EXPERIENCE WITH A PROCESS FOR SOFTWARE ENGINEERING WEB-COURSE DEVELOPMENT

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Abstract - In 1999 The Software Engineering Program at University of Houston - Clear Lake elected to be one of two programs that would be the first in the university to participate in the development and delivery of official web-based course offerings. The Software Engineering program had operated as a Distance Education program for the past six years via two-way live interactive video broadcast into multiple receiving sites. The new venture into web-based delivery would prove to be quite different from the live broadcast distance courses since the lecture component and live classroom interaction were not provided. With the live broadcast method heavy use was made of the web to provide easy access to all assignments, supplementary material, lecture notes, class messages, bulletin boards and an ftp site for assignment submission. This reduced phone and email time with the distance students dramatically and it certainly helped with the transition to the development of strictly web-based courses. However, the content-related materials that had been provided to support the broadcast courses were found to be inadequate once the live lecture component was removed and the course became strictly web-based.

Fall 2000 will see the completion of the design, development and testing of three strictly web-based Software Engineering courses that will form the basis for a certificate in Fundamentals of Software Engineering which will be issued by the School of Natural and Applied Science. This paper presents an overview of the activities that took place during this effort and the basic process used. This process could be used to help guide other programs and faculty interested in developing similar initiatives.

THE WEB-BASED COURSE DEVELOPMENT PROCESS

The web-based development process is basically one that is a combination of three concurrent sub-processes. These three are the Standards and Policy Creation sub-process, the Course Material Creation sub-process and the Web-Site/Web-Page Creation sub-process. Each of these sub-processes can be dealt with separately but there are innate dependencies among the phases that require a more evolutionary style (evolutionary style as is defined in Sommerville, 1996 [6]) of development. Figure 1 shows the three sub-processes and the interactions between them. These three sub-processes are in effect concurrent processes though the figure may not readily convey this. The input boxes to each sub-process represent the key process players that interact with each sub-process and the output boxes show the major results/documents produced. Each of these sub-processes is briefly discussed in the following paragraphs.
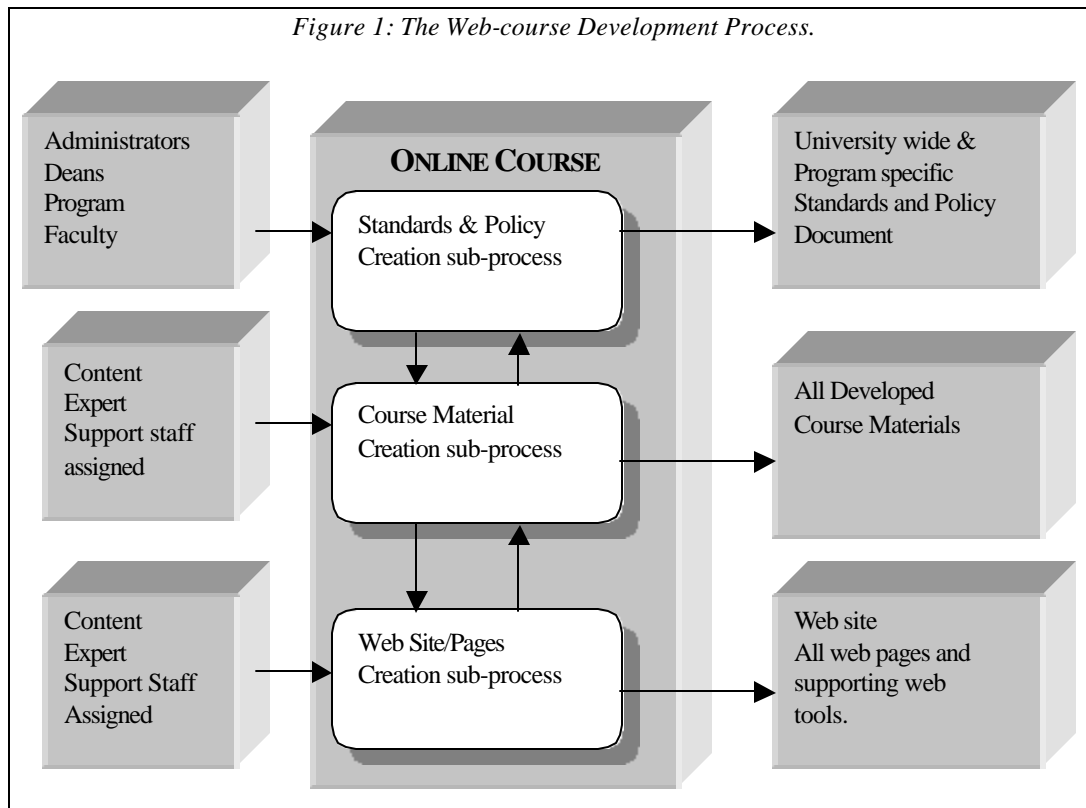
Standards and Policy Creation

