A Comprehensive, Competency-Based Education Framework Using Medium-Sized ERP Systems

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ABSTRACT

Graduates with industry-relevant ERP competencies are highly sought after. This requirement is due to a dominance of Enterprise Resource Planning (ERP) systems and the positive affect which good quality ERP specialists have on the success rate of ERP system implementation projects. Universities are therefore increasingly pressurised to supply graduates with the appropriate competencies and as a result have adopted a hands-on approach to teaching ERP systems in Information Systems (IS) degree programmes. Whilst several frameworks for ERP education have been proposed, they are not comprehensive and do not link the competencies required for ERP specialists with an appropriate approach to ERP adoption in the IS curriculum. A comprehensive, competency-based education framework for ERP education is proposed and implemented at a South African university. Analysis of the results reveals that the students enjoyed the hands-on use of the ERP system and that there was a positive improvement in self-efficacy and the competencies of the students.

Keywords: Enterprise Resource Planning (ERP); learner-centered education; experiential learning & education.

1. INTRODUCTION

The decline in the number of personnel with the required Information Communication Technology (ICT) skill sets over the past few years is of major concern (Cameron, 2008; Cohen, 2012; ITWeb, 2011). The forecast in South Africa for 2012 indicates a continued demand for ICT skills that would exceed the supply by more than 20% (ITWeb, 2011). One aspect of the ICT skills debate currently focuses on the misalignment or gap between ICT competencies provided by Higher Education Institutions (HEIs) and the graduate skills required by industry (Cohen, 2012; Harris, 2011; ITNews, 2012; ITWeb, 2011).

The misalignment of competencies in ICT is also evident in Enterprise Resource Planning (ERP) systems which have become dominant in all types of organisations worldwide (Mohamed & McLaren, 2009) and for which a substantial future growth has been predicted (Forrester, 2011). This dominance of ERP systems has led to a need for ERP specialists and to difficulties with recruiting graduates with the appropriate competencies globally (Mohamed & McLaren, 2009) and in South Africa (Scholtz, Calitz & Cilliers, 2011). As a result pressure has been placed on HEIs to include ERP education as an important part of the Information Systems (IS) curriculum (Ask, et al., 2008; Boyle, 2007; Kreie, Shannon, & Mora-Monge, 2010).

A number of HEIs in South Africa have implemented ERP systems into their curriculum but the incorporation of technical competencies of ERP systems into IS curricula has been slow (Boyle, 2007) and this has increased the gap between the competencies required by industry and the content of ERP education programmes (Boyle, 2007; Mohamed & McLaren, 2009). This gap between industry requirements and graduate competencies has led to a need for addressing how well ERP education programmes of HEIs meet the requirements of organisations (Boyle, 2007; Jensen, et al., 2005). This gap can be reduced by introducing a competency-based curriculum where designers of ERP curricula must first identify the key competencies expected from ERP specialists (Jensen et al., 2005). Competencies can also be developed by preparing students for their careers and exposing them to the various ERP systems available on the market (Peters & Haak, 2010; Winkelmann & Leyh, 2010). It is necessary therefore for HEIs to adopt one or more appropriate ERP systems into the curriculum.

Studies of the adoption of ERP systems in the curriculum have shown that students enjoy performing exercises using the ERP system, that they are able to gain a better understanding of the various business processes and how they relate to each other and they also gain a better understanding of ERP concepts (Seethamraju, 2007; Surendran, Somarajan, & Holsing, 2006; Wang, El-Masry, & Zhang, 2009; Winkelmann & Leyh, 2010). Surendran et al. (2006) reported that students valued getting exposure to an ERP product that has a high market share. It has also been shown that IS graduates who have hands-on experience of ERP systems will have a stronger and more desirable set of work skills and are viewed favourably by industry (Kreie et al., 2010; Scholtz, et al., 2011; Wang et al., 2009).

Educators are thus faced with the challenge of meeting the needs of industry in providing graduates with industry-relevant competencies (Jensen et al., 2005; Peters & Haak, 2010; Scholtz, et al., 2011; Wang et al., 2009) and still incorporate abstract, formal, conceptual knowledge in accordance with the aims of higher education (Surendran et al., 2006). Despite the many potential benefits of ERP system adoption, step-by-step ERP exercises are not always adequate to convey to students the business process concepts embedded in ERP systems (Rienzo & Han, 2010), and students do not always understand why tasks are performed (Wang et al., 2009). Students often get lost in the details of how to perform processing transactions using large ERP systems such as SAP R/3 (Léger, et al., 2011).

Researchers and educators are unclear as to the degree to which ERP systems should be integrated into the curriculum, and the selection and quantity of ERP systems adopted vary from institution to institution (Seethamraju, 2007). The majority of ERP system adoptions use large ERP systems, such as SAP R/3 which are designed for large organisations, are feature-rich, complex and not specifically designed for learning (Winkelmann & Matzner, 2009). Medium-sized ERP systems designed for smaller organisations can achieve similar results to using large ERP systems, but with less frustration.

This paper will investigate the application of a framework for ERP system adoption in education using a case study approach. The research question that this paper addresses is "*What comprehensive competency-based framework can be used to adopt medium-sized ERP systems into the IS curricula?"*. ERP systems play an important role in IS education but introduce many challenges to educators. In an attempt to solve some of these challenges various ERP education frameworks have been proposed (Section 2). A framework is defined as "*a set of beliefs, ideas or rules that is used as the basis for making judgements or decisions*", or "*the structure of a particular system*" (Oxford, 2010). ERP education frameworks therefore need to provide a basis for making decisions regarding ERP education. These decisions relate to the level of ERP adoption required, the type of ERP system to adopt and the adoption approach to use. Existing ERP education frameworks are not comprehensive since they only include some of the decisions to be made and do not map the various methods or approaches of ERP system adoption to the competencies required by industry.

An ERP education framework which is comprehensive and is based on industry relevant competencies is proposed in order to address the shortcomings of existing frameworks (Section 3). The research methodology followed for this study is a case study approach whereby the proposed ERP education framework was applied and evaluated at a HEI in South Africa (Section 4). The results of both the qualitative and quantitative feedback suggests that the application of the framework was successful and that the adoption of a medium-sized ERP system in the case study was well received by students (Section 5). Several conclusions and recommendations from this study for assisting educators with the design of ERP system programmes as well as for future research can be made (Section 6).

