Controlling Curriculum Redesign with a Process Improvement Model

Dennis Drinka
Minnie Yi-Miin Yen
Computer Information Systems Department
University of Alaska Anchorage
Anchorage, Alaska 99508, USA
drinka@uaa.alaska.edu afmyy@uaa.alaska.edu

ABSTRACT

A portion of the curriculum for a Management Information Systems degree was redesigned to enhance the experiential learning of students by focusing it on a three-semester community-based system development project. The entire curriculum was then redesigned to have a project-centric focus with each course in the curriculum contributing to the success of students' learning experiences. Implementation of this new design involved an evolutional enhancement from an existing traditional curriculum with modifications proceeding in stages over a four-year period. Early on, it was recognized that the curriculum redesign was progressing through a series of stages similar to that encountered in software engineering processes. As a result, the general guidelines and framework developed for continuous improvement in software engineering: the Capability Maturity Model were adopted and modified for guiding the curriculum redesign. This paper presents a description of the authors' experiences in implementing a curriculum redesign from one based on a traditional course-based design to a project-centric design using the Capability Maturity Model as a process improvement tool. Our successful experience with using this tool suggests a need for the development of a specialized process improvement tool for future use on similar curriculum redesign.

Keywords: Curriculum Redesign, Capability Maturity Model, Project-Centric Curriculum, Management Information Systems

1. INTRODUCTION

An academic curriculum can be viewed as a process that transforms students (Grundy, 1987). The components of this process include courses, instructors, teaching materials and methods. In theory, when viewed from this perspective, various process improvement measures can be adopted to improve the quality of the transformation. However, in reality, the differences between students and between the components transforming them can be so significant that control over quality becomes difficult. As a result, the importance of having quality control procedures for curriculum development is no less important than that for other processes.

The Capability Maturity Model (CMM) was developed by the Software Engineering Institute at Carnegie-Mellon University (Software Engineering Institute [SEI], 1995) as a tool for stage-based improvement of information system software development projects. It contains a framework for identifying five stages of maturity in the control of these projects. Moving from stage to stage in this framework corresponds to increasing control over the development process leading to increased quality of project outcomes. The focus of this paper is on the adoption and modification of CMM to the stage-based improvement of a curriculum design.

The original impetus for adopting the CMM grew out of a problem recognized in one of the required courses in our curriculum. This course was centered on the design and development of practical information systems for community organizations (See Figures 1&2). Lack of quality and consistency in the projects indicated a need to revise the project development process. We first became interested in using the CMM for improving project quality. As we took steps to move through the levels of the CMM for student projects, we noticed that the benefits derived from it could extend beyond improving the projects themselves to also improving control over the evolving development of the curriculum. As a result, rather than focusing solely on the quality of the projects, we used the experiences and lessons learned to broaden the concepts and to adapt the general guidelines of the CMM for improving curriculum redesign.

1.1 Original Curriculum

The Management Information Systems (MIS) curriculum in the College of Business at the authors' university was originally designed where each course was a self-contained, independent module requiring limited interaction between instructors. This design was originally based on the IS'97 Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems and followed the same guidelines in IS2002 Model Curriculum. These Model Curricula were the collaborative curriculum effort of the

ACM (Association for Computing Machinery), AIS (Association for Information Systems) and AITP (Association of Information Technology Professionals) societies and is supported by other interested organizations. (IS'97, 1997) (IS2002, 2002). According to the published guidelines, the scope of Information Systems, as an academic field, encompasses two broad areas: (1) acquisition, deployment, and management of information technology resources and services (the information systems function) and (2) development and evolution of infrastructure and systems for use in organizational processes (system development).

Our curriculum was built around five interrelated categories of courses: networks, database, programming, web development, and systems analysis/project management which covered both technology and technology-enabled business development categories of capabilities and knowledge expected for our graduates from the Model Curricula IS'97 and IS2002. In addition to these five categories of courses, the program also included three MIS courses required by all majors in the college, usually in the early stages of their studies and often before a major is declared. These courses are: a personal productivity applications course, *Computer Concepts in Business*, that covers computer concepts and MS Office suite software; *Management Information Systems* that involves an introduction to general MIS concepts, historical developments in IS, and emerging technology, etc.; and *Managerial Presentations* which involves the development of professional-level quality oral and written communications and presentations.

In order to enhance the experiential learning of students majoring in MIS, a community project was incorporated into a capstone course, *Systems Design and Development,* taken by graduating seniors. This course has become known as the Senior Projects course.

1.2 Revised Curriculum

In the revised curriculum, the Senior Projects course was placed as the central theme and unifying thread in three required courses in the MIS curriculum: *Systems Analysis (SA), Project Management (PM),* and *System Design and Development (SDD)*. Teams of students work on one community project per team that spans the three-semester sequence of these courses (See Appendix 1). At the same time, other courses in the program, as well as the sequencing of those courses, were redesigned to support the success of the three courses and their projects. The relationships between courses in the new curriculum and their sequencing are illustrated in Figure 1. The deliverables for the courses in the three semesters sequence are shown in Figure 2.

There are two major results of the redesigned curriculum in terms of student success and program success. First, measures of student success have been extended from course-specific knowledge measured exclusively on a course-by-course basis to a comprehensive measurement. This measurement is an assessment of students' capabilities to integrate and apply their knowledge and to conduct independent learning. Second, measures of program success have been broadened from individual courses to program-wide measures. In this case, student projects are reviewed by all faculty and shortcomings and gaps observed in project outcomes are signals that indicate a need for curriculum improvement.

1.3 Learning Theories Supporting and Enabling the Curriculum Redesign

The benefits of our design, an enhanced project-centric curriculum, are based on our perception of the value of enhanced student learning. However, these benefits are also strongly supported by two established curriculum model theories: (1) the product model theory which sees education similar to technical exercises that follow the processes of setting objectives, drawing up a plan and then applying this plan and measuring the outcomes (Grundy, 1987), and (2) the process model theory which sees curriculum as a process designed to transmit knowledge. The curriculum is the interaction of teachers, students and knowledge and includes what actually happens in the classroom and what people do to prepare and evaluate learning (Stenhouse, 1975). Kolb's Learning Cycle which explicitly advocates linking theory and practice is a well-known curriculum model which recognizes that neither the learning of new concepts (abstract conceptualization) nor experiential learning is, in itself, sufficient for complete learning. A learner should link theory and practice by planning how the theories will be put into action, by carrying out that action, and then by reflecting upon it, and relating what happens back to the theory (reflective observation) (Kolb, 1984, Kolb & Kolb, 2006).

