AC 2004-17: EARLY REFLECTIONS ON ENGINEERING WEB-BASED PORTFOLIOS

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Abstract

During a four or five year undergraduate education, engineering students produce a variety of materials that are indicative of their knowledge and skills. Current digital technologies enable the storage and presentation of such materials in an easy to create and easy to access format. At the University of Texas at Austin, we are developing a web-based tool for undergraduate engineering students that provides an environment for them to display and reflect on their engineering accomplishments. The electronic portfolio system (http://pf.engr.utexas.edu) is now available to all students in the College as a result of three years of development.

While we are confident that the portfolio system will enrich our students' university experiences and prepare them for a career in engineering, we have faced a number of challenges that we would like to share in this paper. First of all, since various portfolio activities are in development across the country, we are seeking ways to substantiate our principles in an approach that does not reinvent or overlook important features of other established methods. Secondly, we will share a number of technical issues we faced in creating a web-based tool for undergraduate use (security, storage, etc.). Third, we discuss the difficulties in getting students and faculty to voluntarily adopt the portfolio tool and to incorporate it within their course materials. Finally, we conclude with the current issues we are facing and our future plans.

Introduction

In the last ten years, rapid developments in computers and digital technologies (such as the Internet) are influencing instructional practice. Online portfolio systems are a culmination of technological advances and current curriculum reform efforts. While a dictionary definition of portfolios still describes a paper-based tool (A portable case for holding material, such as loose papers, photographs, or drawings.) [1] many of today's portfolios are electronic and can store a variety of multimedia files. Lankes defines electronic portfolios as a "purposeful collection of student work that exhibits the students' efforts, progress, and achievements." [2] Portfolios have been in use for a long time in disciplines such as art or photography and in K-12 education, yet they are still relatively new in other disciplines such as engineering and in higher education. ABET 2000's Criteria 3[3] identifies portfolios as one method of documenting and assessing student outcomes. Others suggest that an electronic portfolio is a student tool "that

highlights abilities, achievements, and intellect."[4] Furthermore, there are concerns that assessment should move beyond multiple-choice and highly structured measures and as such, portfolios are seen as a means to showcase students' problem-solving skills and their ability to analyze and synthesize information.

In the College of Engineering at the University of Texas (UT), an electronic portfolio system called Polaris is in use and undergoing iterative development. This system developed in house has been created so that students can document their educational progress and share what they have accomplished with an audience (i.e., their professors, their peers, prospective employers, their parents). By using Polaris, students have a tool to record their course work, present projects, and evaluate their own educational progress.

Polaris benefits students by giving them a personalized yet professional looking website. Also, the system provides students with a forum to reflect on the "whys" of their course work and their development as engineers, thus giving them a better sense of how they fit within the larger realm of engineering. Through this reflection, students are better able to present their interests and skills, not just through the materials they present on the website, but also in conversation with recruiters and faculty. Furthermore, the portfolio system can benefit an academic institution by facilitating student advising and collecting accreditation materials.

Background

Across the higher education landscape, electronic portfolios are emerging. Interest in portfolios is evident, "We often hear [electronic portfolios] associated with assessment, but also with accreditation, reflection, student résumés, and career tracking. It's as if this new tool is the answer to all the questions we didn't realize we were asking."[5] Given that technology is prevalent on campuses and a significant portion of what students produce is electronic, it stands to reason that electronic portfolios are appealing. Not only can portfolios be useful for students, but they can also "become catalysts for change and institutional improvement, while also serving as multimedia self-studies for accountability and accreditation."[6] The American Association of Higher Education (AAHE) has a website[7] with a searchable database on current portfolio information and resources, and AAHE participates in an initiative to develop a prototype portfolio with six universities called, "The Urban Universities Portfolio Project: Assuring Quality for Multiple Publics." [8]. Universities, technology vendors, and publishers are currently developing electronic portfolio tools because of their budding usage and the notion that they may in fact become, "the biggest thing in technology innovation on campus. Electronic portfolios have a greater potential to alter higher education at its very core than any other technology application we've known thus far." [5]

Literature on portfolios often makes the claim that they can be "powerful tools" when it comes to learning and assessment. Four basic electronic portfolio characteristics highlight how these tools have the potential to transform information into knowledge:

- Portfolios can feature multiple examples of work.
- Portfolios can be context rich (by providing detailed descriptions).

