

The use of student portfolios to encourage industrial ties in undergraduate engineering education

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ABSTRACT

As educators are increasingly called upon to justify their effectiveness, the connection between educational programs and industrial experience is receiving greater scrutiny by students and other stakeholders (parents, future employers, etc.). We believe that student portfolios can play an important role in strengthening industrial ties, assessing student performance, and enhancing learning. Practicing biological engineers were interviewed to determine the role of portfolios in industry. Also, examples of portfolios used in industry were collected, such as company technical marketing documents and “statement of qualifications” packages. Based on this data, and on prior work concerning student portfolios, we designed an instrument to document the student’s learning process with respect to the connection between educational concepts and their application in industry. This instrument was assigned as a major component of two biological engineering core courses. Industrial ties to biological engineering were stressed through the use of the portfolio, and also by direct interaction with industrial models and personnel. In this paper, the methods for preparing student portfolios are detailed, comparisons with industry portfolios are drawn, the success of this student portfolio method is discussed, and recommendations for improvement are presented.

INTRODUCTION

Industry needs and the academic-industrial interface

Industry is calling for technically competent entry-level engineers who also have honed their communication skills and possess a deeper understanding of the culture and constraints of the business world. Likewise, students are demanding more demonstrated relevance between their educational experience and future careers. It is therefore important to incorporate innovative methods in undergraduate engineering education which explicitly strengthen the ties between industry and academia.

In two biological engineering courses, a freshman level course at Louisiana State University (LSU) and a senior level course at the Ohio State University (OSU), student portfolios were used to as a tool to bridge the academic-industrial gap. We, the instructors, illustrated to our students the use of portfolios in industry through sharing company technical marketing documents, statement of qualifications packages, and individual employee annotated resumes. We assigned student portfolios that reflected their use and importance in industry, and promoted comparisons between student portfolios and their industry counterparts.

Assessment of student performance and ABET 2000

The Accreditation Board of Engineering and Technology (ABET) recently published

Engineering Criteria 2000, which sets new standards for evaluating, assessing and accrediting engineering programs in North America [1]. The criteria are purposefully vague in nature to encourage innovation in engineering education [2]. Proceedings from the National Conference on Outcomes Assessment for Engineering Education [3] reflect educators' frustration with this issue. The process for implementing new means of assessment will be iterative in nature, and will involve collaboration among educators, industry leaders, accreditors, and stakeholders [2].

Engineering Criteria 2000 cited the student portfolio as a means for meeting criterion three: program outcomes and assessment. Shackelford [4] defined the student portfolio as "a purposeful collection of materials capable of communicating student interests, abilities, progress, and accomplishments in a given area." Portfolios are a useful tool in assessing learning because they require students to review their work and create their portfolio by engaging in a process of reflection, selection and description [5].

Learning and Student Portfolios

While student portfolios have long been used to document student learning and mastery in subjects such as art, journalism, and architecture, their use in engineering education has been a relatively recent phenomenon [6,7], with little supporting literature [6-11]. Panitz [6] briefly described the use of student portfolios in technical courses at five universities. Olds [7] illustrated the use of student portfolios in assessing engineering students' writing skills. Cress and McCullough-Cress [8] discussed portfolios in engineering courses as a means of reflective assessment. Johnson [10] used the student portfolio in conjunction with a professional development course for engineers.

Olds [7] presented two approaches to student portfolios: nonselective/working and selective/final. The first type is an archive of all the student's work, while the second is a collection of representative works selected by either the student or the instructor. Shackelford [4] differentiated among four types of student portfolios: (1) showcase portfolios which document the students' best work, (2) descriptive portfolios which include both completed and works in process, (3) evaluative portfolios which document student mastery of specified skills, and (4) composite portfolios which focus on group process and team accomplishments.

We have used student portfolios in an effort to initiate student-centered learning[11]. The portfolio method encourages students to take greater responsibility for their own learning, and makes explicit the life-long nature of engineering education. Our hope is that if students are given more proactive roles in their learning process, they will better comprehend engineering concepts and their future roles as practicing engineers.

Objectives

Our objectives were to (1) apply the student portfolio method for assessment and for enhancing industrial ties, (2) evaluate the success of portfolios, and (3) reflect on the use of this instrument and make recommendations for future work.

METHODS

Overview

Student portfolios were introduced into two engineering courses to encourage student-centered learning, to encourage industrial ties and the connection between experience in the classroom and experience on the job, and to experiment with one of the less traditional assessment techniques recommended by Engineering Criteria 2000. This is the second year that portfolios have been used in both of these classes.