The engagement theory for technology-based teaching and learning played an important role in both our redesigned curriculum and its associated community-based system development projects. The fundamental idea underlying this theory is that students must be meaningfully engaged in learning activities through interaction with others and with worthwhile tasks. Through engaged learning, all student activities involve active cognitive processes such as creating, problem-solving, reasoning, decision-making, and evaluation. Students are intrinsically motivated to learn due to the meaningful nature of the learning environment and activities (Kearsley & Shneiderman, 1999). With its focus on experiential and self-directed constructivist learning, the engagement theory also has much in common with Kolb's Learning Cycle Model and is similar to other learning theoretical frameworks, such as Knowles' theory of adult learning (i.e., andragogy) (Knowles, 1975, 1984).

1.4 CMM (Capability Maturity Model)

The CMM is a popular tool originally designed for stage-based improvement of information system development projects. It describes an evolutionary improvement path in software development from an *ad hoc*, immature process to a mature, disciplined one. Maturity refers to a software development environment with low risk and high predictability. The five levels of maturity described in CMM are shown in Figure 3. The lower the level, the higher the risk involved. At the fifth level, an organization will have implemented the practices, policies, and disciplines that support the development of software in a predictable, reliable, and repeatable process. The CMM is not concerned with the risks inherent in any particular development

