AC 2008-2808: DESIGN PORTFOLIOS FOR OUTCOMES ASSESSMENT AND PROGRAM VISION

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Design Portfolios for Outcomes Assessment and Program Vision

Abstract

The use of outcomes assessment as a foundation for program improvement has become of increasing importance to accreditation in recent years. For years, the US Coast Guard Academy Mechanical Engineering program has showcased its best work and reflected on design in the curriculum by using a design portfolio inspired by those used by artists. The portfolio provides a snapshot of one year in the life of the program by providing examples of design work completed for each level of the curriculum, along with reflections of educators and students. It can be used to address many audiences including administrators, institutional benefactors, politicians, industry representatives, students, teachers, and parents. A proven template is presented which can easily be adopted by other authors. The template was used for portfolios presented during two ABET visits.

Introduction

While the need for assessment based improvements is almost universally accepted by educators, debate still rages as to what is the most appropriate means of assessment. Indeed the very definition of what is and is not an acceptable means of assessment is often at the heart of the debate, usually gaining the greatest scrutiny in discussions surrounding accreditation. This work does not attempt to bring this debate to a close, but focuses on the design portfolio as a powerful tool by which programs can collect a meaningful snapshot of achievement and use it for reflection and improvement.

Portfolios are used in a wide array of disciplines to showcase the best of one's work. In the case of educational programs, the portfolio consists of a collection of works by an entire department or institution as opposed to an individual[1]. In the model described here, the focus is not on individuals or a particular class, but the program itself. It allows for one means of collecting data for a meaningful discussion and assessment. Portfolios may be used to form and communicate a vision for the program, help describe the relation between outcomes for those involved in the curriculum, or to review the strengths of a program in achieving those outcomes. Intended to give a sense of the scope and depth of the design program in under 20 minutes the portfolio can be used to address many audiences. The Coast Guard Academy has used design portfolios to brief accreditors in the past, first during a 1995 ABET accreditation visit and most recently in 2007.

Design Portfolios for conveying a program vision

The portfolio developed by the Mechanical Engineering section at the US Coast Guard Academy is a snapshot of design projects completed in one year in the life of the program. The layout of the portfolio was inspired by the three chapter model put forth by Wilczynski and Colella[1]. The first chapter is a brief two page description of the curriculum goals and program educational objectives. The second chapter is the heart of the portfolio and consists of one section for each year. The overarching design instruction goal of each curriculum year is described and particular

projects are presented. Each presented project has three components: a description of the design goal, a synopsis of the activity, and a narrative reflection of the activity's ability to meet the goal from both the instructor and one or more students. The final chapter is a brief one page epilogue containing reflections of the portfolio author. The portfolio is short on words, and contains pictures and references to actual hardware on display at the Coast Guard Academy. The portfolio is intended to give a sense of the scope and depth of the design curriculum in under 20 minutes.

The fact that the portfolio describes one year in the life of the program provides more subtle benefits. One benefit is that the portfolio can be assembled in one year to provide a reflection on four years of the educational program, as well as the four separate year groups enrolled in the program. This is in contrast to the typical accreditation focus which tracks the development of individual students or classes. The strength of this format lies in its ability to allow educators to step back from the particulars related to one year group's achievement of outcomes and focus on the health of the program as a whole.

The portfolio also provides a means to convey the vision of the program to the faculty who are part of it. At the Coast Guard Academy design is the backdrop of the entire curriculum. While design is not explicitly the focus of all courses, many contribute to knowledge required for successful design practices. For instance, students will draw on their knowledge of all courses for their capstone design project, including strengths of materials, thermodynamics, and machine design to name but a few. The presence of small design, build, and test projects in these courses is intended to help students develop problem solving and design skills in the context of those courses. The portfolio provides a means for instructors of those courses to quickly see how their class contributes to the design goals of the program. More importantly, it allows instructors of core courses who may be from different departments to see the importance of their course to the Mechanical Engineering program. At a small institution like the Coast Guard Academy, where over 50% of students' technical courses are taught by professors outside of the major, this kind of communication is crucial to achieving program goals.

The brief length of the portfolio makes it ideal for communicating the program's vision to constituents and other parties. An obvious benefit to faculty at many institutions is the vehicle the portfolio provides to orient accreditation visitors to the scope of the program. The portfolio also provides a ready means to gather examples for use in career day events and recruiting. It also provides a very portable collection of work for institution administration members and alumni to review the impact of decisions and financial support on the program.

By presenting the overarching vision of the program, the portfolio helps inspire both faculty and students to improve. It is useful in orienting new students and even new faculty to the goals vision of the program. It also provides a means for faculty and students to discuss the importance of these goals and areas for future emphasis which may be otherwise lost in the day to day conduct of individual courses.

