A Framework for the Adoption of Enterprise Resource Planning (ERP) Systems in Higher Education

Brenda Scholtz

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Department of Computing Sciences

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By

Brenda Scholtz

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Promoter: Prof A.P. Calitz

Co-Promoter: Prof C.B. Cilliers

Summary

Information Communication Technology (ICT) practitioners and Enterprise Resource Planning (ERP) specialists are highly sought after globally and in South Africa. In order to address this need for ERP specialists, several studies propose that ERP systems should be adopted in the Information Systems (IS) curricula in higher education institutions (HEIs) for instructional purposes. Whilst many HEIs in the United States, Australia and Europe have successfully adopted ERP systems into their curricula, less than 30% of South African HEIs have followed this trend. The adoption of ERP systems is a challenging process as such systems are resource-intensive, costly, complex, and have a steep learning curve. Educators are faced with resource problems and a dearth of options relating to the adoption process. In addition it is critical that the skills and knowledge competencies attained in these courses are industry-relevant.

Several education frameworks have been recommended to assist educators with the process of adopting an ERP system in the curriculum, but these frameworks are not comprehensive since they do not consider all the factors relating to the adoption of an ERP system. In addition existing frameworks are not based on industry-relevant competencies but rather on educational objectives. This has resulted in a difference between the competencies required by organisations and those produced by higher education. Whilst there are several research studies on ERP education, empirical studies on frameworks supporting the adoption of ERP systems in HEIs for instructional purposes are limited, particularly on the impact of these frameworks on educational outcomes. The impact of the usability of the ERP system on educational outcomes has also not been fully explored.

A survey of ERP consulting organisations in South Africa confirmed that these organisations struggle to obtain ERP specialists with the appropriate competencies. The survey results also contributed to a standardised, comprehensive, set of industry-relevant ERP competencies. The competency set forms part of a comprehensive Competency Framework for ERP System Adoption in IS Higher Education (ERPEd), which can assist educators with the decisions relating to the adoption of an ERP system into the IS curriculum. It includes all the categories of competencies relevant to industry and maps these onto a recommended ERP system adoption approach, an ERP learning tool, as well as the appropriate level of adoption.

The application of the ERPEd framework to a case study, the Management Information Systems (MIS) course at the Nelson Mandela Metropolitan University (NMMU), resulted in the adoption of the SYSPRO medium-sized ERP system into the MIS course with the hands-on approach. The empirical results of the evaluation of the case study revealed that the hands-on use of a medium-sized ERP system, SYSPRO, can successfully contribute to the attainment of educational outcomes. These outcomes were mapped to the three core competencies addressed by the MIS course, which were ERP Theory and Concepts, ERP Transactions and Business Process Management (BPM).

The educational outcomes evaluated were the measures of performance, self-efficacy and usability. Self-efficacy included satisfaction with the adoption approach. The results were positive in terms of all the metrics of performance, and all three competency categories had positive post-intervention self-efficacy ratings. In terms of growth in self-efficacy from pre-intervention to post-intervention, BPM was the only competency category that did not show a significant growth, however the satisfaction data indicated that students found that the use of SYSPRO improved their competencies in business process understanding. Usability was evaluated in terms of navigation, presentation and learnability. Learnability was the only usability measure in the neutral range, with the other measures falling in the positive range. This confirms related studies reporting that ERP systems are not designed for learning. Overall the students enjoyed the practical application of the theory by using SYSPRO. Several positive and negative features of the user interface were provided which can be used in the design of improved ERP systems for instructional purposes.

The results of this investigation can assist in narrowing the gap between industry requirements and IS education programmes. The ERP competency set provides a standardised list of skills and knowledge which is the starting point for any skills improvement program. The ERPEd framework can improve the quality of ERP courses and the competencies of IS graduates. This in turn, can benefit the business community since it will improve the chances of ERP project success. This research is a major contribution to both government and academic initiatives in South Africa to address both the ICT skills problem as well as the need for ERP specialists.

Keywords: ERP education, ERP consultants, enterprise systems, ERP learning, ICT skills

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Chapter 1: Research Context

1.1 Background

Businesses have become increasingly reliant on Information Systems (IS) to support their operations and it has become impossible to manage business processes effectively without the use of modern IS (Magal and Word 2012). Investments in Information Communication Technology (ICT), and in particular enterprise systems, have significantly increased the profitability and competitiveness of organisations (McAdam and Galloway 2005; Ketikidis et al. 2008; Magal and Word 2012). During the 1960s and 1970s, simple inventory-tracking systems were developed and these then evolved into more sophisticated manufacturing systems such as Materials Requirements Planning (MRP) systems (Monk and Wagner 2009).

The functionality provided by MRP systems continued to expand and MRPII (Manufacturing Resource Planning) systems were developed, which provide methods to plan all resources for a manufacturer (Olson 2004). MRPII was then further extended into integrated Enterprise Resource Planning (ERP) systems. Whereas the focus of MRP and MRPII is on the manufacturing process, ERP systems look at a much broader integration of the planning, management and use of all the resources and data in the entire organisation (Al-Mashari et al. 2003).

ERP systems are dominant in the business community and the application of an ERP system can provide many benefits to organisations, but also introduces many challenges (Section 1.1.1). These challenges include problems relating to a global demand for ICT and ERP competencies (Section 1.1.2). Several studies show that there is a misalignment between the ERP competencies required by business and those provided by education. This situation has led to pressure on higher education to address this need for quality ERP education (Section 1.1.3).

1.1.1 Growth and Benefits of ERP Systems

ERP systems are defined as “a highly unified, consolidated and reliable network of business systems, built on a single integrated platform” (Vaman 2007), and are the biggest and most complex of enterprise systems (Magal and Word 2012). Enterprise systems is a term used to describe systems that involve the entire enterprise or at least two departments from it (Turban et al. 2010). Many organisations that had not previously adopted ERP systems became motivated to do so in the late 1990s because of the Year 2000, or Y2k problem (Robey et al. 2000; Vaman 2007). An additional impetus for adopting ERP systems occurred in 2002 with the introduction of the Surbanes-Oxley Act, a federal law passed in response to the accounting fraud discovered at Enron and WorldCom (Monk and Wagner 2009).

Despite the current economic and business climate, there is still a positive forecast for the ERP market (AMR 2007; IDC 2008; Gartner 2010). According to the Enterprise Applications Software Forecast report by Gartner, the Europe, Middle East and Africa (EMEA) region market for ERP systems will reach $24.7bn by 2014 (Figure 1-1), which represents a compound annual growth of 4.2% (Eid et al. 2010). Another report from Forrester forecasts that the global ERP market will reach $45.5bn in 2011, and increase to $50.3bn by 2015 (Forrester 2011).

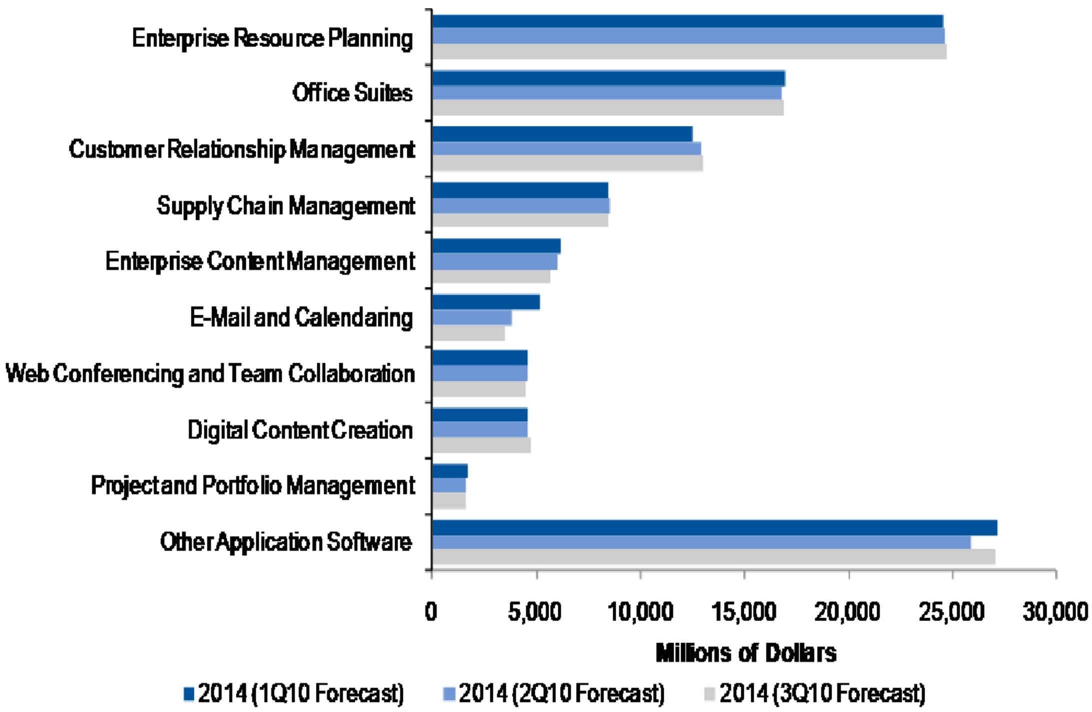

Figure 1-1 Enterprise Application Software Forecast, Worldwide 2014 (Eid et al. 2010)

Several reports have cited the growing dominance of ERP systems in the business community (Wailgum 2003; Mohamed and McLaren 2009; ACM 2010; Winkelmann and Leyh 2010; Panorama 2011), and even in small to medium-sized organisations (Loh and Koh 2004; Pang 2008; Koh et al. 2009). Practically all types of organisations, including non-manufacturing organisations like universities and hospitals (Olson 2004; McGauhey and Gunasekaran 2007), as well as organisations in developing countries, have ERP systems (Sheu et al. 2004; Kanthawongs 2010a; 2011). There are numerous ERP vendors in the market with the company, Systems Applications and Products in Data Processing (SAP), being the leading vendor (Monk and Wagner 2009) with more than one hundred thousand customers in over one hundred and twenty companies worldwide in 2010 (SAP 2010).