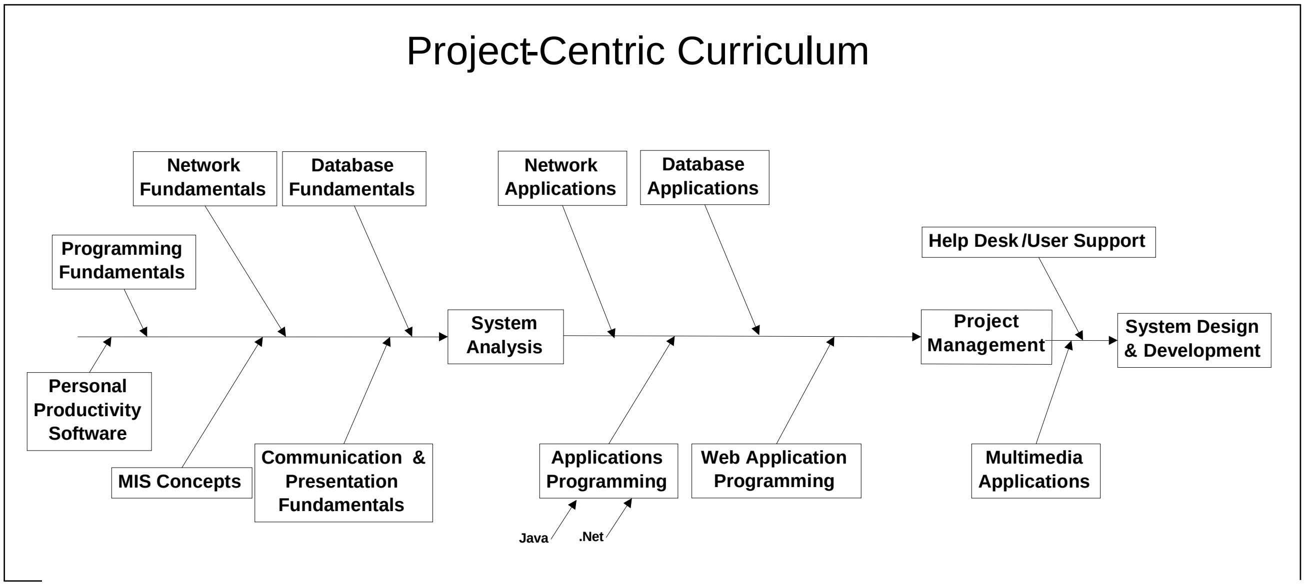

Figure 1: Curriculum

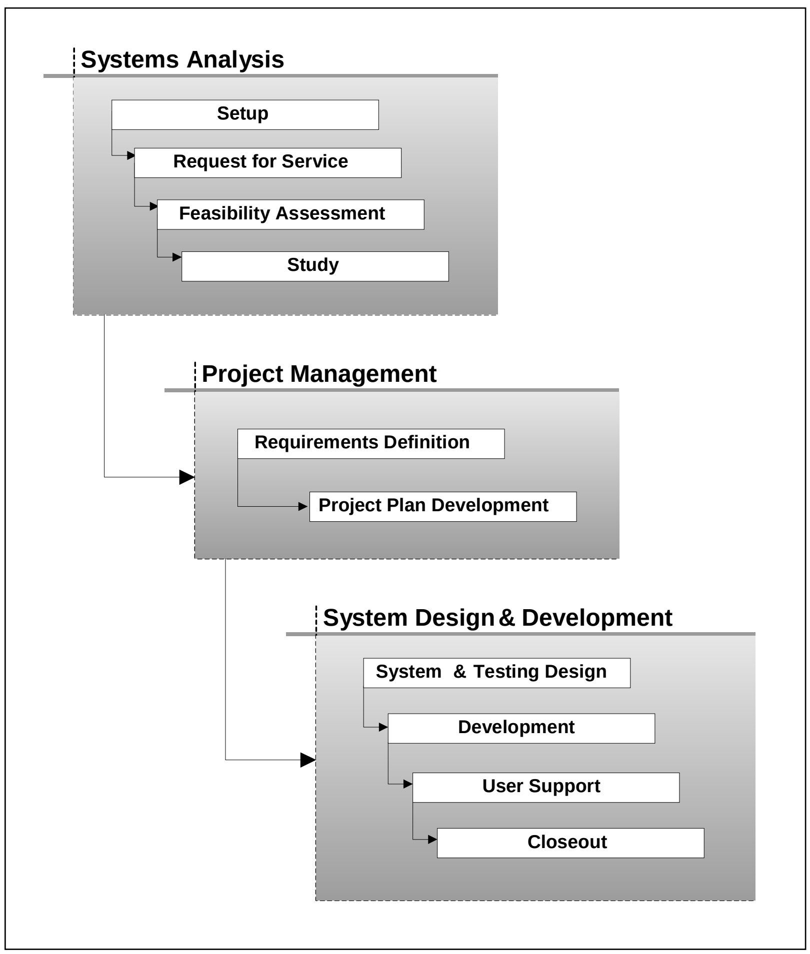

Figure 2: Course Deliverables

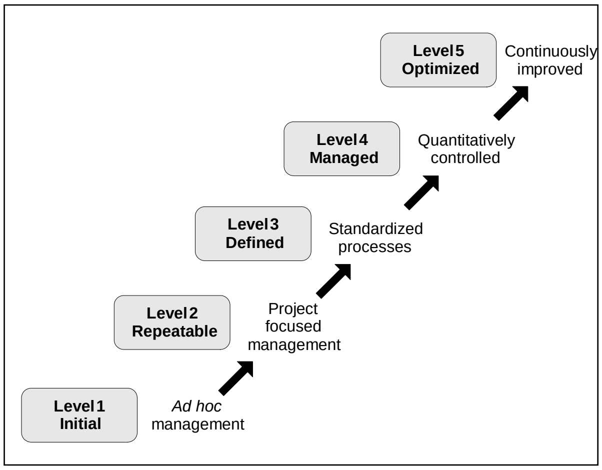

Figure 3: Stages of the Capability Maturity Model

in isolation; it is concerned with the design of a control system under which project development in general operates.

The CMM has been used to assess the maturity levels of organizational areas as diverse as software engineering, system engineering, project management, risk management, system acquisition, information technology (IT) or personnel management, against a scale of five key processes, namely: Initial, Repeatable, Defined, Managed and Optimized (SEI, 1995, 2002). The CMM found its greatest use in large organizations such as governments and government contractors. It was also well received in industries with large, mission-critical projects, such as avionics software (Binder, 2005). The CMM represented a change in the way organizations viewed software development by integrating the lessons learned from high-precision manufacturing. Prior to the CMM, organizations tended to emphasize the results of development, rather than focusing on improving the process. Though it comes from the area of software development, it can be, has been, and continues to be widely applied as a general model of the maturity of *processes* (e.g., IT Service Management processes) in IS/IT and other organizations (Hurst, 2007).

The next section describes the evolutionary implementation of the curriculum as based on the CMM. The final section will present lessons learned, recommendations for design of similar methodologies and curricula, and offer some concluding comments.

2. IMPLEMENTATION OF THE CURRICULUM VIA THE CMM

The CMM was originally designed for stage-based improvement of information system development project. In this section, we discuss how the concepts of the CMM were applied to the evolutionary improvement in the quality of student projects, and how this evolutionary improvement facilitated the transition of the curriculum from one based on the traditional model curriculum for MIS programs to one based on the development of community projects spanning the system development life cycle and spanning the entire MIS major curriculum.

2.1 CMM Level 1—Initial

In the first level of the CMM, the “Initial” level, the development environment is characterized as chaotic, lacking in policies and practices for controlling the project development process. Success, when it occurs, is usually the result of individual heroics. Learning from experience is minimal so that the probability of repeating success is small. Development is focused exclusively on the product with little or no recognition of the process controls needed for ensuring product quality. Projects might be completed on target occasionally, but the probability of doing so regularly is low. The development process is immature because it is focused singularly on project completion rather than on providing an environment conducive to repeated project success.

In our original curriculum, projects were initialized, designed and developed within a single semester in the Senior Projects course. The scopes of these projects were necessarily narrow because teams of students were expected to initiate, analyze, design, construct, and implement a system, all within one fifteen-week semester. The amount of time available was insufficient for completing a full life cycle project, especially since it would be the students’ first attempt at such an endeavor. As a result, the analysis and planning phases were usually neglected; the amount of testing was minimal and inconsistent; development sometimes was based on a code-like-hell life cycle; risks were high; and project success was based almost exclusively on team heroics. The development processes varied from team to team and were therefore very unpredictable. The result of this was that the sponsoring organizations had low expectations of the student projects and considered project sponsorship as a service they were providing to our program rather than a benefit of it.

A cause of the problems in the Senior Projects was that in the original curriculum, courses had been taught as independent units rather than as integrated components within a broader learning process. In terms of the curriculum, we noted the following curriculum design issues

- Courses lacked any integration and were designed, developed and taught independently;
- The quality and scope of courses were based on the isolated objectives of individual instructors; and
- Student learning was constrained to the isolated course objectives, and independent student success, not on providing an environment conducive to long-term success for all students.

These curriculum design issues are similar to the problems encountered in software development projects when an organization is developing within the “initial” level of the CMM. While the CMM was designed to address the development process for projects, it is conceivable that the same influences are in effect in an academic environment. In our curriculum redesign, we recognized the student learning process and the software development process can be viewed analogously. In particular, students and their learning can be viewed as projects while curriculum can be viewed as the process that needs to be designed in such a way as to maximize the likelihood of attaining project (student learning) success.

2.2 CMM Level 2—Repeatable

The second level of the CMM is the "Repeatable" level. At this level, an organization should begin developing practices that allow it to repeat project successes by preserving, through policies and practices, those actions that contributed to prior successes, and discarding those that hindered success. This level is primarily focused on beginning the development of an environment for success, but is restricted to the project level rather than the broader organizational-wide perspective encountered in subsequent levels. At this level, basic project planning and project management processes should be introduced and learning from previous project experiences should begin being systematized. The primary objective is to begin developing processes that are documented, followed, and measured. "Developing" is the key idea of the CMM at this level. As the organization moves towards capability maturity, it inevitably needs to experiment, test, and refine its processes; Level 2 encompasses this experimental-based process improvement approach.

2.2.1 Phase I – Integration of two courses with project planning and quality assurance: Because of the inconsistencies in project quality in our original curriculum design, we experimented with the linking of two previously autonomous courses, PM and SDD. Originally, the PM course was primarily concepts-based, with problems and small cases used to reinforce the understanding of the concepts. In the redesigned curriculum, a linkage between the two courses was accomplished by establishing a deliverable in the PM course, the project plan, which would be used as the initial input in the SDD course. Students were required to develop the plan for their community-based projects. These projects and plans were then evaluated by the PM course instructors based on a set of predefined criteria for their quality in order to verify that they complied with the applicable procedures and standards. Only those projects that passed this evaluation were allowed to move forward into the development course.

