Integrating Enterprise Decision-Making Modules into Undergraduate Management and Industrial Engineering Curricula

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ABSTRACT

This paper describes a framework we have developed for teaching enterprise decision-making using Enterprise Decision-Making Modules linked together through a common case scenario. Each module is situated in an organizational process, e.g., the supply chain and order fulfillment process, and involves students in hands-on decision-making using an Enterprise System (ES) to provide an integrated, process-oriented, data-rich environment typical of modern organizations. Our framework differs from other approaches to integrating ES into curricula because it is designed to teach students to work in an integrated process-oriented environment without changing to an integrated process-oriented curriculum and because it introduces decision-making modules across management and engineering curricula while minimizing the ES knowledge required of faculty and the classroom time devoted to ES skills. The paper also describes our Oracle-based technical infrastructure, the project plan and management, as well as our methods for assessing student learning. It reports results from our successful pilot study testing the feasibility of this approach with two decision-making modules in two classes, and also describes Phase 2 of the project, currently underway, which involves additional faculty and modules and tests student understanding of working in an integrated, data-rich environment.

Keywords: Enterprise systems, decision-making, curriculum, teaching, integration

1. INTRODUCTION

Today's organizations are structured around integrated business processes (e.g., product development, supply chain and order fulfillment) that require close coordination among employees across functions and around the world. Yet, engineering and business schools still teach as though students will work in organizations structured solely around functionally-based silos (e.g., engineering, production, and marketing).

Organizations use Enterprise Systems (ES), also called Enterprise Resource Planning (ERP) systems, e.g., SAP, Oracle Applications or similar computer systems, to provide an integrated view of their many organizational processes through linked applications built upon a common database. Two-thirds of mid- and large-sized companies are using or implementing integrated enterprise systems (Scott and Shepherd, 2002). Despite ES support, companies continue to struggle to create robust processes for developing new products and delivering existing products to customers quickly and consistently. As both design and production activities are sourced internationally, the ability to understand and analyze data from an ES is increasingly important for achieving real-time control of global processes. Companies need employees who are able to use integrated ES data to make decisions (Davenport et al., 2002), to understand the impact these decisions have throughout integrated processes, and to recognize opportunities for improving integrated process performance. Yet, our students rarely see integrated computer applications. They do not understand integrated process operations and supporting data and they lack the ability to work in an integrated, data-rich environment.

Our project responds to this need for engineering and business students who can contribute to enterprise-wide initiatives in today's process-oriented, ES-based organizations. We have developed a framework for teaching enterprise decision-making that is based around a set of ES-based modules, called ***Enterprise Decision-Making Modules***, linked through a common case scenario. These modules engage students in making decisions in the integrated, process-oriented, data-rich environments common in today's organizations. We describe our framework and three-phase project plan in this paper, as well as report on two pilot modules that have been tested in undergraduate engineering and management courses. For these pilot modules, we examined the impact on student understanding of traditional functional topics.

The primary focus of our modules is on decision making in the context of new product development and supply chain and order fulfillment processes, supported by the use of an ES. This contrasts with other ES educational projects that focus on learning the ES functionality itself. The assumption underlying our modules is that management or business students, as well as industrial, manufacturing, and design engineers, should have the ability not only to use an ES and but also to understand the sources and uses of the integrated data in that ES, because this is the environment in which they are likely to work.

Our framework, with embedded decision-making modules, is a significant improvement over current educational practice because it responds to industry needs, addresses barriers to ES implementation in universities, and employs effective educational pedagogy. Industry needs more es-savvy professionals who understand business processes, integrated data and decision-making. Our modules employ an ES as a way to make the abstract concept of integration concrete, by having students examine where data come from, how decisions link to business processes, and how decisions impact the organization and its suppliers, customers, and partners. Our modular approach is flexible and feasible with respect to faculty resources. In addition, the decision-focused modules encourage hands-on exploration and experiential learning, contributing to student learning.

The design of our ES educational project is the focus of this paper. The motivation for the project as found in the literature is discussed in section 2. The project design is covered in section 3, including our framework for linked enterprise decision-making modules and their delivery. We also describe the technical infrastructure, project initiation and management, and assessment of student learning. Implementation of this project is a work-in-process, and we describe a pilot study testing the feasibility of our approach in section 4. The conclusion in section 5 summarizes our project design contribution and ongoing implementation.

2. PROJECT MOTIVATION AND BACKGROUND LITERATURE

During the 1990's companies invested in ES to integrate their IT infrastructure, seeking to eliminate inconsistent data and isolated legacy systems (davenport, 2000). In addition, many companies made organizational changes to promote a cross-functional process orientation (Silvestre and Wesley, 2002; brown and Ross, 2003). In such environments, staff from different functions work more closely together to ensure coordination and increase communication, organizational structures and reporting relationships are more complex, and measures focus on process contributions rather than local improvements (hammer and Stanton, 1999; Silvestro and Westley, 2002; brown and Ross, 2003). Operational integration, in part achieved through the ES infrastructure, is of critical importance (Garvin, 1995).

