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Polaris: An Undergraduate Online Portfolio System that Encourages Personal Reflection and Career Planning*

MATTHEW I. CAMPBELL and KATHY J. SCHMIDT
College of Engineering, The University of Texas at Austin, 1 University Station, C2200, Austin, TX 78712–0292, USA. E-mail: mc1@mail.utexas.edu

Portfolios and other assessments of student achievement are proving to be important topics of concern in engineering education. While portfolios have a long history in other disciplines, their use in engineering is fairly new. This paper provides a case study on the development and implementation of electronic portfolios in engineering education through our Polaris system built specifically for undergraduate engineering students. The end goal of Polaris is to provide students with a presentation of their academic accomplishments in a variety of multimedia formats on a professional looking website. While there are many web-development tools for creating a portfolio, the distinguishing characteristic of Polaris is that it specifically engages engineering students in developmental exercises to help them understand their budding professional skills. This case study provides background history and reveals issues that are germane to creating a developmentally appropriate resource to enhance engineering students' scholastic experiences.

INTRODUCTION

RAPID DEVELOPMENTS in computers and digital technologies such as the Internet have influenced 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], today many professionals from a variety of disciplines have an online portfolio to showcase their talents in various multimedia formats. 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 and photography and in K-12 education, yet they are still relatively new in many higher education disciplines such as engineering. ABET 2000's Criteria 3 identifies portfolios as one method of documenting and assessing student outcomes [3]. Others suggest that an electronic portfolio is a student tool 'that highlights abilities, achievements, and intellect' [4].

In the College of Engineering at The University of Texas at Austin (UT), an electronic portfolio system called Polaris is in use and undergoing iterative development. This in-house system allows students to document their educational progress and to share what they have accomplished with an audience (i.e., their professors, peers, prospective employers, and 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 benefits an academic institution by facilitating student advising, degree planning, scholarship and grant applications, and the collecting of accreditation materials.

This paper provides a case study on the development and implementation of electronic portfolios in engineering education. It begins with background on portfolios and then provides an overview of our iterative development approach to an electronic portfolio. Next we describe the specific features created for engineering students. We include student perspectives on our portfolio and we conclude with future challenges and issues.

BACKGROUND

Across the higher education landscape, electronic portfolios are emerging. Interest in portfolios is evident, as Baston indicates by stating: 'We often hear [electronic portfolios] associated with assessment, but also with accreditation, reflection,

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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 [9]:

- 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.

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].

PORTFOLIOS IN ENGINEERING

While there are many perspectives on portfolios from numerous disciplines, engineering views tend to agree on the benefits of using portfolios. 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]. That is not to say, though, that portfolios are not being examined in engineering curriculums. Brodeur states that the use of engineering portfolios is on the rise and they are being used to 'assess specific learning experiences within a course or program, the entire set of learning objectives of a single course, entire programs, or combination of these' [14]. Empirical studies of these efforts may be lagging for a variety of reasons, but there is real value, however, in papers and information that describe the process and issues related to electronic portfolios.

If we are to successfully integrate such resources into our students' experiences, we can learn a great deal from the insights gained from these innovations. 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' [15]. In January of 2003, the Open Source Portfolio Initiative (OSPI) [16] was founded to lead the way in providing open source electronic portfolio software and to promote widespread 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 hands-on projects within the courses offered in mechanical engineering [17]. 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 and hands-on activities. The envisioned portfolio system is seen as a way to track PROCEED's accomplishments for both students and faculty. Table 1 shows a synopsis of the significant development achievements made in the past three years.

Early in the development process, we strived to develop our system to meet three goals. The website should be *fun*. It should 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 web pages proved to be a delicate balance of usability versus variability. If students were given complete freedom to design pages any way they wished (choosing colors, layout, and connectivity between pages), then the process would be more arduous and the end product more prone to error and disorder. On the other hand, reducing the freedom in creating web pages 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.

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 2004	• Promote further development of individual portfolios. • Implement general reflective questions.