Design Portfolios for outcome assessment

The discussion above alludes to many benefits of the portfolio to assess outcomes. While not an assessment in itself, the portfolio is a collection of work and as such provides a means of

reflecting on the program and whether or not projects and courses are aligned with necessary outcomes. Because the portfolio does not contain all student work it is not a method to determine individual student achievement.

The portfolio can help identify the context in which many courses fit into the curriculum. At the Coast Guard Academy a unique matrix is used to map particular course contributions to specific outcomes. Weighting courses on a scale from 'no knowledge development' to 'significant knowledge development' the matrix allows faculty to tailor their course to contribute to the achievement of outcomes by students in their course. The portfolio is one tool which can be used to compare how projects in some courses help achieve applicable outcomes.

The process of gathering information for the portfolio provides numerous benefits which relate to effective assessment. By making an effort to talk to faculty about the curriculum and ask them for reflections on the impact of particular projects, the portfolio provides a natural way to engage colleagues in discussion about the impact of specific courses. Discussions related to portfolio development can foster relations between faculty and offer areas for collaboration in the achievement of outcomes outside of the program's normal assessment procedures.

The portfolio is not intended to be a collection of all work, or to serve as the primary means of assessment. In fact it is quite the opposite. At the Coast Guard Academy a regular process of assessment and improvement already exists for curriculum review. In end of course reviews, items such as course syllabi, exams, and other assessment instruments are gathered and discussed on a regular basis. Program and department reviews require the collection and reflection on the collective course information. This process allows for the specific focus on individual courses and how they fit in the program in the context of individual assignments and outcomes. The portfolio focuses on design related activities and is distinctly different from the process which reviews and implements outcomes. While it can be used as a tool for this purpose, the spirit of the portfolio remains to communicate and celebrate a vision.

Portfolios at the Coast Guard Academy

The Mechanical Engineering section at the Coast Guard Academy developed its first portfolio shortly after the program was established in 1995. At that time the portfolio provided an invaluable means of reflecting on where the program should go and how new courses and established core courses fit into the overall goals of the program[1]. Indeed this portfolio was a tool by which the program developed and its vision was communicated to the institution. Inspired by how the 1995 portfolio's message was still used to communicate the program's goals after 12 years, the 2007 design portfolio was created to show how the program had followed the original vision and how it had improved in quality over that time. The 2007 portfolio was also used to further convey the vision of the program and communicate and celebrate the exceptional design work carried out by students and faculty in the major.

The 2007 portfolio contains three chapters as discussed above. The goal of the first year of the program is to understand design as a process. Students are introduced to the design process and shown how they can conduct meaningful design work even when equipped with limited knowledge of fundamentals. Examples in the portfolio include a Statics project involving the

construction of a floating barge and crane, powered by a DC motor, and an introductory freshman course's bridge competition. The second year of the curriculum focuses on fabrication skills and solving open ended problems. The year goal is to convey an appreciation that engineering problems often have more than one correct solution and build confidence in student ability to tackle such problems. Portfolio examples include the reverse engineering, machining, and construction of a small pneumatic engine in the sophomore Introduction to Mechanical Engineering Design course.

The third year is devoted to component and system design and as such the year goal is to introduce small scale design assignments that focus on the design of a particular component of a larger system. Project examples include the design and fabrication of a solar water heater in the Thermal Systems Design course and the fabrication of working models of small systems in the Mechanisms course. The fourth year is devoted to integration of concepts and capstone design. The goal of this year is to provide students with a design experience that mimics what they can expect in their chosen profession. Projects are chosen to encompass all areas of the student's education. Examples of projects from this year are many and include the design, build, and test of a barge powered by a rat trap for the Machine Design course as well as several examples from the senior capstone design course. Capstone design examples include very successful entries by teams in the FIRST robotics and SAE Mini Baja competitions as well as the design, build, and test of a remote underwater vehicle, which was subsequently used by one graduate to inspect light house foundations for the US Coast Guard.

Portfolios may be developed to reflect different aspects of a program. If implemented annually, portfolios can be quickly collated to reflect the work of a particular course, graduating class, or even an entire accreditation cycle. Used individually portfolios may provide an excellent tool for students to showcase their own work to faculty, fellow students, and potential employers.

As stated above, the portfolio is composed of few words and many examples. The binder itself contains pictures of students in action and actual design deliverables. It also contains examples of student reports where appropriate. It very purposefully is void of course syllabi or homework assignments as it is intended to showcase the very best of student work. Figure 1 gives an example of one page of the portfolio for the second year air engine project.

2.2.1 Air Engine – IMED

2.2.1.1 Exercise Synopsis

The IMED course starts with two weeks on how to undertake a situation appraisal. This involves recognizing concerns, prioritizing, and planning for resolution. One of the main results is the recognition that design is only one of several possible ways to resolve a concern and should not be the first and only solution attempted.

For the first few weeks students are re-introduced to the art of paper and pencil sketching. They learn how to make estimates and justify assumptions, and finally how to carry approximate solutions through to reasonable conclusions and preliminary design suggestions. Invariably these exercises involve open ended and relatively poorly defined problem statements. Typical of 'real world' engineering problems these may be foreign to students and therefore particularly challenging.

