The Learning Portal

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Abstract

Undergraduate engineering education is experiencing a paradigm shift, from teacher-centered to student-centered pedagogy characterized by student teamwork and integrative curricula [1]. The research and experiences underlying this shift have revealed that effective learners not only learn actively, but they develop an awareness of their skills in learning, and engage in self-assessment and reflection. Research in psychology has found that the reflective process engages students and helps them develop, particularly as self-regulated learners. As the educational enterprise undergoes this radical change, there is an increased recognition of the need for methods that allow students to develop such cognitive and metacognitive skills.

This paper presents our explorations in defining and constructing a system that helps students organize their work, review their and others' work, and reflect on their progress. The system we are building includes the support tools for student-centered knowledge construction and management. We examine our early prototypes and discuss how our experiences with those systems led to the current system requirements. These requirements include the knowledge/document management, self-assessment, reflection, planning, and collaboration. We discuss the intended uses for the system, and provide examples from our current uses of the system to highlight the potential. The paper includes a review of the literature supporting our work.

I.   Introduction

Undergraduate engineering education is experiencing a paradigm shift. An essential feature of this paradigm shift is a movement from teacher-centered to more appropriately student-centered pedagogy. The teacher-centered tradition has been the cornerstone of higher education, with engineering education merely adhering to the dominant doctrine, for what seems an eternity. The teacher-centered model characterizes students as products. As such, the educational outcomes are expressed as exit skills or competencies [2]. Catalano and Catalano [3] enumerate three assumptions associated with the teacher-centered model:

    1. An(y) educational process is considered culturally neutral as well as
         linear and rational.
    2. Language serves as a conduit for the transmission of information.

3. The teacher becomes the "manager" of the classroom with the learning process heavily dependent upon the pronouncement and enforcement of rules.

The last element in the list indicates why the moniker teacher-centered is applied to this model. Students are the vessels instructors fill through knowledge-telling activities. The final step is the "assessment" task where students relate to the teacher the contents of the vessel.

The shift to a learner-centered approach was fueled by a number of instructional research projects [4,5,6] demonstrating that students in active learning environments learn better. The model of learning that informed these studies is constructivism, in which the learning process is conceived as an activity where new information is linked to prior knowledge. Thus the things we "know" are tentative and are refined and changed through actively assimilating knowledge— self-explaining, writing, interacting with others and with other ideas. The implications for teaching practices are enormous. In constructivist learning, students interact with each other and connect what they are learning to their own experiences and knowledge, thus making their learning conceptually coherent and personally meaningful. The key teaching practices require opportunities to reformulate and articulate newly found meanings. This activity is critical to successful learning.

Associated with the constructivist approach is a focus on helping students become aware of their learning and learning processes. This entails helping students develop a sense of how they know what they know as well as what they have learned. This reflective process is an essential factor in the emergence of expertise. Experts are often characterized as having three distinctive kinds of knowledge: (a) declarative knowledge ("knowledge that"), (b) procedural knowledge ("how to knowledge"), and (c) metacognitive knowledge with its attendant processes of self-monitoring, agency, reflection. Declarative knowledge refers to the kind of knowledge typically learned from textbooks--facts and concepts. Procedural knowledge refers to being able to do something, be it writing code, proceeding through analysis and design, using a software process approach, or writing a paper about ethics in the software industry. Metacognitive knowledge refers to a person's skill at planning strategy, monitoring process and progress, changing what one is doing when appropriate, and reflecting on the process so that one can discover ways to improve. Educational curricula traditionally focus on the acquisition of declarative knowledge. The paradigm shift toward active learning has primarily been focused on procedural knowledge. To complete the shift we must include metacognitive processing. What seems apparent from this discussion is that the transition from teacher-centered to learner-centered education requires new ways of engaging students, new considerations of what engagement means, and new methods for determining if this engagement is effective. Hence the challenge for engineering educators is to identify and implement mechanisms that help students develop in all areas, including the metacognitive and reflective. Several studies have demonstrated that (a) students who reflect on what they are learning learn better both on declarative and procedural tasks [7], (b) most students do not naturally do this [8,9], and (c) inducing students to reflect upon the material is effective, thus demonstrating that it is the metacognitive activity that produces the improved [10,11]. In the larger domain of research on the acquisition of expertise, it has been found that those practitioners who develop into the most skilled experts engage in deliberate and reflective practice [12]. This paradigm shift has implications for what occurs in classes. In the teacher-center model we review

