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Glenn Stewart
Queensland University of Technology

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Glenn Stewart
Centre for Information Technology Innovation
Queensland University of Technology
Australia
g.stewart@qut.edu.au

Abstract

This paper discusses the design of an introductory unit in a Master of Information Technology program that seeks to develop in the student a deeper understanding of the systemic effects of ICT in organisations. Participating students are converting from another discipline to IT. Graduates tend to become IT managers, consultants or project leaders. This paper discusses how using an Enterprise Architecture framework approach provides students with an integrated view of the complexity and diversity of ICT theory and a vehicle for understanding the socio-technical interdependences occurring in twenty-first century organisations.

Keywords

IT Curriculum, Enterprise Architecture, Systemic Thinking

INTRODUCTION

Novice students of information and communication technologies are expected to develop systemic thinking integrating Information Systems, business and business as organisational units. The Information Systems Centric Curriculum '99 Document (Lidtke et al 1999) state that an important characteristic of the ISCC'99 include the integration of interpersonal skills, systemic thinking and problem solving. This was the challenge accepted in the development of a new conversion masters course. This paper reviews the design of the Master of Information Technology; the design of the unit teaching systemic thinking, problem solving and evolving interpersonal skills. The student response to the first offering of the unit is summarised and the future evolution of the unit is described.

BACKGROUND

There is an ongoing debate on the skills and capabilities required of Information Technology graduates in the 21st century. In Information Technology, identifying these skills has led to the Information Systems Centric Curriculum 1999 (Lidkte et al 1999), the IS2002 (Longenecker et al 1999) and CS2002 (IEEE and ACM taskforce) curriculum documents, which specify personal, interpersonal and discipline-specific skills. The importance of encouraging independence, autonomy, the ability for self-direction (Ball, 2002; Otter in Dumelow, MacLennan & Stanley, 1999) as well as adaptability, resourcefulness, and enterprise (Manidis, 2001:27) is seen as integral to student educational experience. The Engaging Learning Experience report (2003) suggests that students need an opportunity to set personal goals and undertake self assessment. It also suggests that learning should occur in contexts which are as authentic as possible. We thus conclude that learning environments must develop this wide range of capabilities, link with the real world through engaging in learning based on authentic tasks.

The post-graduate curriculum at Queensland University of Technology includes research degrees (PhD and Masters), advance course work masters and a conversion master's degree. It is this latter degree that is examined in detail in this paper.

Conversion masters students either have a degree in another discipline or a sub-degree qualification plus many years experience as an IT professional. In the previous design of this degree, all students had to have successfully completed a unit of programming. This new award removed this pre-requisite.

The degree is designed around three modules of four units. The first module (called the Basic module) gives all students an introduction to the ICT environment. Students are introduced to programming (using C#), networks (using sponsored

curriculum from CISCO), database (covering design and application development in ACCESS) and Enterprise Architectures. This latter unit is to provide an integrated and holistic understanding of the ICT phenomenon in an organisational setting.

Following successful completion of these four units, students select four units from a list of intermediate units. Though these units are based on second and third year units within the bachelor's program of the faculty, the units must complement the advanced standing of the students and realistically leverage off the prerequisites covered in the basic module. The School of Information Systems provides students with eight options: Web Application Development, Application Development in VB.net, Enterprise Systems, Business Systems Analysis and Design, 4 GL Programming, Programming in an E-commerce environment,

The School of Software Engineering and Data Communications allows the students to select from any second or third year unit, or select from the following units.

On successful completion of four units in the Intermediate strand, students must select four advanced level 1 units.

The next section details the design of the unit Enterprise Systems and then evaluates how it supports the development of systemic thinking in post-graduate students.

UNIT DESIGN

The unit presents a holistic and integrated view of complex enterprises through the use of enterprise architecture frameworks. These frameworks integrate the multiple dimensions and views of complex organisations, and gives you a coherent appreciation of alternative modelling techniques used by different sets of professionals designing, implementing and maintaining infrastructure and information systems. You will understand the important role of an enterprise architect and the various facets of enterprise architectures. In addition, the frameworks will act as a linking model, showing you the role that each of your other units will play in developing the comprehensive skill set required to function as an Information Technology Professional. These concepts are foundational for all IT professionals, for regardless of what you design, develop or administer, your work impacts on an organisation – the enterprise.

