Computer Productivity Initiative

Annual Project Progress Report

submitted by

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1 Progress and Results

1.1 Fundamental Computer Productivity Initiative Goals

- Increase Student Productivity Using CPI Multi-Year Project
- Teach Students how to Develop and Specify Realistic Productivity Enhancing Systems
- Development of Materials and Tools Supporting CPI at other Universities over the network

1.2 Development Approach

- Development New Course Requirements and Supporting Materials
- Expand Existing Course Requirements
- Successfully Teach Series of CPI courses
- Document Methods Used
- Establish Library of Resources for Exporting the Model Electronically

1.3 Support Actions

The long lead time of equipment procurement and the reconstruction of the CPI facility (see Appendix D.) indicated that these efforts demanded immediate action in order to support the scheduled trial run of the first CPI senior level course in the Spring of 1993. The development of the Multi-Year Course Schedule and the Multi-Year Key Event Schedule (Appendices B and C) also helped to solidify the general actions that were necessary for the success of the project.

Several concurrent actions had been identified along with the facility modifications and the procurement of the facility support equipment. The decision of what type of project and the details of the project had to be identified. The establishment of the CPI Advisory Board and the first meeting had to take place. The development of the critical course material had to be accomplished. These major elements of the CPI were all required to be accomplished prior to the beginning of the Spring semester and the initial offering of the first CPI course.

Overshadowing the urgent requirements to meet the first course, were the development of the overall milestone schedule for the multi-year effort and the establishment of the CPI evaluation and distribution plans and methods. The Fall '92 weekly action meetings focused on several of these problems. Appendix D contains a portion of the early work and results achieved during the Fall '92 time frame.

As the last days of December 1992 passed, the efforts of all concerned slowly began to formulate the necessary components to support the first offering of CS 410 (Computer Based Productivity I). Several construction problems and associated delay issues were being solved, the required equipment was being received almost on a daily basis. The facility began to take shape. Even the simple facility furnishings were beginning to be received and installed. Most of these early CPI support efforts required significant expenditures of the planned budget. Appendix F. reflects these expenditures along with those through the Summer '93 preparations for the Fall '93 semester offering of CS 410.

The most critical events were completed in time to support the test case course CS 410 in the Spring '93 semester. The Center for Computer Productivity was furnished and was sufficiently intact to use as the lecture room, seminar discussion and group meeting room. The work stations were installed with sufficient multimedia connectivity for students to utilize. The course CPI project was selected from several candidates and confirmed during the November meeting of the CPI Advisory Board. The CPI selection process is contained in the Advisory Board Meeting report of Appendix D. That Appendix also contains the initial draft of the course syllabus for the first offering of CS 410 using a Senior Project course listing (CS 495). This course outline was discussed during the Advisory Board Meeting. Several board member comments and suggestions were subsequently incorporated into the final course syllabus. The conclusions of the combined CPI faculty and Advisory Board members ultimately defined much of the details of the Computer Based Productivity I course (CS 410). Appendix E contains the history of the decision process for the success of the project.

Although the other CPI related courses were not critical for the Spring semester, the faculty continued to develop and modify the course contents as necessary. The course content for CS 411 (Computer Based Productivity

II) was defined in terms of continuation of the efforts of CS 410 into the broad scale development of the product. The modifications to the laboratory courses CS 250 and CS 300 were defined in terms of the implementation timing. Initial modifications for CS 300 were installed in the Spring '93 semester with the final modifications to be added in the Fall '93 semester. The modifications to CS 250 were defined for installation during the Fall '93 and Spring '94 semesters.

Essentially the planned actions for the Fall '92 were completed in sufficient detail to support the Spring '93 semester. Additional actions were required to complete the CPI Center renovations, additional required equipment had not yet been received, and required system software to support the student's use of multimedia equipment was not yet installed.

The initial offering of CS 410 proved to be both a challenge and as well a significant resource for valuable data in more accurately defining the content and presentation of course material. The challenge was evident in fine tuning the course material to insure students received sufficient guidelines and methods to pursue the course project. The semester weeks were a combination of seminar descriptions of appropriate methods to use in solving the current state of student prosecution of the course project along with active applications of those methods. Identifying pertinent presentation material and coordinating the course project efforts became a crucial and time consuming effort. A guest speaker and a field trip to a "smart house" provided significant assistance to the students in defining the CPI problem solution.