2. ERP SYSTEMS IN IS EDUCATION

Several frameworks for the adoption of ERP systems in higher education have been proposed (Section 2.1), however ERP education programmes need to also consider recent educational trends and context (Section 2.2).

2.1 ERP Education Frameworks

Several frameworks for adopting ERP systems in the curriculum have been proposed and these include those which classify the adoption of the ERP system into the IS or business curriculum in terms of its depth (Guthrie & Guthrie, 2000) and breadth (Rosemann & Watson, 2002). The depth of adoption refers to the level of immersion or adoption at which the ERP system is introduced into a curriculum and this can be done incrementally (Rosemann & Watson, 2002). Guthrie and Guthrie (2000) describe five levels of ERP adoption depth into the business curriculum (Table 1).

The least immersive means is the Enterprise Model level where ERP systems are discussed at a theoretical level, requiring students to understand conceptually what ERP systems do but actual ERP system. At the Tutorial level, students simulate transactions using a Web browser, or CD-ROM, simulation tool or tutorial. At the Laboratory Project level and higher, students must enter transactions into the actual ERP system. In this approach, transaction entry may involve only a few transactions in one or more modules (Laboratory Project) or many transactions in a Dedicated Course level.

Level of Adoption Depth (Guthrie and Guthrie, 2000)	Description	Approach
Integrated Practicum	Integrated term-long project in which students use ERP systems as they would in industry	Hands-On
Dedicated Course	An entire course dedicated to teaching participants the skills and concepts associated with the ERP	
Laboratory Project	Some level of ERP is implemented so that students perform hands-on assignments, requiring them to access, manipulate and report information using the ERP	
Tutorial	Web, CD-ROM, Simulation or Tutorial based training in specific systems that students perform outside of the classroom	Tutorial
Enterprise Model	Exposure to ERP through class lectures and demonstration (PowerPoint Approach)	Lectures Only

Table 1: Level Of Adoption Depth

The most immersive means of adopting ERP education into the classroom is the Integrated Practicum level with a full ERP system, requiring students to use hands-on exercises, with assignments which merge business disciplines so that they can experience the full integration capability of the system (Guthrie & Guthrie, 2000). These levels can thus be grouped into three approaches, which in this study will be referred to as lectures only, tutorial and hands-on approach, where the lectures only approach is passive and the tutorial and hands-on approaches are active approaches.

In addition to the depth of adoption, Rosemann and Watson (2002) describe ERP education as being characterised by the *breadth of the solutions used* in the programme, or level of adoption breadth (Table 2). Four levels are identified and all of these apply to the active approaches. The breadth of the educational experience will increase as the involved team grows from a single faculty to a multi-faculty team from different departments and faculties. Four different levels of breadth are described, namely: Browsing (Level 0), Transactions (Level I), Modules (Level II) and Integration (Level III).

Level 0 is the lowest level of breadth (Browsing) and involves the use of an ERP system for browsing or display only tasks. The principle advantage of using the lowest level is that system complexity and potential problems with inter-relationships among modules are avoided. However, this method also offers the least value to the student, because the integration capabilities of ERP are not visible. At Level I (Transactions) students enter transactions into the ERP system. Breadth of ERP adoption increases as students are exposed to an entire sub-module or module at Level II (Modules). At the highest level (Integration), utilisation of an ERP can be broadened to include the entire core of the ERP system with more than one module which allows students to see true business process integration between modules.

Springer, Ross & Human (2007) propose a similar approach to implementing ERP in a curriculum consisting of three-tiers, where Tier II is equivalent to the combined Levels I and II proposed by Rosemann and Watson (2002). However in addition to the levels of adoption, Springer et al. (2007) allocates additional course properties such as Laboratory Type and Percentage Laboratory time onto one of the three tiers. Students at Tier I do not have much experience navigating the ERP interface and time for practical sessions is usually limited (5-10% of Laboratory Time), therefore in order to make the laboratory session run smoothly, tasks at this tier should have a Laboratory Type of Display Only. Display Only tasks instruct students on how to navigate through transactions and related master data.

At Tier II students gain specific, in-depth knowledge of the ERP components related to the course and therefore needs a larger time investment from students. At Tier III, students focus on the cross-functional and integrative nature of ERP. A course in Tier III focuses on implementation, configuration and integration issues and students should therefore develop competencies in the ERP implementation and configuration category. Tier I and Tier II must be completed before students can progress to Tier III. The Springer et al. (2007) approach provides a verified starting point as a framework for making decisions regarding the tier or level of breadth and the associated Laboratory Type (Display Only; Master Data/Transactions; or Configure) to adopt.

The Springer et al. (2007) approach has two limitations. Firstly at Tier II the Laboratory Content is 10-50% whilst in Tier III it is 75-100%. There is no level which caters for a Lab Content of between 51-74%. Tier II can therefore be split into two secondary levels, resulting in four levels (Table 2) similar to those described by Rosemann and Watson (2002). A second limitation of both the Springer et al. (2007) approach and the Rosemann and Watson (2002) approach, is that no link is provided from the level of ERP adoption to ERP specialist competencies, or to the type of ERP system tool and the approach to use.

The level of breadth and depth of adoption can be combined into an ERP Adoption Levels Matrix for IS Higher Education (Table 3) in order to provide a complete view of all the options of levels of ERP adoption into the curriculum. These are then mapped to the adoption approach and the ERP learning tool. The cells which are shaded are the combination of levels that are possible. Two levels of ERP adoption approaches are identified, namely the tutorial approach, and the hands-on approach.

