Enterprise Systems: Challenges and Opportunities for Information Systems Education

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ABSTRACT

This paper presents a perspective on "learning" in managing information, applied to enterprise systems. As its name suggests, an enterprise system encompasses a total view of all *parts* (functions, sub-systems) of the complete *whole* (organization, system). This approach of designing solutions for system component within the overall framework of the total system offers unique challenges and opportunities for designing, developing and implementing information systems. To meet its mandate, information systems education should offer a multidisciplinary learning environment especially in engineering and sciences curriculum where it is not adequately emphasized. A framework that is designed to deliver a comprehensive learning environment for the entire academic community has been proposed.

I. CHANGING ORGANIZATIONAL DYNAMICS IN AN EMERGING GLOBAL MARKET SYSTEM

The continuous change in the economic, political, and technological climate of the world has presented modern organizations with unprecedented opportunities and challenges in their quest for finding new ways to compete[1]:

- *Globalization*—Large corporations have graduated from operating on a national or regional to a global scale.
- *Decentralization*—A decentralized set-up is replacing hierarchical organizational structure with centralized control.
- *Customization*—Firms have to offer customized products in specialized markets in order to stay competitive.
- *Acceleration*—The ability to adapt to changes speedily is key to survival of firms.

As products are reaching a larger population across different market segments, consumer expectations are getting higher. This has resulted in increased complexity in all phases of the product life cycle and rapid obsolescence of products. Firms are realizing that they are no longer in a position to manage the product life cycle alone. They are thus reaching out to foreign companies to engage in meaningful partnerships by way of alliances in the form of supply-chains, manufacturing, and distribution networks.[2] Such an arrangement enables firms to share costs, skills, and access to markets which are basic realities of competing in a global market.[3] Further, alliances have offered global firms to organize their operations to exploit opportunities offered by integrated regions rather than stay within the confines of national markets.[4]

These shifts in the business environment have forced organizations to ensure that they can effectively meet changes that are occurring. Organizations must cope with three types of change[5]:

1. *Social*—Value as perceived level of satisfaction provided by goods and services to consumers.
2. *Technological*—Significant advances in materials, superconductivity, telecommunications and bioengineering have impacted almost all fields including information technology.
3. *Business*—Budget and trade deficits, monetary policies, commercial standards and practices have impacted the way in which organizations conduct their business.

In addition, interrelationships among these change, namely, socio-technical (environmental, quality of life), socio-business (ethics and fair trading practices), techno-business (electronic commerce) have offered new challenges and opportunities to organizations.

II. EVOLUTION OF ENTERPRISE INFORMATION SYSTEMS (EIS)

Changes in the business environment and resultant organizational forms and issues have had profound implications on how information systems are developed and used. These systems are being developed to simultaneously handle complexity, flexibility in their data structure, responsiveness to changing information needs, and adherence to higher quality standards.[6] A significant paradigm shift in achieving these multiple objectives is how development of these systems is approached. From the traditional *island* of problem solving perspective, a *wholesome* view of the organization (or enterprise) is being taken.[7,8] Consider the decision-making hierarchy of an enterprise depicted in figure 1.

Information systems development in the case of a supply-chain management system utilizing the traditional approach, will yield a market demand forecasting system (strategic), product planning and control system (tactical), and production scheduling system (operational), marginally relating the implicit organization form to one another.[9] However, in the integrated systems development approach, the organization form can be equated to "layers" in the enterprise system as depicted in figure 1, and described as follows:

- The bottom layer represents "intelligence" of an organization captured by identifying technology classes. These are elements of an operational strategy of a firm.
  > **Example**: The *production scheduling system* will be tightly coupled to capacity planning and lot sizing decisions by