With the initial baptism of core design skills complete the course launches into the traditional design sequence and the lab commences with 3D Solidworks instruction. After approximately 5 weeks students enter the machine shop and after safety and instruction from the lab staff commence manufacture of their first two test parts. On completion statistical analysis is undertaken and students gain an appreciation of what tolerances they can obtain and how they compare with industry standards.

The final part of the course involves the drawing and 3D CAD modeling of an operational air engine. Once this is complete students work in teams of two to fabricate the engine from their own drawings. These engines are tested against each other and graded on performance and quality of manufacture.

2.2.1.2 Instructor Reflections

"As an instructor I have decided to focus on the basics whilst stretching cadets' existing knowledge base. Ideally the course would finish with a small independent design exercise but invariably time is not sufficient. That said there is usually the opportunity in the classes leading up to capstone design to put these practical skills to good use." Prof Andrew Foley

2.2.1.3 Student Examples

An example of two of the machined parts from the course as well as an air engine. Examples of other engines and drawings are on display in the lower lobby of McAllister Hall.

Figure 1: An actual page from the 2007 Design Portfolio. Most projects contained more than one page with photos.

An important aspect of the portfolio is the reflection section for each entry. Here instructors and students take a step back and reflect on the purpose of the projects away from the pressures of day to day administration of such assignments. Reflections often lead to improvements and fruitful collaboration. An example of an instructor reflection on an experimental design project from the Experimental Methods course reads:

> "This experiment provides an opportunity for the cadets to participate in the experiment design process-"from scratch"--for the first time. As with any first-time process, this raises the possibility that the experiment might not work--for any of a number of reasons. The pressure to get it right within the time allowed forces the cadets to carefully reason through the entire experimental process..."

A reflection from a student working on the Machine Design project reads:

> "The team learned from previous experience (last year's project) that starting early on required tasks was a good idea. Therefore, the group made good use of it's time during the week instead of saving everything for the night before the due date. For future reference, the earlier tasks can be completed, the better in the long term. Because the report is so detailed, it takes a lot of time in order for it to be done right..."

Reflections were also gathered from students not directly involved in the projects. Each year the Coast Guard Academy holds a research symposium in which seniors present their capstone work to the underclass. After watching a presentation on the remote underwater vehicle project, a sophomore reflected in a follow on essay:

> "This project captured my attention last semester when I first heard it was being offered…I was amazed by the ability of the team to work in such tight time constraints and with a very limited budget"

Reflections and Results

The 2007 Design Portfolio proved extremely useful in encouraging collaboration, fostering faculty relations, communicating the program vision, and demonstrating achievement to accreditation visitors, administrators, and students.

Early discussions about creating a portfolio led directly to a significant collaborative effort between instructors in the freshman introductory Statics course and the senior Machine Design course. The result was the development of two projects which involved the construction of a floating device to complete the task of lifting a weight out of a body of water. What was unique about the collaboration was the effort to relate the projects together in such a way as to highlight the breadth of skills developed over the four year Mechanical Engineering program. Seniors presented their findings and analyses to freshman who now had a deeper appreciation for what was being discussed. Additional information is contained in another paper submitted to this

conference, “Demonstrating the Value of Undergraduate Analysis Skills Using A Common Design-Build-Test Project For Freshmen and Seniors”.

The portfolio development process provided an opportunity to engage faculty from many programs on the importance of their courses to the Mechanical major. Many commented that they were not aware of the level of importance of projects in their courses to achieving overall curriculum outcomes. The process inspired the development of a joint project in the Mechanisms and Thermal Systems Design courses to integrate a solar tracking device onto the solar water heaters mentioned above.

The portfolio’s most ostensible benefit was its power to communicate the exceptional work of the program. The 2007 portfolio was used along with the 1995 edition to demonstrate significant program improvements to accreditation visitors. The breadth and quality of student participation in design projects throughout the curriculum was frequently commented on during the visit. Faculty and student enthusiasm, particularly related to these projects, was also cited as a strength. The portfolio is routinely used during tours and recruiting functions. One senior institution administrator remarked with excitement that they had no idea of the successes of the Coast Guard Academy FIRST robotics and Mini Baja teams until seeing the portfolio and hardware. This was one of many examples of the effectiveness of the portfolio in conveying the relevance of the program to the institution.

The portfolio had the benefit of conveying to students the significance of their achievements. During a collection of feedback for the Machine Design and senior capstone design projects one student remarked: “[These courses] helped me appreciate what I have learned and provided me with a chance to look back and go ‘wow, I can’t believe how much I can do that I never even knew existed’ ”.

[1] Wilczynski and Colella. “Using Design Portfolios to Improve Design Education.” Proceedings. 1996 Annual Conference. ASEE. 1996. Session 2625.