THE INTEGRATION OF ENTERPRISE INFORMATION SYSTEMS IN THE OPERATIONS MANAGEMENT CURRICULUM

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ABSTRACT

Over the years, the integration of information systems technology with production management techniques has created opportunities for greater efficiencies in the production and operations environment. We propose that the concepts around general systems theory create a powerful linkage between the two areas, and a jumping-off point to integration information systems with an operations management curriculum. Examples of this linkage can be found in evolutions of material resource planning (MRP) systems and systems analysis and design techniques as well as in today's business enterprise information systems. Further, we propose that recognition of these linkages are crucial in developing a successful operations management curriculum. The initial results of applying this approach to a business school operations management curriculum are presented.

INTRODUCTION AND BACKGROUND

A business Enterprise Information System (EIS) can be viewed as the natural extension of two of its predecessors: general systems theory and information systems analysis and design methodology (SADT).

In the broadest sense, EISs are information systems which must organize and control another complex system – the organization. It seems logical, therefore, that insight into what EIS can be extracted from the varied and rich literature on general systems theory and information systems analysis and design techniques. A review of this literature reveals necessary characteristics for a successful EIS.

Churchman's book, **The Systems Approach** (6), provides a starting point by defining a system as "a set of parts coordinated to accomplish a set of goals" and goes on to outline five considerations for defining a system.

1. The total system objectives and more specifically, the performance measures of the whole system;
2. The system's environment – the fixed constraints of the system;
3. The resources of the systems;
4. The components of the system, activities, goals and measures of performance;
5. The management of the system.

Buffa (4) traces the general systems theory concept back to 1947 and relates L.V. Bertalanffy's "hallmarks" to a production management perspective by stating "it (the word 'system') describes so well the general interaction of the myriad of elements entering managerial problems that we can no longer talk of complex problems without using the word." He adds that "one of the great values of systems concepts is that the concepts help us to order and structure a very complex problem."

A model which tries to incorporate and address the issue of complexity is Warfield's Task-Oriented Transient Organization or TOTO (17). Here Warfield posits two dimensions of complexity: scope and depth. Further, he suggests that satisfactory answers to complex problems must concurrently address depth and breadth. Warfield contributes a valuable list of important implications of the systems approach as applied to complex organizational problems.

1. Individuals can, at best, contribute to a solution;
2. The number of elements is large;
3. Given there are a large number of elements (2), there are a large number of linkages;
4. Complexity feeds upon itself.

The classic systems theory starts with the Input-Transformation-Output block diagram and its logical extensions of feedback control loops and adaptive systems as the fundamental components for systems analysis. All the components function at varying levels of abstraction. For example, the transformation construct operates as a generic, nondescript "black box" to describe the transformation from input to output. At a second level, the logic of the transformation is fully detailed. Here the approach treads the "intellectual battle line" between pluralism and monoism proposed by Churchman in his **Design of Inquiring Systems** (5). It follows that an information system managing a complete organization must also function and support the many different levels of abstraction.

An adaptive system is defined as one which reacts to its own environment in a way which "contributes to the continued operations of the system" (6). Inherent within the definition are the following premises: the system knows what to monitor, the system is capable of making a decision, and the system knows how to initiate the appropriate actions. All of the factors are included in the systems approach through the concept of feedback control. A feedback control loop consists of: a sensing unit, a comparator, a decision maker, and an effector. The system senses its environment and makes a comparison between the desired state and the sensed state. A decision on the appropriate action is made and initiated.

Ackoff (1) categorizes systems using the level of

sophistication of their feedback control loop. Systems at the first level, "state maintaining," reach to their own performance. A memory component characterizes a second level system, which uses feedback to anticipate and seek goals. Ackoff named his third and most involved system "purposeful." This system operates to collect information, to store information in memory, and then to use the stored contents in order to formulate new courses of action. We submit here that an EIS must strive to be a level-three adaptive system – a purposeful system (Table 1).