Numerous potential benefits of implementing ERP in industry have been reported (Shang et al. 2000; O'Grady 2002; McAfee and Brynjolfsson 2008; Esteves 2009; Schubert and Williams 2010). One of the main benefits of an ERP system is its ability to provide all of the enterprise's needs by means of its integration of all department and function information across a company into a single system (Wailgum 2003; Vaman 2007; Turban et al. 2010).

1.1.2 Demand for ERP Competencies

The potential benefits of ERP systems have led to a global demand for ERP systems in organisations (Muscatello and Chen 2008; Koh et al. 2009; Mohamed and McLaren 2009). However, ERP implementations are faced with many challenges which include problems with obtaining resources and a demand for quality ERP specialists worldwide (Wang and Chen 2006; Muscatello and Chen 2008; Beer 2010; Law et al. 2010). Gartner (2010) has reported that ERP and SAP specialists are some of the most difficult to recruit and hire for positions in Information Technology (IT) today. The high costs of consultants are considerably higher for ERP projects than for other system implementation projects (Robey et al. 2000; Sahadi 2007). In South Africa there is also a need for ERP specialists with appropriate competencies (Seymour et al. 2006; Scholtz 2011).

ICT has been identified as a catalyst for growth in the current economic crisis by the World Economic Forum – The Global Information Technology Report 2008-2009. In the United States (U.S.), congress passed an ICT skills shortage national priority plan to try to address the ICT skills shortage problems (WEForum 2009).

The European e-skills Forum report has defined ICT practitioner skills as "*the capabilities required for researching, developing and designing, managing, the producing, consulting, marketing and selling, the integrating, installing and administrating, the maintaining, supporting and service of ICT systems"* (European e-skills Forum 2004). In South Africa, there is a similar ICT skills shortage to that of the rest of the world and this has been acknowledged by the local government (Pandor 2006; e-skills 2008). The South African Minister of Science and Technology, Mrs Naledi Pandor MP, stated at the South-Africa-Ireland education conference in Dublin that *"We are short of men and women with IT skills. All recent studies and* 3 *surveys confirm what we already know about scarce skills – management, engineering, and IT are key areas of shortage"* (Pandor 2006). This was confirmed again by the minister when she signed the Birchwood Declaration in 2008 in Johannesburg, stating that government intervention was required in the ICT skills shortage.

The South African Medium Term Strategic Framework (MTSF) has documented the contribution that competencies make to society and to the development of the national economy and has set objectives, amongst others, to improve South Africa's competency base and produce quality outcomes in the field of Science and Technology (DOC 2009). According to the e-Skills council, "*South Africa's Information Communication Technology (ICT) needs have to be addressed in order to further development and service delivery"* (e-skills 2008). The e-Skills Institute of the Department of Communications (DOC) indicates that several reports in South Africa in the period since 2000 consistently report an ICT skills shortage. This ICT skills shortage was the focus of the e-skills summit in Cape Town in 2010 (e-skills 2010).

The ICT skill shortage problem impacts the availability of ERP specialists since the competencies required to install, develop, integrate, support and maintain ERP systems required by an ERP specialist fall into the category of ICT practitioner skills. The scope of responsibility of the ERP specialist discussed in this study is that of those not employed in-house by the organisation and referred to as ERP consultants (Boyle and Strong 2006).

In order to address the need for ERP specialists in particular, the South African Qualifications Authority (SAQA) has defined several qualifications for ERP specialists (SAQA 2010). In addition, the higher education community in South Africa established an Enterprise Architecture Research Forum (EARF) at a workshop held in June 2010.

The primary objective of the EARF workshop was to address the need for ERP specialists and for enterprise systems education in South Africa (EARF 2010). The international education community has also taken cognisance of the importance of ERP systems and a need for the required ERP competencies, and has identified a career track for the ERP specialist in the IS2010 curricula (ACM 2010).

Research conducted in South Africa on ICT graduate skills indicates that a misalignment exists between ICT skills required by business and the ICT skills provided by higher education and training institutions in South Africa (Kim et al. 2006; Lee and Fang 2008; Calitz 2010; Merkofer and Murphy 2010). A similar problem exists with ERP education programmes which are not adequately addressing the needs of industry (Hawking and McCarthy 2000; Joseph and George 2002; Boyle 2007). According to Cameron (2008), students are not adequately prepared to work as IS practitioners in the enterprise systems environment. IT departments in higher education institutions (HEIs) need to change their focus and go beyond the traditional programming approach to accommodate the employment requirements for enterprise systems competencies generated by a global economy (Mahoney 2005; Strong et al. 2006; Dawson 2008; Tuson 2008). The provision of quality education in HEIs can bridge the gap between the competencies attained by graduates of ERP programmes and those required by industry (Barnes and Ferguson 2008).

1.1.3 ERP Education in Higher Education Institutions (HEIs)

Related studies (Hawking and McCarthy 2000; Jensen et al. 2005; Seethamraju 2007; Mohamed and McLaren 2009; Lindoo and Wilson 2010; Winkelmann and Leyh 2010) have shown that a lack of ERP competencies, together with an increased demand for ERP specialists, has also led to students and future employers placing pressure on HEIs to provide ERP courses in the IS curriculum. IS graduates who are employed as ERP specialists are primarily involved in the implementation and support of ERP systems, therefore the competencies attained by these graduates must be relevant to the industries in which they will be employed (Antonucci et al. 2004; Boyle and Strong 2006; Wang and Chen 2006; Winkelmann and Leyh 2010).

In an effort to address the need for ERP education, several HEIs have entered into Academic Alliance agreements with ERP software vendors (Springer et al. 2007; Desai and Pitre 2009; Kreie et al. 2010). These alliances provide educators with software and data resources for ERP courses, and in some cases with training material.

In response to the need for ERP education, several HEIs have adopted ERP systems into their curriculum (Hawking et al. 2004; Surendran et al. 2006; Hustad and Olsen 2011). Several education frameworks for adopting ERP systems into IS and business curricula in HEIs have been proposed (Shtub 2001; Joseph and George 2002; Peslak 2005; Boyle 2007; Pellerin and Hadaya 2008; Wang et al. 2009). 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 2009). ERP education frameworks can be categorised on the types of decisions for which they provide support to educators (Chapter 3). These decisions relate to the level of ERP adoption required, the type of ERP system to adopt and the adoption approach to use.

There are several levels of ERP system adoption available to educators depending on the competencies required and the resources available (Section 3.4). The level of adoption can vary from a lectures-only approach, to a tutorial approach and finally to the most resource-intensive level of the hands-on approach. The tutorial approach uses simulators and tutorials to teach ERP systems, whilst the hands-on approach involves students actually using an industry ERP system, for example SAP ERP, to process transactions.

Studies have shown that the adoption of an ERP system such as SAP R/3 for instructional purposes in IS and in business curricula has many benefits for students and can improve the quality of learning (Becerra-Fernandez et al. 2000; Hawking and McCarthy 2000; Nelson 2002; Bradford et al. 2003; Kirkham and Seymour 2005; Seymour et al. 2006; Seethamraju 2007). An improvement in the quality of learning can be measured by the students' achievement of the required levels of academic performance and by a significant, perceived improvement in several ERP competencies (Davis and Comeau 2004; Jensen et al. 2005).

Students enjoy the hands-on use of ERP systems and appreciate the importance of having exposure to ERP systems used in industry (Bradford et al. 2003; Wang et al. 2009). The adoption of ERP into the curricula can improve the students' understanding of ERP systems and business processes (Davis and Comeau 2004; Draijer and Schenk 2004; Peslak 2005; Jensen et al. 2005). In addition, studies (Fedorowitz et al. 2004; Sager et al. 2006) have shown that students who graduate with ERP skills have greater earning potential than those students who do not graduate with ERP skills.

