy after they had worked several years as an engineer, including the make, the color, the options, the sound system, the performance, the pride of ownership, and the positively envious comments from co-workers and family. Because it was such a great car, they were told, they would undoubtedly install some type of anti-theft protection. This introduction provided an emotional tie to what happened next. They were told that one day, right before they were to leave for a well-deserved vacation, their car had indeed been stolen from their parking lot at work. Worse still, it had been totaled when the thief couldn't stop the car (which was what this device was supposed to do, as it turns out). The students were asked how they felt and what they thought about the anti-theft device in particular. By using journal entries, the students could really get into the exercise. Once this was done, the students were eager to learn about products liability and perform a homework analysis on the anti-theft device in terms of product liability.

At the end of the course, the student course evaluation was given again; the results this time were far more mixed, with some students still rating the course high, but others were quite negative. It was clear to both authors that the students had learned the material in the second portion of the course more deeply and had become much better learners.

Total Quality Management, Winter Quarter 1991-92. The instructor for this course was a visiting professor who had come from a career in industry. It was offered to juniors and seniors in Industrial Engineering and business, as well as to MBA students. The second author worked closely with the visiting professor to design the course to maximize student learning.

Interdisciplinary undergraduate teams were made of IE and business students, who arranged a small version of a Malcolm Baldrige National Quality Award quality assessment of local companies. The work with companies provided a setting in which students could observe how firms actually worked, and the interdisciplinary teams exposed the business students to more quantitative thinking and it exposed engineering students to more of the people side than a traditional course.

Course evaluations at the end of the term indicated that the students recognized the value of working with other majors and with companies. Comments also indicated that the students would have preferred to be taught in their "normal" methods and worked with homogeneous (rather than interdisciplinary) groups so that they "could have learned more." These types of paradoxical remarks are not uncommon.

Introduction to Engineering Management, Fall Quarter 1997. This sophomore-level course for IE majors covered planning, organization, communication, leadership, motivation, and career planning. Again, the co-authors collaborated to develop the experiential and reflective observation skills of the students. Case studies were used frequently to provide more experience. Weekly journals allowed students to reflect on the material and what it meant outside the classroom.

One day, the students were asked what they viewed as the "biggest pain in the neck" about the university. Parking, or the lack of it, was the overwhelming response. This became the basis for a quarter-long project to apply the course material. They were required to find out how many lots were on campus, where they were located, how full they were at what times, and student and administration opinions. They discovered that it wasn't a lack of spaces or lots, but unwillingness to walk more than a block that was the root cause of the parking problem. This then led to other issues of how to motivate students to park in these underutilized lots and how to communicate it. Final presentations included all this, plus their plans for an ideal parking garage, to faculty and staff. The campus Parking and Police Department actually implemented several of the suggestions the students made.

Obviously, the students had learned a great deal. However, their course evaluations at the end of that course indicated that they felt that the instructor hadn't taught much. These students were able to remember what they did in great detail years later as seniors, including the concepts and methods. This demonstrates the long-term effect of incorporating all facets of learning.

Production and Operations Management, Spring Semester 2001. This course was taught by the first author to juniors in Industrial Engineering. It deals with production systems, forecasting, capacity and facility planning, production planning and scheduling, inventory and supply chain management, and quality. Early in the semester, students took the learning styles assessment and the concepts of individual and organizational learning were discussed. The intent was that the students would understand the unorthodox approach of the instructor when it came to teaching.

In an attempt to make the learning more experiential, the students were given the task of selecting a site for the UMD Homecoming bonfire. Over the last few years, the bonfire had become a contentious issue because it was seen as a NIMBY event (not in my back yard). The students were required to find out who the stakeholders were, the key issues and considerations, possible alternatives, methods to evaluate the alternatives, and finally to make recommendations. The four teams presented their findings to key people in the community, the Homecoming Committee, Parking and Police, athletics, the alumni office, and faculty and staff. This exercise required much more actual discussion, fact-finding, and contemplation than the traditional approach to sitting in class and hearing about the concepts. At the presentation, the basis for a consensus decision was essentially reached and most of the recommendations were implemented in this Fall's Homecoming, which proved to be a great success.

