Reflective Assessment: Portfolios in Engineering Courses

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Abstract

Quality problems in engineering education are caused by the wide range of student backgrounds and abilities, the need for integrating interpersonal and technical skills, the lack of feedback mechanisms for the assessment of quality, and the overall lack of relevance between the students' needs and the coursework. Steven R. Covey's seven habits and Peter Senge's five disciplines provide a framework for converting the classroom into a learning organization—an organization capable of addressing such quality issues.

Portfolio assessment, a tool seldom used in engineering courses but particularly effective, is the key organizing element. By student portfolios, we mean a systematic and purposeful collection of student goals for learning, works in progress, peer and instructor feedback, and reflections on the work and processes.

We will show that the portfolio with reflective assessment supports each habit and discipline, promotes continuous improvement for both students and instructors, and clarifies the relationship between course learning and lifelong career development. Several examples of portfolio assessment will be examined. These illustrate using portfolios with reflective assessment as a framework to link students' learning goals with team and individual projects. The portfolios focus both instructors' and students' attention on the quality of learning processes.

Begin With the End in Mind

At Marietta College (advertised as America's Leadership College) we strive to promote leadership behaviors in our courses. We see a leader as one who envisions a desirable future and develops strategies for getting to that future, who acts on those strategies and takes responsibility for the consequences. We also expect this leader to examine the consequences, to consider carefully and use creatively, the tension between reality and the vision.

We believe that to embrace leadership, students must take responsibility for setting their own learning goals, par-ticipate in setting common learning goals for the class as a whole, help evaluate the results of learning, and put that learning into context. "Begin with the end in mind" is the second of Steven R. Covey's seven habits [1]. Having good leaders for the future is the end we have in mind.

We will show that the student portfolio supports each of Senge's disciplines, promotes continuous improvement for both students and instructors, and clarifies the relationship between course learning and lifelong career development.

Serving Students

Engineers exit good undergraduate programs with excellent technical skills and the ability to work hard but short on vision and the interpersonal skills required for true leadership. Thus, engineering graduates often lack a sophisticated self-image and do not have a sense of how to integrate personal goals with the goals of their work organization or the community to which they belong. As they progress in their careers, they not only have responsibilities for their own work, but other people's work as well. This requires well-developed interpersonal skills. How can an undergraduate engineering course help? If built as a learning organization, the course can provide participants with an opportunity to develop a personal mission; such an organization also acts as a place to develop and practice the needed social and communication skills.

What is a learning organization?

The acquisition of information is often confused with learning, a confusion which contributes to quality and efficiency problems that make courses ineffectual. By practicing the five disciplines as defined by Senge [2], course participants make the classroom a learning organization. They build shared vision to bring diverse groups of people together and develop personal mastery so that individual students use improved communication skills to bridge their classroom experiences to their work on the outside. They learn to examine the mental models and bring out internal rules

and assumptions (paradigms) for open discussion and consideration and with such reflective examination to align personal goals into a larger vision. Finally, they practice systems thinking and realize that *all* is connected, that the learning classroom itself is a system of processes and products.

What is a student portfolio?

Long before education entered the scene, the portfolio led a valid and meaningful life in the professional worlds of art, architecture, business, journalism, and photography. Diversity and accomplishment announced themselves in exemplary collections designed to overview and promote abilities, strengths and specialties, and signatures which made one different, a cut above the competition. We expanded this classical idea of the exemplary portfolio so it better serves the goal of lifelong learning, to acknowledge both purpose and the individual's influence to shape the portfolio. With purposes clearly defined for the participants in portfolio development and assessment, it is possible to meet a variety of student/instructor needs.

We see a quality engineering course portfolio as including: student personal mission, personal learning goals, course mission statement, whole class learning goals, seminal work in the course with periodic reflection papers asserting progress toward goals. The portfolio documents feedback with revisions and changes on the part of the students as well as suggestions for the instructor. It can also include evaluations of work and progress by peers and instructor.

State of the Art in Engineering Education

Why is it that our classrooms fail quality tests? We believe that instructors often limit themselves with preconceived ideas about teaching and learning—about what an engineering course *is*. Developing an organization which has a balance between a vision of the future and a perception of reality is a challenge. The microcosm of the engineering course is simpler than most organizations, but learning is too rare and group learning still rarer. We have taken one of the pre-eminent books about learning organizations, *The Fifth Discipline, The Art and Practice of The Learning Organization* by Peter M. Senge, and applied it's five disciplines to organize our strategies for achieving a quality course.

Systems Thinking

One way to enable students to make the desirable and necessary connections is by encouraging systems thinking on the part of the students. Examples of class activities to encourage this include having the participants develop a personal mission statement with personal learning goals as well as write papers reflecting on the application of the course principles to their envisioned careers. Some professors have students keep reflective journals or learning logs. Most of our engineering students prefer to write reflection papers. We provide feedback loops that measure how effectively the course works and encourage continuous quality improvement. Products from these activities serve as the foundation of the portfolio. The written version of the personal learning goals is used as a guide for progress; the reflection papers at several stages of the course explicitly record progress on goals and help plan for the future; peer and instructor evaluations provide external validation of progress; and both original and revised projects promote thinking and rethinking.