During this time of the early part of the Spring '93 semester, the CPI faculty submitted and received acceptance of the paper of Appendix G for the 7th CSEE conference. This paper presentation will be the first significant exterior publication of the CPI method of achieving increased student productivity. Additional papers based upon significant portions of the CPI method are in preparation.

In May we presented the project and its status, Appendix H, at a workshop held by the NSF EI division.

By the mid-term in the semester, the CS 410 students began to formulate a concise set of problem solution concepts. Their presentation of these concepts to the Advisory Board (acting as a Board of Directors) was well received. The Board members provided glowing comments concerning the relatively professional presentation and technical support for the proposed solution. Essentially, this initial effort was judged to be a success in achieving the productivity goals of the course.

The weekly meetings of the CPI faculty during the Summer focused in on three main issues, what we learned from the trial offering of CS 410 in the Spring '93, completion of the requirements as outlined in the original plans of the Fall '93 schedules of Appendices C and D, and the requirements for the formal beginning of the first full academic year of CPI. With the first offering of the Spring completed, and completed rather successfully, the cursory look of what remained to be accomplished seemed small as compared to the achievements already accomplished. The myriad of tasks, administrative, functional, and developmental became clear as individual requirements for the Fall semester were prosecuted. The most significant included the identification of course numbers and content in the university catalog and the associated registration process for new courses, the implementation of the modifications to the CS 250 and CS 300 support courses, and the changes required to CS 410 as a result of analysis of the results of the Spring semester. Each of these requirements has been completed in sufficient detail to adequately support the Fall semester courses.

1.4 Achievements

The early impressions from the Spring semester course are very positive from the student's perspective. Their skills in developing and presenting technical material were increased. Reports from graduated seniors reflect in two cases an immediate use of these skills in their first weeks of employment in commercial industry. The students also report that their use of multimedia equipment during the design and development of project specifications provided them with an insight that was not present in their contemporaries of the availability of the vast offerings of multimedia tools. Several other key areas were also mentioned by students who completed the Spring CS 410 course as providing them with skills and knowledge not provided elsewhere. These included the large number of requirements to participate in group efforts to develop or design parts of the course project, the requirement to conduct personal interviews with domain experts to obtain critical project support data, and the presentation to an external group of business leaders. In general, it would appear that the initial offering of the CS 410 course largely achieved the expected goals of the CPI method to increase student productivity.

The overall goal of developing the CPI model continues to expand and be refined. The CS 410 course has been slightly modified based upon the Spring course, but the original rough model remains intact. The Fall semester use of the support courses (CS 250 and CS 300) are expected to yield valuable information regarding the coordination of the laboratory effort and the effectiveness of the model concept of multi course support. There is not sufficient data yet to reach any conclusion or draw any inference on these aspects of the CPI model.

We have identified DHC, a tool developed at Old Dominion University, as the means for the students to guide their problem solving activities and to organize and manage the multitude of multi-media documents they produce to develop their solution. DHC is a hyper-link, multi-media, CASE environment which is a tool supporting the Decision-Based System Development paradigm. This choice will also allow us to port the model curriculum easily to other universities using Internet. We have used DHC to document the decision structure of the process of developing the curriculum and a specification of our implementation of the curriculum. Since the students use it as well to document the process and the product(their solution) of the problem to be solved in the courses we have examples of how the courses can be taught.

The curriculum has been revised to make CPI required for CS majors and the catalogue modified to reflect these changes. The cost of these changes were the increasing of the total credits required for graduation by three and we used one of our free electives to cover the other new course. The catalogue descriptions of CS 250 and CS 300 have been modified and we have included a brief statement about CPI in our curriculum description.

2 Current Problems and Issues

In the undertaking of this project, we have had to address numerous issues which affect the course of its development. Many of these issues were identified during the writing of the original proposal. In this section we discuss our progress on addressing these and those other issues identified during the first year of effort.

In the most abstract sense a solution to meeting our objectives is the selection of a non-trivial Productivity Project, development of specifications by the most experienced students (seniors) and management (again by seniors), of students in the lower level courses to obtain needed software and impact studies.

The mechanism is a series of additional courses and the addition of formal laboratories to existing selected courses.

2.1 Original Issues Identified Prior to Implementation

We identified a number of potential problems during the development of the proposal to NSF. These included the difficulty of managing multi-year projects, the ensuring of quality in the process of the projects, the adaptation of requirements to the capabilities of students in lower level courses, the avoidance of modification to the curriculum each time a new project is undertaken, the maintenance of accreditation and a set of reasonable graduation requirements despite modifications to the curriculum, and the accessibility of the new curriculum to transfer students. These problems are discussed below.

