Developing Electronic Portfolio Software for Assessment Purposes

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ABSTRACT
Electronic portfolios, or e-portfolios, have recently become a fashionable and well-publicized method used for assessment and accreditation purposes. Despite their seeming popularity, however, departmentally maintained e-portfolios are not widely used. Further research needs to determine whether or not e-portfolios are an effective means of helping departments with their assessment outcomes. This paper reports on our initial experiences integrating e-portfolios with our Computer Science curriculum—including a survey of what our students thought of the exercise—and of future changes we believe will illustrate that well-designed e-portfolio systems can in fact provide significant advantages over traditional assessment methods.

1. INTRODUCTION
Electronic portfolios, or e-portfolios, have recently become a fashionable and well-publicized method used for assessment and accreditation purposes. Students, faculty, administrators, and accreditation experts can all use e-portfolios to monitor how well a department is measuring up to their stated learning outcomes. Despite their seeming popularity, however, one study reports that departmentally maintained e-portfolios are not widely used [11]. According to this study, several schools who do not utilize e-portfolios have the perception that they are difficult to maintain and that they would not provide any additional information than is already garnered via other assessment techniques.

While the maintenance issues associated with e-portfolios—such as storage, volume of data, and security—are well documented (e.g. [3]), a number of commercial, home-grown, and open source software packages now exist to facilitate their implementation (e.g., [6], [7], [10] respectively). However, the question of whether e-portfolios actually help with assessment, and, if so to what extent, is not as well-researched. Many see the inherent promise of using e-portfolios for tracking and aggregating student work and comparing the results with departmental objectives, but it's not clear how widespread these techniques are, or if they are effective.

This paper reports on our initial experiences integrating e-portfolios with our Computer Science curriculum—including a survey of what our students thought of the exercise—and of future changes we believe will illustrate that well-designed e-portfolio systems can in fact provide significant advantages over traditional assessment methods.

2. INITIAL USE OF E-PORTFOLIOS
As with many science departments at institutions of higher learning, our Computer Science department recently looked for new ways to respond to the Accreditation Board for Engineering and Technology's (ABET) Computer Science evaluation criteria (CAC 2003-2004). In particular, we were concerned with the CAC requirement that "programs must have an assessment process with documented, measurable objectives", and that assessment should be conducted outside the confines of individual courses to enhance credibility. In an attempt to find new ways of measuring our departmental learning objectives, and having researched some novel assessment techniques promoted in a variety of workshops (e.g., [5], [10]), we decided to implement electronic portfolios during the spring semester 2003 on an experimental basis. All Computer Science seniors were required to create a Web-based e-portfolio, and our initial departmental goals for these portfolios were as follows:

- Have CS undergraduates engage in self-assessment
- Demonstrate the accomplishments and growth of undergraduates throughout their years in our department
- Illustrate the diversity of projects completed
- Use e-portfolios for accreditation purposes (i.e., showcase to accrediting agency during next review)
- Determine the feasibility of implementing e-portfolios as a permanent departmental requirement for graduation
- Have undergraduates hone Web-programming skills

The rollout of these initial e-portfolio projects was done in a course required for all graduating CS seniors (CS415 Computer Ethics). While we recommended that students use simple HTML for their e-portfolios, other software implementations were accepted (Dreamweaver, etc.). The requirements stated that each student's e-portfolio had to contain a table of contents, representation of 4-5 computer

science projects (preferably from different years/semesters), a reflective essay, and a current resume. While projects from CS courses taken at the UM were considered most appropriate for the e-portfolios, exceptions were made in the case of transfer students or if a student wanted to showcase previous work experience. For each project included in the e-portfolio, students were asked to answer the following questions: 1) What was the project assignment? 2) What did you learn from the project? 3) What would you do differently next time? The reflective essay that students were asked to include was meant to discuss the variety of work completed, the skills acquired, and the student's future plans. All students presented their e-portfolios orally to the class at the end of the term.

