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INFORMATION SYSTEMS EDUCATION JOURNAL

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Incorporating Capstone Courses in Programs Based upon IS2010 Model Curriculum

Ken Surendran
ksurendran@semo.edu
Department of Computer Science

Dana Schwieger
dschwieger@semo.edu
Dept. of Accounting and Management Information Systems

Southeast Missouri State University
Cape Girardeau, MO 63701-4799, USA

Abstract

Currently, most CS and IS (CIS/MIS) curricula include a capstone course to help achieve some of the program objectives such as soft-skills development. Since the scope of the IS2010 model is limited to the consideration of high-level capabilities, the recommendation lists only core courses common to all Information Systems programs and some sample elective courses. This list does not include a capstone course. In this paper, the authors examine the implications of key characteristics of IS2010 – i.e., *reaching beyond the schools of management and business* – in formulating a suitable capstone course. Based on their experiences in teaching capstone courses, they discuss the various ways in which capstone courses can be facilitated and analyze the issues influencing course design. They then suggest various strategies for incorporating capstone courses into CIS programs based upon the new IS2010 curriculum and provide a sample course outline.

Keywords: IS2010 model curriculum, Capstone course, CS/CIS and MIS programs, IS program threads

1. INTRODUCTION

Most programs in Computer Science (CS) and Information Systems - Computer Information Systems (CIS) / Management Information Systems (MIS) - culminate in a capstone course. Among other things, a capstone course provides an opportunity for students to undertake a significant project under supervision (Clear, Young, Goldweber, Leiding & Scott, 2001) in which students apply what they have learned in their program of study. It also helps in demonstrating the achievements of program objectives (Murray, Perez & Guimaraes, 2008; Schwieger & Surendran, 2010,).

We (the authors) collectively have over 20 years experience in teaching capstone courses in CS/CIS/MIS programs. We recognize the need to revise our capstone courses in light of the new IS2010 model curriculum (Topi, Valacich, Wright, Kaiser, Nunamaker, Sipior & de Vreede, 2010) which, through its broad key characteristics, cuts across the usual departmental silos. This well thought out model curriculum, with just seven core courses addressing the high-level of IS capabilities, offer

considerable flexibility for designing IS programs with several threads emphasizing different application domains. It is more challenging to come up with a somewhat generic capstone course in such a flexible program. Following a systematic analysis, we present a capstone course for a CIS program that is undergoing revisions in light of the new IS2010 model curriculum. Currently, we have yet to identify all of the CIS threads. Hence, we limit the scope of this paper to just the capstone course.

For lack of space, we are forgoing a section on literature review regarding capstone courses. (For a review of capstone course literature, we refer the reader to Clear, et al. 2001.) In the next section, we discuss the current IS programs at the authors' university and the relevance of the IS2010 model in our current curriculum development plans. In Section 3, we identify the important issues surrounding capstone courses and the various ways in which this course is currently facilitated. In Section 4, we suggest, based on the previous sections, a few strategies for incorporating a capstone course into a CIS program that reflects the characteristics of the IS2010 model. Finally, we present a high-level course description of a capstone course that is generic yet flexible enough for adoption in our revamped, multi-threaded CIS program.

2. IS2010 AND OUR IS PROGRAMS

At the authors' institution, there are two Information Systems programs: MIS in the College of Business, having AACSB accreditation, and CIS in the College of Science.

MIS

The MIS program was first designed using IS1997 model curriculum and input from industry (Ehie, 2002). The program was later revamped to reflect the IS2002 extensions. The intent of the MIS program was limited to the management and business domains. Like most MIS programs, our program has experienced a steady decline in student enrollment.

CIS

The CIS program was designed to be more like an Applied Computer Science (ACS) degree. Differing from its sister programs, this program has fewer higher level CS courses relative to the CS program and very few overlapping courses with the MIS program. Unlike CS, CIS has no requirements for science courses other than those required under the general education requirements for all majors. Instead, the CIS program requires students to complete a minor, or another major, in an unrelated area of study. Like MIS, the CIS program is experiencing, as of late, a decline in enrollment numbers.