TABLE 1
EIS Characteristics Prescribed by the Systems Approach

1. Adaptive
2. Memory Component
3. Feedback Control Loops
4. Varying Levels of Abstraction
5. Aggregate Information
6. Memory Storage and Retrieval
7. Information Reflection

Interestingly, the systems analysis and design techniques (SADT) used in management information systems theory have long been based upon envisioning the entire organization as a system. Historically, SADT addressed the interfaces between the various information systems of the functional business areas by using various manual methodologies. In the early and middle 70s IBM developed three, fourth-generation SADT techniques: Business Information Analysis and Integration Technique (BIAIT), Business Systems Planning (BSP), and a Business Information Characteristics Study (BICS) (7).

BSP was initiated to furnish executives with a more complete view of business activities across functional and operational lines, thus acknowledging and establishing an information system with a business-wide viewpoint. BIAIT uses the concept of an "order" (as in an order placed by a customer), and seven binary questions as a basis for its evaluations. Answers to questions relate the "order" to the customers and suppliers of the organization and are used to place the organization into one of "128 unique cells." Analysts use previously determined characteristics for each cell to propose a "strawman" model of the organization. BICS is an amalgam of BSP and BIAIT. So, after using BIAIT to get a "strawman" model, BICS added standard information system data stores to the BSP processes to more fully define the organizational model (7, 9, 10).

In summary, the organization can be viewed as an adaptive system. To properly develop or encode an information system for an adaptive system, the information system itself must be an adaptive system. The systems analysis and design techniques used in information systems have long tried to model adaptive systems. This selection has demonstrated the foundation on which a working perspective of an enterprise wide system may be based. Now it seems that EISs have addressed the challenge of having a single information system which can encompass the entire organization.

SAP R/3 OVERVIEW

SAP AG produces a client/server, enterprise information system (SAP R/3) which contains an integrated set of comprehensive software (16). These include a set of mature business applications and tools for financial and cost accounting, sales and distribution, materials management, human resource, production planning and computer-integrated manufacturing. With these fundamental software modules, companies are able to model a wide variety of business processes. The system is available in many languages and has the capability to work across the myriad of different currencies, accounting procedures and tax laws encountered by today's global organization.

SAP is being used by major corporations to automate and to manage their complete organization. Companies are counting on their SAP systems to coordinate inventories, sales, marketing, cash flows, order processing, financial management, etc. In addition, by interfacing SAP systems between companies, organizations are partnering to create electronic commerce. These systems are large and complex and by their nature require the understanding of both a focused, functional perspective and a business-wide perspective at the same time. Again, we see one of the main components – monoism and pluralism – recognized by systems theory.

SAP has taken the enterprise information systems (EIS) market by storm. Price-Waterhouse reports the EIS market at $3.86 billion in 1996 and growing at an annual rate of 68%! SAP has over 30% of the market and according to Price-Waterhouse, "its [SAP's] position in the market has boosted SAP R/3 to the de facto industry standard" (15).

This incredible growth in the market has created a dire need for students with a unique set of skills: functionally focused and business literate. The more a student knows about the complex interactions inherent in a business and how to capture those interactions in an enterprise information system, the more employable that student becomes. The software companies offering this type of software include PeopleSoft, Oracle, Baan, and SAP/AG.

SAP America, Inc. is the world leader in business enterprise software systems, with over 30% of the market. In 1996, they selected the College of Business (COB) at California State University, Chico (CSUC) as the first partner in the company's newly established University Alliance Program. The SAP University Alliance Program is a partnership between the University and SAP in which SAP provides the University with its R/3 software product, a training database, technical support and faculty training. The University uses the software to facilitate student learning regarding the concept and application of enterprise software.

BUSINESS ENTERPRISE INFORMATION SYSTEMS AND SAP R/3

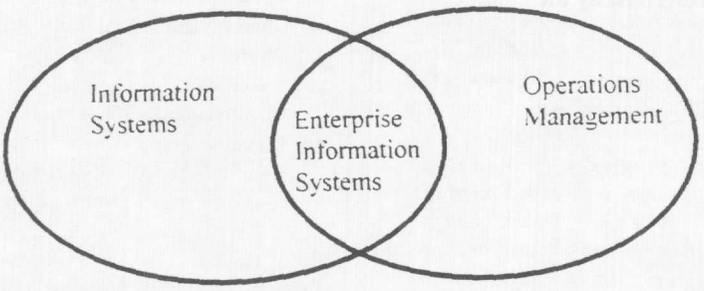
Systems theory can become the basis from which to create a natural interaction of information systems and operation management areas. Conceptually, the intersection is easily identified and embraced by both areas (Figure 1). Practically, Enterprise Information Systems become the link.