Although the ES market has experienced tremendous growth, there is emerging consensus that companies have not yet achieved the much-heralded benefits of these systems (Smith, 1999; Legare, 2002). With the ES infrastructure in place, organizations must learn to utilize these systems effectively. A challenge is finding people who understand both business processes and the technology and can identify quickly where a business can change to improve process performance (smith, 1999). Similarly, there is a short supply of individuals who can effectively comprehend and manage integrated operations both within enterprises and among supply chain partners (Closs & Stank, 1999; davenport et al., 2002). Although the need for ES-savvy individuals who operate effectively in an integrated environment is apparent, engineering and management educational programs have not responded adequately.

2.1 Integrated Curricula

Educators in both engineering and management have stressed the importance of providing students with an integrated view of decision-making (Incropera and Fox, 1996; Hamilton et al., 2000). One approach has been to create separate capstone courses or projects, usually completed at the end of a student's degree program. For example, engineering students usually complete a capstone design project, which requires students to integrate and apply technical material as well as to incorporate customer requirements and address economic and other constraints. In business schools, students often take a Strategy course in the senior year that integrates topics from three or four functions (e.g., accounting, marketing, and operations). Such capstone experiences usually do not focus on operational decisions, or explore the role that extensive, shared, real-time information plays in decision-making, both critical to the strategic process orientation of many organizations today.

Team teaching has also been used in engineering and management programs to address curriculum integration. In such courses, instructors from different functional areas teach a course together, each presenting topics in his/her area of expertise. Team-taught courses are resource-intensive, requiring additional faculty time for coordination (Mullins and Fukami, 1996).

The challenges to curriculum integration across departments include historical faculty lines and departments, entrenched courses and programs, and limited availability of integrated teaching material (Closs and Stank, 1999). We address the last challenge in a way that minimizes the first two challenges. That is, our proposed modules provide integrated teaching material for use in traditionally structured courses.

2.2 ES Projects at Other Universities

Business school educators have recognized the opportunity for ES to serve as a curriculum integration mechanism (Elam et al., 1999; Quinton, 1999). Implementations differ in their content and learning objectives, which focus on implementation expertise and/or user expertise. For example, Queensland university of technology in Australia (Stewart et al., 1999) has developed an international collaborative effort (Rosemann et al., 2000; Tracy et al., 2001; Stewart et al., 2002) with a technical focus on the is program and developing sap implementation expertise. Program content addresses issues such as ES process modeling, system implementation and configuration, and application development, providing students with better job opportunities and improving a school's competitiveness in recruiting (Becerra Fernandez, 2000; hawking et al., 2001; Bradford et al., 2003). Watson and Schneider (1999) describe the development of online learning modules at Louisiana State University that include presentation material and notes, as well as ES hands-on exercises.

Learning objectives focused on user expertise include exposing students to ES concepts and their process focus (Rosemann and Watson, 2002; Bradford et al., 2003) and to realistic datasets and data handling (Rosemann and Watson, 2002). Content focuses on simulating an aspect of the enterprise (Rosemann and Watson, 2002; Watson and Schneider, 1999) in a functional area. For example, the college of business at California State University at Chico, the first school in the USA to implement sap in its business school curriculum as part of sap's academic initiative (Corbitt and Mensching, 2000), has addressed user expertise by integrating sap in six accounting/finance courses, five production courses, and has plans for incorporating it into several management and marketing courses (Corbitt and Mensching, 2000). For the oracle e-business suite, Bradford et al. (2002) describe using the financial modules in accounting courses at two schools.

While integration across the business curriculum is a common goal, most ES adopters in universities have not succeeded in integrating the software across disciplines. In a recent survey of 35 educational adopters, only five used the ES in more than two disciplines. Most schools used an ES in either accounting or in MIS or both (Bradford et al., 2003). An example of planned integration efforts is the college of business administration at Florida international university, which has implemented sap into its undergraduate and graduate MIS programs, and is working toward an integrated MBA course using sap that combines operations management, managerial accounting, and marketing management (Elam et al., 1999; Becerra Fernandez et al., 2000). Thus, while there is interest in using ES for integrating management curricula, especially among mis faculty and accounting information systems (AIS) faculty, most ES educational efforts have made progress only within the is curriculum or within the accounting curriculum, rather than across the management curriculum (Bradford et al., 2003), with a few notable exceptions, e.g., California State, Chico (Corbitt and Mensching, 2000).

Our review of the literature suggests several challenges to integrating ES into the business curriculum (Corbitt & Mensching, 2000; Bradford et. al., 2003). We highlight the four critical challenges that have driven the design of our curriculum integration project:

- Faculty motivation and commitment: curriculum integration through ES requires strong motivation for cross-disciplinary faculty collaboration, and a significant commitment of faculty time, effort, and training.
- Confounding technical implementation expertise with user expertise: because technical implementation expertise adds significant market value to graduates (Corbitt & Mensching, 2000), this often becomes the focus of ES projects instead of utilizing new opportunities for using technology to link functional areas, concepts, and processes (Quinton, 1999; Elam et al., 1999; hawking et al., 2001).
- Cost and technical infrastructure: integration of ES into business curricula requires a sizeable resource commitment to software, hardware, and maintenance. According to Bradford et al.'s (2003) survey on the status of ES integration in business schools, insufficient funds and insufficient it support staff were cited as the primary reasons for not adopting ES for teaching purposes.
- Management issues: the presence of strong leadership and support has also been identified as one of the most important factors in enabling ES integration into the curricula (Becerra Fernandez et al., 2000).