student products with little regard to the underlying mental process. A typical grading scenario is to check the answer, if correct mark then go to the next question else check work. The implicit assumption is that if the product is correct then the process that produced it is sound and if the product is incorrect then informing the student should be enough to correct the process. This assumption is wrong in two ways. First, correcting the product does not ensure that the students' understanding is corrected. Second, getting correct answers does not ensure that students are developing processes that will be effective in life-long learning. With this is mind we are seeking a strategy that helps expose students' mental activity and processes required in learning, to make their processes visible to them (and to the faculty so that the faculty can promote its development). To do so we must change from the typical adversarial relationship between teacher and student imposed by the teacher-centered model to a collaborative model where the student and the teacher have shared goals.

Educators must explicitly provide learning environments in which their students can develop procedural and metacognitive skills, as well as declarative knowledge. The most important aspects of instruction are **not** the format of the material, but rather providing conditions under which students can develop habits of work that will sustain them through the years of deliberate practice needed to acquire expertise. To help students develop such habits requires a process orientation, exemplified by documenting plans and measuring effort, so that students can see how they are working, can reflect on those processes so that they can develop better processes, and to do this repeatedly. Metacognitive skills developed in this way in turn will demonstrate to students that through hard work and repeated, focused practice they can improve in ways that can be measured and such experiences should result in increased tendencies toward persistence and in feelings of self-efficacy.

II.   Portfolios

Many have suggested portfolios as a strategy for increasing the visibility of student learning. Portfolios have properties that seem most appropriate for the task. According to [13], the advantages of portfolios are that they are longitudinal and collaborative, and have diverse content. Thus, a portfolio is a collection of student work that tells the story of achievement or growth, exactly the criteria needed in a learner-centered paradigm [14].

Acquisition of factual knowledge can be assessed and evaluated at a single time, but tracking the development of procedural and metacognitive skill requires a longitudinal approach.. One of the most widely replicated findings in the field of expertise is that, in all fields studied, it takes at least 10 years to reach expert level [12]. We can't, and shouldn't, expect more than incremental changes in short periods of time. Hence, the portfolio should contain information that allows students and instructors to track and expose progress over time. In addition, as is true of professional portfolios, which tend to be collections of work that are representative of skill and competence, learning portfolios should have diverse content. We extend the notion of content here to include not only products developed in response to learning activities, but also process documents, such as work plans, records of effort associated with those products, process postmortems, and improvement plans. This is in keeping with our work in process education [15,16].

Somewhat surprising is the collaborative view of portfolios because in this respect learning portfolios differ from professional portfolios. In the professional portfolio we have samples of finished product that demonstrate ability. The learning portfolio's purpose is to provide visibility to ongoing cognitive processes. Since our perspective here is developmental, we adopt a cognitive apprenticeship [17] view. Under such a model the mentor, perhaps the instructor, provides needed feedback and critiques to help the student assess their state of learning and to develop understandings about the nature of their knowledge and skill. Hence, the portfolio should provide a forum for student-teacher interaction. In such a forum, the interaction is captured and recorded too for it has educational value. We, as others, have explored the use of portfolios in supporting our classes. Our earlier efforts [15,18,19] used a web-space secured by username and password. Students posted their work electronically. The work posted was typically web-based forms requiring short-answer or narrative responses to instructor-provided prompts. For each project, students completed a work habits survey prior to initiating activity. Students completed a postmortem on each project [16]. In the postmortem, they documented the development process they used for that project and used the size, effort, and defect data from their project, along with self-reflection, to assess their development process, and established personal, measurable goals for the next project. Since the design notebooks contained the pre/post survey and all the data they collected during the semester, the students had a fairly complete record of their work and attitudes over the course of the semester. A culminating event for the semester was the student's personal, critical assessment of how their practices changed during the course. This final writing assignment was to compare the manner in which they worked on projects at the beginning of the semester and at the end. Our experiences led to a realization that the portfolio is a critical component in the type of learning environment we need for our students. In particular, the longitudinal record of work and attitudes provided learning opportunities we had never conceptualized. One particular avenue that has proven useful is the reflective essay [20], which became a critical component of the software engineering classes. Unfortunately, our efforts over the years were only partially successful. While we expected students to take the challenge of thinking through the ins and outs of the course with its rationale, there was really no practical reason why they should arrive at the outcome we wanted. This is consistent with the findings in cognitive and instructional research that students do not automatically or naturally think reflectively [21]. We wanted students to make connections, yet we were asking them to determine what is connected and how with very little assistance. Hence, we revised activities to provide metacognitive scaffolding [22,23,24]. For the assignment on initial expectations, we devised prompts to direct students to think about certain issues in relation to the course and to their program of study [20]. The results were that students provided more information about their expectationsThis was combined later with an assignment to review their initial expectations and determine how the course met these. The electronic notebook made providing the scaffolding convenient and workable for both faculty and students, and having an accessible record of prior work was critical to tying the two activities together.