- Portfolios can offer opportunities for selection and self-assessment.
- Portfolios can offer a look at development over time. [9]

A review of the literature on electronic portfolios suggests a number of advantages: electronic portfolios promote learner self-evaluation [10], result in students taking more responsibility for their own learning [11] and throughout the process [of using a portfolio] they are actively involved in their own assessment. [12] While there are many perspectives on portfolios from numerous disciplines, a search using the terms "electronic portfolios" and "engineering education" on the engineering web-based information service, Engineering Village 2, resulted in 75 citations (papers published from 1990 to 2004). Most of the papers reflect that, "Efforts to initiate student portfolios in engineering instruction have been reported anecdotally in the literature, but a formal study on student portfolios in engineering has not been presented"[13]

There is real value, however, in papers and information that describe the process and issues related to electronic portfolios. At Stanford, for example, the Folio Thinking Project is a collaborative effort of six research groups at three universities: the Royal Institute of Technology (KTH), Uppsala University, and Stanford University. Their efforts are based on the premise that "the reflective practice of creating portfolios enables students to document and track their learning; develop an integrated, coherent picture of their learning experiences; and enhance their self-understanding." [14] In January of 2003, the Open Source Portfolio Initiative (OSPI) [15] was founded to lead the way in providing open source electronic portfolio software and to promote wide spread use.

Development of Polaris

Early in 2001, the mechanical engineering faculty at UT met to brainstorm specific activities to work under the PROCEED (PROject CEntered EDucation) initiative. This initiative, sponsored in part by the Ford Motor Company, seeks to foster more projects within the courses offered in mechanical engineering.[16] Project PROCEED involves curricular innovations at all levels of the undergraduate mechanical engineering degree and is intended to encourage both teachers and students to focus more on course projects. The envisioned portfolio system was seen as a way to track PROCEED's accomplishments for both students and faculty.

As seen in Table 1, the first year of the project was consumed with establishing a clear vision for the portfolio project. From the beginning of this endeavor, efforts have been made to gather input from various stakeholders. A committee of faculty and instructional developers was formed to review feasibility and to make recommendations on how to proceed. During this process, the committee examined existing engineering portfolio projects and discussed how the site would be maintained, how much freedom should be allowed in creating such portfolios, and how security and plagiarism would be handled. Dr. Matthew Campbell, chair of this committee, organized an optional course for seniors interested in developing an online portfolio of their accomplishments. The course met one hour a week and learned about traditional portfolio design as well as web design basics. At the end of the course, students had a complete website that showcased their undergraduate accomplishments. The websites, however, were not of a professional quality; many suffered problems indicative of novice web developers. For example,

Table 1: Timeline for the Development of Polaris

Period	Accomplishments
Spring 2001	• Project conceived. • Committee formed. • Goals and Objectives formed.
Summer 2001	• Initial research with undergraduate research assistants.
Fall 2001	• Course offered to seniors. • Decision to develop dedicated online system.
Spring 2002	• Development of website.
Summer 2002	• Development of website. • Initial testing in Technical Communications class.
Fall 2002	• Opened to all mechanical engineering seniors. • Three workshops in latter half of semester. • Results presented at ASEE03
Spring 2003	• Contest for best portfolio. • Refinement based on feedback from Fall03 workshops. • Opened to all mechanical engineering undergraduates
Summer 2003	• Testing of reflective questions in Tech. Comm. class
Fall 2003	• Released college-wide (all engineering departments). • Promotional CD mailed to all faculty. • Presentations to faculty and students group leaders. • Reflective questions implemented.
Spring 04	• Promote further development of individual portfolios. • Implement general reflective questions.

pictures were too large, pages were not well formatted, and the content was presented in a cryptic manner. The results of the course indicated to the committee that a customized web solution would be necessary to help the students.

In 2002, efforts were focused on implementing the portfolio system. We strived to develop a system that met three goals. The website had to be *fun*. It had to be *easy to use*. And, it should leave the students with a professional website that they would be *proud of*. Creating a web-based system to create webpages proved to be a delicate balance of usability versus variability. If students were given complete freedom to design pages anyway they wished (choosing colors, layout, and connectivity between pages) then the process would be more arduous and the product more prone to error and disorder. Reducing the freedom in creating webpages allowed for pages to be created easily while maintaining professional results, but as a consequence all pages would look similar. Our tradeoff tended towards less variability to maximize the ease of use and professional results.

In the summer of 2002, we performed the first test of the portfolio system with students in a mechanical engineering Technical Communications class. This is a mandatory class focused on technical writing for engineers usually attended by junior level students. The test session provided data on how to improve the system in time to make it available to all senior mechanical engineering students in the fall of 2002.[17]

Through several promotional workshops in the fall of 2002 (where pizza was provided as incentive), senior mechanical engineers logged on to Polaris, and began constructing their portfolio of academic accomplishments. A total of 34 mechanical

engineering students participated and responded to a one page questionnaire. When asked to list the ways the electronic portfolio could benefit them, most of the responses indicated that it would help with job searches. Some did note, however, that it can help to showcase their school work and as one suggested, "It can be a place to find out my standing among my contemporaries with regard to projects and assignments." The ability to "quickly organize work" was something all students thought the portfolio would do.[18] Additional feedback was gathered to further improve the web-based portfolio.