The Standards & Policy creation sub-process deals with two major activities: 1) the creation of policies that will make explicit faculty compensation, copyright, staffing, funding, resources provided, plans and procedures required, as well as issues such as the allocation of roles and responsibilities at the University, School and Program level, 2) the creation of a set of standards for web pages that will be created at the Program, the School, and University level. This sub-process results in two documents, a standards document and a policy document. Our standards document is almost complete. The Policy document is under going much discussion and revision and is not yet finalized. Ideally one would like the standards and policy documents completed before beginning course and web site design. However, if you are new to web-course development then in practice these activities will run concurrently until the Standards and Policies have been defined. The activities of the Standards and Policy creation sub-process is not documented here, but it is included and briefly discussed because it addresses very important issues that must be resolved. Faculty involved in course creation should be very active in this sub-process in order to ensure a sensible Policy and Standards document emerges.

Course Material and Web Site / Web Page Creation

The other two sub-processes are the Web-site / Web-

them do. This includes providing a chat facility, bulletin board for threaded discussion, online testing, quizzing, and grade reporting support, etc. However, as with most

Figure 1: The Web-course Development Process.

Page-Creation sub-process and the Course-Material-Creation sub-process. These two sub-processes proceed concurrently with each other (also with periodic interactions with the current version of the standards and policy that have been set) resulting in the evolutionary development of the final web-based course. The concurrent nature of the Web-site/Web Page and Course-Material-Creation sub-processes reflects an actual change that we made to our process after our experience with the development of our first web based course. Originally, the design and development of all course materials was completed before we began web development. During web development we found that the design and structure of the course was heavily influenced by the web based tools (both support tools such as bulletin boards, chat, and the delivery tools, such as WebCT, that we chose to support the course. This resulted in quite a lot of unnecessary redesign of many documents and html pages to accommodate the structure the delivery tool imposed on our course. The delivery tool we choose was WebCT. There are several such tools on the market and WebCT provides the usual support that most of

of these tools, it restricts the layout and look-and feel of your course to a great degree. Therefore if one is to use such a tool one must begin the web design at the same time as course material design in order to work most efficiently and productively (that is, to avoid re-design and re-implementation of possibly major portions of the course).

The following section depicts and discusses a few (certainly not all) of the most salient activities of the overall web-course development process. These activities represent a partial slice though the entire web-course development process presented in Figure 1. We end this section with a table (Table 1) that summarizes the major activities of this process, the documents produced, and the key milestones that should be reached after each activity.