Revising IS Programs

When the CS and IS departments started seeing declining enrollments, these declines were initially credited to the dot com burst along with offshore outsourcing (Rajaravivarma & Surendran, 2006). However, soon realizing that these declines were permanent, many institutions decided to redesign their curricula (e.g., McGann, Frost, Matta & Huang, 2007).

Based upon periodic reviews, the IS Curriculum Task Force came up with the current IS2010 model curriculum (Topi, et al., 2010) that is flexible, domain-independent and well structured. Similar to the intent of the above CIS program, it allows, unlike IS2002, the inclusion of any application domain (i.e., going beyond schools of management and business).

IS2010 specifies a set of structured outcome expectations starting with high-level IS capabilities which are translated into three categories of knowledge and skills: foundational, IS specific and domain fundamentals. The framework has only seven core courses and provides descriptions of a few elective courses. Obviously, a capstone course is outside its scope and specifying one might be considered prescriptive.

Implications to MIS and CIS

In the case of the MIS program at the authors' institution, the domain remains business focused. The revisions, therefore, have to do with courses that are IS-specific.

The original intent of the CIS program (entitled Applied Computer Science (ACS) at that time) has been to provide a generalized curriculum in the applied aspects of computing or informatics (Duben, Naugler & Surendran, 2006) to complement the CS program. Although this CIS program is attempting to address the domain fundamentals of IS2010 (by requiring a minor or another major), it lacks courses that link computing with the application domains pertaining to those minors or majors. Hence, in the case of CIS, we expect the revision to be extensive since we need to address both the IS specifics (revising its core courses) and domain fundamentals (designing *domain-specific IS* courses).

We will start with identifying candidate domains with each becoming a CIS Thread. The initial academic threads for consideration, other than business, are: arts/entertainment, healthcare, law/security and science. The respective domain interface courses will have to be jointly designed in conjunction with faculty from the concerned departments. The idea of requiring a minor may be retained as it can be absorbed into the respective thread.

Irrespective of how these CIS threads are formulated, we intend to retain a capstone course in the program that is equally flexible to implement. Because we are designing a capstone course ahead of formulating the various CIS threads, flexibility is of paramount importance. Otherwise, this bottom-up design might require refinements as new threads are added.

3. CAPSTONE COURSE

A capstone course, as the name implies, is intended to provide students with a culminating and integrative learning experience. Depending upon the circumstances, the students in a capstone course develop a product or carryout a research study. Usually, students enrolled in computing curricula work in groups on a client-sponsored project (Williams, Bair, Borstler, Lethbridge & Surendran, 2003) to offer real-world experience. Capstone courses can provide a comprehensive experience for the students addressing soft skills, experiential learning, conceptual elements as well as career readiness (McGann & Cahill, 2005). Like other courses, a capstone course will have a set of learning outcomes pertaining to both technical and professional skills. Clear et al. (2001) considered the following issues that normally require attention in facilitating a capstone course: *goals of the courses, characteristics of projects, project deliverables, sponsors, teams, prerequisites and preparation, grading and assessment, administration and supervision, reflection, analysis and review*. Similarly, the main issues pertaining to the design of a capstone course in our context include: type of capstone course, student learning outcomes, nature of the project to suit different IS program threads, matching assessments (including project deliverables), and selection of topics. In the following sections, we examine these issues in some detail.

Types of Capstone Courses

Capstone courses vary depending on the educational objectives of the program. We discuss below, based on one of the author's experiences, three capstone course variations as well as alternatives available for providing such culminating experiences.

Regular capstone: Senior level capstone courses are most often offered for three credit hours. In this proposed course, a team of four or more students work for a semester (or two quarters) on a client-sponsored project (Surendran & Young, 2001). The instructor interacts with the client to identify projects and lets the students select the projects on which they wish to work. As the students start working on the projects, the instructor supervises the teams closely. The students struggle to manage time, in view of their other courses, along with the requirements of the capstone course and project.