The aim of this unit is to equip you with a broad awareness of various systems and models providing a complete solution to the information needs of an organisation, and to provide linkages with other units that you will be doing in your degree. This unit will introduce comprehensive frameworks that show the diversity of infrastructure and information system requirements and introduce the issues involved in aligning business and IT strategy. These frameworks link technology architectures, application architectures, data and information architectures and business architectures showing the inter-connectedness of systems.

On successful completion of this unit students should have an understanding of:

1. the context, value and need for enterprise architecture within an organisation;
2. the characteristics of enterprise architectures and the steps needed in the architecture development process;
3. the management of enterprise architectures;
4. the capability to identify, model, and manage enterprise architecture domains;
5. the issues concerning the implementation of an enterprise architecture;
6. the role of enterprise architectures in fostering business and IT alignment; and
7. how to identify, analyse and consider interdependencies between architectural elements.

Students develop practical skills in modelling through using enterprise modelling tools, such as ARIS ™ and Popkin's Enterprise Architect ™. Students design simple enterprise models in developing a business architecture for a representative business. Finally students compare and contrast different enterprise architecture frameworks.

Students are expected to develop the following types of graduate capabilities:

1. apply reflective, critical, integrated and creative thinking in solving IT related problems intersecting with enterprise architectures;
2. improve your capability to work independently;
3. improve your capability to work effectively in groups;
4. manage complexity by using models;
5. demonstrate effective oral and written communication to a variety of stakeholders;

6. demonstrate leadership by taking on different roles within an enterprise architecture development project; and
7. demonstrate an appreciation of the interdependencies between architectural elements and the related consequences for sustainable enterprises.

ASSESSMENT OBJECTIVES

This unit seeks to develop these skills in a series of authentic tasks. These tasks are conducted in groups of four to six students. Teams are formed using a team formation algorithm. This algorithm profiles the students according to their MBTI type and their preferences in exercising along the de Bono Six Thinking Hats. This approach has been used successfully by Jensen (1999, 2002) in improving creativity of mechanical engineering design teams and also in improving team effectiveness. This approach has been trialled in the undergraduate curriculum within the university, but its application in the graduate school was novel.

The major assessment piece is to develop a level 1 Enterprise Architecture for a representative organisation. A level one view is defined in the Federal Enterprise Architecture Framework (FEAF) as the '*view from 20,000 feet'* which shows eight components: (http://government.popkin.com/frameworks/feaf.htm)

- the Architectural Drivers – external stimuli causing the organisation to change;
- the strategic direction of the organisation;
- the current architecture in the organisation;
- the target architecture for the organisation, integrating the drivers, the strategic direction and the emerging innovations;
- the transitional processes that move the organisation from its current state to the target state;
- the architectural segments – consisting of independent large business units within the organisation;
- the architectural models summarising the documentation of the of the business architecture, the data architecture, the application architecture and the technology architecture for the target state; and
- the standards to be applied in the formulation and promulgation of the enterprise architecture.

The assignment is directed a completing the first four of these eight components, viz. the architectural drivers, the strategic direction of the business, the current architecture of the organisation and the target architecture of the organisation.

DESCRIPTION OF THE OUTPUTS

This section summarises the assignment outputs and the student performance in the assignment.

Thirty-three students started the unit, with twenty-one completing the unit. The unit was offered in compressed mode over summary, with two lectures/workshops per week (of 3 hours) over a six week period. The major assignment was due four weeks after the conclusion of the lecture series. A tutor was available for guidance during this development phase. The final exam was held three weeks after the completion of the continuous assessment.

Students had an interim group assignment to complete in week four of the course: a comparison of the Zachman Enterprise Architecture Framework with an industry framework (GERAM, TOGAF, PERA or CIMOSA). This assignment was designed to ensure that students understood the base framework and to commence operating as a group.

The second assignment on developing the enterprise architecture was issued in week 5 of the compressed semester, so discussion of the expectations could occur before the semester closed.

The format of the enterprise architecture assignment follows.