III.   Learning Portal

As indicated above, learning portfolios are more than a place to collect and store work. Rather, they should be an integral part of the educational enterprise Portfolio has for most people a predefined meaning that does not admit the new educational interactions we foresee. In response

to this we began thinking of the system as a learning portal. In our case, referring to the system as portal provides the metaphor we need to think about the potential uses of the system. As a portal it offers faculty and students ways to look at and think about conceptual change. We have been experimenting with two distinct instructional uses of the Learning Portal. One is to create an ongoing record of students' work and both instructor and peer reviews of that work. The second is to help students collect data about the way they go about working and to embed that assessment in a continuous improvement loop.

Portfolios in our view are dynamic and evolving, offering unprecedented learning opportunities because of the developmental nature of the record. Note we consider the archive as consisting of both student work and reviews of that work. We use reviews rather than grading to emphasize our perception that in a continuously improving system feedback must be considered as positive. Part of the power of the portfolio comes from changing the students' view of the system from a product to an improvement orientation where assessment represents a learning opportunity, not a terminal event. It stands to reason that if students are to work that hard at improvement, they will do so only if they believe that they can and will succeed through their efforts. This has been experimentally demonstrated in a study of organizational decision making with graduate business students. Half the students were told that in "acquiring a new skill, people do not begin with faultless performance. However, the more they practice, the more capable they become." The other half were told that the task would identify whether they had the underlying ability to be good managers. The group who expected to improve with practice showed continued improvement with practice, whereas the fixed ability group showed a steady decline in performance goals, efficiency of problem solving, and actual performance [25]. Furthermore, in studies of the effectiveness of instruction in mathematics it has been found that effective instructional techniques have their major impact through improving students' tendencies to persist and feelings of self-efficacy [26]. Similarly, increasing students' persistence and thereby time-on-task has been found to increase the quality of writing [27].

Our conception of portfolio as a learning portal was guided by our earlier work in helping students learn about their development processes during software development [15,16,18,19]. As part of that project, we had the students establish collect effort data [28] related to their development activities. These data were posted in their design notebooks. This captured much of the student's development habits, and allowed us to construct activities requiring students to comment on the efficacy of their development behavior. This reflective act was part of the postmortem required on every project. The concluding activity on the postmortem was questions related to how they would approach the next programming task based on what they understood about their work on the one just completed. The pattern of behavior we established in this way was a continuous improvement loop. The addition of process and product measurement added considerable value to the student's understanding of their work and work habits, giving them more control.

The transition to portal actually occurred recently. We completed a prototype of a system where students would upload work to decrease the dependence on web-based forms. This allowed students to work in their environment. Once material was finished they would upload the file to their workspace in the portfolio system. The structure of the portfolio was driven by the courses they were taking. The model we had imposed the semester and course view of work. As we began to look at this structure we became less pleased. With the course/semester structure we

were not allowing broader or flexible perspectives. Furthermore, as the number of artifacts increased it would become difficult to gain a reasonable perspective. Indeed, we began to see that what we wanted from a repository was the ability for the students or faculty to "look" at student work in different ways. Our realization was that our system needed to support different "views" of the artifacts existing in the system [29]. A course is merely a view as is a semester. The portal should allow a student differing views depending on the audience or use [30]. It is the view that provides a structure to the collection of artifacts, thus access to items of interest should be specified at a high level in terms of view.