Level of Adoption Breadth (Rosemann and Watson, 2002)		Description	Tier (Springer et al., 2007)		
Name	**Level**		**Tier**	**Laboratory Type**	**% Labarotary Time**
Integration	III	Teaching the entire ERP core where more than one sub-module is used and examples of integration are examined.	Tier III	Configure	75-100%
Modules	II	Students are exposed to an entire sub-module (for example, accounts payable).	Tier II	Master data, transactions	10-50%
Transactions	I	Only selected transactions are executed (for example, entering a purchase order).			
Browsing	0	Browsing through the software and repositories that exist in the system by means of a model company. This level would be a display only adoption.	Tier I	Display Only	5-10%

Table 2: Level of Adoption Breadth

The tutorial approach includes the use of ERP simulators, tutorials and multi-media and therefore does not include the hands-on use of an ERP system. At a Browsing level the ERP use comprises 5-10% of the practical laboratory time. The hands-on approach involves the hands-on use of an industry ERP system by the students. All levels of breadth except Browsing in the ERP Adoption Levels Matrix involve entering transactions in an ERP system and therefore cannot be used with the Tutorial level which does not use an industry ERP system.

At a Transactions level the ERP use still comprises 5-10% of the practical laboratory time, as with the Browsing level, however the type of use is different since the students now perform simple transactions. A Laboratory Project therefore involves the hands-on use of an industry ERP system and can include just display only transactions (Browsing), or entering of several simple transactions (Transactions) or entering transactions in a full module of ERP (Modules). The Dedicated level must involve entering transactions in more than one module (Modules), so a Browsing or Transactions depth cannot be used. An Integration Level (Level III) of breadth must include more than one module to show true integration and therefore requires an Integrated Practicum depth, so no other combinations here are possible. The ERP Adoption Levels Matrix for IS Higher Education (Table 3) provides a comprehensive structure for classifying the level of adoption. Based on the level of breadth and depth selected, an appropriate adoption approach and learning tool is recommended. However, the matrix does not provide any

Level of Depth	*Level of Breadth (% of Practical content)* 5-10% 0 Browsing	5-10% I Transactions	11-75% II Modules	>75% III Integration	ERP Adoption Approach	ERP Learning Tool
Integrated Practicum				X	Hands-On	ERP System
Dedicated			X			
Laboratory Project	X	X	X			
Tutorial	X				Tutorial	ERP Simulator

Table 3: ERP Adoption Levels Matrix for IS Higher Education

link between the level of adoption selected and the competencies required for ERP specialists.

2.2 Educational Context

ERP education frameworks cannot operate in isolation but need to consider recent trends and policies in education as well as curriculum standards at both a national and international level. The trend of higher education policy for a number of countries is to define qualifying learning outcomes or competencies rather than objectives (AQF, 2010; Dearing, 1997; NQF 2010).

The concept of a competency-based curriculum is supported by computing sciences curricula (Pinto, 2010), where curriculum designers are advised to identify the core competencies that a student is required to achieve after completion of a course. This competency-based approach to education differs from the traditional method which imparts a generalised knowledge base that might prove useful sometime in the future.

Studies of ERP education (Ask et al., 2008; Peters & Haak, 2010; Wang et al., 2009) also support a competency-based education approach where students take a more active participatory role and emphasises the need for a better fit between academic education and requirements from industry. A competency-based curriculum stems from a pedagogical shift to the constructivist learning paradigm which leads to shifted roles of lecturers and student since the lecturer creates the learning situation together with the students (Fosnot, 1996). This is sometimes referred to as learner-centred teaching which incorporates a learning-by-doing approach and motivates students to learn new materials by themselves (Wang et al., 2009). The concept of a competency-based curriculum is also recommended by the international IS 2010 curriculum (ACM, 2010), which incorporates an "*ERP specialist"* as one of several IS career tracks and promotes the hands-on use of an ERP system in education programmes.

3. A COMPREHENSIVE, COMPETENCY FRAMEWORK FOR ERP SYSTEM ADOPTION

A comprehensive Competency Framework for ERP System Adoption in IS higher education (ERPEd) is proposed (Figure 1) to address the limitations of other ERP education frameworks. The framework incorporates a competency-based curriculum in accordance with trends in education as well as international curriculum guidelines. The framework was derived from the ERP Adoption Levels Matrix for IS higher education (Table 3) which is extended by mapping the eleven industry-relevant competency categories for ERP specialists (Scholtz, et al., 2011) onto the appropriate levels of breadth (Browsing, Transactions, Modules and Integrated) and depth (Laboratory Project, Dedicated and Integrated) of ERP system adoption.