In 2003, the portfolio system was opened to all engineering students. Since developing a portfolio is strictly a voluntary activity, many of the efforts focused on promoting the system to our undergraduate student body. Figure 1 shows a graph of the number of portfolios created in the last two years. As the graph indicates, the number of portfolios more than doubled in 2003. We held additional workshops, organized a contest for the best portfolio with a $300 cash prize, and hung flyers in the mechanical engineering building describing the system. It appeared that nearly all students had initiated a portfolio through one of the organized workshops or as a result of a particular course project. Faculty members of the original portfolio committee championed the portfolio by bundling its usage within assignments they were currently offering. In some instances, adding a project to their portfolio was mandatory; in others, students were given extra credit. This fact led us to create a multimedia CD-ROM presentation for faculty to show in class to undergraduate students to make them aware of the benefits of creating a portfolio of their engineering accomplishments. The six minute presentation is targeted to courses that include one or more projects since projects done within

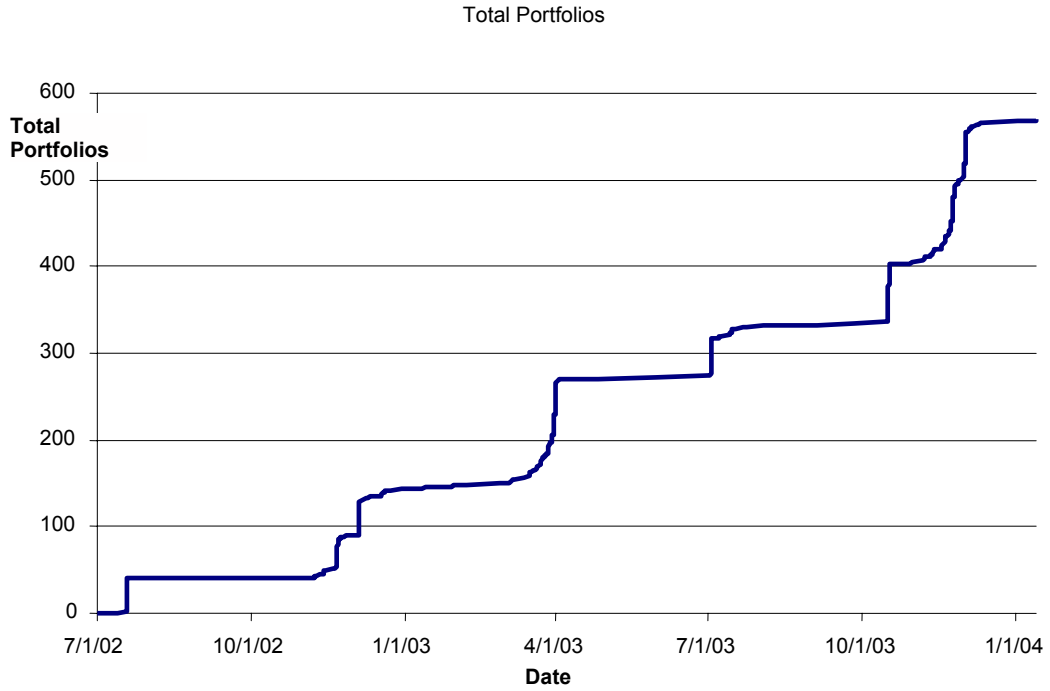

Figure 1: Despite the Polaris being a voluntary activity, the number of portfolios drastically increased in 2003.

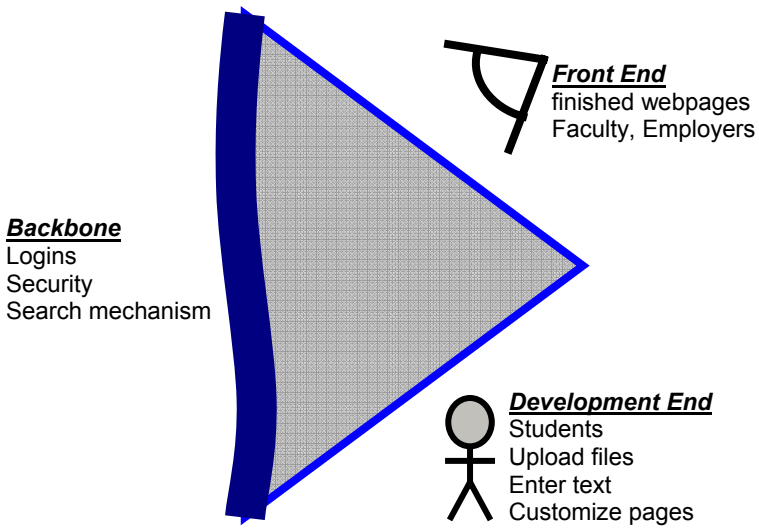

Figure 2: The Polaris web-based system has three main aspects: a development side used by the students to create webpages, a front end, which is viewable by the general public, and a backbone which manages accounts performs searches and retrieves webpages.

engineering courses, summer internships, and extracurricular engineering activities are valuable components in a good engineering portfolio. We hope that the CD-ROM will be shown throughout the College of Engineering, so that all undergraduate engineers will be aware of this useful tool.