This new model adds a powerful conception to the portal. Now, not only are students concerned with the artifacts as representations of their learning, they are also concerned with what views best indicate what they have learned. By adding the audience property to the system we can now ask student to think in terms of how to best to portray themselves to various audiences, such as instructors and employers. This change also provided the needed simplification in our thinking. With the view being considered a lens/filter over the collection of artifacts (see figure 1), then the course, or semester for that matter, is simply one way to view the work. Different lenses can be developed to help departments or colleges look at student work to evaluate the effectiveness of the program [31] or specific program outcomes such as design [32]
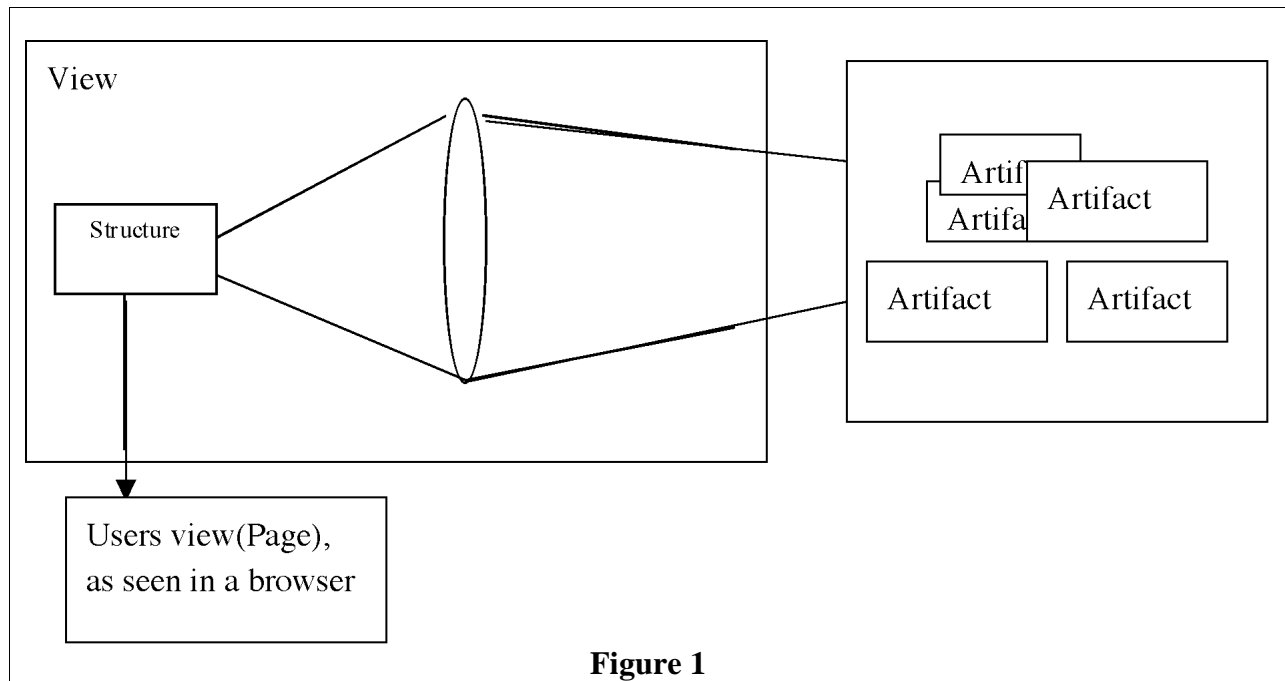

Figure 1

IV. Building a Learning Portal

The requirements for a portfolio system, given in [30], make an excellent beginning. We concur enthusiastically that the system must be easy to use. We translate that requirement to a collection of requirements related to artifact management. The system must archive student work, providing mechanisms to support student uploading of work in different formats. In our case, we are interested in source code, essays, and design models. The ease of use requirement must be

met; otherwise students will not archive their work. To truly capture the snapshots of learning the system must contain interim as well as final products.

As part of artifact management, each artifact has a set of properties that the user, artifact owner, can manipulate – file name, visibility, course, assignment type, specific assignment, group membership. These properties are used to give students more control over artifacts and their use. In the current prototype students can post their drafts privately, so that only they can view them. Once an artifact reaches a certain level of completion then the owner modifies the visibility property to allow the instructor alone or to the whole class access. By establishing user changeable properties we hope to allow students to make informed choices regarding who has access to their work. By adding the visibility property we hope to support methods of both making work available to others to view, and increase the ability for peer reviews.

1. Students should be able to associate a non-default assessment for feedback.
   a. Students should be able to specify an assessment for specific assignments.
   b. Students should be able to specify an assessment for assignment category types.
   c. Students should be able to specify an assessment for a course.
   d. Students should be able to specify an assessment for themselves (All courses).
2. Students should be able to review all feedback for an assignment, artifact or course.
3. Students should be able to provide feedback.
   a. Students should be able to provide feedback for an assignment.
   b. Students should be able to provide feedback for an artifact.
   c. Students should be able to provide feedback for a course.
4. Students should be able to provide self-feedback.
   a. Students should be able to provide feedback for their own artifact.
   b. Students should be able to provide feedback for their own assignment.
   c. Students should be able to provide feedback for their own course.
5. Students should be able to submit self-feedback to instructor.
6. Instructors should be able to provide feedback to students.
7. Instructors should be able to use any assessment they wish to provide feedback, supplementing the student's choice.