In the next section, we describe the design of our project, delineating how we address each of these challenges.

3. PROJECT DESIGN

3.1 Module Framework: Developing User Expertise with Limited Faculty Resources

Our framework is focused around Enterprise Decision-Making Modules, using the integrated databases and web-based information-sharing of ES software to explore links among functional areas of engineering and management. Our approach addresses two challenges associated with integrating ES into curricula: first, faculty investment and commitment to ES projects, and second, developing user expertise, rather than technical implementation expertise.

3.1.1 Process Orientation and Decision Modules:

The framework we have developed for teaching enterprise decision-making is highlighted in Figures 1 and 2. In this framework, students complete decision-making modules that are embedded in the context of broader business processes. The framework reflects the modern process view of organizations (Stalk et al., 1992; Garvin, 1995; Hammer and Stanton, 1999), and is consistent with our focus on the ES user's perspective.

The set of business processes that define an organization is unique, but generic business processes common to many organizations can be defined (Davenport, 1993). In our framework, we depict two, broadly defined processes that are integral to most organizations. The product development process (Figure 1) involves the creation of new products or the modification of existing ones (Ulrich and Eppinger, 2003). The supply chain and order management process (Figure 2) involves the delivery of products or services to customers (Shapiro et al., 1992). ES have traditionally supported the supply chain and order management process, but are just starting to support product development through product data management systems (Davenport, 2000).

Each module focuses on a decision-making problem and is designed for use in a traditional functional course. The decision problem is presented in the context of either the product development process (Figure 1) or the supply chain and order fulfillment process (Figure 2). Working through the decision problem builds depth and expertise in the functional area. Students use a commercial ES to find appropriate data, and to explore the benefits and risks of their decision on other functional areas in the organization as well as its customers and suppliers. As they are developed, modules will be based on the same fictitious company, *Integrated Enterprises,* supported by a detailed database describing company operations, to provide a common scenario for linking concepts and topics across courses. Examples of modules include:

- ***Budgeting Module (Figure 1):*** A critical supporting decision in product development as well as other organizational processes is to develop a budget capturing expected sales and expected production costs. Students develop a budget using estimated manufacturing and distribution costs, pricing, and volume sold. They use what-if analyses to investigate ranges of values because the cost and revenue figures during product development are not yet firm. Students use their analysis results to make recommendations to product development in terms of reasonable ranges for final production costs.
- ***Design Change Module (Figure 1):*** Engineers often work on design changes to a single component of a larger product, altering materials or specifications, for example. Such design changes can wreak havoc in manufacturing, and impact lead times and purchasing requirements. Using the ES, students investigate several alternative component designs by examining the bill of material and manufacturing cost data, as well as customer information regarding performance. Based on this analysis, students select the best component design, and then explore how this change is reflected in the ES data.
- ***Dynamic Planning Module (Figure 2):*** Manufacturing planning models (e.g., MRP) are usually taught using data from one point in time. The dynamic nature of such plans is difficult to convey to students in a lecture. In the dynamic planning module, students first use the ES to develop a manufacturing plan. They then explore how this plan fits into the overall supply chain and order planning process. As time passes, students respond to late part deliveries, marketing promotions affecting demand, and quality problems by using the ES to explore the impacts of these changes on their plans and customer deliveries.

3.1.2 Module Delivery

The modular approach is adaptable, and mimics how ES are used in practice. Because modules cover independent topics, which can be taken in any order, the overall structure is flexible. A student taking just a single course with such a module will be introduced to the concept of business processes as well as the complex data environments that support daily decision-making in organizations. Students taking several courses with modules will develop a deeper understanding of integration as a day-to-day issue, across many different decisions. Each module is expected to require 2-3 classroom hours, with a 7-10 hour homework assignment. Part of the homework assignment is completed as a supervised lab, to provide students with additional support. These lab sessions are modeled on lab-based science and engineering courses, which are often taught by advanced undergraduate or beginning graduate students.

Prior to working on their first decision-making module, students need some background on the software and the case study company. A foundation module is used to first introduce students to the basic navigational features and functional modules in the ES, as well as the product development and supply chain and order fulfillment processes of the case study. Each decision-making module then builds on the foundation module. Operationally, students encounter one or many modules as they move through their academic program, but they only need to complete the foundation module once.

The foundation module is designed so trained undergraduate assistants can teach it as a 2-3 hour exercise to other undergraduates. Students in a course who have not yet completed the foundation module would schedule time in a computer lab with the undergraduate assistants, and work on it outside of the classroom in addition to other homework.

3.1.3 Developing User Expertise with Good Pedagogy

The focus of our project, as evident in the above module descriptions, is decision-making in a data-rich, integrated ES environment, not learning a particular software package. Students use the ES to accomplish organizational tasks, rather than learning the ES functionality itself. Students develop depth in enterprise understanding by exploring more and different decisions as they take different courses.