This course is taught much like any other course following a class syllabus. However, some of the class time is allocated for working on the client-sponsored project deliverables. Class time is also allocated for student presentation of several of the intermediary products including: project scope and plan, requirements specification, design specification and user interfaces. Because they work in teams, this course offers considerable opportunities for students to hone their professional (soft) skills. At the end of the semester, students present their products to the client and faculty for final evaluation.

It is also possible to design a university-wide capstone course (Schwieger & Surendran 2010) where students from different educational backgrounds work together on a project. Even though such a course is difficult to coordinate, they offer considerable flexibility and integrative learning opportunities for the students. For instance, two CIS students can work on the IS components of a capstone project assigned to a group of students from another application discipline (i.e. music, biology, history, etc.). In such projects, the IS students get considerable opportunities to develop professional skills.

Intensive capstone: In a CIS program that focuses on developing work-ready graduates, the capstone course has the equivalent of six credit hours (Surendran & Young, 2001). In this experience, one or two students, based at the client site, work full time on a capstone project for a semester. The students identify the client

and a project. The client and the instructor work together to scope the project and then expectations are communicated to the students. Even though the students work at the client site, they meet with the instructor once a week to discuss the progress and intermediary deliverables (e.g., analysis and design documents). The students follow a project plan. They also interact with the client constantly and follow the client's house-standards in developing the product. At the end of the semester, the student(s) present their products to the client and the entire faculty in the department who then evaluate the work. This can work better if the client is located somewhat close to the university. However, in view of the current workplace technologies, proximity to the client is not necessarily a factor.

Product-driven capstone: In programs where the emphasis is not on system development but on using and supporting enterprise applications, the capstone course can be centered on a comprehensive domain-specific product (e.g., an Enterprise Resource Planning system). In this experience, the students learn an enterprise product and the associated tools provided to carry out simple maintenance suggested by the instructor (Surendran, Somarajan & Holsing, 2006). Students normally work on these exercises in pairs. Such a course requires extensive instruction and close supervision.

Alternatives: Two alternatives to a system development project-based capstone course are "Research on CIS topics" or an "Internship in CIS." Both of these options are ideal for students who are capable of working independently and have specific goals in mind. The first one may be especially appropriate for students who intend to pursue graduate coursework. In regards to the second alternative, instead of trying to simulate a system development apprenticeship (Surendran, Hays & Macfarlane, 2002) through a project-based capstone course, an appropriately instructor-managed internship in CIS could provide a more realistic apprenticeship experience to the students.

Student Learning Outcomes

Student Learning Outcomes (SLOs) for capstone courses vary depending upon where the IS program is located (since program outcomes are somewhat departmentally dependent) and the role of the course in the program. Often times, capstone courses include outcomes that help achieve some of the program objectives that are hard to achieve in other courses (e.g., (1) demonstrate fundamental IS (or system development) skills on a non-trivial project, and (2) demonstrate the ability to communicate effectively). While using the capstone experience course as a program assessment tool, Murray et al. (2008) considered both the general SLOs and [discipline-] specific SLOs.

Our university offers two programs under IS: MIS that is located in the College of Business and CIS that is located in the College of Science. Several of their SLOs overlap as students work client-sponsored projects in both courses. We can group the programs' SLOs under two categories: those pertaining to technical skills development and those pertaining to professional skills (soft skills) development.

Example SLOs for technical skills:

1. Apply concepts and techniques (or knowledge from their major discipline) for developing quality software products.
2. Create analysis and design documentation pertaining to the system being developed.
3. Discuss project management and communications management issues in software development.
4. Discuss the various testing concepts for establishing quality assurance.

Example SLOs for professional skills:

1. Obtain practical experience with working on an information systems development project in a team environment.
2. Orally present the intermediate system artifacts (generated during analysis and design) for review and evaluation.
3. Carry out research on a recent development in the field of software development and present it to the class.