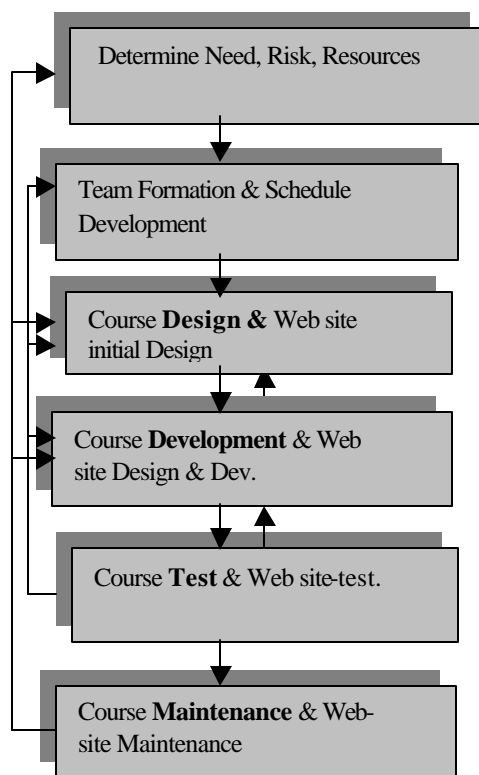## MAJOR ACTIVITIES / STAGES OF THE WEB - COURSE DEVELOPMENT PROCESSES

Figure two shows a graphical view some of the major activities (or stages) involved in the web-course development processes shown in figure one. Each major

activity is represented by a shaded box in figure 2. (The activities are taken from a cross section of the three sub-processes shown in figure 1. Due to space limitations not all activities are shown) The arrows between boxes in figure 1 indicate the major influences and interdependencies that were found to be present between various stages. Putting more than one activity within a stage (indicated by use of "&") indicates concurrent activities within a stage. Each stage in this process is discussed below including a brief discussion

Figure 2: Major activities of the web-course development process

of our experience with the activity. Table 1, which is presented at the end of this section is helpful to refer to when looking at figure 2 since Table 1 summarizes for each activity in figure 2, the output produced as a result of each activity, and the key milestones to be met.

Activity: Perform Needs Assessment & Risk Analysis

The determination of the market for, and the risk and benefits of, online web-course development is the first

step. The result of this activity is a Needs Assessment and Risk Assessment document.

This was an informal activity at our school that occurred through meetings with Marketing, Deans, Dept. Chairs, Program Chairs, the Provost and other key administrators. The Dean and faculty of various programs were assigned to analyze the risks and benefits online courses could bring to their program. They were also to decide the level of participation a particular program should commit to for online offerings. After such analysis, a proposal was produced which outlined a possible course of action, i.e., a preliminary plan. This plan briefly laid out the courses that could be offered, how they fit in with the program, which courses should be offered, who will develop the course materials, etc.

Activity: Determine general resources needed

Once the decision to provide online courses has been made the specific hardware, software and people support needed to successfully develop these courses must be decided upon.

In our process the support was outlined in the Policy document. The support provided to all official web-course development projects centered around three major phases: the Design, Development and Test phases. (These phases are not explicitly represented in figure 1 or 2 but some of the major activities of these phases are shown in figure 2 and summarized in Table 1.) The structure of support provided for course development centered on these three phases. For example, our support policy provided to each faculty member developing an "approved" web-based course, two course releases for the design and development of the online course. The test offering was counted as part of the regular teaching load. The support team for design, development, and testing included a Graphic artist, an Instructional Designer, a Web Designer, a Web Programmer, server space, and $1500.00 for special purchases to support the faculty member developing the course, plus $1000.00 cash bonus to the faculty member.

Activity: Team Formation & Schedule Development

Once the university support is known, the online courses that were selected for development were assigned a content expert (usually a faculty member) to develop the course materials and this person was assigned her/his team of people. One of each of the Instructional Designers, Graphic Artists and Web Designers was assigned to one or more content experts. (Each of the support team members was assigned a set of courses to work on). A schedule for development of the course was laid out. This schedule determined the

various phases of the development over time. Using our process model this was a three semester schedule: one for design, one for development, and one for testing. These three important activities are discussed below.