The portfolio method was implemented in the OSU course, Agricultural Engineering 625, by having each student maintain a selective, evaluative portfolio. The contents of the portfolio were at the students' discretion, but each was required to include a cover page, competency matrix, referenced work examples, and a narrative essay portion. As the learners progressed through the levels of learning for each competency topic, they referenced one or more examples of their work which demonstrated that they had achieved the stated level of mastery. These examples were drawn from completed assignments or any other items a student chose to undertake. All assignments were submitted to the instructor who graded and returned them to the students. Additional competencies could be added by the student beyond those required, as long as these elements could be demonstrated by referenced documentation in the portfolio. The completed portfolio was worth 10-25% of each student's final grade.

The portfolio method used in the LSU course, Biological Engineering 1252, was nonselective/working [7] and descriptive [4]. The instructor chose the assignments required for the portfolio, but all drafts were included, and the student chose the method to organize and present the material. Self-assessment narratives for selected assignments were required, and a self-assessment narrative describing the students, overall experience with the course and the portfolio was also required. Students were encouraged to include additional thoughts, feelings, and insights gathered during the semester. The portfolio was presented to the student as a means of documenting the student's thought process in identifying her/his motivation for choosing engineering, choosing areas of interest within biological engineering, and learning fundamental concepts involving engineering design. Resubmissions were not required, but encouraged. The portfolio was interpreted by students as both a requirement for the course and a method to help them in their quests to be engineers. Portfolios were checked at mid-semester and were evaluated based on completeness, organization, and creativity. The portfolio was worth 30% of a student's total grade.

Industry portfolios

The instructor of the senior course brought in examples of portfolios used in industry for the class to examine. These included company technical marketing documents and statement of qualifications packages. The class was assigned the task of locating similar materials for the company of their choice. Each student was to pick an industry, agency, or engineering service firm and obtain a copy of their current statement of qualifications portfolio. This gave the students the opportunity to interact with the company of their choice in a non-job hunting mode, potentially letting them make some new contacts and learning about their chosen career field.

Student portfolio assignments to encourage industrial ties

One facet of the OSU portfolio assignment was a narrative portion of the portfolio notebook which included the student's short essay responses to the "portfolio self-assessment questions" included in each homework set and a concluding summary paragraph reflecting on the student's overall experience of the course. These short writing assignments (maximum two pages each) allowed the student to evaluate their own performance and learning style, to identify areas of strength and weakness, and to serve as a reminder of what areas to emphasize with prospective employers during future job interviews.

Internet report

In the freshman course, students were asked to complete a detailed Internet search on their respective area of career interest. Students were required to address the following points: (1) describe projects that the student envisions working on after graduation; (2) what are the trends in the subfield the student identified; (3) do the projects the student envisions doing and the trends in the field match up; (4) describe how the exercise helped the student learn about the prospective career; (5) is biological engineering the most appropriate place for the student to pursue his/her career goals?

Interviews with professionals

LSU students were required to contact and interview a professional involved in their area of interest, and to submit a written report detailing the interview. Students were also asked to assess their interest in the field based on what they learned through the interview.

Interaction with clients for class design project

Students in the LSU course were assigned in groups of three to five members to re-design animal enclosures owned by local businesses. Each business was contacted by the students, who offered their services as practitioners. The businesses owners were asked to serve as clients during the design process. Contact between students and client was accomplished through site visits, letters and phone communication. The semester culminated with students proposing their designs to a panel including habitat enclosure experts and the business owner(s).

RESULTS AND DISCUSSION

Myers-Briggs Type Indicator results

The instructors and the majority of students in both classes found that student portfolios were successful. Exit surveys showed that 80% of the BE 1252 students and 78% of the AE 625 students thought that portfolios enhanced their learning.

The freshman were further divided by their learning style based on the Myers-Briggs Type Indicator (MBTI) [12]. The MBTI has been widely applied in education [13], but its use is not without controversy [14]. Wankat and Oreovicz [15] suggested that the dichotomy between MBTI sensing and intuitive types may be the most important one in engineering education. The sensing student prefers working with detailed observations and uses linear thinking, relying on facts and established methods; the intuitive student relies upon imagination and inspiration, preferring to work with complex big picture concepts. The BE 1252 class included nearly equal numbers of sensing and intuitive students, which is typical of the engineering classroom [16]. Of

these freshmen, 69% of the sensing types found portfolios useful, whereas 87% of the intuitive types found them useful. This suggests that the type of portfolio used was better suited to students who have a preference for intuition. The instructor, as is typical of college professors [17], is an intuitive. Further study is warranted to characterize the connection between the type of learner, the type of instructor, and the type of portfolio used.