Furthermore, the portfolio system was augmented by a series of reflective questions aimed at helping students create concise and informative descriptions of their accomplishments. This reflective aspect is becoming the main focus of our recent developments in the Polaris portfolio system. In 2004, we hope to develop an extensive set of webpages to initiate a "dialogue" with the student to inspire them to reflect, question, and reaffirm their decisions in pursuing an engineering education. The hope is that they not only gain purpose in their quest for an engineering degree, but that their drive is perceived by the phrasing and overall quality of their portfolio.

Current Polaris System

The portfolio system is more complex than a series of webpages. Figure 2 shows a simple way to visualize the Polaris system. There are three main sides to the website. The front end of the website is accessible by the general public (http://pf.engr.utexas.edu). The introductory page, shown in Figure 3, is targeted to a general audience of potential employers, faculty, and students' acquaintances. Further description of this side of the system is discussed below in Section 1. The development side where students spend most of their time creating their portfolio is accessed from the Polaris main page with the button labeled "Login in with UT EID" (see Figure 3). This launches the portfolio wizard which is described below in Section 2 and is accessible to those who have a UT electronic identification. The final side of the portfolio triangle is the backbone of the website. This side of the system manages the interactions of the other

Figure 3: The Polaris homepage is located at http://pf.engr.utexas.edu

two sides and has been developed by specialists using ColdFusion[17] and Microsoft SQL Server.

1. *Polaris Public Site*

All individual student portfolios are publicly accessible from the homepage shown in Figure 3, as well as through unique web addresses. The basic format for a student's portfolio is to first show the student's picture and brief biography. In this way, students can indicate to their audience their strengths and interests, and guide them through their projects. Figure 4 shows an example student homepage.* As can be seen in the website, the student has links to a number of different projects including relevant extracurricular activities, and work experience. He also has a page created for detail

* The names of the students have been changed for their protection.

contact information, and for downloading his résumé. These two pages are created along with the homepage and one project during the initial session with the development wizard discussed below.

Figure 5 shows an example project page from the student's portfolio. Project pages are the basis for the portfolio and also the most demanding elements for both the

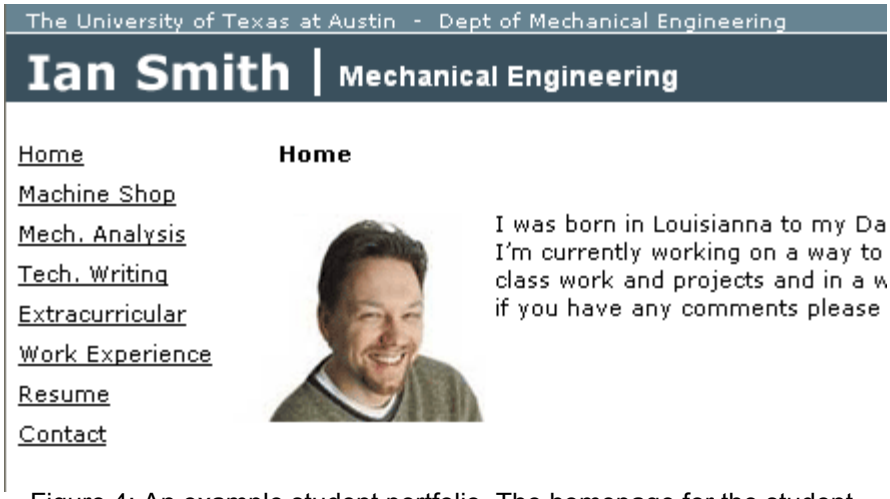

Figure 4: An example student portfolio. The homepage for the student includes his or her picture, bio, and links to projects.