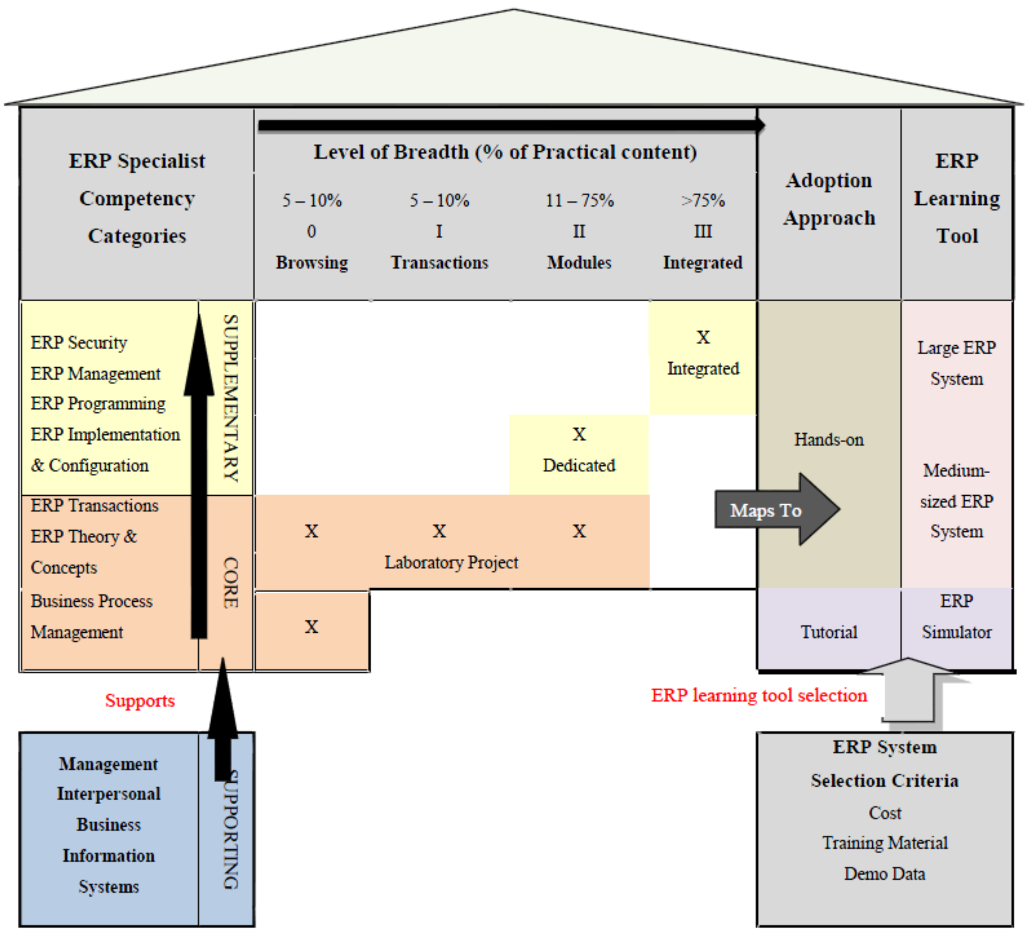

Figure 1: Competency Framework for ERP System Adoption in IS Higher Education (ERPEd)

Each of the eleven ERP specialist competency categories consists of several competencies that are required of an ERP specialist (Scholtz, et al., 2011). These competencies can be classified as supporting, core or supplementary competencies. Supporting competencies are those competencies that are required for ERP specialists but are not specific to the ERP domain but are also required for IS practitioners in general. The four supporting competencies required are Business, Information Systems, General Management and Interpersonal. The core competencies are the technical competencies which are core to IS specialists working with ERP systems and these are ERP Theory and Concepts, ERP Transactions and Business Process Management (BPM).

Courses aimed at the BPM competency category can successfully make use of the tutorial approach where an ERP simulator is used to illustrate business process concepts and understanding of process flows. Several more advanced or supplementary competencies are required, namely, ERP Implementation and Configuration, ERP Programming, ERP Management, and ERP Security.

The ERPEd framework can assist ERP educators with decisions regarding the design of an ERP education programme. These decisions include the type of ERP learning tool to select, the appropriate level of adoption, and the adoption approach to use, based on the competencies required of the students. The ERP competencies, in conjunction with the level of breadth and depth, can be used for designing the tasks that an ERP student should perform.

The core ERP competencies can be successfully attained by the hands-on use of a medium-sized ERP system which may have a simpler, more familiar interface (Ask et al., 2008; Hustad & Olsen, 2011). Allowing students to work with medium-sized ERP systems that are less complex than large scale systems can be adopted successfully in the curriculum and still provide an understanding of ERP systems (Ask et al., 2008; Hustad & Olsen, 2011; Rienzo & Han, 2011; Winkelmann & Leyh, 2010). In addition these systems have been shown to avoid the problems relating to student frustration encountered with large ERP systems (Scott and Walczak, 2009). Winkelmann and Matzner (2009) argue that the policy of adopting a large ERP system into the curriculum does not expose students to smaller and possibly better fitting alternatives.

The Laboratory Project level of depth is the only level with more than one option of breadth, as it has three options, namely: Browsing, Transactions and Modules. It is recommended that at the initial stages of an ERP module, a Browsing level of breadth is adopted, where students are given exercises which consist of browsing or display only tasks in order to familiarise them with the complexity of the user interface. After they are familiar with the navigation and interface of the system, they can perform some simple hands-on transactions (Transaction level of breadth). As more competencies are addressed in the ERP module, so the level of breadth increases to a Modules, Dedicated or Integrated level. The supplementary competencies can only be developed in a Dedicated level of depth where more than one module is taught, or at an Integrated Practicum level where integration between modules is illustrated, where the use of a large ERP system is recommended.

The ERPEd framework also provides criteria for educators to use when selecting an ERP learning tool to adopt in the curriculum. These criteria include the cost of the software (Cameron, 2008), the training material provided and the quality and availability of demonstration data (Ask et al., 2008). Consideration of these criteria can reduce the challenges faced by educators when incorporating an ERP learning tool into the curriculum. These criteria are shown in the right hand pillar at the base of the framework (Figure 1).

4. RESEARCH METHODOLOGY

The research strategy used for this study was selected, based on its ability to answer the research questions and was a combined case study and survey strategy (Section 4.1). The research instruments were designed based on those used in other studies and allowed for quantitative and qualitative feedback (Section 4.2).

4.1 Case Study Protocol

A case study is an in-depth investigation on an observation or occurrence within a specific context so as to unveil hidden evidence within a real life phenomenon (Lee, 1989). The case study selected was the Nelson Mandela Metropolitan University (NMMU) in South Africa, where a Management Information Systems (MIS) course was presented. The MIS course aims to establish a sound knowledge of management information systems and ERP systems, as well as the attainment of the core ERP competencies. The application of the ERPEd framework in the MIS course at NMMU resulted in a medium-sized ERP system, SYSPRO, being adopted into the course for instructional purposes using the hands-on approach (Figure 2).

A case study strategy is particularly well-suited to IS research (Benbasat et al., 1987; Lee, 1989) and is useful when detailed knowledge of any particular case is required (Benbasat et al., 1987). Determining the impact of the application of the ERPEd framework at NMMU requires a detailed knowledge of the experience of students at NMMU while learning to use the ERP system. A single case study was considered sufficient and multiple cases were not required since the single case was selected on the assertion that it was well positioned to generate a variety of evidence. The scope of the study was limited to undergraduate IS degree programmes using a face-to-face mode of lecture delivery.

The popular method of student surveys was used in this study to evaluate the quality of ERP programmes and ERP system adoption success (Seethamraju, 2007; Surendran et al., 2006). This method was complemented with techniques to identify and measure well defined learning outcomes and academic performance (Alshare & Lane, 2011; Pinto, 2010). User satisfaction with the ERP adoption approach (Alshare & Lane, 2011) and subjective self-assessments of self-efficacy (Seethamraju, 2007) were also used as evaluation measures.