Other possible SLOs: Different learning outcomes may be needed when the capstone course does not involve a system development project. This is especially true if the course is offered as part of a university-wide general education requirement offered through the College of University Studies (http://ustudies.semo.edu/handbook/misc/objectives.html. In such situations, it may be necessary to have two sets of learning outcomes, one that is major specific and the other that is common (generic) to all majors. Some examples of generic SLOs are:

1. Demonstrate capabilities for critical thinking, reasoning, and analyzing.
2. Demonstrate effective communication skills.
3. Demonstrate the ability to integrate the breadth and diversity of knowledge and experience.
4. Demonstrate the ability to make informed, intelligent value decisions.
5. Demonstrate the ability to function responsibly (ethically) in one's professional environment.

Projects for Different CIS Threads

In order to simulate real-world experience, we use client-sponsored projects (as opposed to instructor-specified ones) in a capstone course. These clients are from an actual business or industry. The instructor plans these projects prior to assignment, identifying and scoping client-sponsored projects to suit student-team sizes and their workloads (Williams, et al., 2003). One student in each team takes on the role of a manager while the instructor takes the role of a project director overseeing all of the class' projects.

Current projects

Currently, the instructor compiles all of the project outlines from the clients and presents them to the students during the semester prior to the assignment. The students form their own teams and choose their projects. These projects come from various application domains and are sponsored by different organizations. Thus, some projects may require students to research and learn new tools. In some cases, the students may have to seek additional domain knowledge. Listed below is a sample of the projects (the application system and the type of sponsoring organizations) the authors supervised in past years from different institutions:

- **Workflow management systems** (IT functions from telecom, auto-parts manufacturing, and food product companies)
- **Purchase order systems** (Wooden cabinet manufacturing and radiator manufacturing companies)
- **Sales system** (Web hosting service provider)
- **Inventory management system** (Regional food-bank – non-profit)
- **Maintenance management** (Two local IT service companies)
- **Contract management system** (Medical-equipment supply company and software consulting company)
- **Trucking and dispatching system** (Wooden cabinet manufacturing company)
- **Labor scheduling** (Local gas-station chain and library at the University)
- **Time clock system** (Wooden cabinet manufacturing company)
- **Training management system** (Athletics Department at the University and law membership training enforcement – by court house)
- **Billboard management system** (Local advertising company)
- **Flight data simulation** (Aircraft manufacturing company)
- **Optic bench (2-D) simulation** (Printer manufacturing company)
- **Chat facility** within online instruction suite (Learning technology unit at the University)
- **Online logic puzzle** (Local IT consulting company)
- **Diagnostic articulations test systems** (Paramedical training unit at the University)
- **Academic music search system** (Music Department at the University)
- **Set list / gig manager** (Local IT consulting company)
- **Test score evaluation** (Elementary school)
- **Course management system** (Small Business Development Center at the University)
- **Scholarship management system** (Financial Aid Department at the University)

CIS Threads and Projects

Program Threads, or focus areas (application domains) outside CIS (i.e. Music, History,

Biology, etc.) may be a convenient mechanism to exploit the domain enhancements characterized in the IS2010 Model Curriculum Guidelines. Each CIS thread will focus on one CIS/application domain combination. Each thread will require a few courses from the application domain and two or three CIS specific courses. The capstone course will be common to all CIS threads with appropriate projects chosen for the students in the different threads. For instance, students in the Music Thread could be given, from the above list of projects, "*Academic music search system"* or the "*Set list/gig manager"* projects. Student groups in the Education Thread could be given the "*Test score evaluation project*." Student groups in the Art/Entertainment Thread could be given the "*Online logic puzzle,*" the "*Flight data simulator,"* or the "*Optical bench simulator project."* Health Thread student groups could be given the "*Diagnostic articulation test system*" or the "*Medical equipment supplier's contact management system."* Business Thread students can be given several of the standard business management projects, especially those from manufacturing organizations.