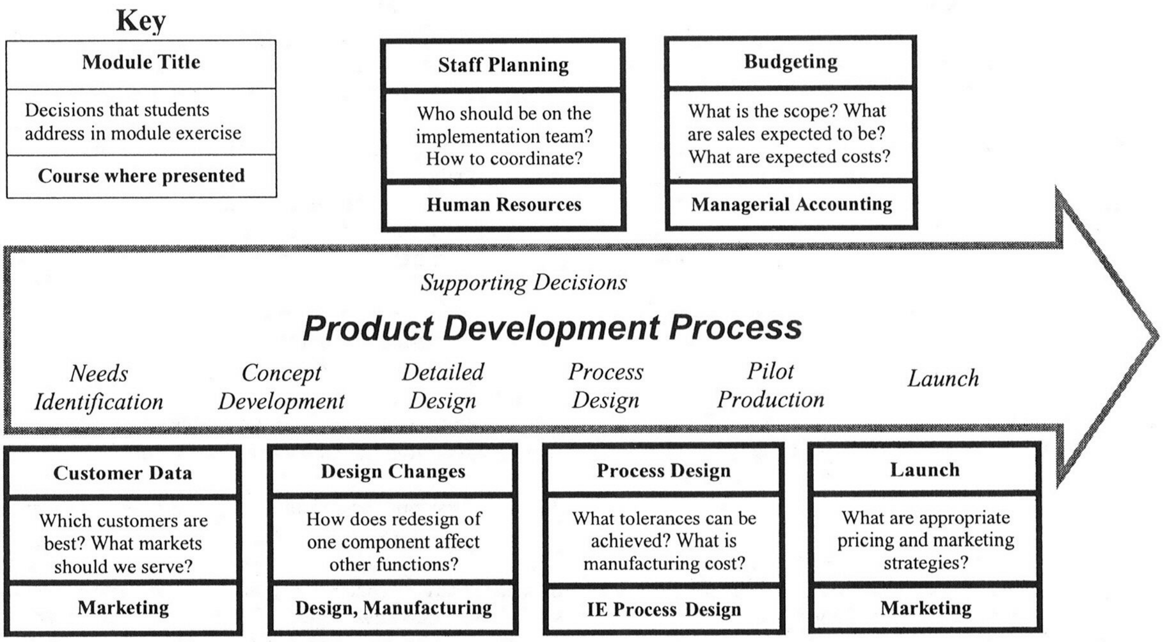

Figure 1: The Product Development Process and Enterprise Decision-Making Modules

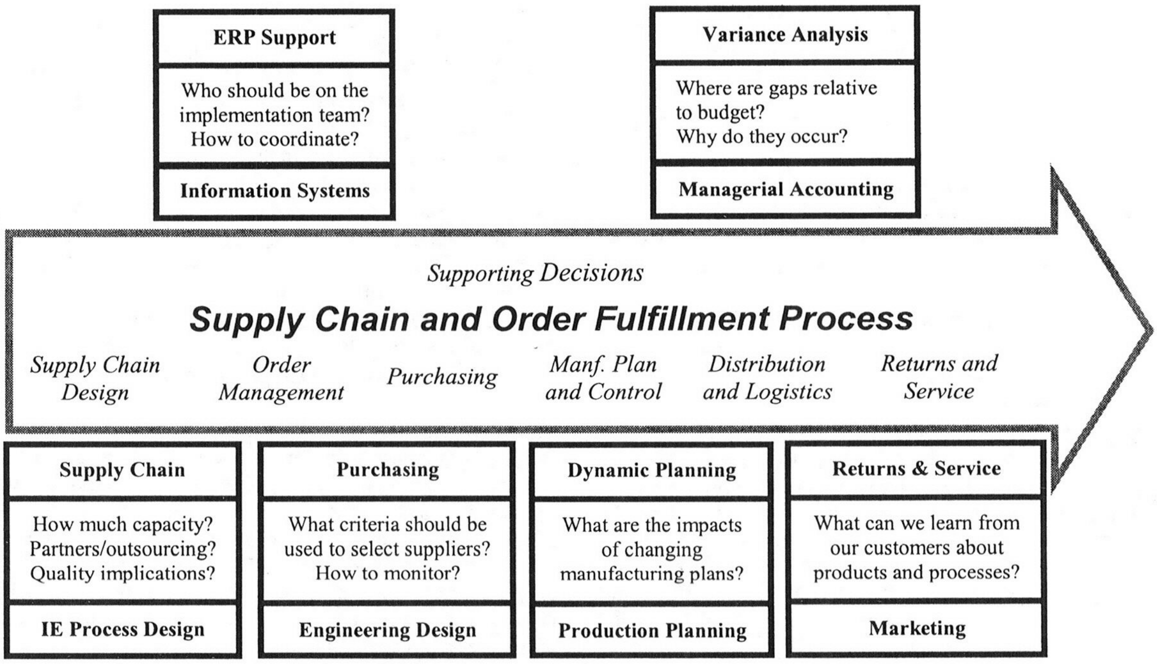

Figure 2: The Supply Chain and Order Fulfillment Process and Enterprise Decision-Making Modules

In other ES curriculum models, depth is described by the amount of the system architecture that is covered; ranging from individual transactions, to modules or submodules, to all ES core modules, to extended systems and modules (Rosemann and Watson, 2002; Bradford et al., 2003).