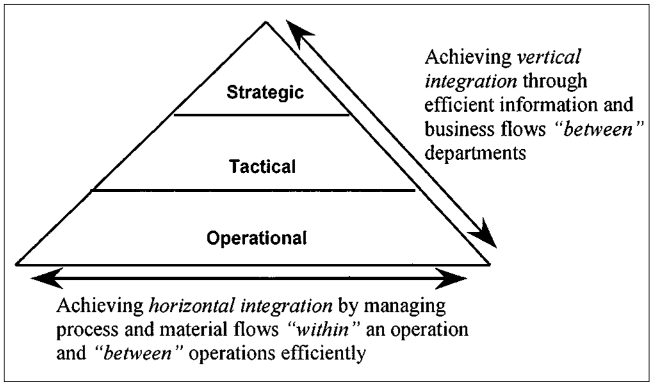

Figure 1. Enterprise decision-making hierarchy.

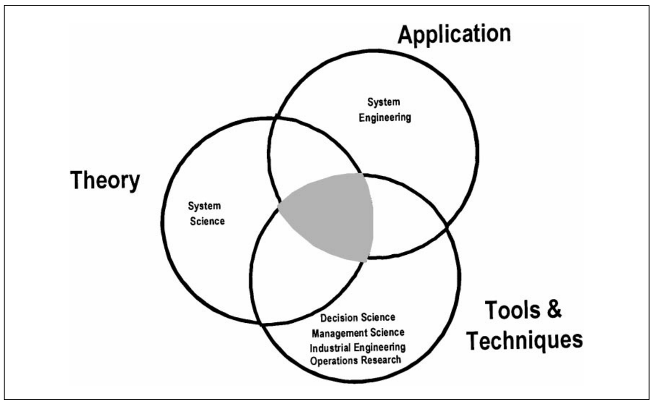

Figure 2. EIS domain facilitates a multidisciplinary learning environment.

the *production planning and control system* and product demand trends of the *market demand forecasting system*.

- The intermediate layer represents "specialization" in ways technology is modeled for competitive advantage aimed at implementing specific management policies. These make-up the tactical strategy of the firm.
  > **Example**: The *production planning and control system* will be linked to the *market demand forecasting system* to reflect changes in capacity planning and lot sizing decisions, as well as to pass on signals dynamically to the *production scheduling system* communicating variations in the original plan over time.
- The top layer signifies "assembly" of applications of technology in a system, packaged to serving differentiated market segments. These represent elements of functional strategy of the firm.
  > **Example**: The *market demand forecasting system* will be linked to the *production scheduling system* in order to reflect supply lead time variations, as well as to the *production planning and control system* in order to update capacity planning and lot sizing decisions due to demand uncertainty and forecast errors.

Such an approach enables analysts to scrutinize underlying relationships *within* and *between* system components in greater depth, as well as enhances their capabilities to understand problems and design appropriate solutions. The end product is an open, flexible, and modular system enunciating integration and synchronization among its components.

III. Learning Objectives in the EIS Domain

As noted in the preceding section, the design and development of EIS requires a wholesome view of the system. Therefore, learning objectives in the EIS domain are to[10]:

a) Gain insights on principles from theories, hypotheses, problem solving strategies, models and methodologies in three primary disciplines* that have origins in the systems problem, as depicted in figure 2,
b) Learn tools and techniques to manage enterprise information system life cycle phases (plan, analyze, design, implement, and support), utilizing these principles as the basis for enrichment, elaboration, association and expounding of ideas and thought processes, and
c) Additionally, learn about interactions between these three disciplines. These interactions highlight complementarily of systems, engineering and analytic views of EIS problems that these disciplines represent both separately, as well as jointly. Also, these interactions can be the basis for design and development of a common framework to implement models and methods in an enterprise system.

IV. Proposed Framework for Learning in the EIS Domain

From the discussion in the previous section, it is reasonable to infer that learning in the EIS domain requires a regimen of pedagogy complemented by practice. Figure 3 depicts outline of the framework that would facilitate such a learning process.

Pedagogy in EIS is both an art and a science. Art because modeling and design of EIS relies heavily on perceptual and conceptual abilities of the analyst. Science because analysis of EIS utilizes proven methodologies, tools and techniques requiring technical abilities of the analyst.