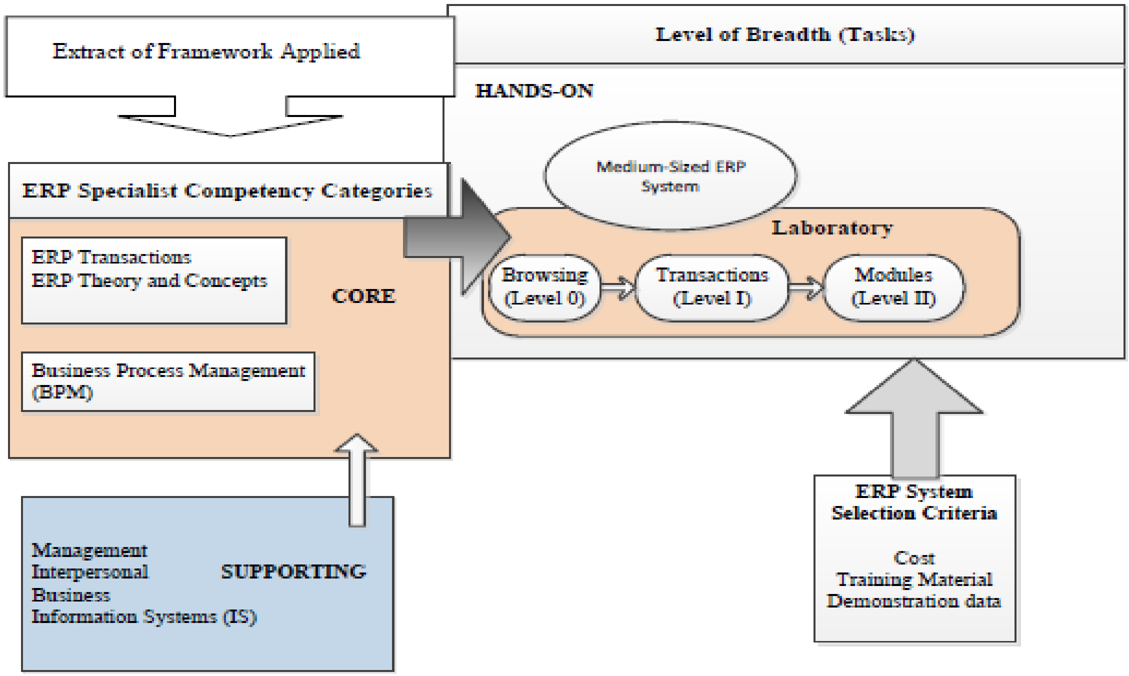

Figure 2: Extract of ERPEd Framework applied at NMMU

4.2 Research Instruments

Questionnaires were used for the student surveys as this is consistent with the case study methodology (Yin, 2003) and has a low cost of administration, provides confidentiality and is a relatively easy way to administer and analyse data (Burns, 2002). The demographic research instruments were administered at the start of the course unit, and were a background questionnaire and a prior knowledge profiling test. The prior knowledge profiling test is a 15-point multiple-choice quiz that tests basic concepts about business, ERP theory and ERP transactions. Based on the results of the prior knowledge test, a student is classified as having low prior knowledge (Low) or high prior knowledge (High). A score of less than 50% is considered low prior knowledge, whilst a score of at least 50% and higher is considered high prior knowledge. The classification of students according to Novice or Experienced expertise level was adapted from the one used by Rusu et al. (2008) for ERP users and is calculated as follows:

- Novice group – students who have no ERP system experience and a Low prior knowledge; and
- Experienced group – students who have either ERP system experience, or a High prior knowledge.

Students of the MIS module are required to attend three lectures and four practical sessions (Prac 1, Prac 2, Prac 3 and Prac 4). Theoretical concepts are expected to have been understood in order to solve the problems addressed in the practical sessions. The hands-on tasks that students are required to perform in order to reinforce the theoretical concepts require students to perform several tasks involving hands-on transactions in the medium-sized ERP system, SYSPRO (Table 4). Each of the tasks is designed in such a way that the concepts covered address the three core ERP specialist competency categories in an incremental manner. The ERPEd framework maps these competency categories to the appropriate level of breadth of ERP system adoption. The first two practical sessions include a Browsing level of breadth (Level 0) so as to familiarise the students with the user interface of SYSPRO, and to reinforce the theoretical concepts covered in the previous lecture session. In the third session the tasks are based on a Transaction level of breadth (Level I) and students enter transactions, such as adding suppliers and inventory items. In the last session in Week 4 the complexity of the transactions is increased to a Module level of breadth.

During the practical sessions, students are required to complete a practical assignment form, each of which consists of a description of the practical tasks as well as a pen-and-paper assessment testing transactional skills and conceptual knowledge. The practical assignment mark, awarded for each session is used as the metric for accuracy. The test of ERP competencies, at the end of the four week period, is a formal assessment and includes a pen-and-paper theory test as well as a practical test. The practical part of the assessment requires the student to use the SYSPRO ERP system to complete tasks similar to the tasks performed in the practical sessions. Each of these tasks relates to one of the three competency categories identified as being relevant for the MIS course, namely ERP transactional skills, BPM and ERP theory.

Eight self-efficacy questionnaires (SE1 - SE8) were administered at various key points throughout the course to get students to rate their self-efficacy of the three core ERP competency categories in order to measure perceived improvement in competencies. Self-efficacy questionnaires were administered directly prior to lectures L1, L2 and L3, and these were SE1, SE3 and SE5 respectively. A questionnaire was administered after each of the three

Practical Session	Week	Tasks / Task Description	Level of Breadth
Prac 1	Week 1	Login	0 Browsing
		Navigation	
		Viewing Features of SYSPRO	
		Viewing types of data in G/L and Inventory	
Prac 2	Week 2	Viewing Modules of SYSPRO	
		Viewing supplier and purchase order data	
		Add a supplier	I Transactions
Prac 3	Week 3	Add an operator	
		Add a branch and a warehouse	
		Add an inventory item and a supplier	
		View G/L balances	
Prac 4	Week 4	Add an operator	
		View a branch, warehouse, supplier	
		Add a purchase order	
		Receiving Goods	II Modules
		Posting Invoices	
		Post entries from accounts payable to G/L	

Table 4: Tasks Performed in SYSPRO ERP Practical Sessions

lectures and before the related practical session, Prac 1, Prac 2 and Prac 3, and these were SE2, SE4 and SE6 respectively. A self-efficacy questionnaire was also administered between Prac 3 and Prac 4 (SE7) and after Prac 4 (SE8).