The process focus we propose provides an operational view of integration, linking functional knowledge to the work of the organization in a manner consistent with how employees actually carry out their jobs. Our learning objectives include better knowledge of enterprise processes and integration, as well as an increased ability to use enterprise data to support decision-making. These objectives are balanced against the need for students to develop depth and expertise in a particular functional area. Our approach differs from traditional engineering and management curricula because it introduces this broader viewpoint, which is critical to supporting today's team-based environments and global, coordinated processes.

In completing each module, students are presented with a concrete situation and a hands-on experience, rather than an abstract model. Our use of a specific case scenario, as well as hands-on exercises supported by an ES, is consistent with educational research on learning and good undergraduate educational practice (Chickering and Gamson, 1987). Research suggests that hands-on learning approaches are at least as effective as traditional teaching methods (Kearsley, 1984). At best they are more effective because, although people retain 40 percent of what they see and hear, they retain 75% of what they see, hear, and do (Fletcher, 1990).

3.1.4 Faculty Collaboration and Commitment

A significant barrier to implementing an integrated, ES-supported curriculum is the need for collaboration across functional areas as well as the significant commitment of time, effort, and training required for participating faculty. Collaboration is strongly influenced by effort, but also by concerns about autonomy and diluting functional content. The module framework we propose, in both the design of modules and their delivery, addresses these barriers.

The enterprise decision-making modules are designed to encourage collaboration and maintain autonomy, with realistic faculty effort. Because each module is based on the same fictitious company, supported by a detailed data describing company operations, across-course integration is achieved through the common scenario linking concepts and topics across courses, rather than by complete redesign or integration of existing courses. The integrated ES database is utilized as a basis for linking different functional areas, as are applications and process models inherent in the software. Designing each module for use in traditional functional courses reduces faculty effort by avoiding major course redesign or time-intensive team teaching. Faculty maintains the focus on their functional expertise, connecting functional decisions to broader business processes, a natural and effective mechanism for integration and collaboration.

Module delivery is also designed to facilitate faculty involvement. The modular feature of the project design enables faculty to continue to have autonomy over their courses, requires redesign and development of only sections of existing courses, and thereby optimizes conditions for faculty commitment while minimizing faculty resistance to loss of control over what they teach within their courses. Each decision-making module requires limited classroom hours, and focuses on the decision and associated data, not on the ES itself. The foundation module, presented and completed entirely outside the classroom, avoids classroom time for introducing the software. Watson and Schneider (1999) developed SAP-based modules, also arguing that the modular approach encourages flexibility and autonomy. While some of their modules address business processes, these processes are not used as an integrating mechanism across courses and learning objectives stress ES functionality rather than business decisions.

The lab sessions associated with each module can be supervised by advanced undergraduate or graduate students. Thus, we expect that a course that has an associated decision-making module would not necessarily require significant ES knowledge from the faculty member. The faculty member must be able to discuss the decision, the data associated with that decision, which might come from other functional areas, and the potential impacts of that decision on other functional areas in an organization, but the details of the ES transactions involved could be defined as the lab assistant's responsibility.

3.2 Technical Infrastructure

As discussed in the literature review, a primary barrier to ES implementation into academic curricula is the substantial monetary and technical infrastructure investment that is required. Because these packages are expensive to purchase and have specific hardware requirements, most universities are hesitant to invest in them. Further, these systems require trained and experienced personnel who have the technical expertise to maintain and provide support to students and faculty that use these systems. Worcester Polytechnic Institute (WPI) chose the Oracle e-Business Applications Suite (11*i*) because it was particularly suited to implementing the decision modules and WPI has the technical infrastructure to support its use.

The oracle ES suite is an integrated set of software modules that each supports a major business function, and uses a common underlying oracle database populated with operational and planning data (boss, 2002). Oracle's product was chosen over other ES because of its popularity in the market (second largest ES vendor), size, breadth, and feasible cost. Oracle's software is large enough to include engineering, manufacturing, and supply chain functionality, as well as the usual functionality included in all packages, financials, human resources, and inventory. The software is less complex than sap's, the market leader, providing an easier-to-use alternative for many schools. At the time that WPI made its decision, licensing fees for the oracle ES suite were less expensive than sap at $500 annually (later raised to $3,000).

A final reason for selecting oracle was the technical infrastructure and expertise at WPI. WPI's computing center has extensive oracle database expertise. It also has ES expertise from its close partnership with a company that develops and markets an ES specific to the education industry (the banner system), frequently serving as a beta test site. While not all this expertise is directly transferable to the oracle ES suite, we have had no problems with technical support from the computing center. WPI provided oracle licensing fees and a server, an approximately $25,000 investment. Computer center staff installed the software and continues to provide technical software support. Students use the oracle software suite in a multi-purpose lab with 24 Pentium IV computers, each with 256mb. These computers are similar to those in other WPI-supported labs, and so were not considered a special investment to support the ES project.

Purchasing and implementing ES software remains a significant investment. While the decision-making modules are framed to work with any ES package, implementing the modules requires selecting a particular one. We are using the oracle ES suite for initial development of the modules, but portability is a key design issue that we plan to explore. Choices and cost also change over time. Currently, oracle is not accepting new members to its e-business academic initiative. To alleviate initial hardware and installation costs, the sap university alliance program now offers hosting services.