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 engineering 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 distributed flyers, organized a contest for the best portfolio, and held workshops. We also targeted faculty members by creating 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.

Recently, the portfolio system was augmented by a series of reflective questions aimed at helping students create concise and informative descriptions of their accomplishments. In 2004, we are focused on developing an extensive set of web pages 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 demonstrated by the phrasing and overall quality of their portfolio.

CURRENT POLARIS SYSTEM

The portfolio system is more complex than a series of webpages. There are three main sides to the website. The front end of the website is

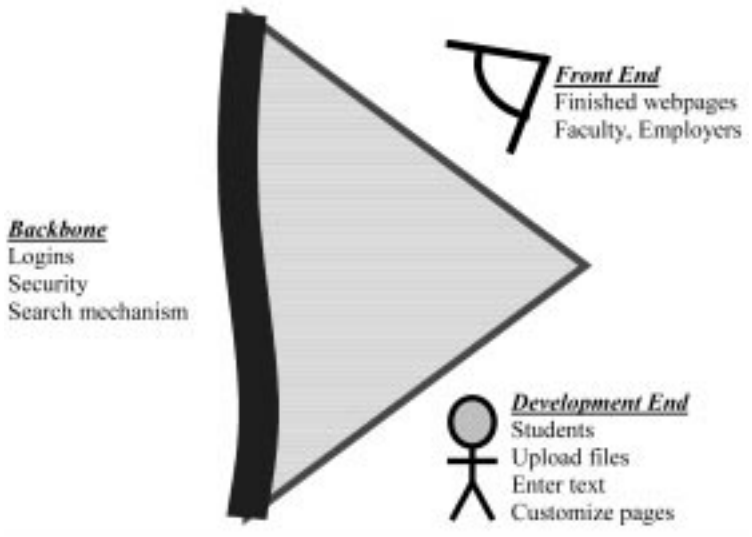

Fig. 1. Despite Polaris being a voluntary activity, the number of portfolios increased considerably in 2003.

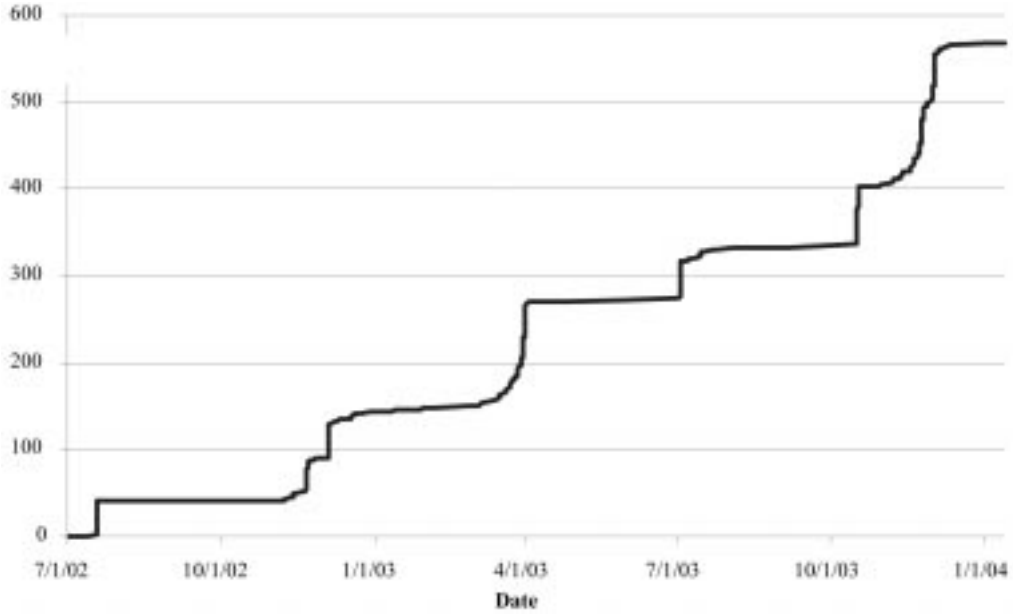

Fig. 2. The Polaris web-based system has three main aspects: a development side used by the students to create web pages, a front end, which is viewable by the general public, and a backbone which manages accounts performs searches and retrieves web pages.

accessible by the general public (http://polaris.engr.utexas.edu). The introductory page, shown in Fig. 3, is targeted to a general audience of potential employers, faculty, and the students' acquaintances. Further description of this side of the system is discussed below.