In spite of the potential benefits of the adoption of an ERP system in the IS curricula, the process is challenging for ERP educators and requires detailed planning (Fedorowitz et al. 2004; Léger 2006; Strong et al. 2006). ERP systems are resource-intensive, costly, complex and have a steep learning curve (Eicker et al. 2007; Wang et al. 2009). Continual evaluation of the effectiveness of ERP courses is critical (Seethamraju 2007; Winkelmann and Leyh 2010) and these courses should be kept in line with changing business needs and technologies as well as with the changing demographics of students (Seethamraju 2007).

The hands-on use of ERP systems by students can result in user frustration due to the poorly designed user interface (UI) of the ERP system (Shtub 2001; Surendran et al. 2006). Several usability problems with ERP systems used for instructional purposes have been reported (Nelson 2002; Surendran et al. 2006; Scholtz 2010). The amount of time required to learn the details of all screens and functions of an ERP system is excessive as these systems are not specifically designed to support teaching (Shtub 2001). The usability problems associated with ERP systems results in additional challenges for educators who adopt an ERP system into the IS curricula.

1.2 Research Rationale

A need for the adoption of ERP systems in the IS curriculum exists in order to keep abreast of the ERP competency requirements of industry (Section 1.1). Existing ERP education research is limited to discussions on various frameworks for adopting ERP systems in the curriculum, with the majority of these studies having been administered in the U.S., Europe and Australia (Chapter 3). The impact of ERP educational offerings on students has not been examined to a great extent (Kanthawongs 2010a).

Existing frameworks are not comprehensive as they do not take into account all the industry-relevant competencies required for ERP specialists (Chapter 2). They also do not consider the impact of the usability of an ERP system on the attainment of these competencies and thus on educational outcomes in ERP courses (Chapter 4). More systematic investigation into the role of consultants in ERP consultation and implementation is required (Wang and Chen 2006).

Studies relating to the correlation of ERP competencies covered in subjects and those required by industry are limited (Hawking and McCarthy 2000; Boyle and Strong 2006). In South Africa, only one such study was identified, but this study did not consider the effect of the usability of the ERP system on the attainment of educational outcomes (Seymour et al. 2006). In addition several educational outcomes for ERP were not addressed by this study (Chapter 3).

Research that evaluates the effectiveness of an ERP system adoption is continually required in an attempt to keep IS educational outcomes in line with changing business needs (Bendoly 2005; Peslak 2005; Sager et al. 2006; Seethamraju 2007). The gap between the ERP skills required by industry and the content of IS programmes has increased (Wang and Chen 2006; Boyle 2007). ERP systems have been used for educational purposes and several successes of ERP adoption have been reported. However, little objective, empirical evidence supporting the success of ERP education has been presented (Grandzvol 2004; Sager et al. 2006). In comparison with the number of articles on ERP implementation in industry, the number of articles on ERP adoption for instructional use in education are relatively few (Moon 2007; Hustad and Olsen 2011).

The educational benefits of instructional uses of ERP systems have, thus far, been established on the basis of anecdotal statements from faculty and students rather than on empirical and objectively measured data, secured by educational research (Noguera and Watson 2004). Sager et al. (2006) believe that gathering empirical data on the value of ERP systems in education from both the student and company points of view can be extremely useful to both HEIs and organisations. An ERP education framework is required which can assist ERP educators with the decision-making process when adopting an ERP system in the curriculum. Empirical data is required on the impact of the application of ERP education frameworks which support this ERP system adoption on educational outcomes.

Research on industry-relevant, competency based ERP education frameworks can assist educators with addressing the requirements of industry. The relevance of this research is thus to complement existing research with empirical data and to evaluate the application of the proposed framework by measuring ERP usability and its relationship with educational outcomes.

1.3 Research Problem

The **practical problem** researched in this study is based on the realisation that there is shortage of quality ERP specialists globally and specifically in South Africa (Seymour et al. 2006; Gartner 2010). A gap exists between the skills required by organisations and the content of IS programmes both internationally (Boyle 2007) and in South Africa (Griesel and Parker 2009). Whilst several HEIs have adopted ERP in their curricula, it is not certain that they are providing students with industry-relevant competencies (Desai and Von der Embse 2001; Boyle and Strong 2006; Cameron 2008). Existing ERP education frameworks are not comprehensive and do not necessarily take into account the usability challenges of the adopted ERP system. ERP systems are not designed to specifically support teaching and this can negatively affect the learning process, especially for students who are novice users (Shtub 2001; Surendran et al. 2006). As a result, users tend to focus on the completion of tasks and not on the underlying concepts (Davis and Comeau 2004; Winkelmann and Leyh 2010).

The **core problem** of this study is that existing ERP education frameworks are not comprehensive and are not competency-based. They are not comprehensive since they do not address all the decisions relating to the adoption of an ERP system in the curriculum. Existing ERP education frameworks are also not based on industry-relevant competencies. This study will propose a comprehensive ERP education framework for South African HEIs, which is based on industry-relevant competencies and also takes into account the usability of the adopted ERP system on these competencies and on educational outcomes. An improvement in these competencies and in educational outcomes can thus improve the quality of ERP education (Davis and Comeau 2004), which in turn can increase the employability of graduates and better satisfy the needs of employers in terms of acquiring their required ERP capability (Calisir and Calisir 2004; Seymour et al. 2006; Strong et al. 2006; Hawking et al. 2009).

1.4 Thesis Statement

A comprehensive framework for the adoption of ERP systems into the IS and business curricula in HEI undergraduate degree programmes will be investigated. This framework will provide guidance to educators for planning the adoption of an ERP system in the IS curriculum. The framework should therefore be comprehensive and include all decisions relating to the adoption of an ERP system in the curriculum, as well as all the ERP knowledge and skill competencies that are relevant to industry. In this way the framework can increase the ERP competency levels of ERP graduates.

The following thesis statement of this student is based on the core problem statement:

> *A comprehensive, competency-based ERP education framework which supports the attainment of educational outcomes and industry-relevant competencies can be implemented in the IS curriculum at a South African Higher Education Institution (HEI).*

The success of an ERP programme in the IS curriculum can be measured by the educational outcomes of performance, self-efficacy and the usability of the ERP system. The usability of the ERP system adopted in the curriculum can impact on the academic performance of students. The success of the adoption of the ERP system can also be measured in terms of self-efficacy and student satisfaction.

1.5 Research Purpose and Objectives

The purpose of this research is to propose, apply and evaluate a comprehensive, ERP education framework that assists educators with decisions regarding the adoption of an ERP system into the IS curriculum. Factors that affect the successful adoption of an ERP system into the curriculum will also be examined. In particular, the factor that will be examined is usability of the ERP system tool used. In order to achieve the research purpose, the following research objectives have to be realised:

- **Primary Research Objective**
    - To propose and apply a comprehensive, competency-based education framework for the support of the adoption of an ERP system at an HEI in South Africa.

- **Secondary Research Objectives**

  RO1. To identify and compile a set of competencies for ERP specialists;

  RO2. To validate the ERP competency set according to the requirements of South African ERP consulting organisations;

  RO3. To compare frameworks and approaches which can be used to adopt ERP systems into the IS curricula;

  RO4. To propose an education framework which can be used for the adoption of ERP systems in an IS curriculum in HEIs in South Africa;

  RO5. To propose a set of educational measures for ERP system adoption in an IS curriculum;

  RO6. To apply the ERP education framework at the Nelson Mandela Metropolitan University (NMMU) to support the adoption of an ERP system in the IS curriculum;

  RO7. To evaluate the application of the proposed ERP education framework at NMMU.

1.6 Envisaged Contribution

The main difference between this study and other similar studies is that it proposes and validates a comprehensive framework for ERP education. The framework will provide the following:

- A standardised set of competencies for ERP specialists that are relevant to employers of IS graduates in South Africa (Chapter 2); and
- A classification of the possible levels of ERP system adoption for education in IS curricula that is appropriate for the industry-relevant competencies (Chapter 3).

The proposed framework is different from existing frameworks in that it is comprehensive since it assists with all the decisions relating to the adoption of an ERP system into the IS curriculum. These decisions are related to which industry-relevant competencies to address, which ERP system adoption approach to use, which ERP learning tool to adopt and which level of adoption to implement in the curriculum. Evaluation measures for ERP education and the usability of ERP systems are also proposed.

This study can provide benefits to the business management, education and Human Computer Interaction (HCI) communities. The competency set can assist ERP employer organisations with the recruitment and selection of ERP graduates, whilst the results of the usability evaluation can be used to assist HCI designers with the process of designing more usable ERP learning tools. Measures and metrics for evaluating ERP education (Chapter 4) provided by this study can contribute to education research in South Africa.