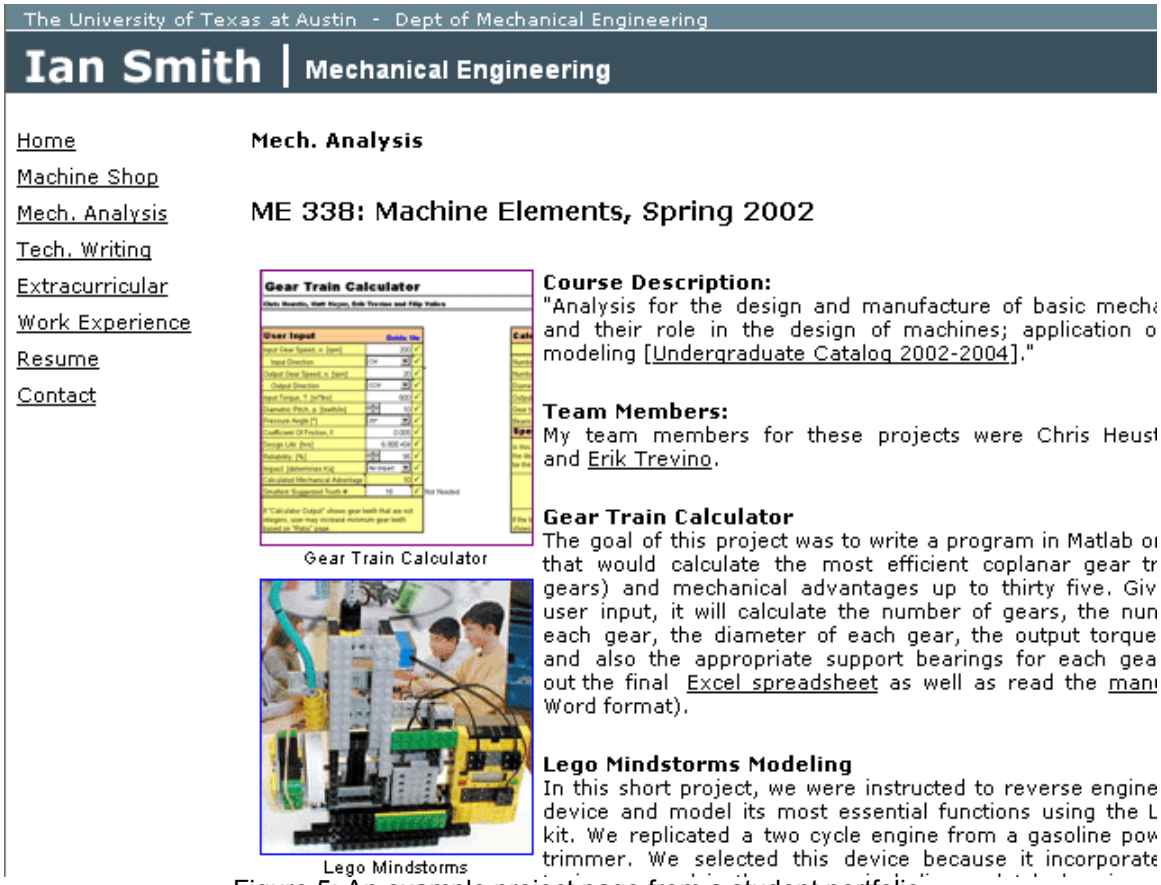

Figure 5: An example project page from a student portfolio.

student developers and the web audience. Since the portfolio is intended to show the strengths and interests of the student, care needs to be taken in writing the description. As is typical for a webpage, various pictures should be used to quickly convey what was accomplished. Often however, students may lack the expertise in knowing what pictures to include if any are even available for the project. This student cleverly uses a screen capture of the developed spreadsheet and stock photography from a related website. In addition to the challenge of adding pictures, the student must also focus on what a clear abstract should say about the project. All the details of the project are most likely not of interest to the web audience, so the student must carefully plan the text so that he/she communicates the newly found skills and interests.

The simple and professional look of the website is maintained through all student pages allowing someone to quickly move about a portfolio to gather the essence of a student's capabilities. While the layout is constant through Polaris, students are free to choose from numerous color schemes for their particular portfolio.

2. Wizard and Development

When students log on to Polaris, they are directed to a series of pages that guides them in creating their website. The wizard takes about 20 minutes to complete if the students are prepared with the proper materials, and leaves them with a fully functional portfolio that consists of four basic pages: a homepage (such as the one shown in Figure 4), and résumé page, a contact page, and one project page. Figure 6 shows the first page in the introductory wizard. On the left side of the page, one can see the various tasks involved in the wizard as well as the progress towards completing the basic steps. After completing the wizard, students can return at any time to modify or add to their portfolio. We are encouraging students to update their portfolio often as it will save time in the future, and will convey their most recent accomplishments to potential employers.

As discussed above, the most difficult part of a constructing a portfolio is deciding what should and what should not go on a project page. Many students breeze through the first few steps of the wizard, and then get stuck in creating their first project. Students are perhaps surprised or intimidated by a text box asking them to summarize their project. As a result, we have recently implemented a series of webpages that preps the student for drafting a project synopsis as shown in Figure 7[†]. The dialog in Figure 7 starts with simple questions about the affiliated course and the size of the project team. This is followed by a series of checkboxes where the student reflects on what was learned in the course of the project. In fact, the items under "What did you learn or experience?" are a rewording of ABET criteria. This is followed by a list of specific mechanical engineering skills (this will be substituted for other lists from other engineering disciplines) that were gained as well as querying what software was used. The final set of questions focuses the student on things that can be included in the summary of the project. By asking students, "What would you do different?" and "How does it relate to real-world applications?" we are hoping that students provide insightful answers that display what they gained from doing the project.