Activity: Course and Web site Design

This is first phase of work directly related to the creation of the course materials that will make up the course and the creation of the web pages that will be used to present the materials to the student. The design phase includes the creation of the following: course syllabus, course policy, course objectives, content design restricted to 1 page weekly unit overviews which detail only the weeks topic, objectives, and a brief description of each major assignment. This determines the overall design and timeline for the course. The design is produced by the content expert and the instructional designer working together. The resulting design document is given to the web developer who designs the top level web structure of the course which contains this material and incorporates chat rooms, bulletin boards and other needed communication mechanisms as part of the initial web site design. The graphic artist should begin the design of class logos, banners, etc.

Activity: Course & Web Site Development

This is the second major phase directly related to course material creation. During this phase all course content is created and finalized. In the author's case, a Word Document was created that contained the content for each week of the class and associated "getting started guides". The content consisted of professorial notes that introduced and explained the topics, online quizzes for reinforcement of key ideas, frequently asked question files, and many more supporting files. The guides serves as essential html indexing documents that served to help the students get through complex material, and be able and prepared to do the work assigned. All of these items were additional items we had to create in order to compensate for the loss of the live classroom. In addition, many graphics were created and passed to the graphic artist for animation that would help convey the story the graphic is supposed to tell. In the traditional classroom the story would be told in class but with a strictly web class the graphic had to be animated to tell this story and in some cases audio or video may need to be added. It is during this phase that all assignments for the course had to be detailed and any special student guides, supporting material, etc., needed to do the assignments had to be created. All rubrics for assessments were created and made part of the course materials. All course materials were then converted to appropriate format needed, html, pdf, and so on. The

major lesson we learned was that using Word in the beginning actually became a burden. It became much easier and more productive to create everything from the beginning in html format using an html editor such as Netscape Composer or Dreamweaver. This saved all the conversion time and reformatting problems that we experienced using Word.

Activity: Course Test

Once the course is fully developed and available online it is time to let students take the course and assess how it goes. This phase should include the development of student surveys to determine the success of the course, its strengths and weaknesses. The idea of the test phase is to determine the weak points and correct them before offering the course at large. During the test phase a classroom was secured and students were invited to come at a weekly-designated time if they were having trouble, or wanted to talk to the instructor or meet classmates in person. Class time was not used for lecture but used to answer questions about the materials provided, the assignments, give major exams and so on. This allowed us to gain immediate feedback as to what was working and what was not with regard to student interaction with the materials and to better gauge learning. It also allowed us to determine how many of the students opted to come to class and the grades they made versus those that not to attend. During the test phase corrections and adjustments needed should be documented (and made) before offering releasing the course to a wider more distance audience. We restricted the courses in test phase to only local Clear Lake Area and Fort Bend County students. All students enrolled were required to meet as a class on campus on the first day for orientation and for all exams. All other attendance for was optional.

Activity: Course Maintenance

Once the course has been tested and modified it should be fairly stable with the exception of usual modifications to content and assignments. However, the nature of these modifications could at times make access to the original support team necessary. For example, replacement of content units could require a set of new complex graphics. Support for maintenance of the site should therefore be taken into account within the school's support policy. If not, the course quality will most likely degrade over time or the content will eventually become outdated. Regretfully, as of the time of this writing our university has no policy in place for maintenance of the course, though it is in discussion and everyone is aware of the need to make some decisions regarding long term course maintenance.

The table below summarizes the key activities that were presented in figure 2 but adds the details of the output produced as a result of each activity and the key milestones to be met

Table 1: Summary of Process Activities, milestones and documents produced.