As discussed, SAP R/3 is an integrated set of software

modules that cover all major business processes, including sales and marketing, materials management, procurement, production planning and execution, distribution and logistics, and accounting and financial reporting and controls. In addition, numerous modules address support processes, including HRM, quality management, plant maintenance, and service management. So, in some ways, SAP R/3 touches all the main functional areas in a business school just as it touches those areas in the real world.

When new information systems are being designed and acquired there is always a trade-off between the functionality of the specific system and its integration with other systems inside and outside of the organization. Traditionally, those on the side of functionality were the clear winners. For example, if an organization were evaluating a production scheduling software package, it was commonly required that all current system functionality, along with substantial additions to functionality, be present before any new software package would be considered acceptable. Any thought of application integration was secondary at best.

FIGURE 1



Software that focused on one functional area was easily justified and usually chosen, as long as the decision remained within that functional area and was evaluated from one manager's set of criteria. However, most decisions have cross-functional area input and impact. Bigger problems arose when organizations attempted to have two or more of these function-based software systems communicate. The results have been slow transactions, corrupted data, and a large software support organization. Adding further complexity is the fact that the purchase and use of information systems have evolved into strategic and competitive decisions well beyond the scope of one manager or decision maker (12, 13).

Business enterprise information software takes a totally different approach. There is a single repository of data, with all the applications using this same database. The software is designed for integration rather than unlimited functionality. This approach may reduce the level of functionality of existing stand-alone systems. However, this reduction in functionality is trivial compared to the ability of having all applications working together.

The major benefit of business enterprise software as a transaction can be uniformly managed from the point of inception to its final disposition. Having the software control the transaction workflow is a powerful force in reengineering processes, so that unnecessary or redundant operations can be eliminated.

For example, in a traditional system if a customer needs to get information about their order they are usually passed from one individual to another until the transaction can be located at its current position in the life cycle of the order process. Some of the employees involved in resolving a problem could be in sales, credit, production, inventory control, shipping, accounting, etc. Because of the large number of potential steps in a process, some organizations have established departments whose sole responsibility is order tracking. Since in a business enterprise software implementation the data is stored centrally, one person can now answer most questions without regard to the physical progress of the transaction.

The rest of this paper provides an overview of the implementation of SAP R/3 into the operations management curriculum, along with the impact of this software package on the entire COB curricula.

CURRICULUM INTEGRATION PLAN

Introduction to Operation Management Curriculum

As one reads the questions below, we see the linkages and interdependencies predicted by general systems theory. In fact, it is the recognition and understanding of these linkages that produce the value for a student or employer.

- Why are we producing these goods?
- Are the goods for inventory or a specific customer?
- If they are for a customer, what is the ordering history of that customer?
- What information do we need to know about the customer?
- How much will it cost us to produce this good, including allocated costs?
- How much money do we make when we sell this good?
- What are the skill inventories of the workers scheduled to produce these goods?
- Do we have enough worker capacity to meet the production schedule?
- Where do we get information about our suppliers?
- What is their quality record as a supplier to us?

Most likely these questions are seldom, if ever, asked by students in an operations management class. If the questions are asked, being able to provide an integrated answer for the student is difficult at best. However, these are some very important questions for a production manager. In fact, dealing with many of these cross-functional issues may be just as important as dealing with the technical issues involved in producing the goods.

This section discusses how an integrated approach using business enterprise information system software can expose business students to issues that are more representative of actual business situations.

The integration of the R/3 software into the operations management curriculum required a cross-functional approach. Because the software is process-focused and not functional-area focused, faculty from Accounting, MIS, and Operations Management formed a team to accomplish this task.

There were several hurdles in developing a plan that would integrate the software into the curriculum, without resulting in only training students in the use of a software package. First, the students must be taught enough about the software package to use it and to further overall comprehension. Secondly, the focus needed to be on problems created by the cross-functional process and solved by the software. Finally, the amount of time needed to develop new course materials had to be well managed since faculty availability was very limited.