Table 1

The artifacts are referenced through a database, which maintains the associations between artifacts, users, and the artifact properties. The current structure of the system is depicted in Figure 2. The system is defined as web-based using the canonical web browser to work with the

portfolio system itself. Using web technology increases accessibility by students and simplifies a number of design decisions.

Figure 2
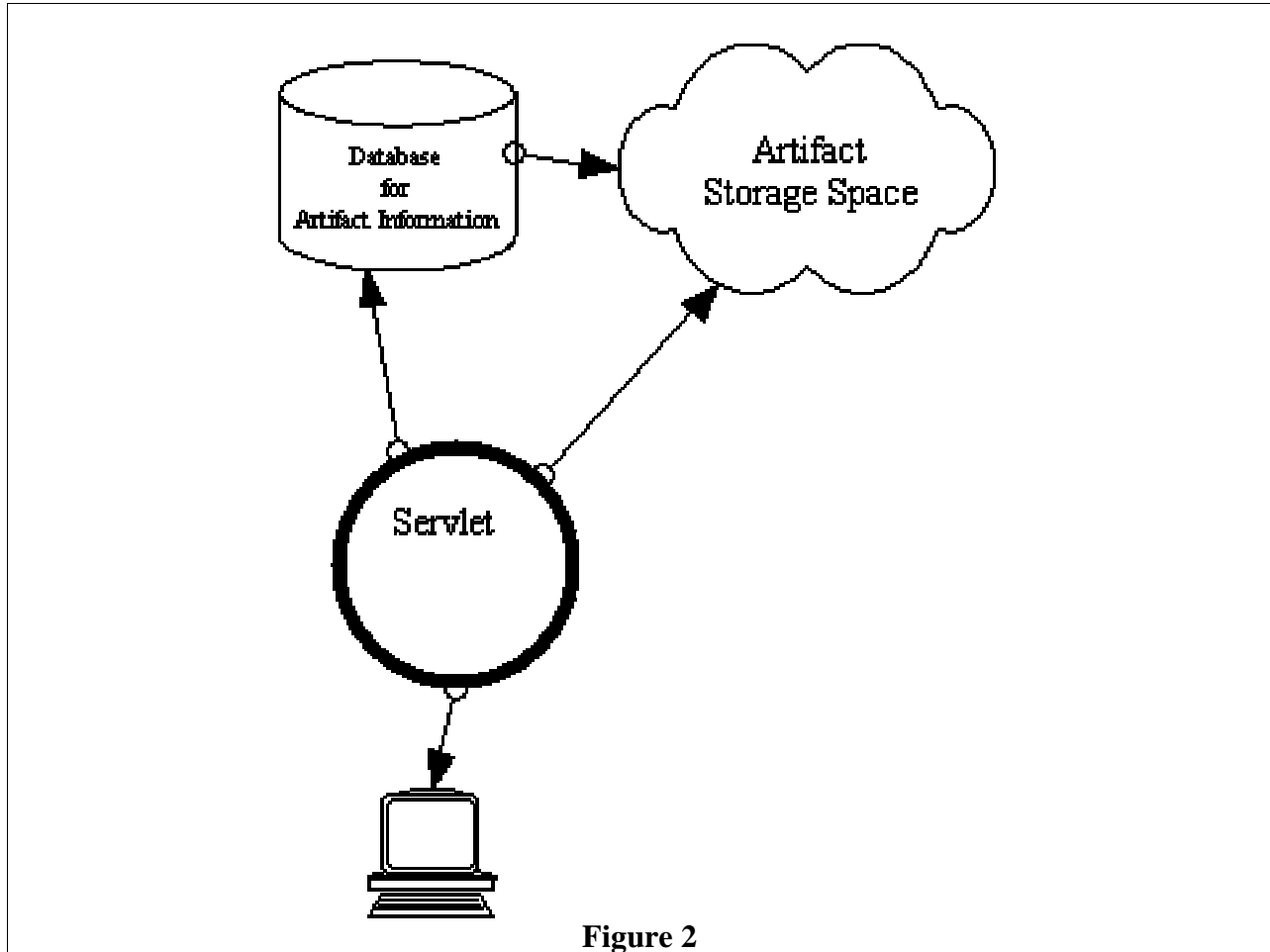
We use servlets to generate the page provided to users. Since the artifact collection is dynamic, when a student enters the system through login they are presented with the contents of their storage space based on the view they have chosen. A student may choose to view the collection based on a particular course or assignment. Figure 3 demonstrates how the system