1.7 Research questions

Based on the purpose of the research and the research objectives (Section 1.5), the main research question can be phrased as:

"What is the impact of the application of an ERP education framework at NMMU?"

Several subsidiary research questions arise from the main research question. These questions are listed in Table 1-1 together with the research methods used to answer each question. The chapter in which each research question is addressed is also included in the table.

Table 1-1 Research Questions and Chapters Addressing the Questions

	Research Question	Chapter	Research Objective
RQ1	What competencies (skills and knowledge) are required for an ERP specialist by ERP consulting companies in South Africa?	2	RO1 & RO2
RQ2	What frameworks and approaches can be used to adopt ERP systems into the IS curricula?	3	RO3
RQ3	What comprehensive education framework can be used in an ERP course in higher education institutions in South Africa?	4	RO4
RQ4	How can the impact of ERP system adoption in a curriculum be measured?	4 & 5	RO5
RQ5	What is the impact of the adoption of an ERP system in the IS curriculum at NMMU on ERP educational outcomes?	6 & 7	RO6 & RO7

The research process entails three distinct but related investigations:

1. Establish what the stakeholders actually require for ERP specialists;
    i. Establish what the ERP consulting companies in South Africa require for ERP specialists (RQ1):
    ii. Investigate what the educational context of ERP systems is internationally and in South Africa (RQ2);

  iii. Establish what international curricula and research communities require for ERP education (RQ2);
  iv. Establish what education frameworks have been proposed by other HEIs to produce ERP specialists (RQ2);
2. Establish the measures and metrics used by HEIs for ERP educational quality (RQ4);
3. Design, implement and evaluate an ERP education framework (RQ3, RQ4, RQ5).

These investigations are required in order to answer the main research question and the five subsidiary research questions. The results of the three investigations will contribute to the artefacts of this study.

1.8 Scope and Constraints

This study will focus on the competencies required by outsourced ERP specialists and not on those employed in an in-house IT department. The scope will be limited to the investigation of undergraduate curricula in universities, and excludes curricula of technikons (now universities of technology) and colleges. It will also examine curricula for one discipline only, namely the IS discipline and will therefore not consider approaches for multidisciplinary education.

The evaluation of the proposed framework will be limited to the practical use of an ERP system in an undergraduate course which teaches core technical ERP concepts (Section 2.3.2.1) at a HEI in South Africa, namely NMMU. Supplementary ERP competencies such as configuration, implementation and programming (Section 2.3.2.2) will not be included in the scope of the evaluation. E-learning applications for ERP systems will also fall outside the scope of this study.

1.9 Research Philosophy and Approach

The research process is used to define the research strategy of this study in detail. Figure 1-2 to follow illustrates a generic research process "onion" showing the relationship between the various aspects of the research process.

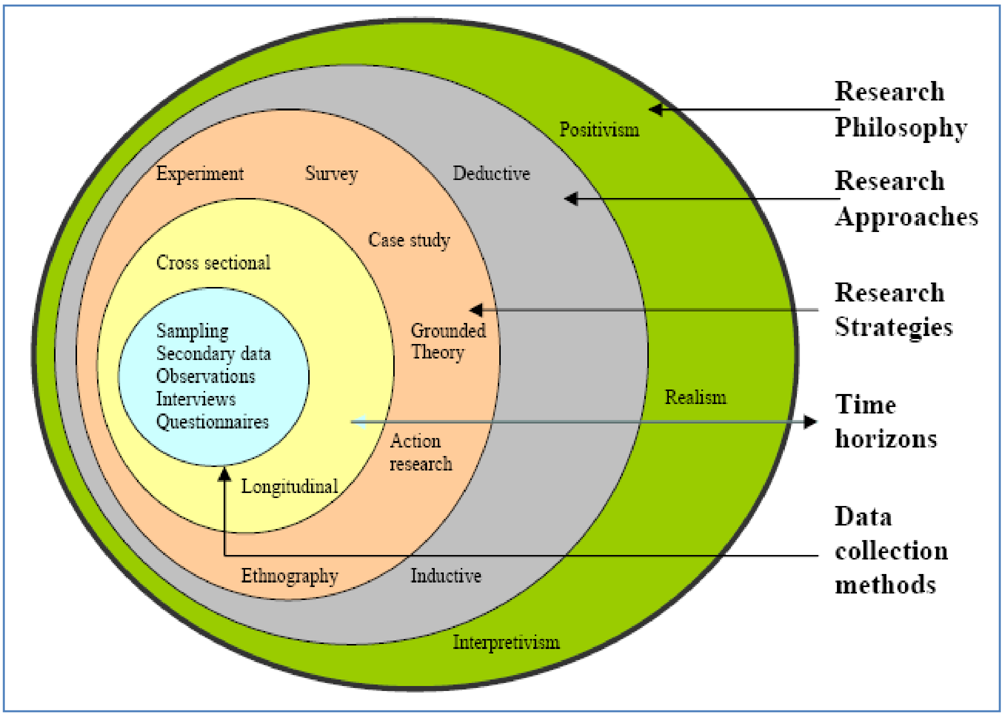

Figure 1-2 The Research Onion Process (Saunders et al. 2009)

Saunders et al. (2009) states that a research philosophy relates to the development of knowledge and the nature of the knowledge (Section 1.9.1) whereas a research approach indicates whether the use of theory is explicit within the research design (Section 1.9.2). Following consideration of the research philosophical stance, research approach and the logic of reasoning to be applied in the research, the next aspect to address is what strategy to employ in the research process (Section 1.10.3).

1.9.1 Research Philosophy

Research studies can be undertaken using one of three primary research philosophies, namely: positivism, realism and interpretivism (Saunders et al. 2009). Positivism is based on the belief that the social world can be studied in the same manner as the natural world. Positivists believe that one reality exists and it is the researcher's task to discover that reality. Realism is another philosophical position which relates to scientific enquiry. The essence of realism is that what the senses show us as reality is the truth: that objects have an existence independent of the human mind. Realism is similar to positivism in that it assumes a scientific approach to the development of knowledge.

Interpretivism advocates that it is necessary for the researcher to understand differences between humans in our role as social actors, and it emphasises that there is a difference between conducting research among people rather than objects, like cars. The underlying assumption of interpretivism is that the whole needs to be examined in order to understand a phenomenon. The focus of this study is on ERP system adoption in education, which is impacted by the social world of the people who are stakeholders in ERP education therefore a combination of interpretivism and positivism will be used.

1.9.2 Research Approach

Researchers can derive meaning from a phenomenon under study by applying any of the following types of logical thinking: Deductive or inductive approaches (Mouton 2001). Induction is building theory, whereas deduction is the process of testing theory (Saunders et al. 2009). An inductive approach emphasises gaining an understanding of the meanings humans attach to events and a close understanding of the research context. It is a more flexible structure to allow changes of research emphasis as the research progresses, and has less concern with the need to generalise.

When researching a topic that is new and on which there is little existing literature, it is more appropriate to work inductively by generating data and analysing and reflecting on what theoretical categories the data suggests. Inductive approaches include generalisation and retroductive reasoning (Mouton 2001). Inductive generalisation involves applying inferences from specific observations (such as a sample of cases) to a theoretical population. Any form of statistical inference in which generalisation is made from a sample to the target population is a form of inductive generalisation. Retroductive reasoning is another form of inductive inference and involves using inference from observations of data in order to construct or "infer" an explanation from such observations. On the basis of observations that have been made and perceived patterns and trends in the observations, explanations that would explain the observed events are derived.

Deduction involves the development of a theory that is subjected to a rigorous test, and is the dominant research approach in the natural sciences where laws present the basis of explanation, allow the anticipation of phenomena, predict their occurrence and therefore permit them to be controlled (Collis and Hussey 2003). Deduction emphasises moving from theory to data and is most suitable where there is a wealth of literature from which a theoretical framework and a hypothesis can be defined. It is often advantageous to combine both the deductive and inductive approaches (Saunders et al. 2009) and therefore, although this study will be mostly deductive there will be some aspects that are inductive, particularly when the design of the framework is introduced. The inductive approach will be used to build new theories that have not emerged previously and to derive the proposed theoretical ERP education framework. A deductive approach will be used to address the initial research questions and test certain aspects of the theoretical framework.

1.9.3 Research Strategies and Ethical Considerations

Saunders et al. (2009) define a research strategy as "a general plan of how you go about answering the research questions you have set". The choice of a good strategy will be driven by set objectives answering the research questions. In the strategy, possible data collection sources and research constraints are explored. This study will use several research strategies, including surveys and a case study. Surveys will be used to determine the requirements of ERP consulting organisations for ERP specialists. This process is described in more detail in Chapter 2. The case study approach is used to test the theoretical framework. A case study is a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon, within its real life context, using multiple sources of evidence (Saunders et al. 2009). A single case study is used for the application and evaluation of the framework. The motivation for using case studies will be presented in more detail in Chapter 5 when the research design is discussed.