The solution to these problems involved a multi-faceted approach. First, a MIS class was developed to create a team of students who understood the workings of the software enough to act as consultants for the Operations Management courses. The second issue was addressed by the development of cases and assignments to illustrate the cross-functional nature of most Operations Management decisions and processes. Addressing the final issue resulted in the decision that the software would be integrated into operations management classes in a phased approach.

It was decided that the initial integration of the software into the operations management curriculum would occur in four operations management courses (Production Planning & Management, Production Control & Scheduling, Quality Management and Procurement). This would be done at the rate of two courses per semester. The first two courses were Production Control & Scheduling and Quality Management.

Basis Support

The SAP system is an extremely complex piece of software (2, 3, 8). It contains over 75 million lines of source code and the database stores data in over 7,000 relational tables. The administration of such a complex system is very important to the success of any SAP project. SAP uses the term "basis support" to describe these activities. There is an impressive set of monitoring and administration tools imbedded in the SAP system. However, it is very important that a talented basis support team is formed before the project is even undertaken. We at CSUC spent an entire semester creating a basis support infrastructure class (Enterprise Software – System Administration) before the system was used in application oriented classes (Quality Management and Production Control & Scheduling).

Cross Functional Assignment

The complexity of demonstrating the concepts underlying enterprise information systems required that complex cases be developed for students. Then, to demonstrate the integration needed for successful operations, assignments are developed that require the students to navigate through the enterprise software into several functional areas. An example of this is one of the purchasing assignments used in class.

The assignment follows the process of generating a purchase order from a planner order, confirming the current supplier for this material, issuing the purchase order, receiving the material, stocking the material, and paying the invoice. The student is required to perform the following navigational steps in the enterprise software system.

- Access the production module where the planned order is created.
- Move to the procurement module where a purchase order is generated based on the planned order.
- Confirm the supplier and current terms for the material to be purchased.
- Issue a purchase order for the material.
- Obtain delivery information and status.
- Receive the material into the warehouse.
- Perform required quality inspections before releasing material to stock. (This requires the student to access the quality management module.)
- Receive invoice from supplier. (This requires the student to interface with the accounts payable module.)
- Perform invoice verification.
- Issue payment to supplier.

During this exercise the students navigate through several different functional areas in order to complete the purchasing process. As a part of the assignment, the student is required to assess the current process and make recommendations for improvements. Completion of this assignment results in the student acquiring a better understanding of the complexity of the purchasing process, the need for integration between several functional areas of the organization, an exposure to all of the internal and external documents associated with the transaction, and an appreciation for the advantages of enterprise software.

This assignment usually takes several class periods to set up and execute. The different parts of the purchasing process are discussed and the software is introduced in phases. The total time required for introducing the software and completing the assignment is approximately 20 hours. This is spread over three to four weeks.

One key learning experience in the case is that the student cannot complete a POM problem without dealing with and satisfying the issues from the quality management, the accounts payable and the information systems functions (Figure 2). Historically, this dependency was briefly discussed or briefly addressed in the purchasing class. Now, the dependency becomes a major component.