provides view information to the student. In this particular case, the buttons on the left side of the window indicate which views, in this case semesters, are available. Once the student selects a view then a page is created with links to the various artifacts available in that view. View management is achieved through defining the contents of the artifact space in terms of an extensible markup language (XML) [33] document, which then uses a style sheet to specify what and how to display the information. Figure 4 shows the sequence for a student entering the system. Notice each choice by the student progresses through the material at different levels of granularity.
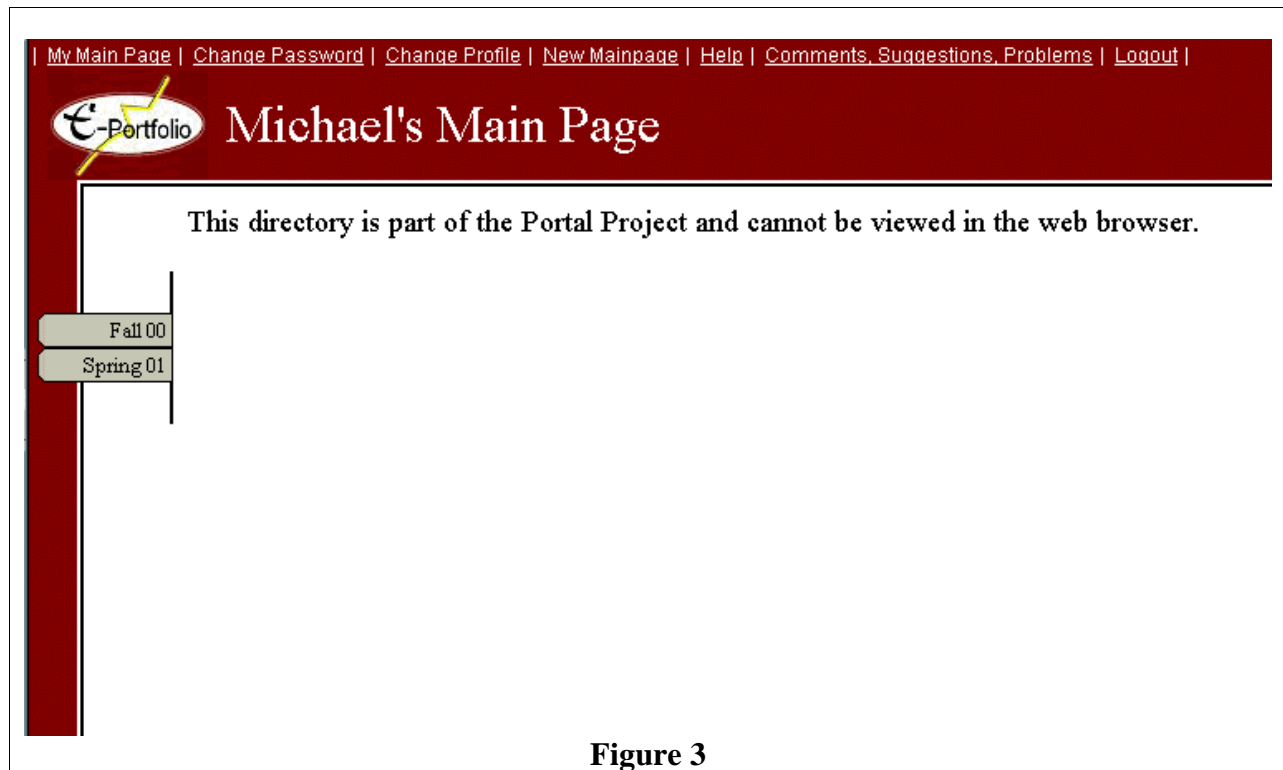
E-Portfolio Michael's Main Page

This directory is part of the Portal Project and cannot be viewed in the web browser.