Practice in EIS provides the laboratory to apply, verify, test, and implement the pedagogy. It offers credibility and legitimacy to theoretical constructs emanating from various disciplines and applied to the EIS domain.

For integrated systems such as EIS, pedagogy and practice are complementary to each other. The proposed framework adapts this relationship as the centerpiece for learning in the EIS domain.

Various components of the framework are described below:[11–17]

Architecture provides the structure for information sharing throughout the enterprise. A supply-chain structure has several

* I. Systems Science based theories on the *abstractionist* (or systemic) view of the problem. Topics of interest in this domain are—agent modeling, feedback and control, system topology and knowledge ontology.

II. Systems Engineering for the *reductionist* view such as, decomposition to represent system in parts of a whole. Decomposition of processes, materials flow, information, and cognitive elements of the system is of primary interest.

III. Industrial Engineering (IE), Management Sciences (MS), and Operations Research (OR) for *analytic* tools and techniques to improve decision-making in systems which takes on an algorithmic view of demand forecasting, inventory management, production planning, resource allocation, operations planning, and scheduling.

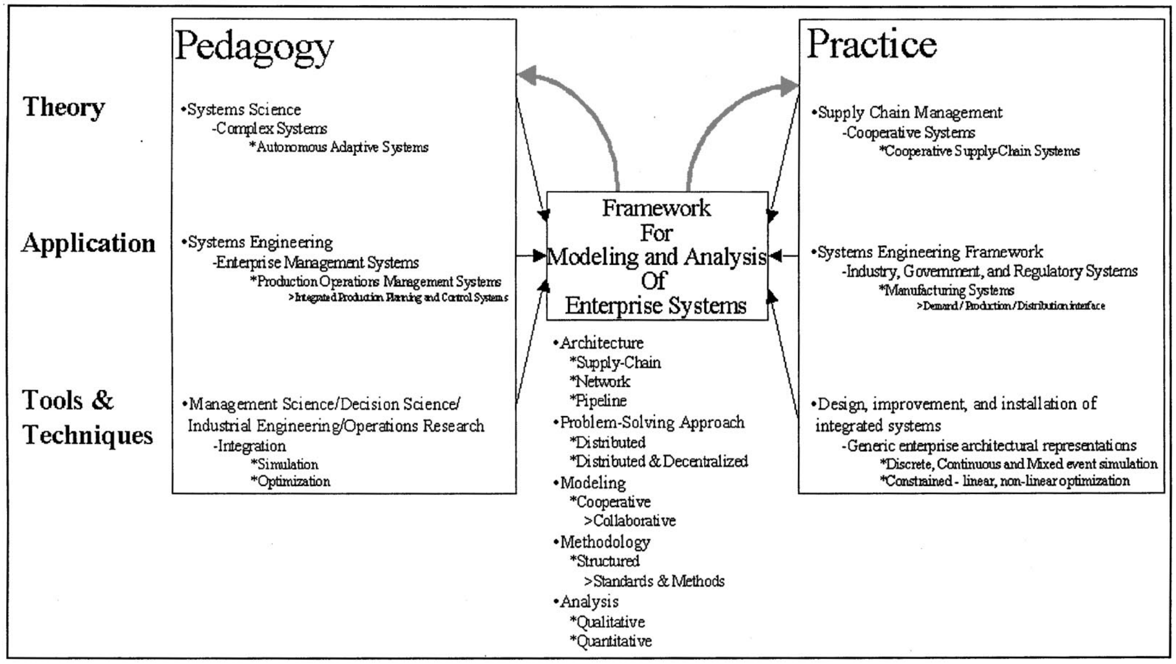

Figure 3. A framework for learning in EIS domain.

source nodes feeding several intermediate nodes that in turn are tied to several sink nodes. It can have a multi-echelon setup for information sharing at each level. In contrast, a pipeline structure has a source node feeding a sink node that in turn may feed another sink node. There is a single-echelon setup for information sharing at each level.

