Enterprise Architecture – An Analysis of IS 2010's Newest Core Course

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Abstract

The IS 2010 Model Curriculum introduced a new course into the core curriculum: Enterprise Architecture (EA). The primary goal of this course is to provide undergraduate students with a top-down view of "computing architecture" replacing a more traditional bottom-up view of architecture. Interestingly, few universities teach an EA course and no textbook on the topic currently exists. This paper studies the proposed EA course by analyzing the proposed learning objectives in the context of the larger overall learning outcomes contained in IS 2010. The paper concludes by recommending several strategies for making the EA course a practical and useful undergraduate course.

Keywords: enterprise architecture, Bloom's taxonomy, systems approach, problem solving, curriculum

1. INTRODUCTION

The IS 2010 Model Curriculum was developed in response to "change in technology and industry practices, including the globalization of IS development processes, introduction of Web technologies, emergence of a new architectural paradigm, widespread utilization of large-scale ERP systems, ubiquitous availability of mobile computing, and broad use of IT control and infrastructure frameworks" (Topi et al., 2010). As a result, this curriculum revision represents a re-evaluation the core principles of the information systems discipline through a careful specification of the learning outcomes

One of the 'surprises' of IS 2010 was the emergence of Enterprise Architecture (EA) as a recommended core course in the model curriculum. Very few undergraduate IS programs offer a course in enterprise architecture. Even fewer offer an EA course in their core IS curriculum. Gartner (Bittler, 2010) reports that the Center for Enterprise Architecture at Penn State University is the first university in North America to offer an academic program in enterprise architecture. It began in 2009.

In addition, there are no obvious enterprise architecture textbooks. Searching the Pearson Higher Education and McGraw-Hill web sites yields no text devoted to a course in enterprise architecture. Nearly all existing books on enterprise architecture would most appropriately be classified as industry trade books.

Enterprise Architecture

"*Enterprise architecture* is a comprehensive framework used to manage and align an organization's Information Technology (IT) assets, people, operations, and projects with its operational characteristics. In other words, the enterprise architecture defines how information and technology will support the business operations and provide benefit for the business." (http://enterprisearchitecture.nih.gov/About/What)

John Zachman's framework for enterprise architecture (Zachman, 2003, P. 4) is a table showing columns of data, function, people and others against rows of scope, business model, system model and others that relate to cells of specific tasks and/or process steps to be taken. It is probably the early framework that popularized enterprise architecture and its origins are in the early 1980s.

The 1980s and 1990s also produced much literature about the systems development life cycle (Necco & Gordon, 1987, Snyder & Cox, 1985, Dekleva, 1992). One distinction between Zachman and others was Zachman's conviction that enterprise architecture was about more than information systems and should be applied to all processes and components of an organization. We believe the current interest in enterprise architectures may be influenced by advances in distributed computing, network accessibility and speeds, software as a service, and other advances.

These are the building blocks of information systems. They may stand alone from the information system in question, indeed from the organization itself. As such these building blocks have their own life cycle and architecture which makes the adoption of enterprise architecture even more important. A discussion of how systems architecture is complicated by the use components is found in Waguespack and Schiano (2004).

The National Institutes of Health enterprise architecture (http://enterprisearchitecture.nih.gov/About/Approach/Framework.htm) is based upon the Federal Enterprise Architecture (http://www.whitehouse.gov/omb/e-gov/fea) but does not have e-govenrment guidelines. It is based on business, information, and technology architectures as shown in Figure 1. Since Zachman has trademarked his framework and further restricts the framework's reproduction, we will use the NIH framework in this paper.