3. RESULTS

The initial rollout of e-portfolios was quite successful. All students were able to complete their e-portfolios according to the given requirements, and only minor technical development issues surfaced (e.g., some students wanted to display projects in a format not supported by the Web server). Overall, the e-portfolios were thorough, aesthetically pleasing, and enjoyable to review. Many students put more time and effort than necessary into their e-portfolios and far exceeded the basic requirements. For example, Figure 1 shows the project section of a typical student e-portfolio. This student has chosen to display a nice variety of projects (i.e., group projects, programming, design, etc.), and she uses attractive thumbnail images that expand into more project detail. A reviewer of this e-portfolio is able to get a sense for the breadth of projects completed as well as the implementation details. The oral presentations of the e-portfolios were also fun and enlightening. Students enjoyed learning about their peers' experiences, and the presentations seemed to unite the class. All the e-portfolios included in this initial rollout are at: http://www.cs.umt.edu/CS/COURSES/CS415/links.htm

At the end of the term, students were asked to complete a questionnaire related to the e-portfolios. This questionnaire asked students to rate their agreement with a number of statements using a scale of 0 to 10, where 0 represents strongly disagree and 10 represents strongly agree. Sixteen students responded to the questionnaire. As the questionnaire results indicate (see Table 1), there was generally a positive response to many of the goals we had in developing the e-portfolios. In fact, since an 11 point scale was used, given the nature of the statements any mean over 5.0 can be interpreted as favorable. While all mean results are greater than 5.0, students most strongly indicated that they thought creation of e-portfolios was valuable and useful, they particularly enjoyed the oral presentations, and they felt that e-portfolios would be an important requirement to impose on all incoming undergraduates.

Figure 1. Sample student e-portfolio.

Table 1. Results of e-portfolio questionnaires (score of 0 is *strongly disagree*; score of 10 is *strongly agree*)

Statement	***MEAN***
1. Creating the electronic portfolio helped me understand the *quality* of the education I received in the CS dept at the UM.	5.88
2. Creating the electronic portfolio helped me understand the *breadth* of knowledge I acquired while a CS student at the UM.	6.06
3. Creating the e-portfolio helped me understand the *diversity* of assignments and therefore the practical life skills I obtained while a CS student at the UM.	5.75
4. Creating the e-portfolio was a useful assignment.	7.75
5. Creating the e-portfolio was a fun assignment.	5.88
6. I plan to use my e-portfolio to interview for jobs.	5.88
7. I learned or honed my Web programming skills by creating the e-portfolio.	5.50
8. I enjoyed listening to my peers—and learned something about who they are and what they have accomplished—during the e-portfolio oral presentations.	7.94
9. I think it would be valuable to make e-portfolios a graduation requirement for CS majors.	7.38
10. I think it would be valuable for incoming CS majors (freshman, sophomore) to start their portfolios when they join the program and maintain them up until the time they graduate.	8.25

4. CHANGES NECESSARY FOR EFFECTIVE ASSESSMENT

Based on our initial success and student feedback of the e-portfolio projects, our department will continue to require e-portfolios from all graduating CS students. Students will begin work on their e-portfolios when they first enter the program rather than at the end of their senior year—a change that is supported by the high mean for question 10 in Table 1—which will ensure that they are able to incorporate a wide variety of class projects from year to year and that they won't inadvertently lose or discard important work. As CS undergraduates progress through our program, projects from individual classes will be flagged as appropriate for the e-portfolios, and the instructor for that class will review and sign-off on the project's inclusion in the e-portfolio. We will continue to use CS415 for final e-portfolio presentations since this class is a capstone class for all graduating seniors.

There are a number of important changes, however, that we feel are necessary to incorporate into the e-portfolio projects in order to maximize their usefulness and usability from an assessment perspective. The e-portfolios that the students generated as part of our experimental rollout contained a wealth of information that is useful for those interested in determining the state of the department and whether or not learning objectives are being met (i.e., faculty, accreditation officials, university administrators, etc.). However, we can already see that it is cumbersome, time consuming, and ultimately impractical to expect these people to wade through individual student portfolios and extract the key data they are looking for. Therefore, we are developing a software prototype to further enhance the use of e-portfolios for assessment purposes. We believe that with the right set of tools—created using a development process that focuses on the end user at all times—we can create an e-portfolio system that will enable the efficient and effective use of assessment data for evaluation purposes.