The research, for all purposes, abided by and followed on the proposals from the Research Ethics Committee (Human) of the Nelson Mandela Metropolitan University (NMMU) and ethical approval for this study was awarded by the NMMU Ethics Committee (Ethics Clearance Reference Number is H10-Sci-CSS-002). In line with this, the researcher made explicit to the selected organisations and student participants that their interests would be safeguarded and would remain anonymous.

1.10 Conclusions and Proposed Thesis Structure

A need for research into ERP education in South Africa exists in order to meet the demand for ERP specialists (Section 1.2). The demand is for ERP specialists with industry-relevant competencies but existing frameworks for ERP education are not comprehensive and do not take into account the requirements of consulting organisations in South Africa. In addition, empirical evidence of the success of the adoption of an ERP system in South Africa is limited. No comprehensive ERP education framework for the IS curriculum in South Africa exists. Similar studies in other countries have not addressed the impact of the usability of ERP systems on the attainment of educational outcomes. Five subsidiary research questions are identified for this study (Table 1-1) in order to answer the primary research question.

In order to address the research questions of this study, this dissertation is structured accordingly and this structure is illustrated in Figure 1-3 together with the research questions asked and the related strategies used to answer these questions. The question of what is required for ERP specialists is addressed in Chapter 2 and several key competencies for ERP specialists are identified by means of a literature review. To confirm the competencies identified in the theoretical framework, a survey strategy is used and a survey of South African ERP specialist employers is undertaken using structured interviews and questionnaires.

Once the requirements for the competencies of ERP specialists are established it is necessary to determine how these competencies can be attained by means of education programmes in HEIs. Chapter 3 therefore investigates several approaches and frameworks used to adopt ERP systems in education. When it is determined how to provide an ERP education that supports the attainment of industry-relevant competencies, it is important to address how ERP educational outcomes and the success of the adoption of an ERP system into the curriculum can be measured. Chapter 4 discusses the criteria, measures and metrics for evaluating ERP education. This chapter will also discuss the design of the proposed comprehensive ERP education framework and the importance of usability in evaluating ERP education quality.

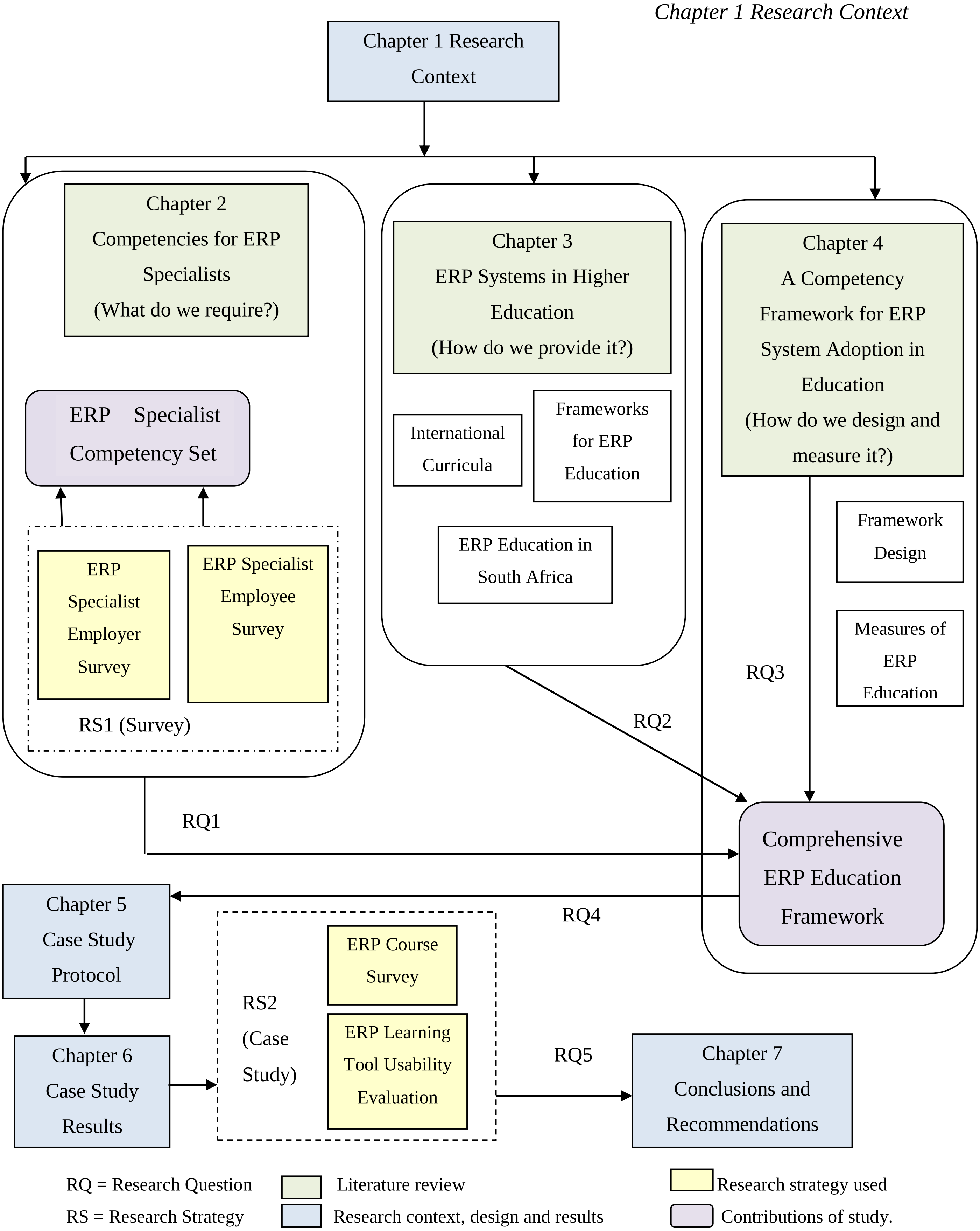

Figure 1-3 Structure of Thesis

Chapter 5 discusses the research design and methodology of the case study at NMMU used to evaluate the impact on educational outcomes of adopting ERP systems. This chapter discusses the case study protocol, the data that was collected, and the reasons and methods for collecting this data. In Chapter 6 the results of the data collected from a single case study of students registered for an ERP course are discussed. The analysis and interpretation of the results relating to the educational outcomes of the ERP course are provided in Chapter 6 as well as the results from the usability evaluation of the ERP system. Chapter 7 summarises the results of the research to show whether or not, based on the results, the framework is useful and usable. Shortcomings of the research and future work will also be identified and discussed.

Chapter 2: Competencies for ERP Specialists

2.1 Introduction

In South Africa finding ICT employees with the right competencies has become a major issue for employers (Alexander et al. 2009; Calitz 2010; ITWeb 2010; Pieterse 2010). Companies in South Africa have indicated that the shortage of ICT skills in South Africa could affect their survival (Textio 2010). ICT practitioners include ERP specialists for which the supply and demand are out of sync (Sahadi 2007). A CNN Money report listed ERP and SAP consultants as one of the top 6 jobs identified in terms of earnings (Sahadi 2007). This demand for ERP competencies challenges academia to produce ERP graduates that have industry-relevant competencies. Competency can be defined as the necessary skill or knowledge required to perform a task successfully (Pinto 2010).

The wide range of ERP systems available on the market will influence the key competencies that organisations expect from graduates of ERP tertiary programmes. Consequently the focus of this chapter is on the identification of competencies (in terms of knowledge and skills) that are required for an ERP specialist by ERP consulting companies in South Africa. This chapter will therefore answer the first research question, "*What competencies (skills and knowledge) are required for an ERP specialist by ERP consulting companies in South Africa?"*.[1]

[1] The results reported on in this chapter were published as a full paper in a double-blind peer reviewed conference at the International Business Conference (IBC) in September 2010. Scholtz, B., Calitz, A., Cilliers, C. Critical Competencies for South African ERP Consultants. IBC Conference. Mauritius (Appendix F).

A number of ERP systems are currently used in the marketplace (Section 2.2). ERP graduates will work on at least one of these ERP systems and will require industry-relevant competencies related to these systems. The set of technical and supporting competencies required for ERP specialists (Section 2.3) is confirmed and augmented by a survey of 22 ERP specialist employer organisations (Section 2.4) and 105 South African employers of ERP specialists (Section 2.5) to produce a comprehensive set of the key competencies required for ERP specialists (Section 2.6). The ERP competency set can be used as a checklist for ERP consulting organisations when recruiting consultants and for job assessments.

2.2 The ERP Systems Market

The implementation of ERP systems brings many benefits as a result of the integration of business processes and related information (Section 1.1). This integration is made possible by a common database which is responsible for storing all of the data from business processes that are essential for business operations and decision-making (Turban et al. 2010). The removal of barriers to sharing information between functional divisions and the holistic management of processes have enabled ERP systems to increase significantly the profitability and productivity of organisations (McGauhey and Gunasekaran 2007; McAfee and Brynjolfsson 2008).