The students commence through developing a Business Architecture. This includes defining the purpose of the business and the business and social drivers dominating the business environment. Student resources include annual reports and the strategic plan. From this data, students should be able to identify the vision for the organisation, its resultant goals, strategies and objectives. Students can render these into a balanced scorecard (Kaplan and Norton), from which they should identify the key business processes. Students model the current organisational structure and the products and services supported by the organisation. From this perspective, the student teams are to summarise the business primary and secondary problems and the resultant need for systems and technologies. Students are encouraged to develop a high level value chain for the organisation from which they identify support application systems. The organisational view and the products and services view are modelled using the ARIS toolset and approach to process engineering (Scheer 1980, IDS Scheer). These models are

appended to the report and they provide a means of clearly identifying the application domain (the IS portfolio) in place in the current system.

Students are then required to identify the architectural principles that will guide subsequent development. In particular, they are to specify any relevant data, application and technology principles. Students use an Australian government enterprise architecture document supporting a federal government initiative called HealthConnect (Architectural Principles 2003). As part of this process, students have to research technology innovations pertinent to the target organisation, the impact of new organisational forms (e.g. ambient organisations) and the expectation of pervasive computing. In the first semester of offering, for example, students were developing models of future libraries at university. Inputs into this process were presentations by the university chief technical librarian and the faculty reference librarian. This was followed by an interview session with students and staff. Students had to develop a set of focus questions, which were then asked of the staff in a semi-formal setting.

From this input, students were able to develop system concepts, integrating the societal expectation of that organisational setting, the business drivers for that sector, together with the emerging technical and organisational innovations impacting the target sector. The outputs for that component of analysis were:

- Current Systems Environment: summarising the current systems in place (data, applications and technologies);
- Application Domains: summarises the key concepts for application domain;
- Data Domains: summarises any data & meta data requirements for the future system with particular identification of emerging data reference models; and
- Target System Environment: in which students summarise the expected social and technical environment to be in place in 2-5 years (data, applications and technologies).
- In the next stage of the assignment, the students summarised their findings in three representative diagrams, with one diagram for each of the major components of the level 1 enterprise architecture: Data Architecture, Application Architecture and Technology Architecture. Students were assisted in the presentation of such output by a guest lecture from Darryl Sim, Enterprise Architecture consultant with DMR

To provide closure to this initial design, and to bring the students back to an understanding of the need to carefully implement and evolve an Enterprise Architecture, students had to discuss the next steps in evolution of business and systems architecture. Again, the presentation by DMR focused the students to the essential elements. Not only were representative architectural diagrams presented, but the key evolutionary questions were posed; viz. What is to be achieved with the Enterprise Architecture? What sort of Enterprise Architecture is needed in order to achieve those goals? How will the Enterprise Architecture be communicated and used once developed? How will the Enterprise Architecture be evolved? In the penultimate section of the 50 page report, students discussed the next steps necessary to take this level 1 architecture to level 2 and the means to evolve the Enterprise Architecture as the organisational environment changes. This section was also to include communication strategies for the Enterprise Architecture development.

The assignment finally concluded with a summary of the current business environment, the expected business environment in the planning framework and the key business architecture outcomes from this analysis.

RESULTS

Student teams in the first semester of offering all succeeded in presenting an effective report. The average report mark was 75% (a Distinction in the Australian context). Though all sections of the report were presented, not surprisingly students had difficulty in visualising the target organisation's technology environment and business environment five years hence. Students had variable understanding of the evolution of various standards impacting on the target organisation. Architectural principles were very high level as a result. The pragmatic outputs of current systems, organisational view and product and service view of the organisation were all well done.

Student teams had worked reasonably well. The team structures, the expectation that students form a team compact governing their behaviours and outputs were well received. Students were genuinely interested in their profiles and the meanings of these strengths. A detailed study of the effectiveness of the application of the team formation algorithm cannot be undertaken due to the small class size.

Students were able to communicate an understanding of the inter-relatedness of the business environment, the social environment, the emerging technology and organisation innovations and link these elements to a level 1 enterprise architecture.

Students in the current semester are now embarking on their major assignment developing a level 1 Enterprise architecture for a real organisation. They have first completed a review of the application of a technology innovation on this organisation and its implication for evolving an Enterprise Architecture. Student could select any relevant technology innovation, but were introduced to innovations as RFID, E-Paper and wireless networking. Results from this semester will be presented at the conference.