[†] Figure 7 is a concatenation of screenshots from three consecutive webpages.

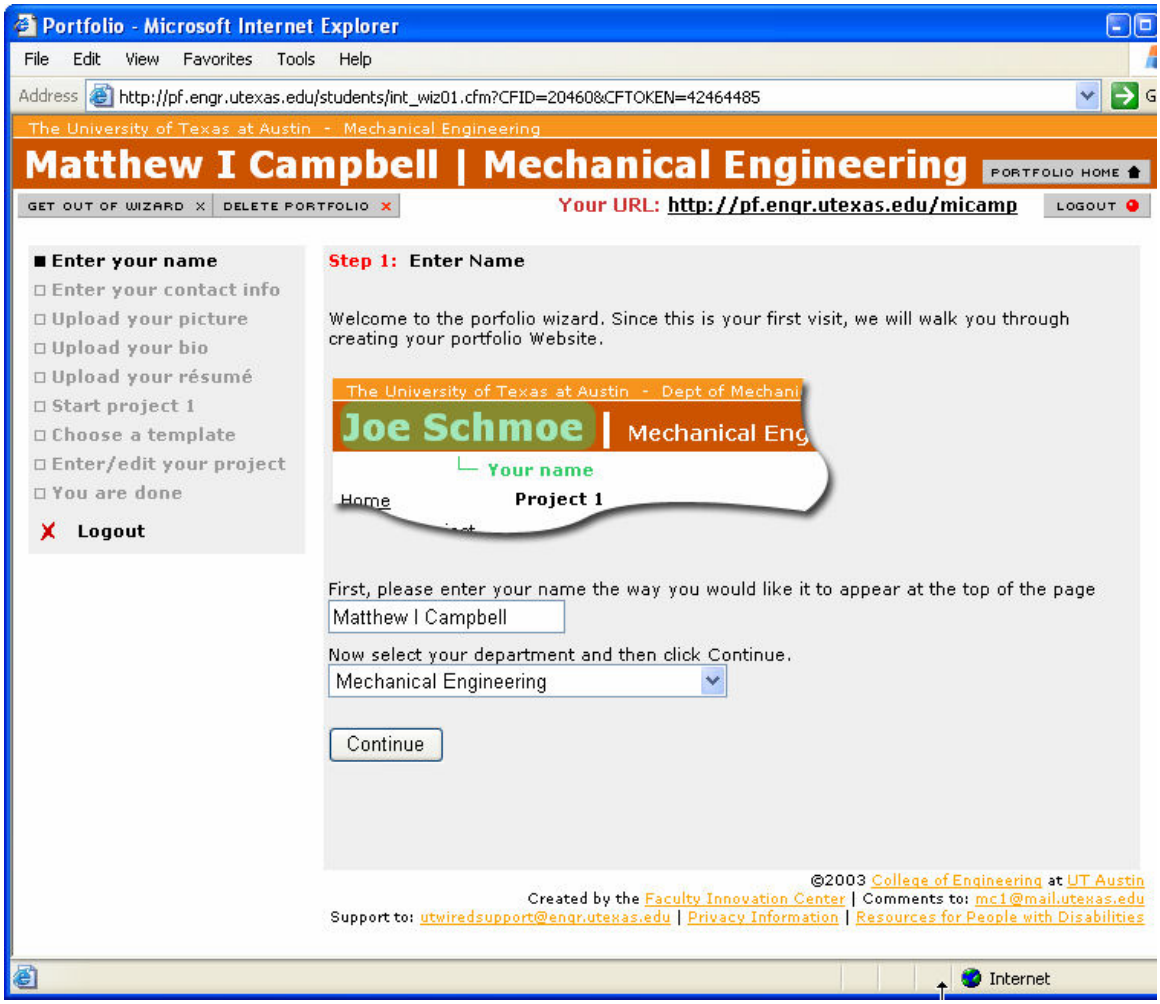

Figure 6: A screenshot of the first step in the nine step introductory wizard.