As a result of this linkage through the institution of the project plan, students were able to dedicate sufficient time and attention to the development of project controls. An outline for project plans and quality assurance was developed by the instructors to guide students in the development of their plans. Each plan was required to include a schedule, budget, and functional and non-functional requirements, life-cycle assessment, risk assessment, uncertainty assessment, and risk management, change management, motivational, and communication plans. Completing these tasks involved regular meetings with the project sponsor and users which helped to secure their buy-in to the project.

To satisfy the Level 2 objective of preserving and propagating successful actions while discouraging undesirable actions, complete project plans from previous semesters were available for review by students. The best prepared sections from among all previous plans evolved into models of best practice and were incorporated into outlines and lectures so that they could be used in subsequent plans. Students were expected to tailor and refine each section of the plan in order to meet the requirements of their particular projects, but all sections were expected to conform to the framework established in the outline.

Each section of the plan was graded separately and weighted equally so as to ensure that the plans were comprehensive and consistent with the outline. Over the course of seven years of projects, improvement across all plans was achieved by modifying the outline based on the observation of overall project development successes and problems. As a result, the quality and consistency of the plans rose over time; the scope of projects broadened; and the time for preparing the plans decreased. This in turn led to community organizations viewing projects as a service they received from the college rather than as a service they provided.

2.2.2 Phase II - Integration of a third course with requirements management: After observing the success of the integration of the PM and SDD courses, the level of maturity of the project development process was further raised by extending the project-wide controls and policies to a third course. In the next stage of the implementation of the curriculum redesign, the *Systems Analysis* (SA) course was incorporated into the process. The systems analysis activities were first moved from the SDD course to the PM course. While this was an improvement, there was still insufficient time available for conducting a proper analysis. Many simplifying assumptions had to be made. Timely feedback was not provided by the instructor. As a result, many adjustments had to be made during the development stage in the SDD course. By moving the analysis further upstream, additional improvements could be made in the process. Templates for a feasibility report and a systems analysis report were added to the process. Students would interview project sponsors and users to establish and maintain an agreement with them concerning the requirements for the projects. They would also develop models of the system being analyzed, propose alternative system designs and, whenever possible, develop user interface prototypes.

Both the SA instructors and the project sponsors reviewed the feasibility and system analysis reports throughout the semester and made suggestions for quality assurance and improvement concerning both presentation and analysis quality, and for consistency between the analysis team, the sponsor and the users. Also, during the semester, students presented their requirements and system analysis for peer review by other project teams. At the end of the semester, the instructors graded the systems analysis report and suggested additional revisions that needed to be made before submitting the final report for sponsor acceptance. The instructors made it clear that the final course grade was contingent on proof of the sponsor's acceptance. Sponsor's evaluation of the projects and estimate of cost savings, if applicable, are included in the project reports prepared by students, but are not formally included in the determination of project grades.

Including the SA course with its templates and controls extended the span of student involvement in the planning of the projects across the entire system development life cycle. This also enhanced their learning. The templates guided and motivated students in their role of communicating with the sponsors and users; they were used to introduce a higher level of consistency across the entire process running from project initiation to final project acceptance; and they served as outlines for the feasibility and analysis reports.

The linking of the *Systems Analysis (SA), Project Management (PM),* and *System Design and Development (SDD)* courses took place over a two-year period. It was motivated by the desire to improve the quality and consistency of student project outcomes. It was in this stage of the curriculum revision that controls on the planning and development processes were first put into place. With this linking process, the curriculum designed had moved the project development process into Level 2 of the CMM. Project success was improved substantially; the scope of the projects began growing; the complexity of the projects increased; and the benefits to student learning and to the community were raised significantly. In addition, measuring of student learning outcomes across the entire life cycle through department-wide faculty review was instituted.

2.2.3 Summary of Level 2 accomplishments: Our accomplishment of tasks indicating attainment of Level 2 of the CMM and a brief description of how these accomplishments were achieved through our changes in the curriculum are summarized in Table 1. However, at this level of maturity, the process was still centered on student success within the three courses directly involved with the individual community projects. According to the guidelines of CMM, in order to reach the next level, it was necessary to extend our revisions to encompass the entire MIS curriculum.

2.3 CMM Level 3—Defined

The third level of the CMM is the "Defined" level. At this level, the organization moves from a focus on project level controls of Level 2 to practices that pervade the entire organization. Best practices developed at Level 3 are developed on an organization-wide basis through a set of standard processes. The focus at this level is on consistency and standardization across projects rather than on individual project success. In order to accomplish this, project success is measured and tracked at the organizational level rather than at the project level, and strengths and weaknesses of the process are reviewed and coordinated at this same higher level. Moving into this level of the CMM requires an organizational-wide understanding of the process and the development of a structure to support the management of the process.

2.3.1 Impetus for continuing curriculum evolution: Our impetus for continuing the evolution of the curriculum to move towards Level 3 was the problems encountered with the process by the addition of the SA course to the PM-SDD sequence. The linking of the PM and SDD courses through the project plan extended the span of the project development process to two consecutive semesters. The use of projects as linkages between these courses was obvious and tangible to the students. However, understanding the linkages between the SA course and the other courses was difficult for students because the SA course was one of the first required courses students had to take in their major program of study. The SA course is typically taken after the programming fundamentals course, but before—or simultaneously with—the network and database fundamentals courses. Adding the SA course to the sequence also extended the project to three courses that spanned at least sixteen months.

Objective	How Achieved
Increase consistency	• Developed templates and project plan outlines; project process was documented and enforced; student performances were being tracked and evaluated.
Improve continuity across the project life cycle	• Built linkages between courses; the process was designed to support continuous improvement of student outcomes.
Increase student motivation for—and probability of—success	• Controls for managing this process were built into the work review and grading scheme of the courses. • Acceptance/rejection of project continuation based on established criteria of quality and probability of success.
Propagate success and minimize failure	• Provided access to previous high quality plans.
Increase quality and consistency	• Standard measures of quality were established; incorporated best practices into course lectures; required confirmation that improvements suggested by faculty were completed; included peer review of course deliverables.
Stimulate improvement in the process	• Rewarded students who initiated improvement to current set of best practices shared through the templates.
Institute continuous improvement	• Modified course designs based on observed successes and failures.