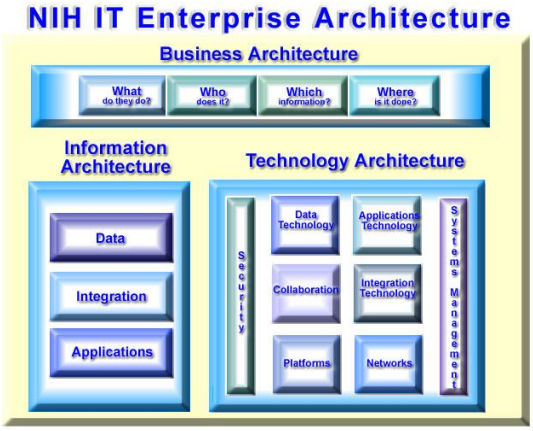

Figure 1
NIH IT Enterprise Architecture

An important dimension of information systems development is IT governance. This was not part of the IS 2002 Model Curriculum and Guidelines. Enterprise architecture explicitly recognizes the importance of IT governance and its inclusion in the IS 2010 Curriculum Guidelines is applauded.

Enterprise Perspective to Systems Analysis

There is probably no better method for implementing a successful and profitable information system than to perform a thorough systems analysis and design. It is also extremely difficult to teach students how to take an enterprise perspective to systems analysis if they have no experience in large, complex organizations. The result is that classes taught by faculty and consultants use assumptions that limit the scope of projects and examples for students. For many years the enterprise perspective in systems analysis and design is only reached when the student becomes an employee and gains years of experience.

In the 1960s information systems and computer processing were widely hyped to be the implement that would transform management and managers into information driven wizards bringing tremendous efficiency and profits to organizations. The assertions of the power and importance of information systems continues

today. But in the late 1960s a leading consulting firm and a leading academic challenged that claim.

The McKinsey & Company (1968) consulting firm found that most companies were unsuccessful computer users. One reason was because the use of computers in companies was not cost effective. Ackoff (Ackoff, 1967) was even blunter in his criticism of management information systems, he termed them "management misinformation systems." In order to understand the deference paid to Ackoff by academia you only have to note that his article in Management Science has a single reference (which he coauthored as the second author) in the first volume of an IEEE Transactions journal.

But after denigrating the assumptions and implementations of information systems Ackoff proposes a procedure for designing management information systems. His guiding principle is as true today as it was in 1967. "No MIS should ever be installed unless the managers for whom it is intended are trained to evaluate and hence control it rather than be controlled by it" (Ackoff, 1967, p. B153). In our current environment of enterprise information systems that means the systems approach to problem solving and enterprise architecture go hand-in-hand.

Purpose of Paper

The purpose of this research is to better understand the goals and learning outcomes of the IS 2010 model curriculum as they pertain to enterprise architecture. Specifically our goals are:

1) to analyze the IS 2010.3 Enterprise Architecture learning objectives from a learning theory perspective,
2) to relate the IS 2010.3 Enterprise Architecture learning objectives to the systems approach to problem solving, and
3) to recommend several tactics/strategies to make the undergraduate EA course a success.

2. ANALYSIS

The IS 2010 model curriculum specifies seven core courses with each course being described with a catalog description and a scope statement, a topic list, learning objectives and a discussion of the explanations and expectations for each course. IS 2010.3 Enterprise Architecture is one of the seven core IS courses.

Bloom's Taxonomy (Bloom 1956) is a well-known classification of forms and levels of learning. It identifies three "domains" of learning (cognitive, attitude and skill), each of which is organized as a series of levels or pre-requisites. The taxonomy provides a useful structure in which to categorize learning objectives, since educators will typically teach at different cognitive levels and will structure exams, homework, projects, and learning exercises within particular levels.

The cognitive domain of Bloom's taxonomy is the domain most often used in the analysis of learning objectives, exam questions and other curricular matters. The cognitive domain consists of six levels which are listed starting from the simplest behavior to the most complex. The categories can be thought of as degrees of difficulties. That is, the first ones must normally be mastered before the next ones can take place.

- Level 1 – Knowledge (lowest difficulty)
- Level 2 – Comprehension
- Level 3 – Application
- Level 4 – Analysis
- Level 5 – Synthesis
- Level 6 – Evaluation (highest difficulty)

The IS 2010.3 Enterprise Architecture course specifies eleven learning objectives. The learning objectives are classified into one of the six levels of Bloom's Taxonomy primarily by examining the action verb expressed each learning objectives. In addition the artifact(s) of learning and a pedagogical interpretation follow in the analysis. The result of this analysis is found in Table 1.