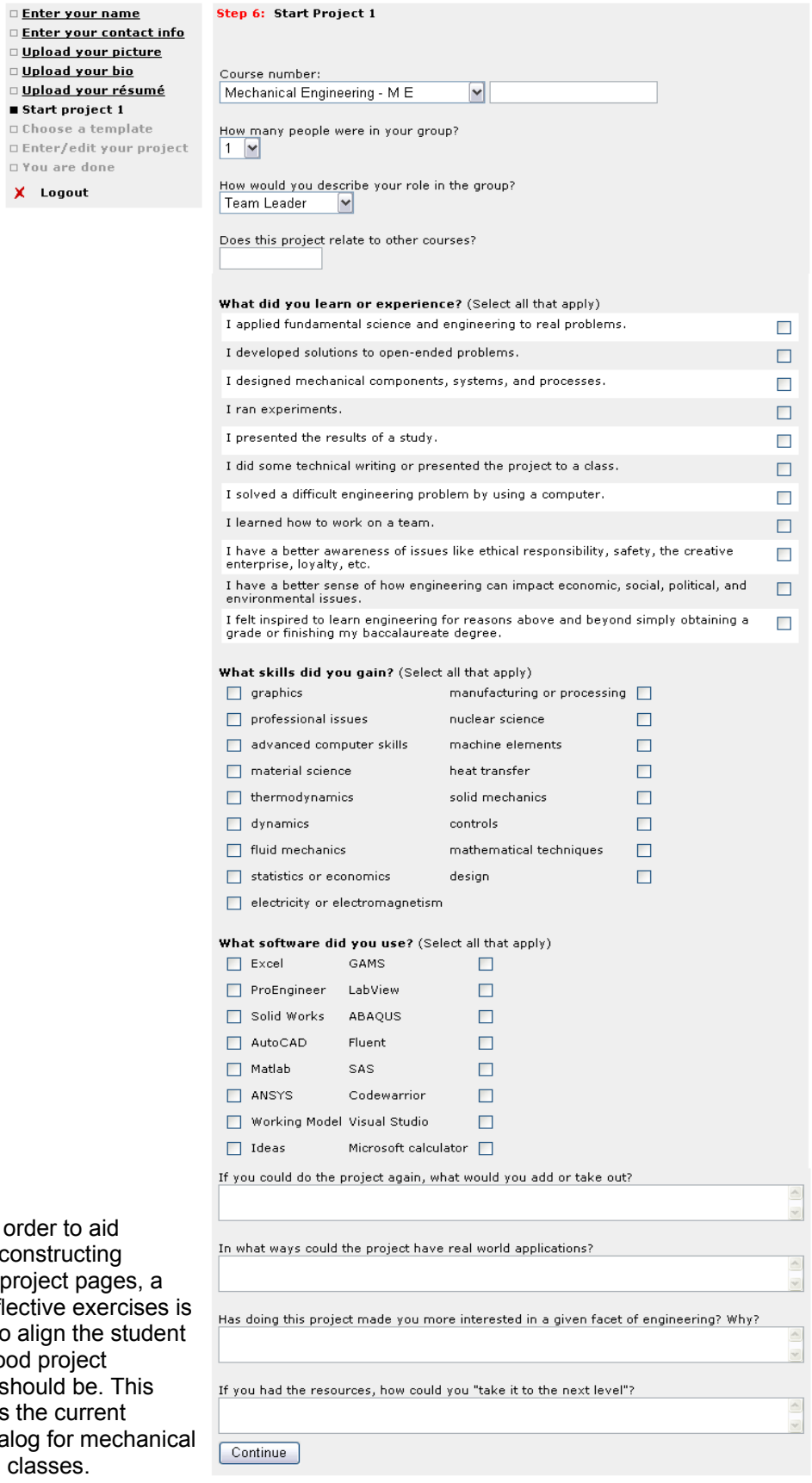

Figure 7: In order to aid students in constructing informative project pages, a series of reflective exercises is performed to align the student to what a good project description should be. This figure shows the current reflective dialog for mechanical engineering classes.

The development end of the webpage is the focus of most of our revisions, as this is where students have provided the most feedback, and where we can direct the quality of the student project pages. In the future we are hoping to add more dialog pages such as those shown in Figure 7, to encourage students to reflect on their engineering education.

Reflections

After developing the portfolio system in the past three years, we have gained valuable insight into how well an online portfolio system works in engineering. Additionally, we have also administered a number of surveys to the student users of Polaris to discover ways to improve the system.

Since Polaris is an optional tool, we asked students if they had any suggestions on how the portfolio can be integrated into their coursework. The students mostly suggested that professors could require some of the assignments to be submitted electronically to the portfolio. A few students thought that their classmates might need incentives like extra credit. One student suggested, "It can be integrated by asking us to write the things we learned from a particular course." One, however, suggested. "I think it should not be a part of the coursework, but a part of the senior year where we need to have a Website to sell ourselves." Another offered this perspective, "However, another student stated, "…introduce it early and have it part of the submission for grading." One student suggested a workshop portfolio class at the sophomore level. Another student wrote that "if it is integrated into coursework then usage will become a tiresome process to the vast majority of student. Keep it an option."

The students were asked to suggest any features they would like added. Responses ranged from "more customization buttons" to "spell check" to "assistance with amount of Web storage space." Given that the portfolio is a dynamic environment, many of the requests have been added. A few suggestions were not technically feasible. A couple of students were curious about privacy issues and one wrote, "I don't feel comfortable showing my résumé to the public." The public does have access to these portfolios and students are not required to post a résumé. Future iterations of the Polaris may include sections that students can keep private and share only if they so select.