Type of information to be organized and how it must be shared within a structure depends on the *problem-solving approach* adopted for a specific problem. In a centralized problem-solving approach, controls on information sharing will be much tighter than in a decentralized approach.

Modeling of the enterprise will depend on the type of policies pursued at various decision-making levels. A policy of cooperation will require dynamic exchange of information between system components in order to modulate their behavior towards achieving a commonly agreed to objective or outcome.

Methodology facilitates implementing common protocols, methods, and performance standards in the enterprise. Thus, designing information to capture temporal behavior of activities in the enterprise in order to evaluate their performance characteristics is essential.

Analysis of the enterprise system in order to evaluate various alternative solutions is essential to decision-making. Thus, designing inputs based on the models to be evaluated for a specific problem is important. Similarly, capturing output from the analysis for reporting and dissemination is essential. The design of an EIS must accomplish this need.

It is proposed that the performance of the framework be evaluated based on five key learning parameters:

1. *Convergence*—promoting a common, yet basic understanding of the enterprise systems problem regardless of the learning approach or the methodology utilized for the purpose.
2. *Specialization*—affording opportunity to acquire specialization among many areas or disciplines represented by the enterprise systems problem.
3. *Diversity*—encouraging acceptance of concepts, principles, theories and hypotheses from diverse disciplines, yet applied in the pursuit of finding common solutions to integration problems in enterprise systems.
4. *Flexibility and Modularity*—providing an environment that enables modularizing learning across width and breadth of disciplines represented by the enterprise systems problem.
5. *Customization*—a curriculum or agenda to suit individual learning needs of students and educators.

V. The EIS Domain Offers A Multidimensional Learning Environment

A systematic representation of learning objectives within the construct of the framework proposed in the section entitled "Proposed Framework for Learning in the EIS domain," reveals several useful ways for its implementation. These are described using the learning pyramid, depicted in figure 4. It is built upon three primary learning dimensions—content, context and pursuit:

Content signifies the depth in the pursuit of knowledge. Learning content becomes more detailed and focused as generic system foundation concepts are applied to a specific implementation of EIS.

Context signifies the breadth of knowledge pursued. Learning context becomes more broad and abstract as the EIS problem is viewed strategically rather than tactically, and

Pursuit signifies the type of learning desired. Depending on the needs of a student, educator, and researcher, learning pursuits can be tailored accordingly. For example, to acquire core knowledge in EIS, it is essential to learn about all five phases of its development (planning, analysis, design, implementation, and support). A familiarity with one or more topics in the supplemental knowledge category is all that will be required of an analyst. A general understanding of system foundation concepts will be essential for sharpening conceptual abilities of the analyst. An educator and researcher may