As mentioned previously, several other software packages are currently available for the creation and maintenance of e-portfolios. We also understand that some other e-portfolio management systems (or Assessment Management Systems as differentiated by [2]) collect assessment data in supporting databases and/or spreadsheets (e.g., [9]). However, we believe that our research is unique for the following reasons: 1) we will use User-Centered Design (UCD) [8][12] methodologies to develop the prototype, 2) the prototype will be designed specifically for those interested in assessment, 3) we will incorporate user feedback throughout all stages of development, and 4) we will conduct task-based usability testing, questionnaires and user interviews, to determine how well our system facilitates assessment-related evaluation.

4.1 Research Questions

Our intention in developing a new software prototype for e-portfolios is not an attempt to replicate or improve on functions that already exist in other systems. Rather, our goal is to focus on the question of whether e-portfolios can be an effective way to conduct departmental assessment. In particular, we aim to answer the following research questions. *Can we develop e-portfolio software that will enable faculty and accreditation experts to …*

1. track and aggregate student work efficiently, and compare results with departmental objectives?
2. evaluate the program outside the confines of an individual course?
3. evaluate the breadth and diversity of projects?
4. monitor change in complexity and diversity of student work?
5. monitor individual student growth?

Another important question we hope to determine is whether or not faculty will feel that electronic portfolios are a better way to assess student work than the current methods being used.

To answer these research questions, we have started the design of a software prototype based specifically on the needs of those users who are interested in assessment. While our system will focus on functions that facilitate assessment for these users, we also plan on building a closed system that students can use to create and maintain their e-portfolios. Providing a standard interface for students will also serve to ensure consistency among portfolios. Following the basic principles of User-Centered Design, we first created low-fidelity storyboards of our prototype (i.e., sketches on paper), which we then used to generate a medium-fidelity prototype (i.e., Web pages of system that only appear functional). We used the medium-fidelity prototype to get feedback from some potential assessment users (CS faculty members). We incorporated this initial user feedback into a redesign of the system, we will soon translate into a high-fidelity Web-based prototype using Active Server Pages (ASP) supported by a Microsoft SQL relational database. Once the high-fidelity prototype is complete, we will conduct formal task-based usability testing using both students and accreditation users (faculty and administrators) as participants. These usability tests will focus on how well users are able to complete a set of real-world e-portfolio tasks. Finally, we plan to use questionnaires and participant interviews to gauge how well our system meets our intended research goals.

4.2 System Requirements and Design

We have identified four primary user groups for our system software: students, faculty and accreditation experts, technical system administrators, and the general viewing public. Based on our stated research goals, our intent is to focus the system requirements primarily on faculty and