Fall 00

Spring 01

Figure 3

E-Portfolio Michael's Main Page

Upload   MTH 182 HST 103 CIS prj ECO 101

Fall 00
Spring 01

E-Portfolio Michael's Main Page

Upload   MTH 182 HST 103 CIS prj ECO 101

Exams :   **Feedback :**
Exam 1
    Rose Test 5
    Test Lab 3
Exam 2
Exam 3
Projects :   **Feedback :**
Project 1
    Rose Test 5
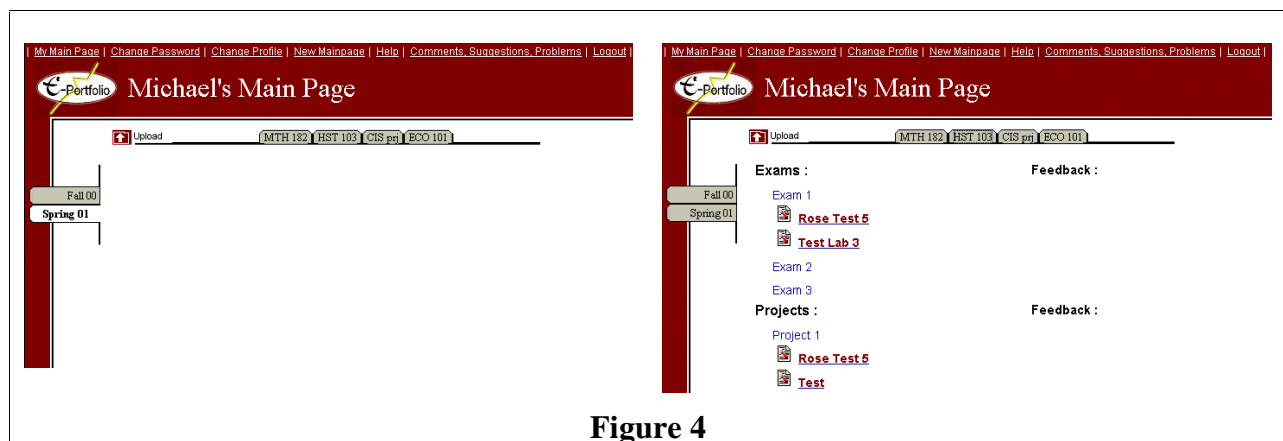   Test

Fall 00
Spring 01

Figure 4

Similarly, Figure 5 demonstrates the perspectives the instructor has to the material available.