The IS 2010 Model Curriculum specifies four high-level information systems specific knowledge and skills. These are:

1. Identifying and designing opportunities for IT-enabled organizational improvement.
2. Analyzing trade-offs.
3. Designing and implementing information systems solutions.

4. Managing ongoing information technology operations.

These four high level learning objectives were then used review and analyze the IS 2010.3 Enterprise Architecture course.

3. RESULTS

An analysis of the IS 2010.3 EA course description, learning objectives, topics and discussion reveals that the course is still at an early stage of conceptualization and that much work needs to be done to evolve EA course topics into higher level learning objectives. Table 1 shows that only four of the eleven learning objectives pertain to level 5 (synthesis) and level 6 (evaluation) cognitive learning. In addition, none of the learning objectives were classified into one of mid-level learning at level 3 (application) or level 4 (analysis).

These results suggest that the IS 2010.3 Enterprise Architecture learning objectives are at an immature stage of development where further work needs to be done to specify the important application and analysis level skills critical to information systems students. In addition, the results of the analysis suggest twelve different learning artifacts:
1) framework for enterprise architecture;
2) total cost of ownership (TCO);
3) return on investment (ROI);
4) techniques for risk assessment;
5) integration of emerging technologies;
6) systems;
7) content;
8) data and information architecture designs;
9) business continuity;
10) service-oriented architecture (SOA) benefits and risks;
11) audit and compliance; and
12) enterprise systems integration. From a traditional viewpoint, these topics appear to be a 'grab bag' of important IS topics without a cohesive higher-level learning theme.

Interestingly, IS 2010 specified several "higher level" learning outcomes that are not explicitly captured in the seven core courses. These "higher level" outcomes include:

A. Guiding Assumptions about IS (IS 2010, pg. 7-8)
   a. "IS professionals must have strong analytical and critical thinking skills to thrive in a competitive global environment. Students must therefore:
      - Be problem solvers and critical thinkers
      - Use systems concepts for understanding and framing problems
      - Be capable of applying both traditional and new concepts and skills
      - Understand that a system consists of people, procedures, hardware, software, and data within a global environment." (IS 2010)

B. High Level IS Capabilities (IS 2010, pg. 16-18)
   - Improving Organizational Processes
   - Exploiting Opportunities Created by Technology Innovations
   - Understanding and Addressing Information Requirements
   - Designing and Managing Enterprise Architecture
   - Identifying and Evaluating Solution and Sourcing Alternatives
   - Securing Data and Infrastructure
   - Understanding, Managing and Controlling IT Risks

C. Information Systems Specific Knowledge and Skills (IS 2010, pg. 19-20)
   - Identifying and designing opportunities for IT-enabled organizational improvement.
   - Analyzing Trade-offs

An examination of these IS 2010 specified higher level learning outcomes reveals the need for IS students to possess top-down, systems-oriented problem solving abilities applied in the information system domain. Creating and analyzing alternative solutions and evaluating tradeoffs are also a critical learning component. Interestingly, many of these higher level learning outcomes are not specified as learning objectives in the seven core IS courses.

4. TEACHING STRATEGIES FOR ENTERPRISE ARCHITECTURE

Based on our analysis, we suggest three teaching strategies for enterprise architecture course. These strategies follow:

Tying Enterprise Architecture to Systems Analysis and Design

Making the enterprise architecture course a prerequisite to systems analysis and design is important. In the discussion of the IS 2010 model curriculum it states "This course operates at a higher level of abstraction than a typical infrastructure course..." (page 44). This makes it a logical place to include the broader, enterprise-wide considerations that are frequently omitted from an analysis and design course and allows the instructor to utilize materials that help students understand the complexity of systems in large organizations before they have actual professional experience.

To do this we need a systems approach to problem solving in the enterprise architecture course that will complement the systems development life cycle, object-oriented, or other methodology used in the analysis and design course.