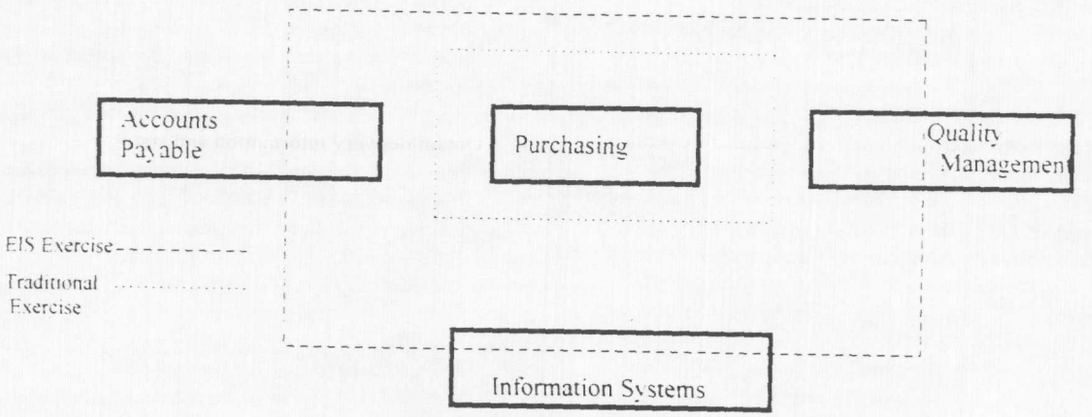
INTERMEDIATE RESULTS

The amount of interest in courses dealing with SAP R/3 has been overwhelming. The student demand was so intense for the MIS class that students were asked to submit applications for the class. Only the very best students were selected to participate. The operations management courses that are integrating SAP R/3 software have seen a 50% increase in the number of students requesting these courses. As we gain more experience and have more faculty trained in using the system, all interested students should be able to enroll in these classes.

Industry response has been just as impressive. Almost all of the companies that recruit business students at CSUC have been extremely supportive. Interestingly, even companies that

are not presently using SAP and have no plans of adopting SAP, see our approach as the best way of educating our students. Of course, companies that are committed to SAP can only be described as being wildly enthusiastic about this endeavor.

FIGURE 2



Some student responses indicated that they were finally grasping how the various functional areas within a business were interrelated and how dependent each was on the data and processes owned by other areas of the firm. As a part of the MIS course, students are required to present a software process analysis of one of the SAP R/3 modules and compare it to current legacy systems. The results of this have been very educational. Students have gained an appreciation for the complexity of a company having separate systems for every functional area of the organization.

Various companies have provided guest speakers during our first two years of implementation. We have had speakers from SAP, Hewlett-Packard, IBM, Applied Materials, Foundation Health, Price Waterhouse, Deloitte and Touche, PG&E, Intel, Andersen Consulting, and Chevron. This has created improved relationships with our recruiters and been extremely beneficial to the students. Our biggest problem this past academic year (1997-1998) has been controlling and scheduling the number of companies that want to send guest speakers to the campus.

SUMMARY

The major question is, "Does this approach work?" Clearly, this question is too complex to answer in the scope of this paper, but the authors can report experiential data and results concerning the curriculum.

In the first two years of this project, many benefits have quickly surfaced. From the students' viewpoint, the use of enterprise software in Operations Management courses has provided the connection that was missing between traditional curricula and understanding the inter-dependencies of the functional areas of an organization. In addition, those students who have gained a greater understanding of the SAP R/3 software have also seen their value in the job market greatly increased.

There has also been a measurable increase in the number of non-operations management students taking Operations Management courses since the software was introduced into the program. The percentage of non-operations management students in the courses is about 30%. What is impressive about this number is that the operations management courses are not needed by these students for graduation, and are in addition to their normal class requirements.

Faculty teaching in the Operations Management program and other business faculty have benefited through the required interface to make the integration work. Several teams have been formed to assist in this integration. These teams have facilitated numerous improvements in several courses both inside and outside the operations management area, as faculty work together to implement the software and integrate the course content.

Other measures include:

1. Student Increase: An increase in the number of students with a declared option in the operations management area (53 in Fall 1994 to 93 in 1996-1997); and in the information systems area (103 to 267).
2. Greater Industry Involvement: The number of industry guest speakers have increased significantly; number of recruiters has increased 16% from 1997 to 1998.
3. Expanded Fund Raising: Corporate contributions to the College of Business are increasing providing even greater plans for expansion.
4. Perceived Value of Students in Marketplace: Salary offers for the May 1997 and December 1997 graduates with SAP skills were 20% to 30% higher than offers last year for the same type of student. Also, students who have taken several courses in which SAP was integrated and taken the MIS SAP course have seen salary offers as much as 50% higher than their classmates.

In conclusion, today's business world requires operations management curricula to provide students with examples of,

exposure to, and experience with enterprise-wide, business perspectives. General systems theory creates a power linkage between classical concepts of information systems, operations management and today's enterprise wide perspective. In turn, this linkage generates a curriculum and environment in which students are exposed to underlying concepts of enterprise-wide business processes. The integration of SAP R/3 into the Operations Management curriculum has complemented the curriculum successfully with practical experience.

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