The criteria and scales used in the self-efficacy questionnaire were adapted and replicated from those used in similar ERP education studies (Seethamraju, 2007; Wang et al., 2009). The first part of the self-efficacy questionnaire consists of a list of industry-relevant ERP competencies for each of the three core ERP competency categories, BPM (BP1, BP2, BP3, BP4, BP5), ERP theory and concepts (ES1, ES2, ES3, ES4) and ERP transactions (TR1, TR2, TR3, TR4, TR5). Participants were required to give a subjective rating of their own level of competency for each of these items using a 7-point Likert scale. The second section consisted of eight yes/no questions (C1 to C8) related to the eight detailed competency items involved in the tasks in the four practical sessions. Students were required to indicate whether or not they felt satisfied that they had improved in the specific competency after the practical session or not.

Several methods are used for testing the reliability and validity of the self-efficacy questionnaire. Quantitative and qualitative data analysis techniques are used since the questionnaires include closed and open-ended questions. Face validity is established since both questionnaires were derived from literature, whilst content validity is confirmed by a pilot test conducted at NMMU which contributed to the refinement of the final research instruments.

Evidence of credibility includes triangulation and time sampling. Time sampling is used at several points throughout the period of the research study, since data is collected at several different time points in the course. Data triangulation is used for the case study analysis to provide reliability and validity of qualitative data. The response data regarding student satisfaction with the ERP adoption approach and the use of SYSPRO to improve competencies can validate the self-efficacy ratings by means of data triangulation.

5. RESULTS

The cohort of students that consented to participate (n = 36) was a convenience sample, and are representative of students that typically enroll in the course every year. The data for 8% of participants (n = 3) was eliminated due to missing values. The majority of participants had more than five years of experience using a computer (91%). A large proportion (70%) of the students had some accounting theoretical knowledge but only 12% had some experience of using an ERP system (Table 5). A total of 61% (n = 20) were classified as having a Novice ERP user expertise level. An analysis of the data provided interesting results and these are reported on according to the two main measures of ERP education used in the study, namely performance (Section 5.1) and self-efficacy (Section 5.2).

		n	%
Accounting theoretical knowledge	Yes	10	30
	No	23	70
	TOTAL	**33**	**100**
Prior knowledge	High	11	33
	Low	22	67
	TOTAL	**33**	**100**
ERP System experience	Yes	4	12
	No	29	88
	TOTAL	**33**	**100**
ERP Level	Novice	20	61
	Experienced	13	39
	TOTAL	**33**	**100**

Table 5: Participant Knowledge Profile

5.1 Performance Results

Performance was measured in terms of accuracy in both informal assessments and formal assessments. Task accuracy

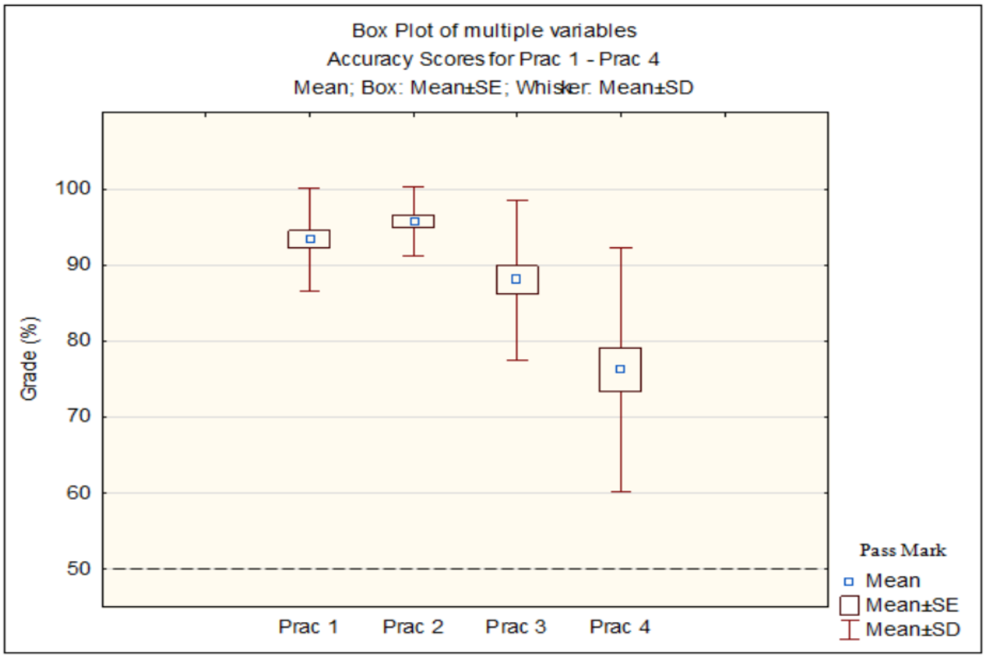

Figure 3: Accuracy Scores in Informal Assessments

is measured by the marks awarded for tasks attempted. The mean marks for accuracy are high for all four informal practical sessions as they are all above 75%, which is considered a distinction at NMMU (Figure 3). The session which had the highest mean score for accuracy was Prac 2 (μ = 96%). The reason Prac 2 had the highest accuracy scores could be related to the fact that although the complexity of tasks is slightly more complex than those in Prac 1, the participants have had time to familiarise themselves with the SYSPRO user interface. Prac 1 had the second highest accuracy score (μ = 93%), probably due to the fact that the tasks were of a Browsing level of breadth and the easiest complexity. Prac 4 had the lowest accuracy score (μ = 76%), which is to be expected as the complexity of the tasks increases from a Browsing level of breadth in Prac 1 and 2, to a Modules level in Prac 3 and 4, as recommended by the ERPEd framework.