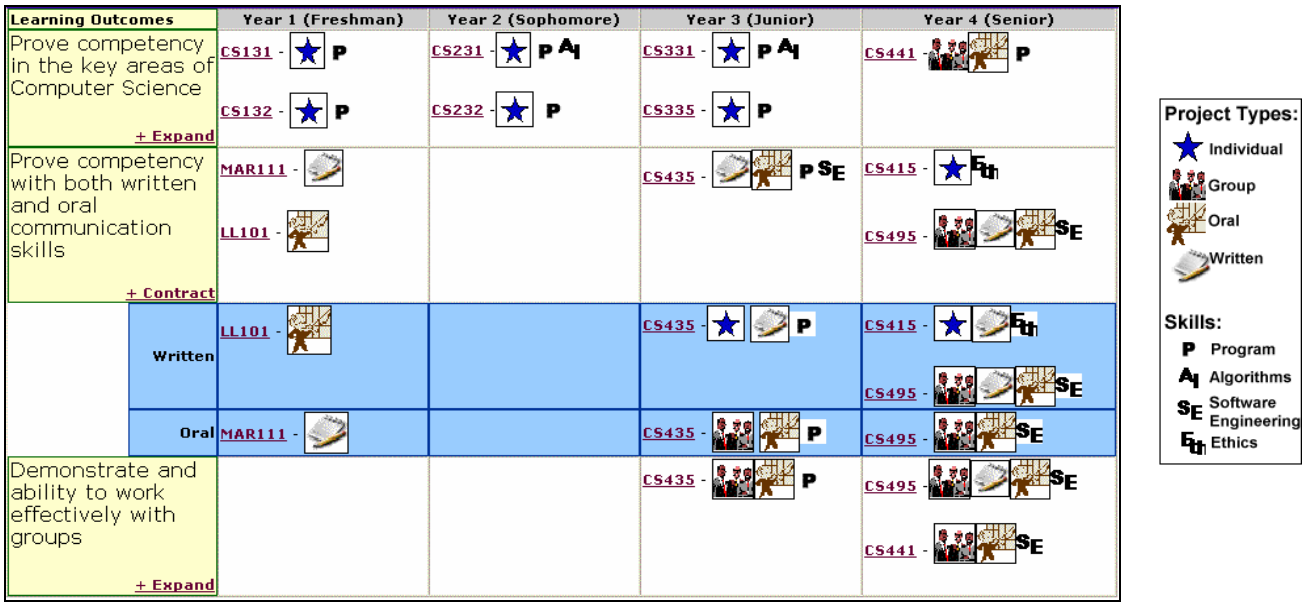

Figure 2. Sample matrix with one learning outcome expanded.

accreditation experts, and secondarily on the students. We will not discuss in this document the functions we think ultimately appropriate for technical system administrators and public e-portfolio viewers.

For faculty members and accreditation experts, the key components of our e-portfolio software will be the query and display functions. These functions will provide users with an effective means of determining how well the CS department is meeting its stated learning objectives and accreditation goals. Just to give two examples of the many possible queries, assessment users may wish to see: 1) *All group and oral projects completed by CS students during their junior or senior years*, or 2) *All intermediate and advanced-level projects that incorporate the core skills of programming, algorithms, and data structures*. Queries such as these would presumably tie directly back to stated departmental learning objectives (e.g., providing students with opportunities to develop teamwork and oral presentation experiences; expecting a high level of proficiency with basic CS skills).

In formulating their queries, users are ultimately constructing a display matrix such as the one shown in Figure 2. Matrices are built based on the user-selected row and column headings (options are learning outcomes, year of study, project type, project skills, and project level of difficulty), and they are populated with project representations. These representations include project names, as well as icons that represent project type and project skills. We believe that the matrix view will provide immediate and comprehensive visual feedback regarding the user's query and, subsequently, assessment-related information. The system will also allow evaluators the flexibility of viewing matrix data by project abstract (either in addition to or instead of the icons), as well as the ability to expand and contract the matrix so that results can be seen at varying levels of detail.

The matrix displayed in Figure 2 shows sample results from the following query: "*Show me all projects that satisfy our stated departmental learning outcomes by student year.*" We can see that project names are identified by course number (which is also a hyperlink that leads to a more detailed project description), and icons that represent the various project types (individual, group, oral, or written) and the primary CS skills that a student learns by successfully completing that project (i.e., programming, algorithms, software engineering, ethics). Figure 2 also illustrates a second learning objective (on the y-axis) that has been expanded, showing results at both the summary and detail level.

Finally, if a user wishes to focus on a particular assessment related question or project criteria, filtering options do exist. Figure 3 shows the ways in which a user can filter out the projects that appear in the matrix view. The default is that all projects meeting all criteria will be shown in the matrix. To make this flexible filtering possible, departmental faculty members will assign the query criteria values on a per-project basis, and this data will be stored in the underlying relational database as meta-data. For example, an instructor who has a project that is suitable for inclusion in e-portfolios will determine which learning objectives, project type, and core skills that project satisfies, as well as the course year and project level of difficulty. Once defined, this criteria data will be maintained by the database administrator.