The demand for ERP systems has led to a demand for ERP specialists (Section 1.1.2). Recent studies (Boyle 2007; Winkelmann and Leyh 2010) have reported that IS graduates who are recruited as ERP specialists will work with one or more ERP systems. One study (Winkelmann and Matzner 2009) argues that the ERP specialist may also have an influence on the investment decisions concerning the adoption, upgrade, or alteration of ERP systems. Organisations that recruit ERP specialists, therefore, require graduates that have product-based ERP competencies related to the ERP systems which the specialists will support. ERP systems include, amongst others, those developed and marketed by the top vendors in the marketplace, such as SAP, Baan and Oracle (Seethamraju 2007). Several vendors have produced ERP systems aimed at the small to medium sized organisation (Boyle 2007), because the ERP systems aimed at very large organisations are often too sophisticated and complex for smaller organisations (Computer Weekly 2010; Winkelmann and Leyh 2010).

An ERP system can thus be classified according to the size of the organisation that it is designed to support (Shaul 2005). Figure 2-1 illustrates the four tiers of ERP systems. Tier 1 ERP systems address the needs of very large organisations and include SAP, Oracle, Microsoft and SageERP (SYSPRO 2010). SAP is the leading ERP vendor and was formed in 1972 by five former IBM systems analysts (Monk and Wagner 2009; Magal and Word 2012). In 2008, SAP's market share in the ERP category was equivalent to the market share of the next four largest ERP vendors combined (Pang 2008).

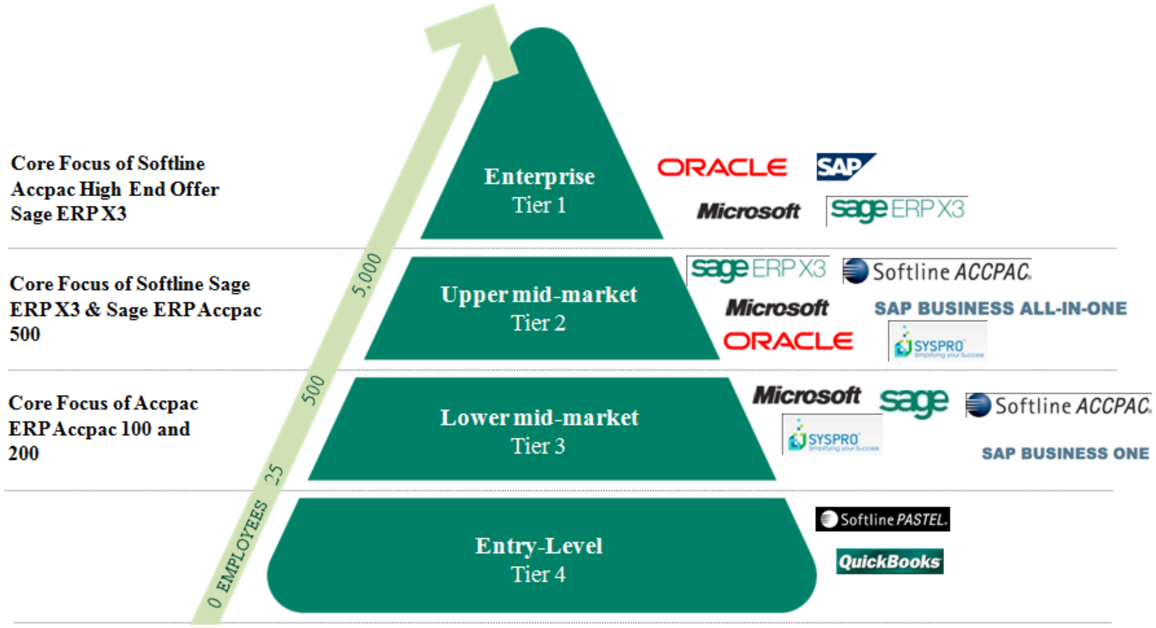

Figure 2-1 ERP Systems by Tier (SYSPRO 2010)

Vendors have introduced less complex ERP systems such as SYSPRO, Softline Accpac and others, which are specifically designed for organisations in Tier 2 (upper mid-market) and Tier 3 (lower mid-market). Tier 2 is the mid-sized tier and organisations in this tier are usually in the $20 million to $200 million dollars income bracket. ERP systems in Tier 2 include those in Tier 1 as well as SYSPRO, Softline ACCPAC and SAP Business All-In-One. Tier 3 software is designed for single site organisations of under $40 million dollars income and with 5 to 30 users. ERP systems for small to medium organisations are classified as Tier 4 software which comprises basic accounting systems and includes products such as Pastel, Accpac and Quickbooks (Shaul 2005).

2.3 Competencies Required for ERP Specialists

There is a shortage of ERP competencies globally and various strategies can be employed to improve these competencies (Willcocks and Sykes 2000). The use of external consultants from the ERP vendor, or from ERP resellers, that can complement or replace in-house skills has become desirable practice (Willcocks and Sykes 2000; Muscatello and Chen 2008; Law et al. 2010). The availability of skilled project members, including external consultants, and how to manage them, is essential for ERP success (Somers and Nelson 2004; Ngai et al. 2008). The high turnover rate of ERP skills and the difficulties with finding suitable ERP specialists have jeopardised many ERP projects (Tsai et al. 2005; Xue et al. 2005; Law et al. 2010). ERP project success is dependent upon an organisation having the appropriate specialised competencies in the project team (Duplaga and Astani 2003; Amoako-Gyampah 2004; Peslak 2005; Gartner 2006; Aloini et al. 2007; Ifinedo and Nahar 2009; Rothenberger et al. 2010). The demand for external consultants can limit ERP implementations (Wu and Wang 2007).

A demand for ERP specialists exists (Section 1.1.2). However, unlike general computer skills, ERP specialist competencies are not widely diffused in the working population (Davis and Comeau 2004). The skill sets of ICT practitioners, required by employers, are changing and employers are seeking an ever-increasing number and variety of skill sets from employees (Gallivan et al. 2004). ERP implementation requires a critical mass of knowledge to enable people to solve problems (Umble et al. 2003).

The wide range of ERP systems in the marketplace requires certain competencies of ERP specialists. Several studies have identified competencies that an ERP specialist should have (Shields 2001; Peslak 2005; Jensen et al. 2005; Seymour et al. 2006; Boyle 2007; Seethamraju 2007; Cronan et al. 2008; Pellerin and Hadaya 2008). ERP consultants must have a diverse set of knowledge and skills, which include system knowledge as well as business and industry-specific knowledge which makes it different from those in traditional IS contexts (Wang and Chen 2006). Only a few studies (Seymour et al. 2006; Mohamed and McLaren 2009; Boyle and Peslak 2010) have investigated ERP specialist competencies from the perspective of what provides value to industry, rather than from an academic viewpoint and only one of these (Boyle and Peslak 2010) included a survey of industry requirements.

This study found that for ERP specialists, common technical skills (for example, programming and networks) were found to be significantly less important than business skills and interpersonal skills such as team skills. Other studies have also identified interpersonal skills, also referred to as “soft” skills, as important competencies for IS professionals (Aken and Michalisin 2007; McMurtrey et al. 2008; Merhout et al. 2009). The Boyle and Peslak (2010) study is the most recent and comprehensive industry based study of ERP competencies; however it only evaluated competencies for core entry-level ERP specialists. Only two of the twenty-seven competencies identified in the Boyle and Peslak (2010) study were related specifically to ERP systems, and these are ERP programming and knowledge of ERP concepts. The other competencies are general competencies required of all IS practitioners. The needs of the organisations in the Boyle and Peslak study (2010) may differ from those in South Africa, since ERP implementation projects are impacted by the differences in language, culture, government, management style, and labour skills in different countries (Sheu et al. 2004).

ERP projects typically require a balanced combination of both business and technical competence (Somers and Nelson 2004). It has been argued that several of the competencies required by ERP specialists are applicable to all IS practitioners (Jensen et al. 2005; Boyle 2007) and are therefore regarded as *supporting* competencies, whilst those competencies that are specific to ERP specialists are referred to as *technical* competencies. A more comprehensive set of 42 ERP specialist competencies, grouped into 11 categories, is proposed (Table 2-1), in order to address the limitations of other studies. These competency categories are classified according to supporting competencies (Section 2.3.1) and technical ERP competencies (Section 2.3.2).

2.3.1 Supporting Competencies

Business, general management and interpersonal competencies common to other business disciplines, including IS, are also required by ERP specialists (Jensen et al. 2005; Boyle and Strong 2006; Boyle 2007). For this reason the four competency categories listed at the bottom of Table 2-1 (Interpersonal, Business, General Management and IS) are regarded as supporting competencies since they are not specific to ERP specialists, but apply in general to IS professionals.