Table 1: Objectives related to achieving Level 2

When students enrolled in the SA course, they were just finishing their required lower-division programming courses and beginning their upper-division MIS major courses. At this point in their educational experience, they were not yet able to visualize the entire project development life cycle, its purpose, benefits, or outcomes. As a result, they encountered difficulty in relating and integrating what they learned in the SA course with what they would be experiencing in the project management and development courses. As a minimum, further efforts were needed to help the students understand the entire project development life cycle and how the three-semester sequence of courses and the entire MIS curriculum were related to it. They needed to view these as a process rather than as separate courses. They needed to see the whole rather than just the parts.

The first effort directed towards this problem focused on relating the system development life cycle to the sequence of courses the students would be taking. Figure 1 was originally developed as a tool to help in advising students in the sequencing of their course selections, and to explain the role of the community-based project in the three-semester sequence of courses.

Viewed from a curriculum perspective, this was the first step towards moving from a course-based project focus, to a wider, department-wide perspective based on a defined process focus. Recognizing the interdependencies between courses and viewing the student learning experience as a process of transformation by these courses led to our recognition of the possibility of adapting the framework of the CMM within a broader context. In this view, the objectives would be directed towards the purposes of an academic curriculum rather than on individual courses or student projects.

Students and their learning experiences could be viewed by the faculty, and by themselves, as the units passing through the process, developing basic skills and knowledge that would be enforced and enhanced through application on their community project, and ultimately producing graduates that possessed the skills and experience necessary for employment contributions through learning enhancement. This perspective also motivated us to consider using the general guidelines of the CMM as a way to examine our curriculum in detail and indentify improvement priorities to address our future needs.

2.3.2 Curriculum redesign: Phase I - Organization process definition and development: The benefits of the CMM must be able to be mapped onto business goals. For most organizations, the goals of the CMM are related to successful project completion. However, the primary objective of curriculum development is education. Within the academic framework of projects developed in our project-centric curriculum, the measures of success are naturally different from those in other types of organizations. Therefore, beyond the standard criteria of project success measured as cost, schedule and functionality, two additional criteria must be included: quality of the student experience and quality of student learning.

It was within this academic structure and with insight of the benefits of the CMM that a broader, organizational-wide perspective of our curriculum was established. In particular, we recognized that in order to progress to Level 3 of the CMM, we needed to accomplish three objectives: (1) move to a department-wide process focus, (2) develop department-wide course coordination, and (3) institute a peer review process for course outcomes and quality assurance.

We also noticed that some indicators of Level 3 were already in place based on the original course design and the process implementation. For example, a methodology for software engineering was introduced at the beginning of the process, and tasks related to it were consistently performed and evaluated across the semesters. Readiness criteria, standards, and review mechanisms were already in place and documented. Therefore, we needed to start working on department-wide process improvements for further improvement in our curriculum design at this stage. As can be seen in Figure 1, the three-semester sequence of student projects can be viewed as more than an independent learning tool, they can be seen more broadly as the core of the entire educational process of the department.

Prior to entering this level of the CMM, the requirements for the three courses were specified, but were embedded within the traditional framework of the distinct SA, PM, and SDD courses. Gaps in coverage occurred between classes. Students understood that there was a sequence, but were unable to understand the direct relationships between the content in these three courses. In addition, the instructors were constrained by the material in specific textbooks, that is, the courses were consistent with the text, but to a certain extent, they were not readily transferable to the sequence.

The solution to these problems was the development of a framework that could be used to guide and organize the entire experience of students across the courses, one that was independent of particular textbooks and cases. This framework would need to describe a department-wide process under which each course had specific objectives to accomplish, the successful completion of which would contribute to successful project completion and high quality student learning. This framework as represented in Figure 1 was used to redirect the curriculum and the department faculty to a process-oriented focus.

With this focus, not only could the projects be planned and managed within the defined process developed at Level 2, but also, the knowledge, skills and abilities of the students could be enhanced in a consistent manner that is well-understood by both the students going through the process, and by each of the instructors preparing their courses. Under the guidance of this process, all faculty members in the department, including those instructors who taught courses that fed into the three-semester sequence and did not teach courses that were included in the sequence, could better understand how their courses contributed to the student learning and project outcomes. In other words, each course should be viewed as a part of a coherent process directed towards student success. The project development process should be integrated across the entire development life cycle as well as across the entire curriculum, and each instructor and each student should be aware of the process and their roles within the process. Developing this focus accomplished the first of our three objectives in moving the curriculum towards achieving Level 3 of the CMM. This was done over about a one-year period.

2.3.3 Phase II: Curriculum redesign: Organization process integration and management: Subsequent to the development of the process focus, the next step in the curriculum implementation was to revise the entire curriculum around that focus. In order to minimize the effect on the courses, these revisions were primarily targeted towards changing the sequencing of courses in the program, not on changing course content. For example, originally the *Managerial Presentations* course and the general MIS course could be taken anytime in the junior or senior year. However, since both of these courses were seen as contributing to the success of the projects only if they were required to be taken prior to the start of the three-semester core, they were moved to the beginning of the curriculum through the institution of pre- and co-requisites.

As another example, the success of any project depended on the skills brought to that project by its team members. Before the curriculum revision, students often postponed taking the more challenging upper-division electives until they had completed their required courses which including the PM and SDD courses. This meant that some team members were not taking the elective courses which would help them bring advanced skills to their projects. Student learning is reinforced when they can apply skills learned in a course to a real-world application. This was not happening when students were allowed to take the project development course prior to taking the courses that taught the requisite development skills. Therefore, a prerequisite was added to the SDD course that compelled students to have completed at least two of a specified set of upper-division elective courses.