During the summer of 2003, 23 mechanical engineering students were introduced to Polaris and then asked to comment on the new reflective exercise shown in Figure 7 to precede the project construction pages. For each question in the exercise, the students were asked two things: was the question clear and was the question useful in writing their summary? Of the 23 students taking the survey, 19 confirmed that the exercise was useful in constructing their project pages. Additionally, we asked these students to describe how answering these questions helped them communicate what they have learned. Many of the students agreed that such questions, "organize your ideas with guidelines." One student noted, "[They] allow me to think about the project as if I were describing it to a stranger"; another stated, "They make me think about what I've learned so I can communicate about it effectively." These comments assure us that the effort required to respond to these questions does have a payoff. A few students offered some additional questions to be included. Suggested questions included "how much time was spent on the

project?", "was the project worthwhile?" and "how did group dynamics affect the group?." Students were also asked how much time they would commit to their portfolio each semester and while there was not a consensus, generally they were comfortable with a couple of hours. Only one student wrote they would spend "quite a number of hours. I think it is useful." The last survey question asked students if they thought portfolios were relevant in engineering education and, for the most part, many saw connecting with potential employers as the biggest benefit.

In general, portfolios can enrich an engineering education in several ways. First, portfolios are useful in that they provide students with a bookkeeping center which allows them to keep track of their courses, projects, and educational objectives. Second, students are able to use the portfolio not only to keep track of courses they have taken, but also to reflect on their development as engineers. This reflective aspect of the portfolio system can facilitate the advising process between faculty and students and give the department valuable information in assessing our effectiveness as educators. Finally, an electronic portfolio gives students a chance to showcase their best work, demonstrate their accomplishments to potential employers, and ultimately attract better job opportunities.

There are also a number of benefits that a portfolio system can have to the faculty of engineering. Namely, the portfolio system can facilitate student advising and can be useful for collecting ABET materials. In fact, the current implementation leverages the ABET criteria to help students establish a clear description for their projects and experiences. We are hoping that when students stop and reflect on the "whys" of their course work and their development as engineers, they will leave our program with a better sense of how they fit within the larger realm of engineering.

There are, of course, a number of tough challenges that we have been facing in developing Polaris. First of all, it is difficult to publicize this voluntary tool to the students. Eventually, we would like students to spread the word about the portfolio system and help to establish Polaris as part of the tradition of the engineering education at UT. But, even with over 500 current portfolio users, we notice that students are weary of the extra work being offered to them from the "administration." Contrary to this view, it is possible, that if the Polaris becomes an integral part of our undergraduate program, communication can be greatly improved between students and faculty. Both students and faculty have indicated how beneficial Polaris would be in student advising since a student's portfolio could provide a basis for discussing with an advisor what is best for their education.

Second, the concern of adding extra work to a student's engineering education is substantial. Some faculty may feel that students are not going to do anymore than is already expected of them. Having students become web designers is clearly not an expectation. This thinking relates back to our initial goals which are to make Polaris *fun*, *easy to use*, and *professional looking*. The success of the system depends on accomplishing these goals. We have improved Polaris multiple times in the past two years, and, we believe, our success is directly linked to how well we are meeting these goals. The reflective exercises that are being implemented in the latest version of Polaris actually provide a means of accomplishing these goals. While it may seem that we are simply asking students to do more work in completing such exercises, we feel that

students will save time in the long run by learning how to better describe themselves. The exercise breaks down the daunting task of writing a project abstract to manageable tasks which can be assembled into coherent project statements. The survey results seem to indicate that students are welcoming such simple exercises.

Third, a number of technical challenges continue to disturb the portfolio system. As the number of student portfolios grows we are faced with issues such as increasing storage space and maintenance. We are currently making plans to accommodate portfolios for each undergraduate student from the time they initiate it in their freshman year until three years after they graduate. Fortunately, the portfolios are not large since they generally consist of only of a handful of pages and less than two dozen images (at most 25 MB). Since maintaining a portfolio long after graduation is also desirable, we are looking at ways students can export their portfolio to CD-ROM or to another website. We also are concerned about hosting student pages that may contain confidential course material or objectionable material. Censoring student portfolios may require constant vigilance and even legal backing, but ignoring such hazardous sites may demean the overall quality of the portfolio system. Finally, such maintenance requirements will demand staff hours be set aside to keep the system running smoothly in the future.

In general, the first three years of developing Polaris have been rewarding. We believe that it is an opportune time to initiate such a system in our undergraduate student training as others nationwide have begun similar projects. The usefulness and ubiquity of the Internet combined with the focus on active-learning and project-based education makes portfolios an ideal innovation. Furthermore, we hope that we can inspire and guide our students by simply having them create a portfolio. At a large institution such as The University of Texas, it is difficult to give each student the attention they deserve. If, in some small way, students are able to direct themselves to a fulfilling engineering career by merely creating their website and reflecting on their progress, then online portfolios can be more meaningful than acting as a simple journal or extended résumé.

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