3.3 Project plan and management

An additional challenge identified in the literature is the need for effective management of ES projects. The implementation of an ES-based integrated curriculum project requires team work and collaboration, which has to be effectively managed. The development and integration of our module framework is being pursued in three phases, as shown in table 1. Currently, we have completed phase 1 and are beginning phase 2.

3.3.1 Leadership and support

A critical factor in implementation is the need for strong leadership and support (Becerra Fernandez et. al., 2000). At WPI, the department of management is responsible for the project. The project is strongly supported because of its consistency with the department's strategic focus on the management of technology. The department is the only management academic unit in the U.S. with both an abet-accredited engineering program and AACSB management accreditation. Its 210 undergraduates complete majors in industrial engineering (IR), management engineering (MGE), management information systems (MIS), and management (mg). The intention of this project is that all these students, as well as students in other engineering disciplines such as mechanical engineering (me), will use these decision-making modules. The department's 21 faculty members cover all functional areas of management and industrial engineering. An important advantage of a small, focused department for this project is that integration across disciplines is not hampered by disciplinary departmental boundaries.

Table 1: Project Plan

Phase	Tasks	Participants	Outcomes
Phase 1: Pilot Study	Identify and train core team	Core Team	• Baseline: Do students have a good understanding of functional concepts? • Feasibility: Can student assistants support modules?
	Develop pilot modules	Core Team	
	Implement pilot modules	Core Team, Student Assistants	
	Evaluate learning, feasibility	Core Team	
Phase 2: Integrated Modules	Develop Integrated Enterprises database and case study	Core Team	• Comprehension: Do students understand integrated ES systems and the integrated nature of organizations? • Application: Can students use ES systems to make decisions? • Analysis: Can students analyze dynamic decisions? • Synthesis: Do students use data from multiple disciplines to make decisions? • Feasibility: Does the framework support faculty participation?
	Develop training for student assistants, participating faculty	Core Team	
	Develop additional modules to test integration	Faculty Team, Core Team	
	Implement phase 2 modules	Faculty Team, Student Assistants	
	Evaluate learning, feasibility	Core Team	
Phase 3: Full Development	Develop additional modules	Faculty Team	
	Implement phase 3 modules	Faculty Team, Student Assistants	
	Evaluate learning, feasibility	Core Team	

This project was initiated by the chair of the department of management, its MIS program director, and its undergraduate policy and curriculum committee, which serves as the steering committee for the project. This committee consists of the department chair, three elected faculty members from the department and one student representative. The oracle package was selected by the department chair and the MIS program director in consultation with other faculty members in the department of management. Advice has been sought from industry to guide the project design; the informal solicitation is resulting in the creation of a formal external advisory committee to provide guidance and data on realistic decision problems

3.3.2 Project evaluation
Because large collaborative curriculum projects require ongoing formative and summative evaluation to ensure success, our project design defines learning and feasibility outcomes as shown in table 1. Formative evaluation is focused on monitoring the feasibility and ease with which faculty can implement the project.

Summative evaluation is focused on assessing student learning, based on four of bloom's six cognitive educational objectives: comprehension, application, analysis, and synthesis (bloom, 1956), as shown in table 1. A baseline learning objective, i.e., that students continue to learn the core material in each course, is also included.

Measuring student learning is multidimensional and context-specific. In each phase of the project, we are considering multiple indicators of student learning (Frechtling and sharp, 1997) and developing appropriate scoring rubrics and measurement tools. Students' course work (module assignment and some quiz/exam questions) is used to assess the learning outcomes. We also measure the change in the magnitude and strength of students' self-efficacy, i.e., their belief in their ability to perform tasks. This is a particularly important affective measure for tasks perceived to be difficult, e.g., using a complex computer system, because it is highly correlated with the amount of effort individuals are willing to expend and their determination to complete tasks (Bandura, 1986, 1997). Self-efficacy measures are predictive of course outcomes and work performance (Locke et al., 1984; Multon et al., 1991), and are used in educational research (Christensen et al., 2002) and research on computer system use (Compeau & Higgins, 1995).

3.3.3 Phase 1: pilot study
The first major task in the pilot study, as shown in table 1, was identifying and training the core team. The other major tasks, developing and testing of pilot modules, is described in detail in section 4. The core team for the project consists of the three co-authors of this paper, that is, the director of the MIS program, the director of the IE program, and an accounting faculty member. The team was formed by asking for volunteers from among the department of management faculty. Like projects at other schools, there is strong interest from MIS and accounting faculty. In addition, we have strong interest from operations and industrial engineering, allowing the project to span management and engineering disciplines. The director of the MIS program is serving as project coordinator. The director of the industrial engineering program is coordinating module development for engineering, manufacturing and service operations. The accounting faculty member is coordinating module development in the financial, marketing, and management areas. As needed, students are hired to support faculty module developers. An internal grant from WPI's educational development council provided support for the core team and student assistants during the pilot study.

The core team attended a four-day oracle training class on the inventory module, at the discounted price for oracle academic initiative members. This provided an introduction to navigation in the oracle ES suite and a sense of how one oracle module works. Additional training has been primarily self-taught using available books, e.g., (Allen and Chow, 2000; Foster, 2001; Boss, 2002), on-line oracle courses, and hands-on exploration using the ES.