Assessments and Deliverables

The main assessment component is the completion of the client-sponsored project by the teams. Table 1 provides a breakdown of the project for assessment and grading purposes.

Table – 1: Assessment and Grading

Assessment	Weight
Project Presentations in Class (four)	20%
Ethics Presentation	10%
Project Reports 3 parts: Analysis - 5% Design - 10% User interface – 5%	20%
Project Review (participation)	5%
Project Demo to Advisory Board	10%
Final Project Report	10%
Personal Reflection (Individual)	5%
Thread Related Assessments	20%

The assessments will involve oral presentations, a demonstration of the project, and written reports (delivered in four/five stages). For details on the deliverables, see Schwieger & Surendran (2010).

Topics

Currently, the CIS/MIS programs do not have a project management course. In these programs, the primary system development workflows are taught in the software engineering/systems analysis and design courses. The support workflow topics, however, are taught in the capstone course: project management, communications management, quality assurance and configuration management. During the last academic year, additional topics such as multi-cultural work environment and global ethical & psychological perspectives were added to course content. A faculty from Global Studies facilitated these sessions. See Appendix-A for a sample schedule.

4. STRATEGIES FOR THE CAPSTONE COURSE IN A PROGRAM BASED ON IS2010 MODEL

The IS2010 model identifies (Topi et al., 2010) *designing and implementing information systems solutions* as one of the IS specific knowledge and skills. The importance of this skill is highlighted by the observation (Topi, et al., 2010) that *the industry would prefer graduates with the ability to integrate high performance in design and implementation along with strong business [domain-specific] capabilities*. Several of the seven core courses and sample elective courses such as *Application Development, Human Computer Interaction,* and *Enterprise Systems* are intended to develop these particular IS specific knowledge and skills. The new CIS curriculum will include these three electives as core courses since they address the basic implementation knowledge and skills.

Most present day IT professionals do not get the opportunity to develop new systems from scratch. Instead, they work on enhancements to and customizations of larger enterprise systems in various application domains (Surendra & Denton, 2009). In view of such realities, a flexible capstone course needs to evolve. Five possibilities described below are suggested based upon existing practices.

Conventional

Under this option, the capstone course students carry out client-sponsored projects from scratch. The main difference is that faculty need to ensure that the projects are from application domains relevant to the CIS thread (as discussed under section 3).

Enterprise System Centered

Capstone courses, under this category, are classes in which students practice a thread-

specific (domain-specific) enterprise system and carry out enhancements (customization). Here, a pair of students work on a set of enhancements to an existing system using the development tools prescribed for the enterprise system. Projects on ERP systems (e.g., SAP and Business Dynamics) are examples for the CIS Business Thread. Open source enterprise systems (e.g., Angel) may be relevant for the Education Thread.

General Education Flavored

Most majors have capstone courses with projects in their respective fields. Last semester, we used a university-wide capstone course for CS, CIS, and MIS majors in which students from two other majors participated. A university-wide capstone course, offered under the general education umbrella, has the potential for allowing students from unrelated disciplines to work on projects that span different domains. These days, such projects may have IS/IT components. In such a university-wide capstone course, one or two CIS students can work on IS aspects of the project (pertinent to their thread) along with a team of non-CIS major students. Usually, instructors from the respective disciplines jointly facilitate such courses.

Apprenticeship

Several large IT organizations offer internship programs (Computer Weekly, 2010). Likewise, most university CS, CIS, and MIS programs have internship courses. Such courses could be turned into capstone courses where a student carries out a set of activities centered on specified learning objectives. The student will then report to an instructor from the university periodically while working under the supervision of a mentor in an organization.

Cross-Discipline Independent Study

Most programs offer independent study courses where a student learns advanced topics. It is possible to have a capstone course that is more like an independent study where a student works (or a pair of students work) on developing a system tool or carrying out a research study involving IS in a particular thread. Here, it is possible that the students will be interacting with two instructors, one from CIS and the other from the thread area.