2.1.1 Management of Multi-Year Projects

Multi-year projects place a dependency between courses: a failure in a prerequisite course will cause problems in later courses. Addressing this concern will place a major emphasis on the intercommunication and coordination between lab supervisors and the Project Coordinator.

Status: CS 410 Tasks CS 300 and integrates their findings into the final presentation/proposal. This dependency has not proven troublesome. There is sufficiently time for the CS 410 students to identify several social impact issues to be studied by the CS 300 students and for the CS 300 students to complete their studies in a timely fashion to have an impact on the final product of the CS 410 class. Since some of the studies undertaken in CS 300 will be better used in CS 410, there is even less a concern about the timing for integration. While this seems to be working out successfully, the integration between CS 410 and CS 300 is certainly expedited by the fact that they have the same instructor.

Integration between CS 410 and CS 250 is a bit more problematic. The kinds of services that can be provided by CS 250 are of a limited and low level nature. These consist primarily of programming simple modules and performing experiments on provided prototypes and simulations. CS 410 is concerned with more abstract problems and is unlikely to be in a position to task very specific low level studies suitable for the CS 250 students in a timely fashion. The tasking from CS 411 to CS 250 seems more appropriate. However, it may not be important for CS 250 to provide any input in a tightly interwoven schedule to either CS 410 or CS 411. Since there will be many problems which CS 410 and CS 411 will not be able to completely address anyway, they must find alternate methods of coming to a decision. The information will be available for a later iteration of the senior sequence. It is important, though, that CS 250 students will be exposed to programming problems and experiments tasked by the seniors and will become familiar early in their academic career with the CPI project concept.

The transition between CS 410 and CS 411 is the most tightly coordinated and therefore subject to the greatest risk. The documentation produced during the first offering of CS 410 would have been inadequate to the transfer of the project to CS 411. During the Fall 1993, we have addressed this problem by using project management tools and documentation standards to assure that the efforts of the CS 410 can be captured in a form which will be useful by the following CS 411. However since we will only offer CS 411 in the Spring 1994 semester, we must wait to see if in fact we have adequately addressed this issue.

2.1.2 Quality Assurance

We believe that this emphasis will be one of the innovations of this proposal. That is, the project does not emphasize building something but rather the process of ensuring that there will be quality in the final product. This objective can be achieved by a combination of the following:

1. making quality a requirement,
2. being prepared to throw away the earlier versions, and allowing time for the improved version to be built,
3. having gold versions generated by faculty,
4. students evaluating and fixing the best of their efforts.

With the reduced dependencies between classes, this has become less of a concern. In CS 300, CS 410 and CS 411, the major part of the grade will be affected by the quality of the work and thus serves as an incentive to produce a high quality solution. Also the use of project management tools, documentation standards, and presentation packages should help maintain quality. However, probably the most important incentive to provide quality is the constant review, both by peers and by the faculty and the outside board of advisors.

2.1.3 Adaptation to Beginning Students

We propose to use the project examples in the formal laboratories at the lower levels. This introduces CPI to the lower level students. Over time, these projects will form a library of building blocks that can be incorporated into future projects.

The selection of problems which introduce the CPI project while still meeting the original educational objective in CS 250 has not been a problem. Rather it provides a more realistic context for small problems which helps to remove the feeling that they are just throw-away programs which do not matter in the long run (even if they are in fact thrown away). It is not yet clear if a library of useful building blocks can be built by the lower levels. This may be more of a matter of the selection of a viable reuse systems development methodology.

2.1.4 Curriculum will Serve the Project

The production of software and hardware to be used by the customer is not a project deliverable. We should limit project exposure to a manageable number of courses - clearly defining the educational objectives of the project in that course. We feel by clearly defining the objectives of each of the labs involved in the project, it will be possible to give all students the advantage of a project oriented curriculum while maintaining flexibility in determining a specific set of activities that any particular class will undertake.

CS 250 has been changed by the inclusion of a scientific method lecture and an experimental laboratory lesson. In could be argued that this change was appropriate regardless of the existence of the Project. We certainly have not changed the educational objectives of either CS 250 or CS 300 to provide slave labor for the Project. We believe we have achieved an appropriate balance between educational objectives and project development.