A secondary method for refocusing the courses towards the process was to encourage faculty to involve students in their three-semester community projects as early as possible beginning in the SA course, then to encourage them to select research topics in their other courses that would help them on their particular project. For example, students in the database and web development courses are allowed to select their own topics for their research project. Since students will have already identified their projects in the SA course, they would know what database management system they should consider for their three-semester project, Oracle, MS SQL Server, or MySql, for example. In their elective courses, they were encouraged to explore and experiment with that system for their database research project or research paper. Similarly, students in the web course might choose to explore a technology such as streaming media, web services, or Ajax as the research project in that course. This approach efficiently focused the students' efforts towards project success, and provided motivation for achieving a deeper and more thorough understanding of their topic rather than on doing just enough to complete the course.

Finally, the last objective we needed to accomplish for moving to Level 3 was a peer review of the process and its outcomes. After reviewing the projects, we began to discuss changes that needed to be made to the project evaluations, to the curriculum and to the process. We discovered gaps in student skills. For example, although we determined that students were proficient in the development of sophisticated data-driven web sites, we found out that some basic web page design skills were needed. As a result, the faculty decided to revise the existing upper-level course content while simultaneously working on the development of a lower-division course that would include basic web design topics.

At this stage in the redesign, the peer review process had not yet been formalized; however, the final project reviews were determined to be the ideal location for assessing course coverage and identifying defects in the curriculum. The formalization of the reviews is discussed in the next section.

2.3.4 Summary of Level 3 Accomplishment: The objectives and accomplishments for Level 3 are shown in Table 2.

Objectives	How Achieved
Move to a department-wide process focus	• Moved from viewing courses as independent entities to viewing them as integrated contributions to student success. • Developed a clear understanding of how each course contributed to project success and ultimately to student development. • Showed students how courses were interdependent and success in each contributed to project success.
Develop department-wide course coordination	• Determined course sequencing and content based on project success.
Institutionalize a peer review process	• Feedback from peer review of projects used to modify course designs in order to improve the process. • As part of college-wide curriculum assessment, mapped curriculum success onto project success. • Feedback from projects used to modify courses. • Faculty involved in development of project assessment tool. • Faculty invited to present their expectations to students at the beginning of the semester.

Table 2: **Objectives related to achieving Level 3**

2.4 CMM Level 4—Managed

Next we began moving towards attaining the fourth level of the CMM, the "Managed" level. The key objectives of this level are quantitative process management and quantitative quality assurance. Metrics must be developed and tracked over time, possibly using statistical quality control measures.

The purpose of quantitative process management is to analyze and control the process performance and to monitor quality of the deliverables. As with Level 3, in an academic environment, high quality student learning must be included as one of the measures of project success. Therefore, two types of quantitative measures were developed: one for project quality and team-based learning accomplishments, and another for learning quality as measured across the entire learning process. The latter of these was developed both for our curriculum redesign process as well as in response to newly instituted AACSB (The Association to Advance Collegiate Schools of Business) accreditation standards.

2.4.1 Quantitative evaluation of project quality: The first measurement instrument was developed as a student grading standard: the project evaluation form (see Appendix 2). This form is used by a project review team composed of faculty, alumni, and software developers from the community. Throughout the three-semester sequence of courses, students are provided with feedback on the likelihood of their project achieving these standards. A copy of this instrument is presented to students early in the PM course and again in the SDD course so that they will be aware of the review team expectations early in the process; at the same time, the evaluators are invited to discuss their specific expectations in relation to the instrument with the students. For example, database instructors will meet with student teams to explain how they will be evaluating the database portion of the project.

This measurement instrument is composed of two portions. The first portion entitled "Minimum requirements for a passing grade" functions as a "lower control limit" on project and learning success. If a project does not pass every requirement within this section (including on-time), the project is rejected. A rejection has occurred in about 9.6% (5 out of 52) of projects over the last seven years. In these cases, students cannot pass the course until the failed requirement items are satisfied.

The second portion of this instrument is used to compare the quality of all the projects submitted in a semester. A final report and oral presentation prepared by student teams are the primary sources of information made available to evaluators. Students must provide proof of successful completion of selected sub-processes that contribute to the overall project quality. Some items such as "Independent research" and "Project difficulty" are included to access students' self-learning accomplishments.

One of the primary measures of project quality is a quality assurance plan developed specifically for each project by the project team. A template for the plan has been developed and examples of previous testing plans are made available to students. Activities included in the plan are: defect tracking, unit testing, source-code tracing, technical reviews, integration testing, and system testing. Of particular interest to our faculty is compliance with Section 508 of the Rehabilitation Act of 1973 (Section 508, 1998), the essence of which is to provide access to and use of information and data by individuals with handicaps that is comparable to that provided to individuals without disabilities. The test plan and test results are reviewed by the evaluators as one of the items in the project evaluation form.

Finally, feedback from users and the project sponsors and owners is provided through a post-implementation survey completed by the sponsoring organization. Again, a template is provided to the students, and this template is tailored to meet the needs of the specific project.

2.4.2 Quantitative evaluation of process quality: The next step in moving towards achievement of Level 4 is to develop quantitative measures of the quality goals of our curriculum. The IS Model Curriculum has been designed to produce graduates equipped to function in entry level information systems positions with a basis for continued career growth. As mentioned in Section 1, the scope of Information Systems as an academic field encompasses two broad areas: (1) the information systems function, and (2) systems development. After reviewing these guidelines and model curriculum, we have currently defined our department learning objectives as follows:

Upon completion of the program, students should be able to

- Analyze, design, develop and document a real world information system; and
- Identify key challenges in the leadership and management of an information systems project and recommend ways to address them.

These objectives are currently being used to assess the success of our curriculum and are another accomplishment in achieve the requirements of Level 4. Summaries of the individual project assessments are used to prepare a quantitative assessment of our MIS program. This assessment is then used in a report of the Assessment of Learning requirements for maintaining accreditation under AACSB guidelines.

2.4.3 Summary of Level 4 accomplishments: The objectives and accomplishments for Level 4 are shown in Table 3.

Objectives	How Achieved
Quantitative assessment of project outcomes	• Established criteria for minimum acceptable level for project completion. • Implemented a standard evaluation form for normalized scoring of projects. • Instituted quantitative project quality assurance planning and testing.
Quantitative assessment of student outcomes	• Established criteria for minimum acceptable level for project completion. • Developed learning outcomes.
Quantitative assessment of program outcomes	• Developed program assessment criteria. • Developed measures of program success.