Table 2-1 ERP Specialist Competencies[2]

Competency Category	Competency
ERP TECHNICAL COMPETENCIES	
Core ERP	
Business Process Management (BPM)	Knowledge of the typical business processes and activities in an organisation Knowledge of the importance of the integrated nature of business processes Ability to map organisational business processes with those in an ES software Process modelling knowledge Ability to use process modelling techniques Process modelling tool technical skills (e.g. Visio or ARIS)
ERP Transactions	The ability to create master data and perform transactions in finance The ability to create master data and perform transactions in sales The ability to create master data and perform transactions in procurement The ability to create master data and perform transactions in other modules
ERP Theory and Concepts	Knowledge of ERP theory and concepts Knowledge of ERP architectures
Supplementary ERP	
ERP Programming	Knowledge of good programming techniques Ability to program reports and interfaces with ERP programming tool
ERP Implementation and Configuration	Implementation knowledge Interface knowledge Knowledge of ERP implementation methodologies General configuration knowledge The ability to determine the appropriate approach for implementing an ERP The ability to evaluate different ERP software products The ability to map the organisational structure with the ERP elements The ability to configure an ES for implementing the relevant module
ERP Management	Ability to analyse the impact of ERP on organisations Knowledge of the nature and role of maintenance and upgrades of ERP
ERP Security	Internet and e-business security knowledge The ability to set up application security The ability to evaluate the current security of an organisation
SUPPORTING COMPETENCIES	
Interpersonal	Communication skills Ability to work co-operatively in a team Ability to interact with various groups Time-management skills Understanding of organisation culture
Business	Knowledge of business functions Financial accounting ability
General Management	General IT management skills Project management skills and knowledge
Information Systems (IS)	Database knowledge and skills Networking knowledge and skills Knowledge of general IS concepts Business analysis skills Systems analysis and design skills e-business knowledge and skills

[2] Core Technical; Supplementary Technical; Supporting

Interpersonal skills are extremely important for IS and ERP specialists who are required to interact with people at different levels in the organisation (Jeyaraj 2010). These skills are often grouped in the category of soft skills. Interpersonal skills include the following competencies:

- Communication skills (Jensen et al. 2005; Pellerin and Hadaya 2008);
- Ability to work co-operatively in a team (Boyle and Strong 2006; McMurtrey et al. 2008; Pellerin and Hadaya 2008; Tesch et al. 2008);
- Ability to interact with various groups in the organisation. This includes relationship and bridge-building skills (Shields 2001; Stratman and Roth 2002; Cameron 2008; Pellerin and Hadaya 2008);
- Time-management skills (Aken and Michalisin 2007); and
- Understanding of organisational culture of the user organisation (Jensen et al. 2005).

Business competencies include a knowledge and understanding of business functions and financial accounting ability (Peslak 2005; Jensen et al. 2005; Boyle 2007; Seethamraju 2007). General management competencies comprise IT management skills which include the ability for strategic IT planning (Stratman and Roth 2002), as well as IT project management competencies (Jensen et al. 2005). Project management skills are critical for ERP professionals in order to manage technology projects (Davis and Comeau 2004; Nah and Delgado 2006; Cameron 2008; Boyle and Peslak 2010) and for the success of ERP implementations and upgrades (Nah and Delgado 2006).

General IS skills include a broad, enterprise-wide understanding of databases, networks and a knowledge of general IS concepts (Shields 2001). Business analysis skills are critical to an ERP system specialist and include the ability to be able to analyse the business needs and translate those needs into technical solutions (Shields 2001; Cameron 2008; Boyle and Peslak 2010). E-business knowledge and skills are important for ERP specialists in today’s Internet-driven society since many ERP vendors now provide Internet versions of their software (Kalakota and Robinson 2000; Shields 2001).

The ability to devise e-business strategy is critical and for this skill it is important to have a knowledge and understanding of Internet technologies and to be able to devise an e-business strategy (Shields 2001; Jensen et al. 2005). ERP specialists must also have knowledge of e-business applications and of web design skills. Several studies (Becerra-Fernandez et al. 2000; Boyle 2007; Boyle and Peslak 2010) highlight the need for ERP specialists to have system analysis and design competencies as they need to be able to accurately elicit requirements and map them into the respective ERP system features.

2.3.2 Technical ERP Competencies

Several studies (Davis and Comeau 2004; Peslak 2005; Jensen et al. 2005; Boyle 2007) have identified technical competencies which are core to IS specialists working with ERP systems (Section 2.3.2.1). Other studies have cited the importance of more advanced or supplementary competencies to ERP specialists (Section 2.3.2.2).

2.3.2.1 Core Technical Competencies

The three core technical ERP competency categories required for ERP specialists are ERP Theory and Concepts, Business Process Management (BPM) and ERP Transactions. Several studies have cited the importance of ERP Theory and Concepts as a key competency for ERP specialists (Hawking and McCarthy 2000; Shields 2001; Davis and Comeau 2004; Peslak 2005; Jensen et al. 2005; Boyle and Strong 2006; Seymour et al. 2006; Boyle 2007). In addition to ERP theory, ERP specialists also need to be competent in the field of Business Process Management (BPM) (Davis and Comeau 2004). Business process knowledge includes understanding the delineation of key business activities within and between functional areas in the organisation, such as financial accounting, procurement manufacturing and sales (Shields 2001; Stratman and Roth 2002; Jensen et al. 2005; Boyle 2007; Cronan et al. 2008). BPM competencies also include process modelling skills as ERP specialists need to be able to identify, model, design, reorganise and implement processes in a business organisation (Becerra-Fernandez et al. 2000; Jensen et al. 2005; Jeyaraj 2010). ERP specialists also need the ability to use modelling tools such as Visio or ARIS (Pellerin and Hadaya 2008).

ERP Transactional or operational capability with the software is one of the primary, required skills of an ERP specialist (Davis and Comeau 2004; Seethamraju 2007; Cronan et al. 2008). ERP Transaction skills represent the extent to which an individual has the information systems' user skills required to utilise the application to perform transactions supporting business processes, as well as set up and understand the associated master data. ERP specialists should be able to have transactional competence in the core business processes of finance, sales and procurement (Boyle 2007).

2.3.2.2 Supplementary Technical Competencies

In addition to the core competencies required by ERP specialists, several more advanced or supplementary competencies are required. Four supplementary ERP competency categories are identified, namely, ERP Implementation and Configuration, ERP Programming, ERP Management, and ERP Security. ERP Implementation and configuration competencies are critical for ERP specialists (Seethamraju 2007) and include implementation knowledge and general configuration knowledge (Dong-Gil 2002) as well as implementation and configuration skills. Configuration is the process of changing a system setting in order to modify the way an application works (Shields 2001). Implementation knowledge is defined as the knowledge of activities associated with installing and testing ERP software and training employees (Dong-Gil 2002; Jensen et al. 2005) and includes the knowledge of implementation approaches/methodologies (Seethamraju 2007; Pellerin and Hadaya 2008). Interface knowledge is defined as the knowledge of the role and significance of ERP in its interface with other applications, for example, Supply Chain Management (SCM) systems and Customer Relationship Management (CRM) systems (Seethamraju 2007).

According to Seethamraju (2007), ERP implementation and configuration competencies include the skills and ability to determine the appropriate approach for implementing an ERP in a business organisation as well as the ability to evaluate different ERP software products and recommend a suitable one. The ability to configure and map the organisational structure with the ERP elements is also a key competency. ERP programming skills are important skills that may be required for ERP projects, especially if customisation is needed (Shields 2001; Rosemann and Watson 2002; Jensen et al. 2005; Boyle and Strong 2006).This includes the ability to program and test reports, interface programs and data conversion utilities for ERP, using tools provided with the package.

ERP management knowledge is defined as the extent to which an individual understands the impact of ERP on the organisation as a whole (Seethamraju 2007; Cronan et al. 2008). The skills required are the ability to analyse the impact of integrated information on managerial decision-making and on organisational structure, roles and responsibilities. ERP managers also require knowledge of the nature and role of maintenance and upgrades of ERP (Seethamraju 2007).

ERP security knowledge and skills are becoming important to ERP projects (Shields 2001; Boyle 2007) because of the increased number of risk areas and threats to an organisation brought about by the Internet. Information security knowledge and skills are therefore becoming important to ERP projects. These skills include the ability to set up application security and evaluate the current security of an organisation by identifying potential threats to the ERP system (Shields 2001).