2.1.5 Impact on Degree Requirements

We can reclassify some courses, e.g., by moving certain mathematics requirements to general education, we can adjust the contents and directions of existing computer science courses and laboratories. We can also use some electives and if absolutely necessary increase the number of credits. Care will be taken not to interfere with the CSAB and ABET accreditation.

We have managed to insert the CPI project into the curriculum without interfering with the CSAB or ABET accreditation requirements. In the interim period during which students under older catalogs are still taking courses, we need to provide a mechanism for these students to take part in the CPI project. This can be done by using the technical elective requirement and by adding the CPI project courses to the list of CS electives. However, until the program becomes established, we have decided not to enforce CS 410 as a prerequisite for CS 411.

2.1.6 Difficulty for Transfer Students

Students can read documentation on the Productivity Project, talk with other students, and the Project Librarian can run orientation seminars at the beginning of each semester for transfer students. It is expected that experienced students will "instruct" the new comers (this is part of the project experience).

With the reduced dependency between the upper and lower level course, this is no longer a major concern. It is expected that transfer students will assimilate the corporate culture surrounding the CPI project through interaction with their fellow students.

2.2 New Issues Identified during the first year of the Project

In addition to the problems anticipated during the development of the proposal, two issues arose during the offering of the courses. These were the need for an experimentation tool kit for the lower level courses and the introduction of large and complex software tools to the students.

2.2.1 Experimentation Tool Kit

The addition of an experimental component in CS 250 requires the development of an experimentation tool kit. For instance in the current semester, CS 250 students will be required to perform speed and accuracy testing of entering information using different kinds of input devices. It would be best if they could design, setup and run the entire experiment. However because of the difficulty of setting up the experiment, we will provide them with only a limited set of tools (and therefore a limited set of possible experiments). We are using the RA's hired under this grant to provide these initial tools. However, the development of prototypes and simulations suitable for experimentation is a new concern.

2.2.2 Teaching Large Software Tools

In CS 411, we have introduced to the students several large and complex software tools. These include DHC, for project management and IslandPresents for graphical slide presentation. While these tools should increase their effectiveness and eventually productivity, there is still a large up-front overhead to learning these systems. To address these problem, we have assigned CPI faculty with the responsibility to provide introductory lectures, user's manual and slide shows. This has been undertaken by faculty other than the instructor of the course in order to off-load this task. Once introductory, tutorial material is produced, this instruction could be undertaken by the RA/TAs or systems staff.

3 Future Activities

Activities in the next twelve months will focus on the following:

1. Refine content, instructional materials (provided to instructors), and support tools (provided to students) for CS 410 class through a second offering of the class. This will also result in a more careful specification of the deliverables which CS 410 students must provide other CS classes involved in the project, particularly the second course, CS 411.

2. Continue efforts to get one or more colleges involved. This will likely result in a joint additional NSF proposal to provide funds for some faculty support and equipment for the participating school.

3. Offer CS 411 for first time. During the current semester, the content of CS 411 will be redefined since our initial offering of CS 410 demonstrated that we were too optimistic about how much material could be covered in CS 410 and what the students in this class could produce. Thus some material originally listed as part of CS 410 will be moved to CS 411. In addition, this initial offering of CS 411 will result in an evaluation of materials required from students in CS 410. We expect a revision to those CS 410 requirements.

4. Continue to search for effective evaluation mechanisms for this project. The initial metrics which we have proposed ignore several key aspects of this project. We will find additional evaluation schemes.

5. Continue preparation of the package of support materials which can be provided faculty and students at other schools. Part of this is the continued documentation of the resources required to run such classes, including instructor preparation time, system support which should be provided, and how much student time is required for this class (compared with other project-oriented computer science classes). Currently transportability of some support materials may be hampered by our use of UNIX; removing implicit UNIX dependencies is desirable but may take more time than is available. Now completeness is more important that system independence.

6. Refine how we use the external board. It is clear that students benefited greatly from their interaction with the external board and we have had excellent participation from all board members. However, since these people are typically very busy, we must be careful in our use of their time.

Appendix A: General Topics of Effort

Appendix B: CPI Multiyear Course Schedule

Appendix C: CPI Multiyear Key Event Schedule

Appendix D: Advisory Board Meeting Report of Nov 20, 1992

Appendix E: DHC Decision Documentation System for CPI Problem

Appendix F: Budget Summary

Appendix G: CPI Paper accepted at SEI Conference of Software Engineering Education 7th CSEE

Appendix H: Briefing on Decision Based Systems Development

Appendix I: CPI Technical Flyer