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 Fig. 3). This launches the portfolio wizard which is described below in Section 5.2 and is accessible to those who have a UT electronic identification. The final side of the portfolio system manages the interactions of the other two sides and has been developed by specialists using ColdFusion [18] and Microsoft SQL Server.

Polaris public site

All individual student portfolios are publicly accessible from the homepage shown in Fig. 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 can guide them through their projects. Fig. 4 shows an example student homepage. (The names of the students have been changed for their protection.) As can be seen in the website, the student has links to a number of different projects including relevant extracurricular activities, and work experiences. He also has a page created for 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 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 web page, 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 many layout elements are fixed throughout Polaris, students are free to choose from numerous color schemes for their particular portfolio.

Wizard and web 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 Fig. 4), and résumé page, a contact page, and one project page. Figure 6 shows the first page in

Fig. 3. The Polaris homepage is located at http://polaris.engr.utexas.edu

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

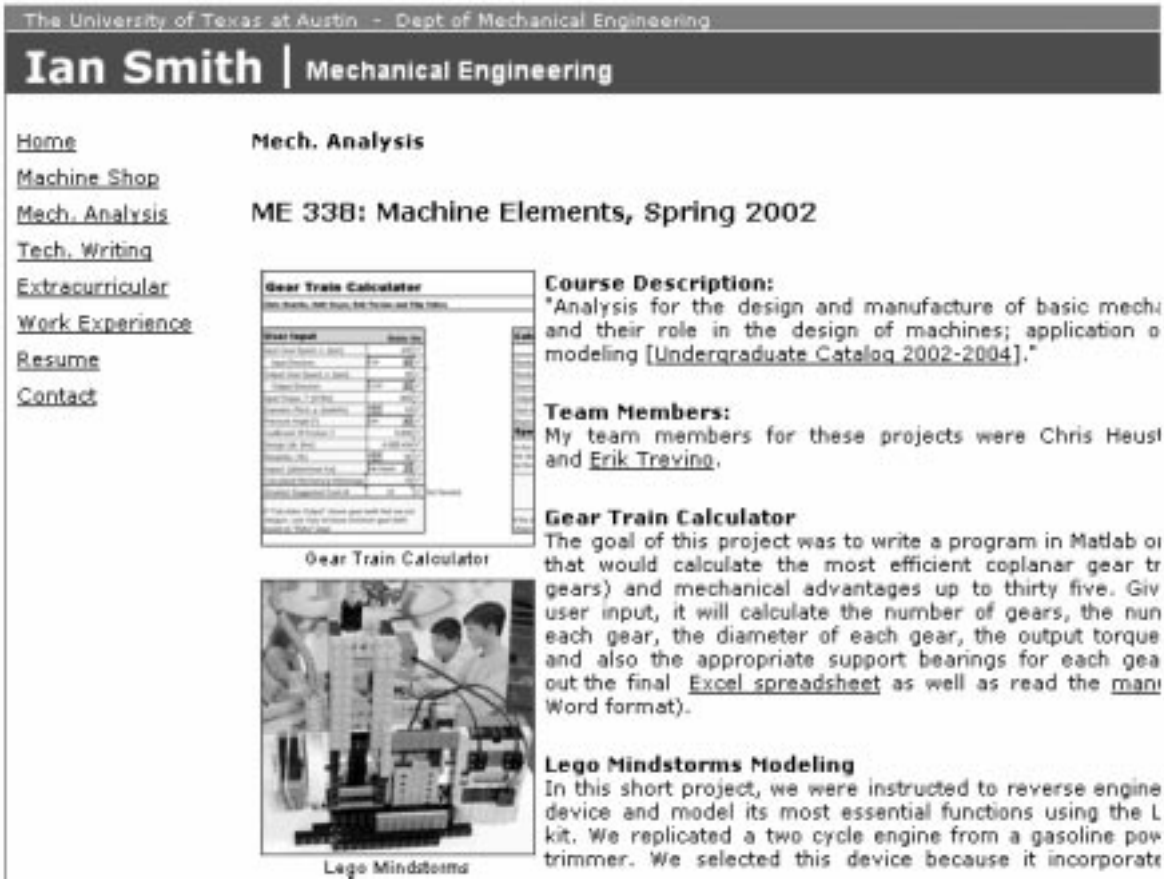

Fig. 5. An example project page from a student portfolio.

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.

As discussed above, the most difficult part of 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 web pages that preps the student for drafting a project synopsis as shown in Fig. 7. The dialog in Fig. 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.

Mission statement

Polaris is not intended to simply be a framework for creating a professional-looking website. Dialog pages such as those shown in Fig. 7 encourage students to reflect on their engineering education, so that they may better understand themselves and a broader sense of what they are accomplishing as they obtain their engineering degree. We have been motivated to develop aspects of Polaris that prompt students to focus on how they can better describe themselves to the outside world. Many people have found that drafting a mission statement provides a way to better describe and solidify a foundation for their life's goals and it often allows them to track their progress and better communicate who they are [19].

In a separate instructional pursuit, the mechanical engineering department is establishing a mentorship or advising program between students and faculty. Within a large institution such as UT Austin, it is difficult to ensure all undergraduates receive direct advising, counseling, or simple one-on-one discussion with the faculty. As a result, all incoming students are randomly assigned to faculty members who must meet with these