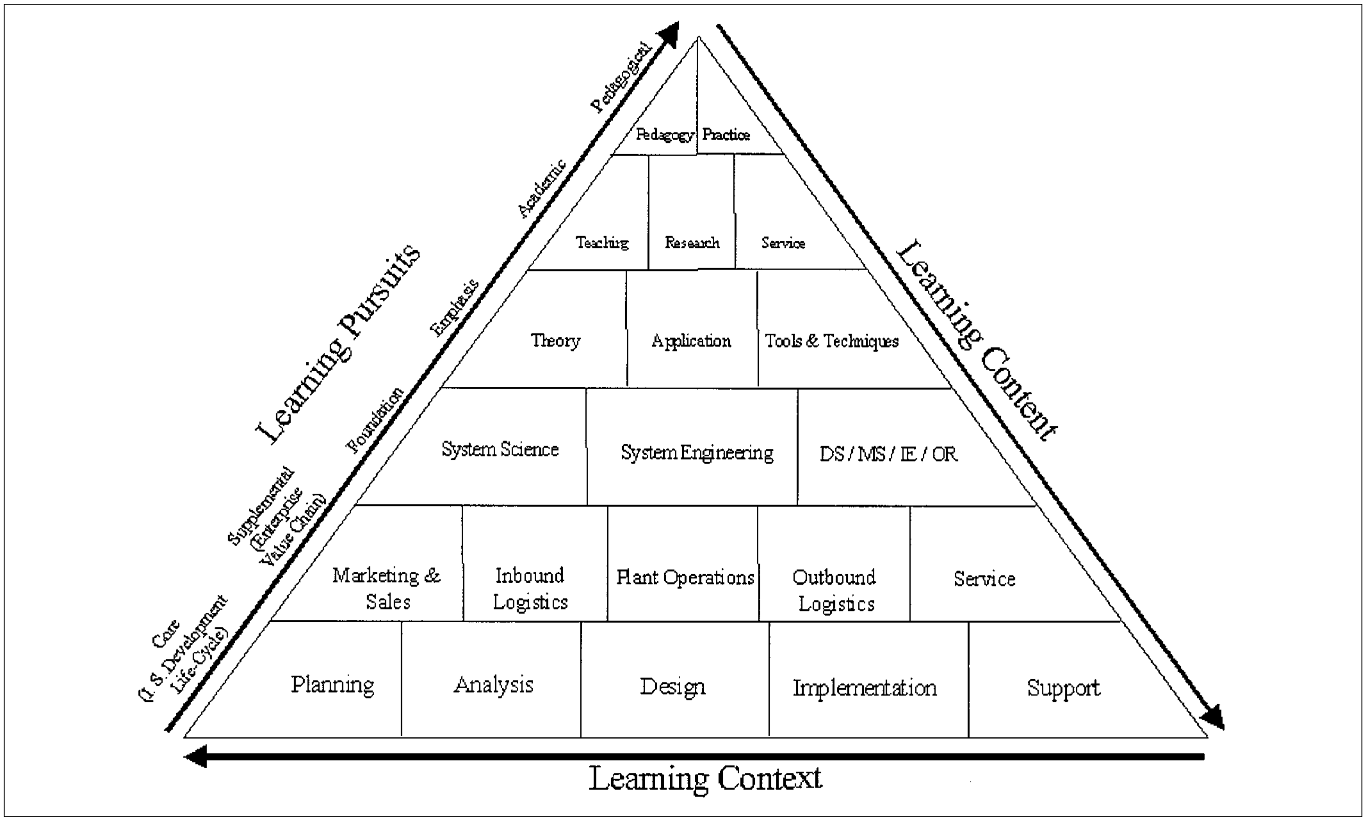

Figure 4. Learning pyramid in EIS domain.

concentrate his/her learning in one or more of the emphasis areas. And, he or she may adapt one or more of academic avenues to disseminate knowledge. Finally, pedagogical expressions require both classroom instruction as well as practice in the application of knowledge in a real setting. An EIS Courses Fact Sheet that describes possible course offerings in this area of learning is provided in the Appendix.

The potential performance of the above-described implementation of the proposed learning framework is now speculated. For this purpose, performance parameters that were elaborated in the section entitled "Proposed Framework for Learning in the EIS domain," are utilized.

Convergence—The interconnectedness of topics or areas of inquiry "within" a layer or "between" layers in the learning pyramid ensure a common basis of understanding of the problem.

Specialization—The breadth of coverage in any topic or area of inquiry ensures that learning will afford a focused and specialized view of such topic or area.

Diversity—The breadth of coverage across various learning pursuits practically ensures diversity in learning many disciplines.

Flexibility and Modularity—The building block structure implicitly present in the learning pyramid offers a flexible and modular approach to designing and delivering education in the EIS domain. Each learning layer follows a sequence from left to right. For example, for core learning in EIS, one must begin with information planning; information needs analysis and so forth. It is reasonable yet optional to learn foundation concepts in system science to enhance learning of information system planning in the core knowledge sphere. Similarly, learning in supplemental topics is not predicated upon learning core information system topics. However, core learning is enhanced, if contextual reference is provided by applications in specific areas of the enterprise value chain.