3.3.4 Phase 2: integrated modules
The phase 1 pilot study investigated feasibility and examined the impact of using ES-based modules to support learning of functional topics. Phase 2 is designed to explore the integrative and collaborative features of the module framework. First, the integrated enterprises case study and associated data will be developed, working with local companies to create realistic scenarios and data. Next, the two pilot modules will be refined and three additional modules (customer data, variance analysis, and design changes) will be developed. Modules were selected for breadth (address both management and engineering issues and both processes), and will allow us to examine the educational impacts for students involved in just one module and those who take several.

In phase 2, additional faculty members will develop modules, including a faculty member in marketing and one in mechanical engineering. There are two ways in which these faculty members receive external rewards for participation. First, to the extent possible, faculty members developing modules receive a monetary reward in the form of a small summer curriculum development grant. Second, WPI is known for its innovative technological education and its faculty generally support and participate in such initiatives. Consistency with the strategic focus and the support of the undergraduate committee including the department chair encourages faculty participation in the department of management. The core team will provide support in the development, in part to determine the level of ES knowledge needed by participating faculty.

3.3.5 Phase 3: full development
Based on successful implementation in phase 2, the final phase of the project will extend the modules to cover more decisions in the business process and involve more faculty.

Examining the process diagram and module descriptions in figure 1, examples include staff planning for design projects in human resources and determining pricing and launch strategies in marketing. Because the learning outcomes in phases 2 and 3 focus on integration, we will also be developing measures for these outcomes and tracking results.

4. PILOT STUDY RESULTS

The pilot study was designed as a first step in assessing the effectiveness of using ES-based exercises to teach concepts in core management and engineering courses. We examined the feasibility of the project design by developing and testing a pilot version of the budgeting module for use in managerial accounting, described in more detail below, and a pilot dynamic planning module for use in production planning and control. Feasibility was assessed in terms of student learning and acceptance, faculty workload and ability to develop modules, and the ability of undergraduate lab assistants to deliver the modules. We used the vision database supplied by oracle as the underlying database for the modules in the pilot study. To measure student learning, we scored student work and developed two self-efficacy questionnaires per course, technology self-efficacy covering ES tasks and task self-efficacy covering contextual decision-making, because both task and technology abilities are needed for the module exercises.

4.1 Pilot Study Design in Managerial Accounting

The sample consisted of 57 students enrolled in two sections of an undergraduate managerial accounting course taught by one of the authors. We utilized a repeated-measures experimental design to compare students' learning of an accounting topic (budgeting) learned through an oracle module to a comparable topic (variance analysis) learned without oracle. For each topic, students completed similar tasks including a case analysis as an out-of-class assignment. For the budgeting topic, students constructed a budget (including both fixed and variable costs) in such a way that varying options or "what if" scenarios could be explored and manipulated. For the variance analysis topic, students completed a variance analysis of a similar case. The instructor spent comparable time teaching each topic and students received comparable assignments and levels of practice on the two topics.

The primary difference between the learning requirements was the method used to conduct and prepare the case analysis. The budgeting module used in the experimental condition required students to use and analyze data from a budgeting case using an oracle module. In the oracle module, students were asked to calculate the revenues and expenses (variable and fixed) associated with various products so that they could develop and formulate a master budget. After they had completed the mechanical aspects of formulating the budget in the oracle ES, the students were required to analyze various "what if" scenarios. Thus, they were asked to examine the budgetary implications of changes in profitability, changes in sales prices, changes in variable and fixed expenses, etc., and make recommendations to determine the options available to the firm to reach the desired objectives.

In the control condition the students were asked to analyze a case on variance analysis. In this case, the students were first asked to prepare a flexible budget as a precursor to conducting revenue and cost variances in order to compare actual results with previous results and budgeted results. This case however, was not analyzed through the oracle ES - the analysis completed by each student was done using excel or manual calculations. Thus, each student analyzed the case and made recommendations without the aid of the oracle ES. While case analysis has some elements of active learning because students are applying material in a case environment rather than only a lecture/quiz format, the oracle ES facilitates exploration and what-if analysis, thus supporting students' analysis and synthesis capabilities.

Students' actual comprehension and learning of budgeting and variance analysis topics were assessed through a quiz with ten items, five questions on each topic. The quiz was administered both at the beginning and at the end of the term, as were the task and technology self-efficacy questionnaires.

4.2 Summary of Pilot Study Results

Our analysis examined whether or not there were improvements in the students' actual learning of accounting concepts by the end of the term, especially for those concepts learned through the oracle-based module. Because budgeting was learned with an oracle-based module (experimental condition), while variance analysis was learned under the control condition, we hypothesized greater gains in budgeting knowledge than variance analysis on the post-test. Table 2 shows pre- and post-test summary statistics for accounting task self-efficacy, technology self-efficacy, budgeting quiz scores, and variance analysis quiz scores, as well as an example question for each.