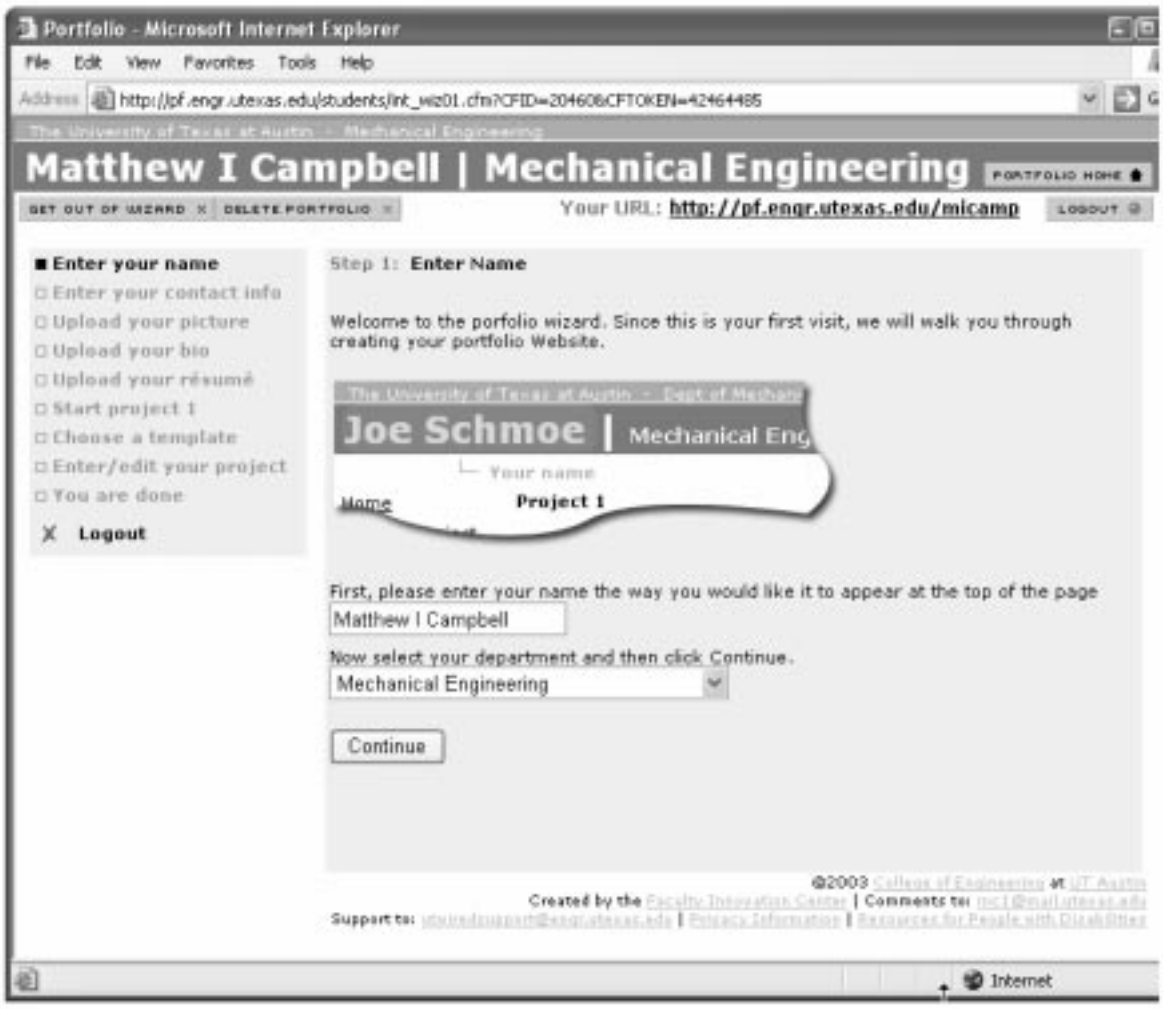

Fig. 6. A screenshot of the first step in the nine step introductory wizard.

students at least once a semester in order for the students to register for the next semester.

Since there is an appointed staff to assist these students in choosing classes, the faculty-student meetings are to help the students better understand their forthcoming vocation. Many meetings have degenerated to discussing the logistics of course scheduling as a result of a lack of a bond between faculty and student. The mission statement or the act of constructing such a statement is seen as a pivotal part of this advising process. Even if such a document is not shared openly within the meeting, the mission statement can provide the student with a better definition of themselves and a source for discussion with the faculty.

The addition of the mission statement functionality provides students with an opportunity to work with Polaris before they feel the need to present their accomplishments. As it stands, many view a portfolio system as something pursued near the end of their undergraduate education in preparation for an incipient career. The mission statement exercise engages students early and allows them to make their Polaris site something that will evolve over their undergraduate education.

Web journaling

Web-journaling is a second recent innovation within Polaris geared towards having students reflect and interact with their portfolio throughout their curriculum. The intent of the journal is to provide a space for student reflection. Reflection in education is not a new concept. The noted educator John Dewey defined it as 'the active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends' [20]. Many contend reflective habits of mind need to be taught since we do not necessarily think like this naturally. Building upon this notion that student reflective practice is beneficial, but that it needs to be a guided process, we are seeking ways to provide such guidance with an online journal. The web-journaling feature is similar to recent trends in web-logging (also known as blogging [21]). Journaling can be employed with the following benefits [22]:

Fig. 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. (This figure is a concatenation of screenshots from three consecutive web pages.)

- journals serve as a permanent record of thoughts and experiences;
- journals provide a means of establishing and maintaining relationships with instructors;
- journals serve as a safe outlet for personal concerns and frustrations;
- journals are an aid to internal dialogue.

Polaris now includes a journaling tool and in the summer of 2004, students studying abroad are the first to use this feature. By providing students an opportunity to chronicle their experiences, they are able to look critically at their decision points and to sort through choices. As students grow intellectually and begin to think more like engineers, an online journal that enables reflective practice can encourage such growth.