Table 3: Objectives related to achieving Level 4

2.5 CMM Level 5—Optimized

We are just beginning to move to Level 5 and are currently working on how to achieve this level. At Level 5, the "Optimizing" level, the department will be focusing on continuous process improvement. At Level 4, our focus was on measuring and removing variability in the process. The focus at this stage will be on raising the average level of the outcomes by changing the process. At the college level, a faculty committee has been formed that is charged with identifying three to five areas that will be targeted for improvement in the academic year. We recognize that our department needs to institute a similar quality improvement process. As we enter this level, we already have the capability to identify problems in our curriculum and should be able to prevent them from reoccurring. Our next step is to enhance quality and consistency through lessons learned and through innovations. By achieving Level 4 of the CMM, we are in a strong position to move to Level 5 with objectives as listed in Table 4.

Objectives
Identify process improvement objectives (preferably quantitative)
Use objectives as targets for curriculum improvement

Table 4: Objectives related to achieving Level 5

3. LESSONS LEARNED AND CONCLUSION

The implementation process of our curriculum redesign was guided by our adaptation of the CMM. In this section, the benefits of this redesign process and the problems associated with its implementation are discussed. The paper concludes with the lessons learned and discusses potential future research.

3.1 Observations and Lessons Learned

Based on our observations, the benefits of this process and its implementation are as follows:

- Based on the process improvement framework we put into our curriculum redesign, we have been able to shape students' expectations of their learning outcomes. As a result, students have begun to engage in early planning of both their project and of their course selection and sequencing. They take their learning more seriously than before the redesign and are more motivated to apply what they have learned.
- By progressing to Level 4 of the framework, all faculty members in our department have developed a better understanding of their roles and that of their courses in the curriculum. As a result, we are able to recognize curriculum improvement opportunities sooner.
- Based on feedback from employers and our own observations of students' course work and senior projects, the quality and consistency of learning has significantly improved.Achieving Level 4 capabilities and being on the verge of achieving Level 5, our department will be meeting the accreditation standard for program assessment as stated by our accreditation association.

Although the benefits associated with a curriculum redesigned around substantial community-based projects are significant to the students, the university and the community, we believe the risks associated with planning and coordinating these projects and implementation of this curriculum cannot be ignored.

Conducting full life cycle projects across three semesters, then integrating them across all courses within a curriculum introduces planning and coordination problems not experienced in typical curriculum designs. The increased complexity of interrelationships between courses, instructors and students requires new approaches for managing them.

We found the CMM that was originally developed for improving the software development process could be adapted to fit our needs. By following the same progressive stages in its original framework, we tried to identify the key process areas and key practices in different stages of our curriculum redesign. We then continued to work on improving our processes in order to move to the next maturity level. The CMM model for reducing risk is a unique process improvement approach to curriculum design and development that warrants additional research and perhaps the design of a similar model specifically for curriculum redesign.

Based on the benefits and risks related to the curriculum redesign and course coordination, we have identified two categories of lessons learned from this experience.

3.1.1 Lessons learned from a curriculum redesign perspective: It is important to design a strategy for controlled change in a curriculum. We started with a one semester project in one course. We built slowly and expanded carefully by adding a second semester course, then a third semester course to revise the curriculum while adding support to student projects with guidelines, templates and coursework. We built on past successes by providing students with examples of highest quality project documentation. We encouraged learning from past mistakes by providing students with examples of what had gone wrong and by changing the curriculum and process control to avoid repeating mistakes. By following the CMM guidelines, we designed courses around improving project quality while designing curriculum around improving project success and student learning.

3.1.2 Lessons learned from the project improvement perspective: To identify potential projects and to develop appropriate process controls, it was helpful for us to start the projects small and locally. The scope of the projects will grow as control over the project development process improves. We started with projects within the college, and then expanded to projects within the university. We then started to undertake projects within the city and across the state. In a few instances we have also completed projects in other states and internationally. Our strategy was to build a reputation for quality. We used to have to hunt for projects; now we screen projects and sponsors that seek us out.

3.2 Some Concluding Remarks

In this paper, we adapted an approach, the CMM, originally designed for monitoring and improving the processes involved in the software engineering field. We used this approach to guide the implementation of a project-based curriculum through different stages. We have identified benefits and risks which were involved in the adoption of this curriculum.

We have found that this redesigned curriculum has been successful in developing high achieving, confident students who are ready to immediately contribute in their career fields; it has also resulted in recognition by the community for outstanding service and was a significant contributor to having our university recognized as a top service-learning institution (The Princeton Review, 2005).

Our use of the CMM has demonstrated that there is potential for developing an approach that is tailored specifically towards monitoring and improving the processes involved in the design and instruction in academic programs. Currently, there is a trend towards developing course assessment for measuring student and program success. Some standard framework for determining the current quality level of instructional processes, and for guiding improvement in those processes, could be useful within the context of continuous improvement. Future research is needed to explore the development of a framework similar to the CMM which would be available for assessing and improving processes in developing IS educational programs.

4. REFERENCES

AACSB International (2003). The Association to Advance Collegiate Schools of Business. “Eligibility Procedures and Standards for Business Accreditation,” Adopted: April 25, 2003; Revised: January 1, 2004, from www. aacsb.edu/accreditation/business/standards01-01-04.pdf.

Binder, J. (2005). “Testing Software: The New Frontier,” Aerospace America, pp. 30–31.

Grundy, S. (1987). Curriculum: Product or Praxis, Lewes: Falmer Press, London.

Hurst, J. (2007). Capability Maturity Model and Its Applications, white paper, GIAC (Global Information Assurance Certification) Organization.

IS’97 (1997). “Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems,” from ww.cis.usouthal.edu/faculty/feinstein/IS97/document /is97_title.htm.

IS2002 (2002). “Model Curriculum and Guidelines for Undergraduate Degree Programs in Information Systems,” from www.acm.org/education/is2002.pdf.

Kearsley G. & Shneiderman B. (1999). “Engagement Theory: A Framework for Technology-based Teaching and Learning,” home.sprynet.com/~gkearsley/engage.htm.

Knowles, M. (1975). Self-directed Learning, Follet, Chicago, IL.

Knowles, M. (1984). The Adult Learner: a Neglected Species, 3rd edition, Gulf Publishing, Houston, TX.