Personal Mastery

In order to assure that engineering students have achieved personal mastery or taken steps to improve personal mastery, we ask that they create a personal mission statement and write their personal learning goals referred to above. These are sometimes revised as personal mastery increases. We use visioning exercises from Covy [1] and have students work up priority lists of values if they have trouble with their vision or learning goals. Senge, et. al., [3] also provides many useful exercises. Written self-evaluations and examinations of current reality vs. vision add to the basic components of the portfolio.

Initial reactions of the students to these activities vary—some dislike the risk-taking; others embrace it from the start, but at the end of the course, most voice appreciation for the opportunity to make their personal vision more explicit.

Shared Vision

Once we have the basis of personal goals, we use several activities to produce a shared vision and set common learning goals for the course. A repeated activity is group brainstorming; exploring important values for the class, learning objectives for the class and learning activities for the class. Afterwards, we develop the class vision statement, set priorities for the learning goals, match learning activities to goals and decide on assessment tools for each goal.

Note that this group work takes advantage of the students' work experiences and expertise. Many times these resources are left untapped by instructors. By investing in the building of vision, goals, and the portfolio, students "own" them. These activities move the group around the mentality that the problems are "out there" or in "the system." Collectively, there is ownership of the vision and the course.

The participants go on, with the instructor's help, to produce a class-designed syllabus which provides a plan for the course. It includes a prioritized list of goals, the learning activities, and the assessment methods. These student syllabi, while satisfying instructor expectations, are quite different from those typically developed by the instructor alone. This procedure helps to address student concerns about relevance, empowers them to accept responsibility for their own learning, and leads them to take ownership of the course. Our observations show this shared vision promoted learning and an heightened awareness of systems.

Mental Models

"The discipline of mental models is reflecting upon, continually clarifying, and improving our internal pictures of the world, and seeing how they shape our actions and decisions." [4] Certainly one of the things we ask of students when writing their reflection papers is to be sensitive to their own mental models and to make their assumptions explicit. The same activities used to encourage systems thinking and develop shared vision and personal mastery help develop awareness of mental models. Other strategies include left-hand column exercises. Using a conversation from their daily lives, students write what was said in the right-hand column; they write what they were thinking in the left-hand column. The class discusses the assumptions and speculates on how to test those assumptions. They consider how different responses may have taken the conversation in a more fruitful direction. These exercises, along with role-playing of work situations, were used in our TQM courses, but they were so useful that we will expand them to other future courses.

Within the portfolio, the reflection paper continues to contribute toward growth of self awareness. Course feedback sheets are often added to the portfolio. These aid the instructor to check assumptions about learning and contribute to the ongoing effectiveness of the course.

Team Learning

With the group pivoting on the practice of inquiry and reflection, the discipline of team learning begins to take shape in "transforming conversational and collective thinking skills, so that groups of people can reliably develop intelligence and ability greater than the sum of the individuals' talents." [5] In addition to the activities cited for the previous disciplines, the students have discussion groups on current literature or relevant issues "in the news." They also choose and develop team projects. Students may take turns observing group process. Evidence of student and group learning appears in the portfolio in the shape of written class goals and a syllabus as a team product, a variety of

written reports, feedback on both written and oral reports, as well as any revised, repaired or completed works from the teams. In written reflections on the team process, the students examine whether they met the learning goals set for themselves and their team.

Assessing, encouraging and coaching of team activities requires quite different skills from the lecture-exam approach. As an instructor, one must learn many new techniques and take risks of occasional failure. The combination of team effort and portfolio assessment gives us a much better idea about what learning *is* going on in the course and *how relevant* it is to the work world and life long learning skills.

Tension Between Vision and Reality

We have a vision of a system of close cooperation between industry and educational institutions with students taking much of the leadership and responsibility for making the connection in the lifelong learning system. With reflection by the instructor and students, and by using portfolios as documentation, we assure quality in our system.

References

[1]   Covey, Steven R., *The Seven Habits of Highly Effective People: Restoring the Character Ethic*, Simon and Schuster, New York, 1989.

[2]   Senge, Peter M., *The Fifth Discipline: The Art and Practice of the Learning Organization*, Doubleday Currency, New York, 1990.

[3]   Senge, Peter M., Charlotte Roberts, Richard B. Ross, Bryan J. Smith, and Art Kleiner, *The Fifth Discipline Fieldbook*, Doubleday—Currency, New York, 1994.

[4]   Reference 3, page 6.

[5]   Reference 3, page 6.

Biographies

David Cress teaches engineering and total quality management courses at Marietta College in Ohio. He is coordinator of the Industrial Engineering program. Projects include; work with performance based assessments for individuals and teams, the development of tools to empower students, using case studies for faculty development, using quality function deployment for curriculum development, and developing pollution prevention modules for industrial engineering courses.

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