STUDENT REACTIONS

After developing the portfolio system for 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 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: '. . . introduce it early and have it part of the submission for grading'. One student suggested a workshop portfolio class at the sophomore level. These student reactions to Polaris were initial responses gathered in the summer of 2002. Their insights served as an initial point for the various modifications and additions performed in the last two years.

The students were asked to suggest any features they would like added. Responses ranged from 'more customization buttons' to 'spell check' to 'assistance with the amount of web storage space'. 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. Current development includes a feature to allow students to keep a page as private or as a work-in-progress which can later be publicly displayed on their web page.

Twenty-three engineering students were organized in a workshop in the summer of 2003 and asked to comment on the new reflective exercise shown in Fig. 7 that precedes formal 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 affirmed 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. 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, whether the project worthwhile and how group dynamics affected 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, students saw connecting with potential employers as the biggest benefit.

INDUSTRY REACTION

In many fields, a portfolio is shared with potential employers. In engineering, this practice is still in its infancy but it is highly likely that portfolios will become standard practice in many job-searching activities. While most of our focus has been on gathering the students' perspectives of Polaris, we have also recently targeted the feedback of industrial partners and potential employers. An employee from Hewlett Packard reviewed Polaris and applauded the concept but questioned how given today's recruitment practices, such a tool could be used to an advantage. For one thing, how can Polaris go beyond being another resume holder? He suggested a clearer tie be created within Polaris to students' course loads and records. While this can be useful there are privacy issues that will need to be addressed. Currently, a student can set various pages of their portfolio to private, but they are not yet able to make pages available to only selected users.

Additionally, staff from our College's Career Assistance Center have reviewed Polaris and offered suggestions for enhancements. We have redesigned the search engine within Polaris to enable easier access by disciplines within engineering and to help promote exemplar portfolios. The career center links to Polaris and encourages potential employers to browse the site. They also

have been critical in encouraging students to use Polaris and to promote it among their peers.

CONCLUSIONS

In general, portfolios can enrich an engineering education in several ways. First, portfolios are useful in that they provide students with a bookkeeping center that 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 an engineering department valuable information in assessing their 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 Polaris and help to establish it as part of the tradition of the engineering education at UT. But, even with over 800 current portfolio users, we notice that students are weary of the extra work being offered to them from the 'administration'. Furthermore, some faculty may feel that students are not going to do any more 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 [23–25] and, we believe, our success is directly linked to how well we are meeting these goals. The reflective exercises 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.

If 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.

Given recent Internet technologies such as Front Page or *blogging* that make web publishing easier, there may be some who question why we created such a customized portfolio developer system. There is no doubt that such an undertaking requires considerable time, effort, and ongoing maintenance. When we first began this process, commercial options were limited and while there has been an increase of available and appropriate tools our customized site enables us to facilitate discipline-specific options. Since Polaris is specific to engineering, we can guide our students in creating a site that best portrays their engineering skills and interests. Given the challenging nature of many engineering curricula, institutions such as the University of Texas are faced with high attrition rates as students leave engineering to pursue less intensive majors. The reflective activities and other specific Polaris exercises provide students with the guidance and nurturing needed to retain their interest in engineering. Furthermore, since Polaris is a site developed and maintained by professional web developers, students can be assured that their portfolio is part of a larger network of other clearly defined engineering portfolios. Our intention is to keep Polaris aligned with technology standards such as the Open Knowledge Initiative and should the need become apparent to merge with a commercial product, we will do so.

A number of technical challenges continue to confront 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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Kathy J. Schmidt is the director of the Faculty Innovation Center for the College of Engineering at The University of Texas at Austin. In this position, she promotes the College of Engineering's commitment to finding ways to enrich teaching and learning. Dr. Schmidt works in all aspects of education including design and development, faculty training, learner support, and evaluation.

Matthew I. Campbell is an Assistant Professor at the UT Austin in the ME Department. His research focuses on theories of engineering design and how the computer can be leveraged to solve complex and conceptual design problems. His teaching activities include Machine Elements, Design Methods, a course in optimization, and a collaborative course in design that combines engineering and art.