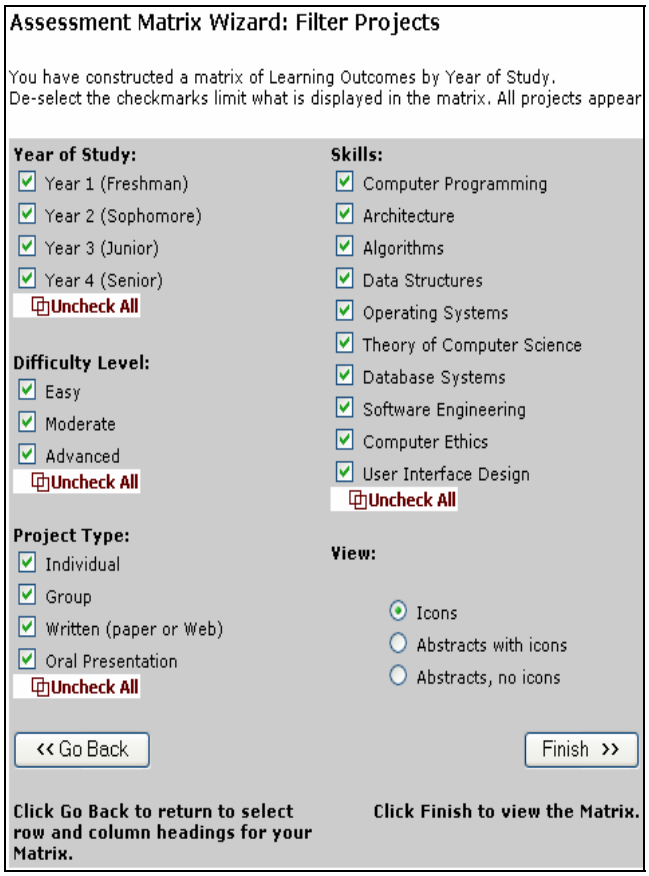

Figure 3. Project filtering options.

Once again, the idea behind the matrix display is to provide faculty and assessment personnel the opportunity to evaluate at-a-glance the results of their query. In the example illustrated in Figure 2, users will be able to quickly determine how well departmental objectives are being met across the years simply by seeing how well-populated the matrix is. It should also be noted that the data presented in the matrix represents all student portfolios that currently exist in the system, and therefore represents *actual* program performance when it comes to accreditation goals. Many other assessment techniques rely on a department's plans or goals for reaching their objectives; the e-portfolio matrix view shows real results. Finally, users can also view portfolios at the individual level using functionality provided in a different part of the system.

For the student users of our prototype system, functions will be provided that support the creation and maintenance of e-portfolios. For example, students will be allowed to upload artifacts such as resumes, project descriptions, segments of program code, graphics, animations, etc. to the departmental Web server for long-term storage. A standard method of uploading and describing projects will be provided. When students add new projects to their portfolio, they are given the option to request faculty approval. Such a request automatically goes into a faculty member's approval queue, where it will then be either approved or rejected. This process requires good communication between faculty and students, which the software must also support.

4.3 Preliminary User Feedback

Three Computer Science professors participated in preliminary user testing of the system. Participants were given a small set of tasks to complete using the e-portfolio prototype, and they were asked to think-aloud as they used the system. The feedback that was provided was very helpful and prompted some key design changes, particularly in the areas of matrix construction and project approval. Even though these user evaluations were quite informal and involved only three users, we purposefully conducted these sessions at this early point in the development lifecycle so we could make effective design changes easily and inexpensively (i.e., before programming started).

One particularly difficult design challenge, and a part of the process that our participants didn't understand very well, is the matrix construction process. This process requires two screens: one to choose the row and column headings of the matrix, and one to filter the projects that appear in the matrix (Figure 3). It is confusing for users to select the matrix headings and filters before having a good understanding of what the matrix is and what it will display. We attempted to resolve this problem by incorporating a wizard metaphor, which we believe most computer users are familiar with and which we hope will better guide them through the process. We also believe that once users actually see the matrix that they construct, that they will better understand the importance of the headings and filters, and that they can then go back and readjust the display options as desired. Only more user testing, which we plan to conduct formally once a newer version of the prototype is complete, will truly indicate how well users understand the matrix, and how well they can manipulate its display.

In addition to completing their given tasks, participants were also asked to fill out a short questionnaire during the usability evaluation sessions. This questionnaire was geared towards understanding how well participants were able to use the system to make certain assessment related evaluations. The three questions and user responses (in italics) follow:

1. Based on the matrix data, what conclusions do you draw about the number of oral presentations a "typical" student completes as she progresses through her study?
   Students are completing at least one in all years except Year 2; more towards the end of the degree, which is good. [There are] more as [students] go on – Senior "capstone" involves presentations. More [oral presentations] each year – from freshman to senior.