As before, the student evaluations of the course were not very high. The students had internalized much of the material through assignments and experiences like the bonfire site selection. However, they still tend to equate concept-homework-concept-homework with learning, and learning activities like the bonfire site selection with busywork. As an educator, it is frustrating to receive low scores when it is obvious that the students have really learned well, and will be able to apply it in the future. Preparing a written assessment evaluating the scores and explaining their relation to the course objectives does help with the instructor's own personal performance evaluation, since the focus is on facilitating learning experiences rather than performance as an entertaining teacher.

Summary and Key Findings

Over the last ten years, the authors have assessed learning styles of engineering students at the University of Minnesota Duluth. Kolb's Experiential Cycle of Learning has been used as the theoretical construct for designing learning experiences for the students to become all-around learners, using skills of concrete experimentation, reflective observation, abstract conceptualization, and active experimentation.

During this time, engineering students have demonstrated a strong tendency to prefer learning by abstract conceptualization ("Give me a theory or equation") and abstract experimentation ("Give me some homework so I can get to the right answer"). There has been no change in this preferred approach to learning. In order to give the students skills in concrete experimentation and reflective observation, the authors have developed numerous exercises and projects. The results of some of these have been discussed in case studies of four courses.

The key findings can be summarized as follows:

- Providing a well-rounded learning experience to students provides a rich environment for deep learning. They are able to recall details over a long time.

- Engineering students may not be able to recognize particular aspects of learning as learning. They may say they didn't learn much when in fact they learned a tremendous amount, and are able to apply what they learned.

- Course evaluation forms that are designed to assess active teaching may provide poor scores if you try to facilitate learning rather than teach. If you are in a position that requires high scores, either develop a new form that recognizes facilitation as valuable or stick with the less effective but more recognizable theory-homework approach to teaching. Regardless, it is worthwhile to prepare a written analysis of the scores to help determine what they mean and what your targets should be (and you can apply Kolb's Cycle to yourself!).

- The reader may use Figure 5 to help select the types of learning tools for the amount of student activity or instructor activity desired.

- It is much more fun and personally rewarding to be an engineering educator when you use the Kolb's Learning Cycle. You can learn a lot from your students!

References

1. Broberg, Anders, "Learners as Knowledge Workers—Some Implications," *Journal of Engineering Education*, Vol. 90, No. 1 (January 2001), pp. 63-68.
2. Kolb, David A., "Management and Learning Processes," *California Management Review*, Vol. 18, No. 3 (1976), pp. 21-31.
3. Kolb, David A., "Learning Styles and Disciplinary Differences," in *The Modern American College*, (edited by A. W. Chickering and Associates), Jossey-Bass, (1981).
4. Sterman, John D., "Modeling Managerial Behavior: Misperceptions of Feedback in a Dynamic Decision Making Experiment," *Management Science*, Vol. 35, No. 3 (March 1989), pp. 321-339.
5. Stice, James E. "Using Kolb's Learning Cycle to Improve Student Learning," *Engineering Education* (1987) pp. 291-296.
6. Svinicki, Marilla D. and Nancy M. Dixon, "The Kolb Model Modified for Classroom Activities," *College Teaching*, Vol. 35, No. 4 (1987), pp. 141-146.
7. Wyrick, David A. and Linda Hilsen, "Creativity and Engineering: Learning Styles, Teaching Styles, and the Development of Engineers," *Proceedings from the 1993 ASEM National Conference,* Dallas (October 24-26, 1993), pp. 220-227.

Biographies

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LINDA HILSEN (1946-2002) was an associate professor and director of the Instructional Development Service at the University of Minnesota Duluth. She had written two books, a text on composition, and a wide variety of publications and presentations dealing with effective teaching. In 1994, she received the Horace T. Morse Alumni Award, which recognizes outstanding professors in undergraduate education in the University of Minnesota system. Linda was very active in several national faculty development societies.