Customization—Another advantage from this structure is in emphasizing learning to suit the needs of the intended audience. For engineering majors, it is reasonable to expect a mixed emphasis on theory, applications and tools and techniques. However, for an audience of business majors, learning may be tailored to concentrate on applied aspects of a topic. An educator on the other hand, may plan his/her learning needs with a view to teach, research or offer service in one or more areas of enterprise systems.

Conclusion

The importance of global trade has aroused interest in Enterprise Systems as catalysts in achieving integration and synchronization among businesses. A framework that offers practical, comprehensive and rigorous approaches to learning in the EIS domain has been proposed. It has been argued that with a judicious implementation of this approach, it is feasible to design course offerings that emphasize learning at various levels of instruction to fulfill this industry need. Similarly, research and service agenda can be drawn up to satisfy institutional focus and priorities. As moves towards integration in decision making in business organizations are made, such a topic assumes a significant importance. This aspect has not been adequately emphasized in the engineering curriculum. Towards this end, it is felt that this paper makes an attempt to link pedagogy with practice, so that students can appreciate benefits of applying knowledge gained through various EIS courses in real-life applications.

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Appendix

EIS Courses Fact Sheet

Purpose: The purpose of the EIS courses is to,

1. prepare students with engineering, science and liberal arts background with necessary expertise and skills to integrate information for global operations,
2. enhance awareness of industry to the need of integrating their operations and associated information flows,
3. offer students with technical expertise to industry in implementing enterprise systems, and
4. prepare students to venture into the promising inter-disciplinary field of very large-scale information (VLSI) systems.

Motivation: Integrated information needs of a growing number of companies with direct and indirect global marketing, sales, engineering and manufacturing operations have to be met with specially trained information system personnel.

Objective: To train students in all aspects of EIS development so that they can manage information system activities at various positions of leadership in these multinational and multicultural organizations.

Course Organization: The EIS courses that emphasize an appropriate blending of theory, applications, and tools and techniques across a multidisciplinary track are organized into four types of courses. These courses impart knowledge about theories, methodologies, tools and techniques in planning, designing, developing and implementing information systems for the enterprise in the quest to optimize its value chain:

1. *Core Courses*—offer instructions in information systems dealing with all phases of EIS development life cycle, that is, planning, analysis, design, implementation and support. These courses are intended to train students in the art and science of EIS development. Such courses include, Enterprise Technology Modeling; Enterprise Information Modeling, Enterprise System Integration, and Managing Enterprise Information.
2. *Supplemental Courses*—deal with functions (operations) of the enterprise value chain. These courses are intended to train students in a focused application of core knowledge in information system development (acquired in core courses) to a particular function of the enterprise. These courses will also afford students opportunities to acquire working knowledge in other disciplines, primarily production and operations management and may cover three areas:
   - (i) **Enterprise Value Chain Management**: Integrated Corporate Information System Design; Integrated Product-Process Planning System Design; and Integrated Logistics Management System Design.
   - (ii) **Enterprise Productivity Management**: Activity Based Cost Management System Design; Knowledge Based Systems in Organizations; and Electronic Commerce.
   - (iii) **Enterprise Optimization**: Supply-Chain Synchronization; Enhanced Product Realization; and Simulation, Mathematical Modeling.
3. *Foundation Courses*—deal with concepts in the general area of systems.

   These courses are intended to broaden student's perspectives on nature and behavior of systems. An example of such a course would be Systems Methodology.
4. *Capstone Course*—provide students with opportunities to apply skills and expertise acquired in the above three types of courses to real problems in a business enterprise.

Prerequisites: Students have basic understanding of following topics either through prior course work, training or both:

- Systems Analysis and Design
- Database Management—relational, object-oriented
- Programming in C++, Visual Basic

Deliverables:

1. Highly trained graduates with exceptional abilities to help their organizations develop integrated information systems.
2. High quality research with potential to offer improved methodologies and solutions to enterprise systems problems, and
3. Forums for sharing ideas, knowledge and expertise in order to enhance awareness of EIS among the user community.