We propose the approach below which is an amalgamation from several areas but leans on works in Decision Support Systems (Keen & Scott Morton, 1978) and others already referenced in this paper. For the enterprise architecture course, each step below should explicitly address each architecture dimension, i.e. business, information, and technology.

Systems Approach to Problem Solving

1. Recognize a problem/opportunity exists
   a. review goals, objectives, standards, and data
   b. review how standards are set and modified
2. Define the problem/opportunity
   a. distinguish symptoms from problems/opportunities
   b. define problem/opportunity scope
3. Establish solution criteria
   a. satisficing versus minimizing risk, versus maximizing opportunity versus others
   b. categorize in business, information and technology dimensions and explicitly note where solution criteria may be in conflict
4. Create alternative solutions
5. Evaluate Alternatives
6. Develop a plan of action

Modeling and Planning the Enterprise

Students should understand the big picture of how IT business functions and processes are mapped into architectures and software solutions. More specifically, students should be able to become proficient in a variety of modeling techniques including functional modeling, physical architecture design, and security and risk planning. It is important that students learn to interpret and evaluate existing models.

At its heart, students will learn to plan, analyze, model, and design an information system to solve an organizational problem. Students will learn to apply EA frameworks to model and evaluate the information architecture, the business architecture and the technology architecture. In the EA course it is far easier to bring in wider views of the organization, technology, and information than in the analysis and design course where examples are frequently specific. Ultimately students will learn to view information systems from a variety of perspectives when evaluating client-centered solutions. The use of Microsoft Visio as a tool to create diagrams and models would be ideal in the EA course.

Quantitative Analysis and Spreadsheets

The EA course is an ideal place to integrate quantitative business skills and modeling skills into the systems analysis process. Current EA learning objectives include "evaluating the total cost of ownership and return on investment for architecture alternatives" and "utilizing techniques for assessing and managing risk across the portfolio of the enterprise". Spreadsheet modeling skills can be advanced in students as they learn to apply these skills in an applied manner.

In addition, the system approach to problem solving lends itself to quantitative decision-making methods such as a) weighted ranking, b) utility analysis, and c) decision trees. Students can easily develop spreadsheet models to assist in the evaluation of solution alternatives.

5. CONCLUSIONS

According to the stated EA course learning objectives, this course is primarily about the evaluation and planning of information systems from a top-down perspective. Knowledge of EA frameworks and strategies provides the foundation to evaluate existing systems and plan for new systems.

According to our analysis, in order to meet the stated course description of "explore the design, selection, implementation and management of enterprise IT solutions", the systems approach to problem solving would be an ideal vehicle to put the various elements of the course together.

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Figure 2: Enterprise Architecture Course Description from IS 2010

Title: IS 2010.3 Enterprise Architecture
Core Course
Catalog description
This course explores the design, selection, implementation and management of enterprise IT solutions. The focus is on applications and infrastructure and their fit with the business. Students learn frameworks and strategies for infrastructure management, system administration, data/information architecture, content management, distributed computing, middleware, legacy system integration, system consolidation, software selection, total cost of ownership calculation, IT investment analysis, and emerging technologies. These topics are addressed both within and beyond the organization, with attention paid to managing risk and security within audit and compliance standards. Students also hone their ability to communicate technology architecture strategies concisely to a general business audience.

Learning objectives
Students will learn to

1) Understand a variety of frameworks for enterprise architecture analysis and decision making.
2) Evaluate the total cost of ownership and return on investment for architecture alternatives.
3) Utilize techniques for assessing and managing risk across the portfolio of the enterprise.
4) Evaluate and plan for the integration of emerging technologies.
5) Administer systems, including the use of virtualization and monitoring, power and cooling issues.
6) Manage proliferating types and volume of content.
7) Understand the core concepts of data/information architecture and evaluate existing data/information architecture designs.
8) Plan for business continuity.
9) Understand the benefits and risks of service oriented architecture.
10) Understand the role of audit and compliance in enterprise architecture.
11) Understand the integration of enterprise systems with interorganizational partners such as suppliers, government, etc.