Kolb, D. A. (1984). *Experiential Learning: Experience as the source of learning and development*, Englewood Cliffs, N. J.: Prentice-Hall.

Kolb, A. Y. & Kolb, D. A. (2006). “A review of Multidisciplinary application of experiential learning theory in higher education,” Sims, R., and Sims, S. (Eds.). Learning Styles and Learning: A Key to Meeting the Accountability Demands in Education. Hauppauge, NY: Nova Publishers.

SEI (Software Engineering Institute) (1995). Carnegie Mellon University, The Capability Maturity Model: Guidelines for Improving the Software Process, Editors: Paulk, M. C., Weber, C. V. Curtis, B. and Chrissis, B., Addison-Wesley Publishing Company, Reading, MA, from http://www.sei.cmu.edu/cmm/cmm.sum.html.

SEI (Software Engineering Institute) (2002). Capability Maturity Model Integration, Version 1.1. CMMI Product Team, http://www.sei.cmu.edu/pub/documents/02.reports /pdf/02tr012.pdf.

Stenhouse, L. (1975). An Introduction to Curriculum Research and Development, Heinemann Educational Books.

The Princeton Review (2005). Colleges with a Conscience: 81 Great Schools with Outstanding Community Involvement, Random House, Inc., New York.

AUTHORS BIOGRAPHIES

Dennis Drinka is an associate professor of computer information systems at the university of alaska anchorage. He received his ph.d. In management science and information systems from the university of texas. His work has appeared in decision science, european journal of operations research, journal of information technology, etc. His research includes the areas of network algorithms, heuristics, optimization, and innovations in curriculum.

Minnie Yi-miin Yen is an associate professor of management information systems at university of alaska anchorage. She received her ph.d. In mis from university of houston. Dr. Yen’s work has appeared in ieee transactions on software engineering, journal of database management, international journal of management, human factors in information systems, etc. Her research interests focus on human-computer interaction, client-server database systems, e-commerce and web-based learning.

Appendix 1: Sample Projects Completed in One Semester

1. **Sporting Events Business -** This is a project allows sporting events business to keep a dynamic events calendar; updateable team information, including players, statistics, and game results; a bulletin board; and automated announcement capabilities on a Website.
2. **State Fish and Game -** This project provides an efficient and reliable method for collecting fish sampling data. It replaces the current bubble sheet data entry system with a handheld logger device that transfers data into a database and reduces data entry time by more than forty percent.
3. **State Department of Transportation -** This is a project allows system users the ability to subscribe to a Marine Highway System notification service through a Web interface. Subscribers will receive information about the expected arrival of ferries at ports via email and can be notified of any delays via email, pager, or cell phone.
4. **American-Russian Entrepreneur Training Center -** This project allows entrepreneurs in the Russian Far East to search and register for courses offered at different instruction centers in Russia. Provides three user levels of administration for maintaining the site, adding information, and viewing reports based on data collected. The site can be viewable in either Russian or English.

5. **Oil Well Accounting** - This project replaces several interconnected components currently in use to allow accounting personnel to maintain their database via one Windows-based application. The system provides reliable tools for tracking, allocating, and reconciling the purchases of diesel fuel and improves data processing efficiency.
6. **Biomass** - This project supports pipeline corrosion mitigation specialists in the collection and storage of bio-film data gather through a probe at remote oil pipeline locations. Handheld devices are used to collect bio-film data and transfer it to a database. Information on bio-film growth is critical in decision making regarding the biocide program.
7. **Material Safety Data Sheets** - This project develops a system which stores and manages Material Safety Data Sheets in a relational database by location, manufacturer, and chemical. Provides access to MSDS information to all company employees via an intranet and replaces the existing manual system currently being used.
8. **High Tech Consortium** - This project provides information through a Web portal to any individual or business interested in learning more about the technology industry in the state. The main focus is to promote the growth and development of the technology industry and strengthen industry ties with the local university. Also allows for job opening announcement by employers and posting of resumes by job seekers.
9. **Athlete Progress Reports** - This project provides a university Athletic Director an automated means to obtain faculty evaluations of student athletes. Student athlete and instructor course information can be retrieved from a university database or entered manually. Instructors respond to a system-generated email request for evaluations by supplying information via a Web form. Results are stored in a database and reports are prepared for the Athletic Director.

Appendix 2: Project Evaluation Form

MINIMUM REQUIREMENTS FOR A PASSING GRADE		
☐	Applied systems analysis and project management skills	For example, ERD's, DFD's, UML, interview notes, PERT/Network charts, risk assessment etc.
☐	Conducted independent research	Examples: ☐Learned new technology ☐Conducted analysis of alternative service providers such as hosting services or credit-card processing services
☐	Integrated advanced technologies	☐Used technology from at least two 300- or 400-level CIS courses. For example, Networks, Database, Web Development, Java, Visual Basic.Net. ☐Using advanced technology not currently taught in CIS might be acceptable
☐	Developed user support/documentation and/or provided training	Training, user manuals and help files are acceptable
☐	A test plan was developed; system was tested and test results were documented	
☐	System has been implemented or is in a state which can be implemented	
☐	Prepared final project report	
☐	Conducted final project presentation	

1	**2**	**3**	**4**	**5**	**x**	**Points**	
○	○	○	○	○	5		Requirements completed as originally specified or as amended through approved change requests
○	○	○	○	○	4		Independent research
○	○	○	○	○	3		Usability: ease of learning, ease of use, user satisfaction
○	○	○	○	○	2		User support, documentation and training
○	○	○	○	○	2		System testing and test documentation
○	○	○	○	○	2		Project difficulty (complexity)
○	○	○	○	○	1		Project report
○	○	○	○	○	1		Presentation
							Adjustment for overall quality and effort (up to ±10)
							Unadjusted = Sum of the above
							Adjusted = Unadjusted/(Average of Unadjusted for all projects graded by this evaluator)

1 = Unacceptable 3 = Average 5 = Outstanding

Information Systems & Computing
Academic Professionals

EDSIG
Serving Information Systems Educators

STATEMENT OF PEER REVIEW INTEGRITY

All papers published in the Journal of Information Systems Education have undergone rigorous peer review. This includes an initial editor screening and double-blind refereeing by three or more expert referees.

ISSN 1055-3096