DEVELOPING SYSTEMIC UNDERSTANDING

The paper so far has discussed the design and delivery of the unit. How is this unit assisting students to develop systemic understanding of Information Systems? Brown (1992) quoted in Collins (1998:145-147) argues that systems thinking involves four components: interdependency, synergy, boundary, and a binding ideology. The use of the Zachman Enterprise Architecture Framework demonstrates the interdependency between the main components of this system: the Business Architecture, the Application Architecture, the Information/Data Architecture and the Technology Architecture. In addition, these components of the Enterprise Architecture represent the boundaries the major system units. The derivation of the Application, Information and Technology Architecture elements from the Business Architecture also demonstrates the required synergy between the system units. The use of the Zachman EA Framework, coupled with the use of Spewak and Hill's Enterprise Architecture Methodology give a binding ideology – the goal of an evolving, integrated and interdependent plan for the Enterprise. These elements constitute a systems view of the Enterprise at the highest level. In addition, concepts of organisational change, organisational learning, and technology innovation diffusion assist the student in understanding the interplay between the business requirements, organisational structures and technology.

Checkland's Soft System Methodology (SSM) (Checkland and Scholes 1990, Checkland 1981) and other work derived from the Tavistock Institute informs the framing of this unit. Students are introduced to the concept of a socio-technical system responding to both business and social drivers, bound within the geopolitical and cultural constraints prevalent in the target organisation. Students are encouraged to examine the external and internal environments framing the context of their assignment. The student is introduced to the notions of pervasive and ubiquitous computing (Weiser 1988 quoted at Weiser 2004), as well as current technology innovations supporting its evolution. Students have to analyse the impact of a technology innovation on the Enterprise Architecture thereby addressing the interdependence of its constituent parts.

Students also deconstruct an organisation strategic plan and render it into a Balanced Scorecard (Kaplan and Norton 1994) in order to identify other appropriate dimensions of organisational purpose and frame relevant goals and objectives for these perspectives. Students are introduced to the concept of a Value Added Chain and the Architecture of Integrated Information Systems (ARIS) developed by Scheer (1992). This approach gives students a deeper understanding of the interdependence of the various views of an organisation (Data, Function, Process, Organisational and Product/Service) and a means of representing these elements in a real problem (using extended event-driven process chains). The unit will close with an introduction to systems thinking using SSM, and hopefully thus position the students to better appreciate the goal of systems analysis.

Unfortunately, the limitations of a one semester unit does not permit anything but a cursory coverage of such important concepts. However, through their assignment work in developing a level 1 Enterprise Architecture for a real organisation, students are confronted with the concepts of systems thinking and its application, thereby gaining a deeper appreciation of the relationship of information systems to business systems. It remains to be seen if students are better equipped to solve complex business problems because of this introductory unit and if they are able to transfer this systemic understanding of information systems to more advanced units on analysis.

CONCLUSIONS

This unit on Enterprise Architecture specifically seeks to develop system thinking, critical and creative problem solving skills and improved inter-personal skills. It does so, through clearly articulating the disciplines' expectations for effective skills and relating these in an authentic and rich task.

In designing this unit, the design team specifically used the ISCC'99 curriculum document. In particular, the design team sought to address the following elements in the personal skills domain:

a. Systemic thinking skills through engaging in the analysis and design processes leading to the development of an level 1 Enterprise Architecture by introducing a systems view and an understanding of an information system as a socio-technical system.

b. Problem solving through structured problem solving methods introduced in the unit.

c. Critical thinking through critical evaluation of industry enterprise architecture frameworks, technology and organisational innovations impacting on the target organisation and critical evaluation of group work.

d. Personal discipline skills in completing individual work set with in a group context, meeting the tight time frame of the project's duration and meeting the expectations of the group and assessors.

e. Persistence to complete the tasks in the unit.

f. Curiosity to find effective enhancements to the products and discover more effective approaches.

A key outcome for this unit is then a focus on developing better interpersonal skills, with specific focus on improved communications (oral, written, visual, listening and group), more effective collaboration and an understanding of and development of skills in conflict resolution strategies. These are specific required outcomes for ISCC'99 and were a design focus for these units. Successful attainment of these outcomes will be evidenced in more effective teams and effective communication products.

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