2. Based on the matrix data, what conclusions do you draw about the number of group projects a "typical" student completes as she progresses through her study?
   Lots in Year 4; not enough in other years. Heavy in last year(s), starts with programs, then to software engineering [the faculty member went on to say that this was very appropriate – students should learn programming fundamentals and work alone during the early years.] Again more starting junior year to senior.
3. Based on the matrix data, what can you ascertain about the diversity of projects represented?
   More individual stuff early, more group later. Very diverse across classes, [based on the]three different classes [shown].

Based on the user responses to these questions, as well as post-evaluation interviews, we believe that early indications show that users are able to answer key assessment-related questions using the e-portfolio system (particularly the matrix view). Users were generally able to draw reasonable conclusions for the above questions, which we believe would be particularly challenging to do without a matrix display. This indicates to us that the incorporation of a matrix view (or something similar), which provides faculty members and assessment personnel with a flexible and comprehensive look at the work their students have completed, is necessary for reaching assessment-related conclusions efficiently and effectively.

5. CONCLUSION

The use of electronic portfolios for assessment purposes is garnering more and more attention at institutions of higher learning. Faculty members and accreditation officials are intrigued by the new possibilities of e-portfolios which include the capability for longer-term centralized storage, more consistent performance review, student self-assessment, and increased flexibility. By digitizing portfolios, other suggested assessment techniques—in particular student sampling and work sampling [4]—can be made easier, more streamlined, less tedious, and not paper dependent.

After initial success and positive feedback on our experimental rollout of e-portfolios, our department has committed to using e-portfolios more extensively and making them a graduation requirement. However, we understood immediately that expecting faculty members and other assessment personnel to wade through student portfolios on an individual basis, even if they are Web-based, is not a practical long-term solution. Therefore, we set out to design an e-portfolio software prototype that would facilitate assessment activities and ultimately make review more effective and more efficient.

Our software prototype, which is currently in the design phase, utilizes UCD techniques and focuses on providing comprehensive, flexible query and data display tools. We believe that these tools will ultimately assist assessment activities and will make e-portfolios a realistic, viable assessment technique for long-term use. Our intention is to illustrate this hypothesis by performing a variety of evaluations of our high-fidelity software prototype, including formal task-based usability testing, questionnaires, and participant interviews.

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7. REFERENCES

[1] Accreditation Board for Engineering and Technology. http://www.abet.org. 2003-2004.

[2] Barrett, H.C. (2004). Differentiating Electronic Portfolios and Online Assessment Management Systems. Published in *SITE 2004 Conference Proceedings*. Available at: http://electronicportfolios.org/portfolios/SITE2004paper.pdf

[3] Batson, T. (2002). The Electronic Portfolio Boom: What's it All About? *Syllabus Technology for Higher Education*. Available at: http://www.syllabus.com/article.asp?id=6984.

[4] Blandford, D.K., and Hwang, D.J. (2003). Five easy but effective assessment methods. *Proceedings of the 34th SIGCSE Technical Symposium on Computer Science Education* (Nevada, 2003), ACM Press, pp. 41-44.

[5] Clemson Digital Portfolio Institutes. Available at: http://www.clemson.edu/caah/Pearce/strateg/digport.pdf

[6] Electronic Learning Portfolio, University of Minnesota Duluth. Available at: http://eportfolio.d.umn.edu/

[7] Electronic Portfolio Consortium (ePortConsortium). Available at http://www.eportconsortium.org

[8] Gould, J. (1988). How to design usable systems. M. Helander., Ed., *Handbook of Human-Computer Interaction*. North-Holland, 1988.

[9] Rogers, D. (2003). Teacher preparation, electronic portfolios, and NCATE. *Proceedings of the 2003 Conference of the Society for Information Technology in Teacher Education Conference*, Albuquerque, March 24-29.

[10] Rose-Hulman Institute of Technology. Available at: http://www.rose-hulman.edu/IRPA/

[11] Sanders, K.E., and McCartney, R. (2003). Program assessment tools in Computer Science: a report from the trenches. *Proceedings of the 34th SIGCSE Technical Symposium on Computer Science Education* (Nevada, 2003), ACM Press, pp. 31-35.

[12] Whiteside, J., Bennett, J., & Holtzblatt, K. (1988). Usability engineering: Our experience and evolution. M. Helander, Ed., *Handbook of Human-Computer Interaction*. North-Holland, 1988, 791-817.