Table 1: Analysis of IS 2010.3 Enterprise Architecture Learning Objectives

Enterprise Architecture Learning Objectives	Action Verb	Bloom's Level	Artifact	Interpretation
1) Understand a variety of frameworks for enterprise architecture analysis and decision making.	understand	none	framework for enterprise architecture	1) Non-measureable learner outcome 2) "To understand a framework" is not a IS 2010 high-level outcome 3) No "hands-on" IT skills 4) No "critical thinking"
2) Evaluate the total cost of ownership and return on investment for architecture alternatives.	evaluate	Level 6 – Evaluation (highest level)	total cost of ownership (TCO), return on investment (ROI)	1) Highest level of cognitive knowledge. 2) Measureable 3) Implied hands-on skill of calculating TCO and ROI (Excel) 4) Evaluating alternative investments requires significant critical thinking.
3) Utilize techniques for assessing and managing risk across the portfolio of the enterprise.	utilize	Level 3 - Application	techniques for risk assessment	1) Uses knowledge in a new situation to solve a problem 2) Measureable 3) Most risk assessment techniques are "template driven", thus implying …. 4) As stated, critical thinking not particularly high. 5) No hands-on skills (Excel?)
4) Evaluate and plan for the integration of emerging technologies.	evaluate, plan	Level 6 – Evaluation; Level 5 - Synthesis	integration of emerging technologies	1) Highest levels of cognitive knowledge. 2) Measureable 3) The evaluation and planning of integration is a "big topic" with little textbook material available for undergraduate students. 4) This topic lends itself well to the systems approach (business case analysis) 5) Overlap with project management? 6) No hands-on skills
5) Administer systems, including the use of virtualization and monitoring, power and cooling issues.	administer	none	systems	1) The term 'administer' is not a measurable learning outcome 2) Learning objective implies "hands-on" learning of system administration, however, based on all other evidence, we don't believe this is the intent of the authors. 3) Course description states "Students learn frameworks and strategies for infrastructure management, system administration, …." 4) Result – no hands-on, no measureable outcomes
6) Manage proliferating types and volume of content.	manage	none	content	1) The term 'manage' is not a measurable learning outcome. 2) Learning objective implies "hands-

				on" learning of content management systems, however, based on all other evidence, we don't believe this is the intent of the authors. 3) Course description states "Students learn frameworks and strategies for …. content management …." 4) Result – no hands-on, no measureable outcomes 5) The hands-on use of CMS in the class could be reasonable.
7) Understand the core concepts of data/information architecture and evaluate existing data/information architecture designs.	Understand, evaluate	None; Level 6 (Evaluation)	concepts of data and information architecture designs	1) The Evaluation of data/information architecture designs is a tall order for an undergraduate student. To our knowledge there is no textbook material on this topic. 2) No hands-on skills (Excel?) 3) This topic would lend itself to the systems approach (business case analysis)
8) Plan for business continuity.	Plan	Level 5 - Synthesis	Business Continuity	1) Business continuity planning would seem to be ideal using a "case study" approach. 2) The systems methodology would be ideal for selecting appropriate business continuity solutions. 3) No hands-on skills.
9) Understand the benefits and risks of service oriented architecture.	understand	none	Benefits, risks (SOA)	1) Non-measureable learner outcome 2) "To understand benefits and risks" is not a IS 2010 high-level outcome 3) No hands-on skills 4) How best can students learn about SOA?
10) Understand the role of audit and compliance in enterprise architecture.	Understand	None	audit, compliance	1) Non-measureable learner outcome 2) "To understand the role" is not a IS 2010 high-level outcome 3) No hands-on skills 4) How best can students learn about IT audit and compliance?
11) Understand the integration of enterprise systems with interorganizational partners such as suppliers, government, etc.	Understand	None	Integration (enterprise systems)	1) Non-measureable learner outcome 2) "To understand integration" is not a IS 2010 high-level outcome 3) No hands-on skills 4) How best can students learn about ERP integration?