A 2 (test) x 2 (topic) repeated measures analysis of variance, with test (pre-test, post-test) and topic (budgeting, variance analysis) as within-subject factors, was used to test the hypotheses of greater learning gains with the oracle-based module. As predicted, there was a main effect for topic ($f = 12.5$, $p = .001$), with students scoring higher on budgeting (the experimental condition) than on variance analysis (the control condition) (budgeting $x = 2.6$, variance analysis $x = 2.2$). More importantly, the test x topic interaction effect was significant ($f = 5.5$, $p = .022$), thus supporting our prediction of greater learning with oracle compared to without.

Paired sample t-tests on pre-test and post-test scores for budgeting and variance analysis further support these results. Paired sample t-tests comparing pre-test scores on budgeting and variance analysis show no significant differences ($t=1.03$, p=n.s.). The paired sample t-test comparing post-test scores on budgeting and variance analysis, however, was significant, with post-test scores on

TABLE 2: SUMMARY OF ACCOUNTING PILOT STUDY RESULTS

	Accounting Self-Efficacy (n=57)		Technology Self-Efficacy (n=57)	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
Mean	3.4	7.8	1.9	6.4
Std. Dev.	1.7	1.5	1.8	2.1
Minimum	0.3	3.2	0.0	0.0
Maximum	7.0	9.9	8.1	9.9
Example question	*I can provide examples of how management control systems affect variance analysis.*		*I can determine the cost of a product or service using the Oracle Applications system.*	
	Budgeting Quiz Scores (n=56)		**Variance Analysis Quiz Scores (n=56)**	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**
Mean	1.86	3.36	1.70	2.70
Std. Dev.	0.09	0.14	0.12	0.12
Minimum	0.00	0.00	0.00	0.00
Maximum	3.00	5.00	4.00	5.00
Example question	*True/False: A just-in-time manufacturer does not need a sales budget.*		*True/False: As a general rule the sooner a variance is isolated, the greater its value in cost control.*	

budgeting significantly higher than post-test scores on variance analysis ($t=3.7$, $p=.001$). These results indicate that students improved their learning of the topic of budgeting (taught through oracle) to a greater extent than their learning of variance analysis (taught without oracle).
Unsolicited comments from student evaluations of the course suggest that students appreciated the oracle-based lab, and would have liked even further integration of oracle-based exercises. Further analysis of results, including the task and technology self-efficacy results, can be found in Mistry et al. (2003).

Results from the production planning and control class indicated an equally successful pilot test. Relative to a control group, students perceived an increased ability to understand ES and apply materials management principles (Johnson et al., 2004).

For both classes, undergraduate lab assistants taught an oracle navigation module and then delivered the decision-making module successfully. The two core team faculty members were each able to develop a module with the limited training provided. Each spent approximately 3-5 days developing their module. Students in the classes and the faculty teaching the classes reported that the oracle-based module was a valuable experience.

5. CONCLUSION

In this paper, we describe a framework for teaching enterprise decision making, structured around independent decision-making modules placed in the context of business processes that integrate functional concepts with broader business goals in a data-rich ES environment. Our emphasis on decision-making from a user perspective, rather than ES functionality, is unique. The modular design provides flexibility to students and faculty, overcoming traditional barriers to integration in education. In their course work, students encounter several modules, but the order of learning is flexible. The delivery of the modules in separate labs monitored by experienced undergraduates minimizes the loss of classroom time and the need for faculty experience with the software. Our pilot study demonstrated the feasibility of using such student assistants. Strong leadership and support are a key component of our project plan, and we have identified feasibility and student learning outcomes to guide project evaluation. Our assessment of student learning ensures that the modules do not reduce knowledge of core subject matter, as demonstrated in our pilot study, and helps us understand what students are learning as they do organizational tasks using data-rich, integrated systems.

We are starting the second phase of the project, which will involve developing modules and a database to test our integration and collaborative objectives. We want students to be better able to articulate the impacts of their decisions on other functional areas and to be able to find and use data from different disciplines to make decisions, while maintaining or improving their ability to make functional decisions. To measure these outcomes, we will continue to assess both student work and self-efficacy. Unlike the functional outcomes measured in phase 1, some extension of traditional assignments and exam questions is typically required to measure integration. These questions need to developed and examined for validity. Because self-efficacy is task-dependent, a mechanism for evaluating integration self-efficacy also needs to be created.

At the end of second phase of the project, we will have developed a prototype of the framework that is fully functional, allowing us to investigate and frame the complete set of student learning objectives as well as other project outcomes. Such outcomes include: (1) cost and time feasibility, perhaps summarized by a total cost of ownership model, (2) use in multiple disciplines and at other universities, and (3) positive interest from industry. The third phase of the project extends the second-phase prototype to additional modules and functional areas and permits more complete testing of outcomes.

In the second and third project phases we are also addressing limitations of our phase 1 pilot study. While we were careful in the accounting pilot to structure the budgeting and variance analysis topics for comparability, comparing across topics may confound the results. We are collecting additional data on budgeting, taught without the phase 1 oracle module, to test this concern. In the production planning and control pilot, confounding factors include adjustments to the measurement instruments, small sample sizes (about 20 per class), and comparisons across classes. We have standardized the measurement tools, and are collecting additional data, to alleviate these concerns.

We believe that a broad business process perspective, combined with ES experience, will provide students with real value as they compete for jobs. Companies striving to improve the performance of supply chain and product development processes need graduates who understand the process-wide benefits and risks of their decisions.

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