The movement to the learning portal increased our concerns, and hence the requirements, related to creating a collaborative environment. We view the portal as a collaborative between students and faculty, and among students. As mentioned earlier, the use of a visibility property increased our ability to have students doing peer reviews. These reviews should become part of the artifact collection for the reviewer and the reviewee. This perspective also pervades the world of the instructor. We need to ensure that instructor feedback is both easy to provide and becomes an integral part of the collection. To support this we detailed a number of requirements (see Table 1) which force us to incorporate this functionality. Our goal, as mentioned earlier, is to create an
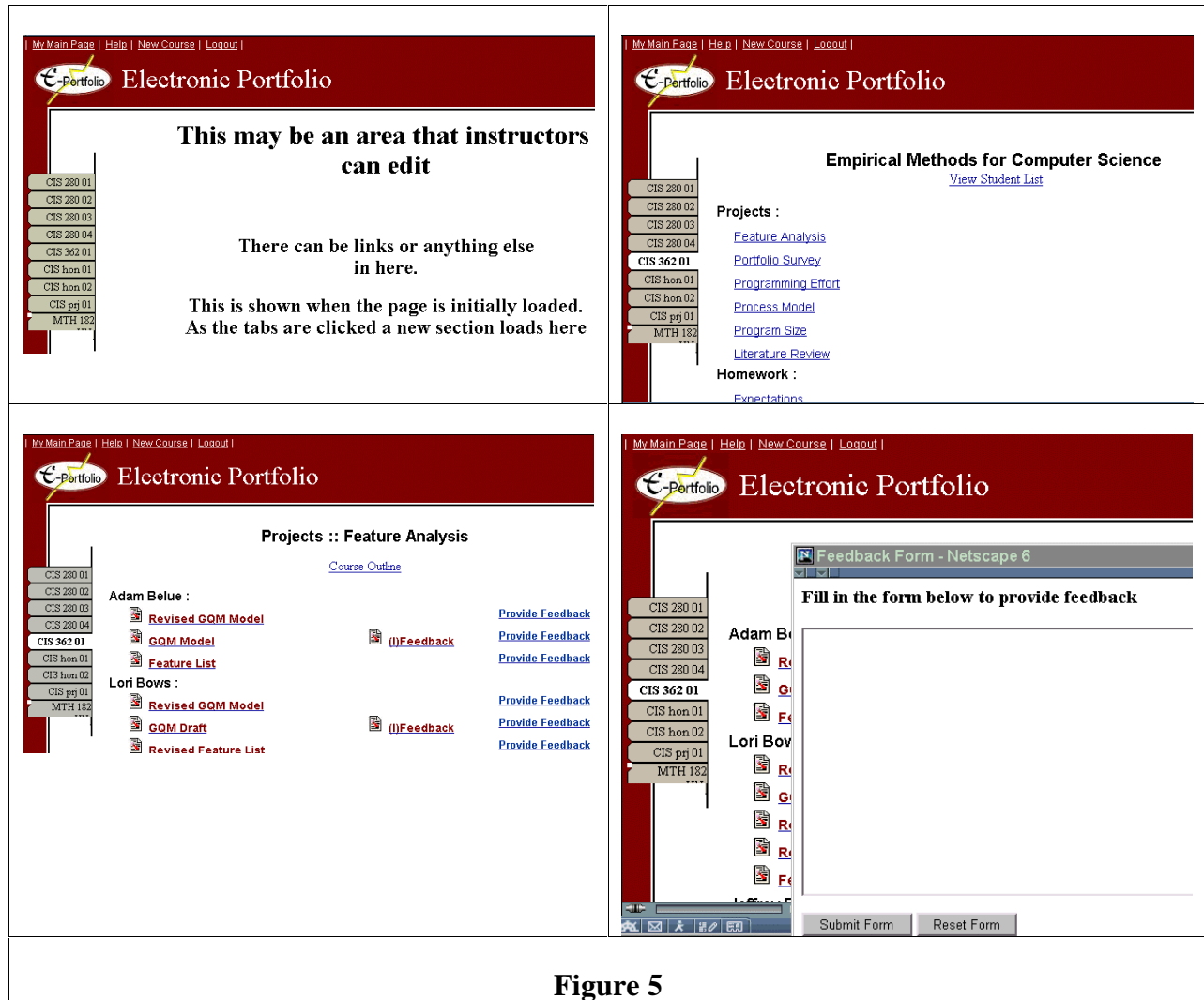
Figure 5

environment where the students and faculty collaborate during the learning adventure. Students will be able to view all feedback (from instructor and other students) together so that they can reflect on changes over time. The final requirements (see Table 2) deal with simplifying the manner in which instructors can interact with the collected material. Numerous authors have described the different roles portfolios can play in the world of assessment [34,35,36,37]. One of those roles is course-based assessment [35] where the instructor looks critically at the type and nature of the learning that occurred during the instructional episodes. The system we envision should facilitate the exploration of the information in the collective for that purpose. Our conceptual model, based on views, allows the instructor to construct a view of a particular assignment that would aggregate the work of all students in a particular course together. This will be true for student products, for students' reflective essays, and for peer reviews. In addition, the system will eventually analyze surveys and multiple-choice quizzes and exams. It will provide item analyses, so that instructors can easily find where their course is succeeding and where it is failing. For example, it will be able to list those questions on which more than 20% students expressed dissatisfaction.

V. Conclusions

We have been engaged on this project for a number of years. Only recently have we become impressed with the real potential of a portfolio system such as the one we have specified. This collection of requirements is the result of many years, and many iterations of prototypes exploring various components we have described. We have also gained an increased awareness of the difficulty instructors will have in dealing with data rich systems, and understanding of how to benefit from such systems. Much has been written regarding the time burden portfolio assessment can have on faculty. Our cognizance of these issues influences the evolution of the system we are building.

Our data, though anecdotal, suggests that students do comprehend the value of such a system, and can deal with such a system effectively. They do in fact come to understand how such a system influences the teaching/learning process. We, like others, await the empirical studies currently in progress at Stanford [38] to provide a longitudinal perspective of how the portfolio influences students and their approach to the learning context. In the interim, we plan to work with the portal system with our students to help us think about our courses and the learning outcomes we expect versus those we actually achieve.

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1. Instructors should be able to collect all submissions for a specific assignment into one view.
2. Instructors should be able to review the feedback provided for those assignments and the associated artifacts.
3. Instructors should be able to provide feedback from this view.

Table 2

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