Institutional course evaluation results

The first year portfolios were employed, the instructors of BE 1252 and AE 625 received above average scores regarding the overall effectiveness of each course compared to other courses in the College of Engineering: 3.4/4.0 and 4.2/5.0 respectively. Each instructor taught a second course concurrently with BE 1252 and AE 625, and neither used the student portfolio in the second course. Evaluations for these courses were higher than those using the portfolio (3.5/4.0 and 4.6/5.0 respectively). While there is not enough data to establish a correlation between student portfolios and teaching evaluations, we believe that the difference could be due to the following: (1) student reticence to active learning; (2) student reticence to non-traditional approaches of teaching (3) no evaluation questions regarding innovation or active learning; (4) differences in course content. At the time of writing, results had not been recieved for the second year's courses.

Student perceptions

Many students who found the portfolio method helpful made comments which indicated that the instructors' goals in implementing student portfolios had been achieved. They reported that the portfolio helped them organize their materials, plan their study activities, recall the topics covered in the course, prepare for the Fundamentals of Engineering licensing exam, and use as a professional reference. A sampling of positive comments follows:

- The portfolio made me think about how things in this class are applied to the real world.
- I think that a lot of times after you finish a class, you have no idea of the things that you accomplished. With portfolios, I got a chance to go back through the material and actually see what I did, how I did it, where I finished, and how I have improved my education, social skills, or just developed more into a different person.
- The portfolio was a very useful tool in the class. They make the student responsible for his/her learning.
 - I learned the material in a more personal way by having it in my portfolio.
- The portfolio is... a future reference and a sample of how I have evolved as a student and an engineer.

However, not all students were complimentary of the method. Example negative comments included the following:

- I am not a big fan of the portfolio method. The assignments are what really mattered. The fact that we kept them in a folder doesn't really affect a person's mentality or growth.
- The materials that we had in the portfolio were not the types of things that one needs to save and look back on.
- The portfolio did not help because I usually keep an organized binder for all of my classes anyway.

Finally, several students recognized the benefits of using portfolios but did not think these benefits contributed to their learning:

- I don't think the portfolio enhanced my learning, but it did help me keep a record of my thoughts on it. I think that I learn by doing, and the portfolio provided a journal of what I was

doing.

- I don't think the portfolio enhanced my learning, but the work I put in the portfolio did. It taught me that being organized is very beneficial and not very hard.

Instructor perceptions

We observed that the use of student portfolios shifted the emphasis toward quality work. The resubmission and feedback process made the quality of portfolio assignments the ultimate goal, rather than a one time submission of assignments with no room for improvement. In this way, portfolios offer an important attribute often lost in conventional engineering education. By leading the student through an iterative process with the ultimate goal of "getting it right," while the student is engaged in reflection and communication concerning this process, higher levels of learning are achieved. This process is analogous to the type of work in which an engineering graduate will engage. Thus, we believe portfolios will better prepare engineering graduates for their careers.

Most students demonstrated increased evaluative and creative skills. We were pleased with the extent to which most students used higher level learning skills to complete their portfolios. Putting students in charge of documenting their own learning generally caused them to make challenging choices, to generate novel ideas, and to be motivated. This instrument appears to encourage the use of evaluative and creative aspects of learning, and we believe that students using portfolios will be much better prepared for their careers, and for the life-long learning process.

We noted some student reticence in self-directed learning. Allowing students to take control of their own learning by means of the portfolio was uncomfortable for several of the students. We believe that this struggle is natural because the majority of students' prior educational experiences have not prepared them for taking as active a role in the education process. We realized that not all students embraced the portfolio idea at the outset, but were willing to work on the portfolios, especially with additional instructor support.

SUMMARY and CONCLUSIONS

Although methodologies were different, results were similar for the two courses; 78% of the seniors and 80% freshman found that the portfolios enhanced their learning. The differences between those for whom this method was helpful and those for whom it was not was found to not be based on class rank but rather upon learning style or personality type. Among the freshmen, 69% of those students who were identified as sensing types by the Myers-Briggs Type Indicator found portfolios useful, while 87% of the intuitive types found them useful. We observed that portfolios helped shift the students' emphasis toward quality work, encouraged use of their evaluative and creative skills, and allowed them to take more control of their own learning. However, for some students the process was uncomfortable and required additional instructor support. We recommend that instructors who choose to use student portfolios carefully explain to their students how and why portfolios enhance learning, provide an appropriate level of structure, and help students design and implement effective time management strategies. Future work will involve interviewing employers and employees to assess the role of portfolios in industry, and providing that information to the students as they build their own portfolios.

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