Activity	Output Documents (and artifacts)	Milestones Reached
Perform Needs Assessment & Risk Analysis	A Risk and Benefits Document Preliminary plan.	Risks and Benefits documented. Decision to move ahead or not, and on what scale, is made. Official Approval to proceed obtained.
Determine Resources	Resource Document. This includes documentation of all hardware, software, support staff positions and instructors needed.	Resource Document produced. General Support Structure Defined
Team Formation & Schedule Development.	Team members documented, Schedule documented.	Allocation of team members to faculty, Course development schedule agreed upon
Course Design	Course design document (Course Syllabus, Course Policy major assignments and project topics , Brief weekly overviews of content and tasks, Broad objectives written) Web Tool support selected	Course design complete. Web tools decided upon.
Initial Web page design and web site creation.	Initial web site created. Upper level web pages developed.	Design documents incorporated into web site. Chat rooms, bulletin boards, and student web-work areas created. Look and feel of course web-site tested and approved.
Course Development	Files that contain the content for each unit produced. All assignments created. All assessment rubrics created. Frequently asked question files complied. All necessary guides to study of the material written.	All graphics for course developed. All audio, video developed. All assignments and content completed. All external information (linked to) found an included in content.
Web site completion	All Web documents in html, cgi , etc produced.	Web site for course contains all materials.
Course Test	Course Assessment Results. Document necessary changes to make to course.	Course tested.
Course Maintenance	Updated Course Materials.	Course material and web site revised as determined.
Standards and Policy Development (This activity starts early and continues concurrently with all others until finished)	Standards Document and Policy Document produced.	Standards and Policies Defined.

OUR EXPERIENCE WITH THIS PROCESS

Though there are many instructors who are putting course materials on the web to support the traditional classroom lecture there is much involved in developing a course that will not be reinforced by classroom interaction time. Even though there were quite a lot of materials web-accessible to support past live lecture courses, once we began serious design for a course that would be without live lecture virtually everything had to be redone and augmented heavily with material that could substitute for the interaction in the classroom. For example, the PowerPoint presentations used in the live classroom and put on the web could no longer be provided as the content portion of the course since the slides were designed as an *aid* to discussion not a replacement. We had to entirely rethink how to combine text, graphics, links to support material, audio tracks, chat discussions, threaded discussions, and so

on, that would combine together to form a unit of information that could provide the student with a replacement for classroom lecture.

The process that is presented here is one that resulted from the last year of working on online course development and delivery. It is formalization of what has shown to be a fairly good process to follow when attempting serious online course development. We believe it is a fairly good process based on the quality of the web-based courses the process has resulted in. The current Course Material Creation sub-process turned out to be a definite improvement over the initial version of this process. The initial version called for completion of the Course Material Creation before the Web-Site/page Creation sub-process could begin. When we began development of the second course we modified the process to begin the Web site/page Creation process concurrently with the Course Material Creation in order to avoid the redesign and rework that was necessary under the sequential model.

4. INFLUENCING PRIOR WORK

The process that appears in the article is not the result of study of previous work but rather is the result of actual practice. However, many of the technology strategies we incorporated into our online course have been the topic of recent publications concerning the benefits and shortcomings of interaction mechanisms. Thus the interaction needs and benefits presented by (Mesher, 1999, [3] and Althause & Matuga 1999 [1]) were beneficial in supporting our belief that interaction support among students and between the instructor and students is crucial. Though this level of detail is not presented in this high level view of our process, it was a major design criteria applied to the courses developed. In addition, recent distance course development experiences related by Cooper [2], and Schrum [5] is related to this work in that the activities involved in creating distance courses and the resulting benefits and risks are discussed but the process itself is not formalized nor make specific.

HOW DID THE STUDENTS LIKE THE NEW WEB-BASED COURSES?

After completion of testing of Introduction to Software Engineering during the spring 2000 semester feedback was extremely positive. Students found the course very challenging and loved the flexibility. Students who did not attend optional class discussion sessions regularly performed as well as students who did. Approximately 60 out of 70 students had no problem with all instructions and written assignments provided in the web-based course and performed all required duties

with minimal problems. However, about seven of the weakest students required extensive oral communication with the instructor to clarify tasks to be performed. As a result of this experience it is evident that the weaker student will not be as successful with a web-based course as those that are well prepared and have strong verbal and written skills in the language the course is supported in. Admission into web-courses may need to look more carefully at the past performance of students. Students who have weak language skills will not perform as well since oral communication is no longer provided as the main communication medium - rather written communication is. As for the enrollment and popularity, all web-courses we offer fill in the first hour of registration.

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