ERP Transactions (μ = 79%) was the competency category in which participants performed the best in the formal assessment (Figure 4). The second highest category was ERP Theory and Concepts (μ = 65%). The lowest performance was for the competency category of BPM (μ = 54%). A 50% score is considered a pass mark for the course, consequently all categories are considered to have successful average grades. This grade is a metric of the educational outcome of accuracy relating to the formal assessment and thus the educational outcome for accuracy has been met.

The pass rate for the course unit for ERP Theory and Concepts was 88%, for ERP Transactions it was 97% and for BPM it was 64%. BPM therefore had the lowest pass rate and the lowest mean grade, which confirms the findings of related studies (Rienzo & Han, 2010; Wang et al., 2009; Winkelmann & Leyh, 2010) reporting that students struggle to understand the underlying business processes when using an ERP system.

5.2 Self-Efficacy and Competency Improvement Results

All of the Cronbach's alpha coefficients for self-efficacy (Appendix A) were close to 1 (0.83 <= α <= 0.96) which implies that internal consistency of the self-efficacy questionnaire is very high (Cavana et al., 2001). A Mann-Whitney test between groups was performed on the self-efficacy quantitative data in order to compare the Novice group with the Experienced group. The Mann-Whitney test (Appendix A) showed no significant differences between these groups except for one item in the very first practical session, namely ERP transactions. For this reason the Novice and Experienced groups can be treated as a single homogeneous group.

The results of the subjective ratings of self-efficacy at various points throughout the course, for the competency categories of ERP Theory and Concepts (ES1 to ES4), BPM (BP1 to BP5) and ERP Transactions (TR1 to TR5) are listed in Table 6. The final mean for self-efficacy measured, after completion of Prac 4 (post-intervention), is positive for all three competencies, namely ERP Theory and Concepts (μ = 3.71), ERP Transactions (μ = 3.71) and BPM (μ = 3.87). A one sample *t* test was performed to determine whether the post-intervention results of positive self-efficacy were significant. The results of this showed that only BPM had a significant positive score at a 95% confidence level (p = .044).

An independent-samples *t* test for differences between means was performed to determine if the difference in self-efficacy for the competency categories measured pre-intervention and post-intervention is significant. The results show that there was a significant growth in self-efficacy from pre-intervention to post-intervention, in two of the three competency categories, namely ERP Theory and Concepts and ERP Transactions (Table 7).

ERP Theory and Concepts had a significant (p = .001) growth in self-efficacy (μ = 1.02). ERP Transactions had the

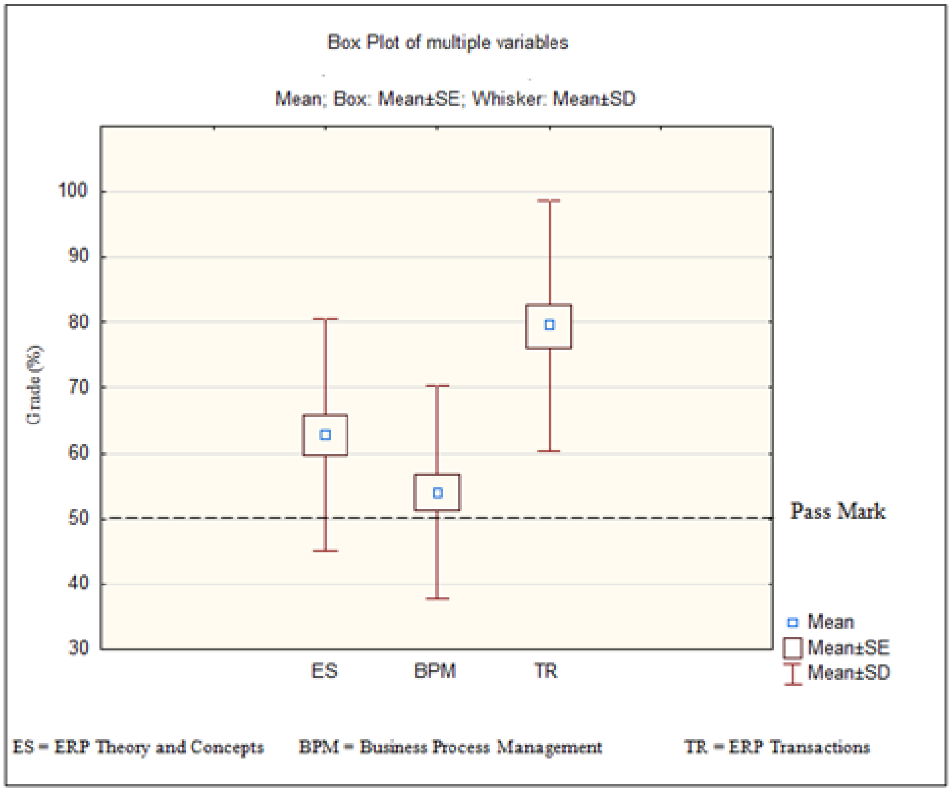

Figure 4: Accuracy Scores in Formal Assessment by Competency Category

highest self-efficacy growth of 1.91 which is significant ($p = .000$). The satisfaction of the use of SYSPRO to improve competencies showed a significant ($p <= .005$) improvement in seven of the eight competency items measured over the four practical sessions (Table 8).

6. CONCLUSIONS

The primary aim of this paper was to report on an investigation of the application of a comprehensive, Competency Framework for ERP system adoption in IS education (ERPEd) in an MIS course at a South African HEI. The ERPEd framework includes industry-based competencies and addresses decisions relating to the mapping of competencies to the level and type of adoption and to the type of ERP learning tool. The application of the framework resulted in a hands-on adoption approach to teaching ERP systems at NMMU, and the use of a medium-sized ERP system, SYSPRO ERP. The educational outcomes evaluated included performance (in terms of task accuracy), self-efficacy, and satisfaction with competency improvement.