5. HIGH-LEVEL DESCRIPTION

It is helpful to use different mechanisms for offering flexible, multi-threaded capstone courses in IS programs based upon the IS2010 model. However, it is not possible to incorporate all of the learning objectives of a conventional capstone course into all of the forms of capstone courses. Perhaps one approach to addressing the objectives would be to describe a capstone course with a few learning outcomes pertinent to IS and a particular thread area (application domain). A provision could be included to add additional learning outcomes depending upon the chosen course offering mechanism.

Catalog Description

University catalog course descriptions are usually rather brief. In Figure-1, however, we provide a longer version of a possible catalog description for a multi-threaded capstone course. In this description, we do not discuss any specific topics to be covered. See section 3 for possible topics including global perspectives and ethics.

Figure – 1: Catalog Description

> This course offers a choice of flexible learning mechanisms including: system building/enhancement projects, apprenticeships, and independent studies in applying IS knowledge in the chosen domain. System development skills are integrated throughout the course via requirements analysis, system design and implementation, managing enterprise systems specific threads, and managing projects. Students may work on client-sponsored projects or instructor-specified studies as individuals, in pairs, or in larger teams including members from other majors. Students apply professional heuristics and tools essential to the system development process throughout the course.

Learning Objectives

The capstone course, described above, provides evidence for assessing the following program objectives:

1. Demonstrate an understanding of information system fundamentals.

2. Demonstrate IS development / enhancement skills on a non-trivial project to the satisfaction of a client in a chosen application domain.
3. Be prepared to enter the workforce as an entry level information system specialist in a chosen application domain.

Furthermore, additional learning outcomes could be included for specific mechanisms. For instance, we could include the following two outcomes under all of the mechanisms except for the independent study mechanism:

1. Demonstrate the ability to communicate effectively.
2. Demonstrate critical thinking skills.

In the case of the enterprise centered mechanism, we could include:

1. Demonstrate understanding and use of an enterprise system in an application domain.
2. Demonstrate the use of tools to carry out enhancements to an enterprise system.

In the case of the independent study mechanism, we could include:

- Demonstrate the ability to learn advanced topics and apply IS skills to develop tools for use in an application domain.

6. CONCLUSION

The new IS2010 model provides considerable opportunity to enhance the IS program for reaching out to all application domains. At the authors' institution, we are in the process of revising our CIS program to have several threads for incorporating different application domains. In this paper, we described, based on our experiences, a process for developing a possible capstone course in IS programs that are based on the IS2010 model. We suggest a flexible approach to cater to the variations in the level of implementation skills that includes use of client-sponsored projects, enterprise system based projects, instructor-directed apprenticeships in industry, and cross-discipline focused independent study. We also provide an enhanced catalog description and a set of flexible learning objectives for a capstone course.

Because we have taken a mixed design approach (top-down for core and bottom up for capstone), we will continue with our efforts to refine the course as we identify the various CIS threads. Likewise, cross-discipline (CIS and application domain) courses will be designed for those threads as well.

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Appendix –A: Topics and Assessment Schedule

Week	Topics
1	Course overview, Project Management (plan)
2	Presentation (1) Project Scope and Plan
3	Communications Management
4	Presentation (2) Requirements Specification; Requirement Spec. due
5	Project Management (control)
6	Working in the global village (Overview of cultural divergence)
7	Presentation (3) Prelim results of the project; Req, Analysis Report due
8	Influence of psychological value in group efforts
9	Global perspectives on Ethics – Case Studies distributed
10	Presentation (4) Project Design (some parts)
11	Presentation of ethical case studies (5) Project Design Report due
12	Project review meeting (Submit Progress report)
13	Project review, planning session for final product/findings presentation
14	Preliminary project presentation to class; formal presentation weekend
15	Project demo of final product/findings to public
16	Project documentation along with system binary due