An analysis of the responses showed that the majority of students' competencies improved and the results were positive in terms of performance and self-efficacy. Two of the three competency categories addressed in the course showed a positive growth in self-efficacy. The results of this study reveal that HEIs can adopt a hands-on approach to ERP systems in their IS curriculum, and can benefit from implementing a medium-sized ERP system which may be less complex than a large ERP system. HEIs which already have adopted ERP systems in IS higher education, and are struggling with the complexity of large ERP systems can consider applying the ERPEd framework and adopting a less complex, medium-sized ERP system. The lessons learned in this study can be useful for other researchers and educators considering adopting an ERP system in their curriculum.

IS departments in higher education are encouraged to consider the requirement for industry-relevant competencies when implementing an ERP programme in their curriculum in order to ensure that they are meeting industry needs. They can apply the comprehensive, competency-based ERPEd framework for IS higher education into their curriculum. Future research into the application of the framework in other environments is recommended and could contribute towards the support for the attainment of ERP competencies of IS graduates, and in this way reduce the gap between industry needs and the competencies of ERP graduates. In addition studies should investigate the design of an ERP system that is specifically designed for learning and provides more guidance to users. Research could also compare the experience of students using such a specialised ERP learning tool as compared with using a traditional ERP system in the curriculum.

ERP Theory and Concepts								
	Pre-Intervention			**Post-Intervention**				
	ES1	**ES2**	**ES3**	**ES4**		**t**	**d.f**	**p-value**
n	31	31	32	29				
Mean	2.79	3.56	4.08	3.71^{+}		1.36	28	0.186
SD	1.43	1.3	1.21	1.23				
Minimum	1	1	1	1				
Median	3	4	4	4				
Maximum	6.5	6	6	6				
ERP Transactions								
	Pre-Intervention				**Post-Intervention**			
	TR1	**TR2**	**TR3**	**TR4**	**TR5**	**t**	**d.f**	**p-value**
n	31	33	30	32	29			
Mean	1.97	2.85	2.82	3.97	3.71^{+}	1.26	28	0.216
SD	1.21	1.55	1.04	1.18	1.32			
Minimum	1	1	1	1	1			
Median	1.5	3	3	4	4			
Maximum	5	7	4	6	7			
Business Process Management (BPM)								
	Pre-Intervention				**Post-Intervention**			
	BP1	**BP2**	**BP3**	**BP4**	**BP5**	**t**	**d.f.**	**p-value**
n	31	32	32	33	29			
Mean	3.98	4.02	3.25	3.67	3.87^{+}	2.1	28	.044*
SD	1.26	1.02	1.06	1.09	1.2			
Minimum	1	1.5	1.17	1	1			
Median	4.17	4.08	3.42	3.67	4			
Maximum	5.83	5.83	5.5	6	6.33			

Table 6: Self-Efficacy Results

* $\alpha \leq 0.05$ $^{+}$ positive rating

ERP Competency Category		**Diff**		**Inference**			
	N	**Mean**	**S.D**	**t-value**	**d.f.**	**p-value**	**Cohen's d**
BPM	28	-0.04	1.66	-0.11	27	.455	-0.02
ERP Theory and concepts	28	1.02	1.64	3.28	27	.001*	0.62*
ERP Transactions	28	1.91	1.64	6.15	27	.000*	1.16*

Table 7: Growth in Self-Efficacy

* $\alpha \leq 0.01$
**Practical significance $0.2 < d < 0.5$ Small, $0.5 < d < 0.8$ Moderate, $d > 0.8$ Large

Prac	Item	Competency	Improved		Chi-square	p-value (d.f.=1)	Cramer's V
			n	%			
Prac 1 (N = 30)	C1	ERP Theory and Concepts (general ERP concepts, features, modules)	25	83	13.33	.000*	0.67
Prac 2 (N = 33)	C2	Procurement process activities and documents eg Purchase Orders and types of data	26	79	10.94	.001*	0.58
Prac 3 (N = 33)	C3	Purchase orders in an ERP	28	85	16.03	.000*	0.70
	C4	Procurement and ERP	19	58	0.76	.384	n/a.
	C5	Procurement process activities, documents eg Purchase Order and the types of data	28	85	16.03	.000*	0.70
Prac 4 (N = 29)	C6	Receiving Goods in an ERP system	26	96	18.24	.000*	0.79
	C7	Procurement Process	26	96	18.24	.000*	0.79
	C8	Understanding of Posting Invoices process in an ERP	23	88	9.97	.002*	0.59

Table 8: Improvement in Competencies for Prac 1 to Prac 4

* $\alpha \leq 0.01$

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Appendix 1

Cronbach's Alpha Coefficients for Self-efficacy Questionnaires

Competency Category	Instrument	Code	Cronbach's Alpha (α)
Business Process	SE1	BP1	0.89
	SE3	BP2	0.83
	SE4	BP3	0.90
	SE5	BP4	0.90
	SE8	BP5	0.94
ERP theory	SE1	ES1	0.93
	SE2	ES2	0.84
	SE3	ES3	0.88
	SE8	ES4	0.89
Transactions	Se1	TR1	0.92
	SE5	TR2	0.98
	SE6	TR3	0.96
	SE7	TR4	0.93
	SE8	TR5	0.96

Mann-Whitney Test Results

	Rank Sum Novice	Rank Sum Experienced	Valid N Novices	Valid N Experienced	U	p-value
BP1	288.0	208.0	19	12	98.0	.530
BP2	283.5	244.5	19	13	93.5	.258
BP3	330.0	198.0	19	13	107.0	.539
BP4	356.0	205.0	20	13	114.0	.568
BP5	298.0	137.0	19	10	82.0	.566
ES1	296.0	200.0	19	12	106.0	.761
ES2	280.0	216.0	19	12	90.0	.341
ES3	292.5	235.5	19	13	102.5	.432
ES4	318.0	117.0	19	10	62.0	.136
TR1	253.0	243.0	19	12	63.0	.041*
TR2	337.0	224.0	20	13	127.0	.927
TR3	273.0	192.0	17	13	101.0	.706
TR4	302.5	225.5	19	13	112.5	.687
TR5	310.0	125.0	19	10	70.0	.261

* $\alpha \leq 0.01$