2.4 Survey of ERP Specialist Employer Organisations

A demand for ERP specialists exists and ERP employer organisations struggle to obtain ERP specialists with industry-relevant knowledge and skills (Chapter 1). In South Africa, the government has undertaken several initiatives to increase ICT and ERP competencies (Chapter 1). However, it is not clear what the extent of the ERP skills problem in South Africa is or what competencies are required by South African organisations. Empirical evidence of what ERP competencies are required by South African ERP consulting organisations is limited. A survey was therefore conducted of ERP consulting organisations in South Africa in order to determine whether ERP consulting organisations have a problem with finding ERP specialists with industry-relevant competencies, and if so to determine the reasons for this problem.

2.4.1 Data Collection

The ERP employer organisations which were invited to participate in the study were selected based on certain criteria. These criteria included the following:

- The organisation had to be in the business of providing the outsourcing of ERP specialists to industry (as opposed to in-house ERP specialists);
- The organisation had to be typical of organisations that recruit university graduates for employment as ERP specialists;

- The organisation had to provide ERP consulting services for well-known ERP systems; and
- The sample needed to include an appropriate mix of employer organisations from the three primary geographical areas in South Africa.

The sampling method used to select participants was based on a combination of self-selection sampling and snowball sampling. The etiquette or netiquette for web-based surveys sampling (Saunders et al. 2009) was followed and a covering letter was sent to each organisation via email.

Twenty of the 22 ERP employer organisations approached to participate in the web-based survey agreed (91% response rate). The objectives of the research were first explained to the managers of each organisation and the managers in turn approached the ERP consultants employed by their organisation and asked them to complete the survey. One manager from each organisation was required to complete an *Organisation Questionnaire* (Appendix A), which consisted of the demographic details of the organisation relating to its size (in terms of number of ERP specialists) and the ERP systems supported.

2.4.2 Results

The size of the organisations varied from small (one to 20 ERP specialists) to large (more than 20 ERP specialists) and more than six different ERP systems were supported. Forty percent of the organisations employed more than twenty ERP specialists (Figure 2-2). The majority of participating organisations (n = 11) support the SYSPRO ERP system whilst several support more than one ERP system (Figure 2-3).

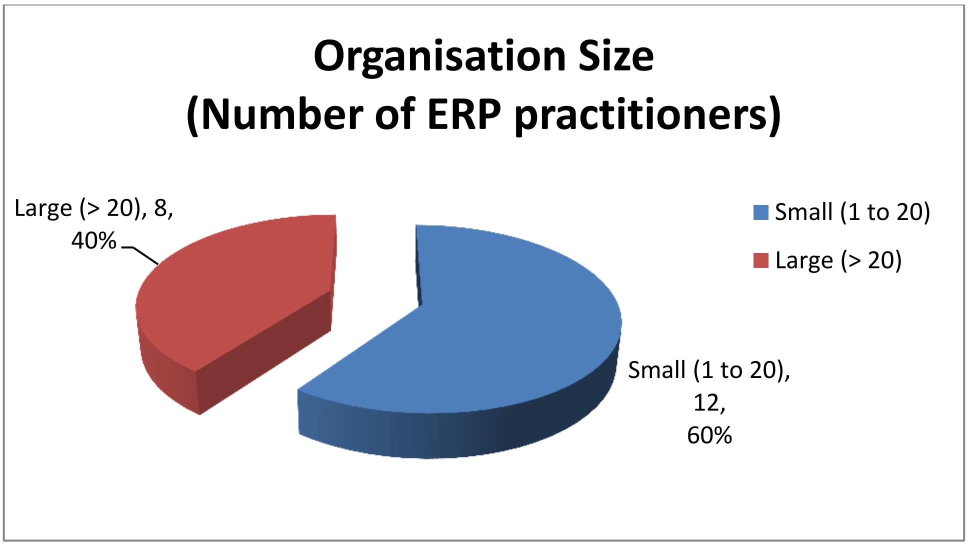

Figure 2-2 Organisation Size (*n* = 20)

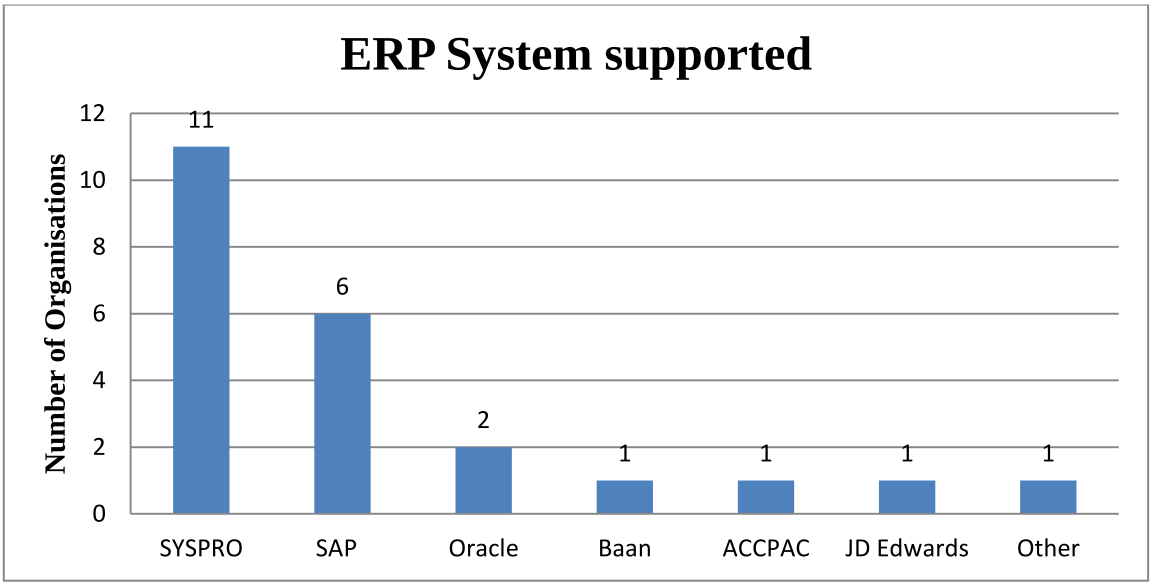

Figure 2-3 ERP System Supported by Organisation

In response to the question, *"Does your organisation struggle to find good ERP consultants?"* (Appendix A, Item 4), the majority of respondents (90%, *n* = 19) answered affirmatively. This high response confirms the challenge identified that there is a problem with finding quality ERP specialists (Chapter 1). The respondents were required to select which of three reasons were relevant to their organisation for struggling to find ERP consultants. More than one reason could be selected by the respondents. Of the total number of respondents, 95% (*n* = 19) said that poor quality of competencies was one of the reasons for the organisation's skills problem (Table 2-2), whilst 65% (*n* = 13) said they had the incorrect competencies.

Table 2-2 Reasons for ERP Skills Problem (*n* = 20)

Reason	Count	%
Poor quality competencies (have the competencies but they are not at the level you require)	19	95
Incorrect competencies (not the competencies you require e.g. too technical)	13	65
Insufficient applicants	11	55

The following question was also posed to the organisations:

"As an organisation what is your biggest challenge with regards to obtaining people with the ERP skills you require?" (Appendix A, Item 4)

A qualitative analysis of the responses to the question regarding the organisations' biggest recruitment challenge was performed and the responses were summarised and categorised (Saunders et al. 2009). As a result of the categorisation two main categories emerged. The first related to the need for business knowledge and skills and the second related to the requirement for ERP specialists to have a balance of both business and development or programming skills. One response, which was typical of the business and programming competency requirement theme, stated the following challenge faced by recruiting organisations: *"Finding people with a balance between analytical skills and development skills. Can find good Business Analysts & good developers, but not someone with both skills."* This challenge was identified by several participants in the survey (*n* = 4).

2.5 Survey of ERP Specialists

A survey was undertaken of ERP consulting organisations in South Africa in order to address the need for empirical evidence regarding industry requirements for competencies of ERP specialists. The primary purpose of the survey was thus to confirm the key core and supporting competencies required by ERP specialists (Table 2-1).

A total of 105 ERP specialists from the twenty ERP consulting organisations completed the web-based survey. The research instruments used in the survey were tested for reliability and validity and data from responses to both closed-ended and open-ended questions was collected from all participants (Section 2.5.1). The quantitative results from the closed-ended questions were statistically analysed (Section 2.5.2) and the qualitative data from the open-ended questions were analysed thematically (Section 2.5.3).

2.5.1 Data Collection

The research instrument used in the survey of ERP specialists consisted of a web-based questionnaire of ERP specialist competencies (Appendix B). A 7-point Likert scale was used to measure the respondents level of agreement with the importance of the competencies listed for an ERP specialist on the questionnaire (where 1 = *Strongly Disagree* and 7= *Strongly Agree*). Similar questionnaires using a 7-point Likert scale were also used in related studies by Nelson (2002), Seethamraju (2007), Boyle and Strong (2006) and Cronan et al. (2008). Respondents were asked to rate each competency on a scale of how important it is for the ERP graduate to possess each of the competencies presented in the questionnaire. In addition, a number of open-ended questions allowed respondents to identify additional competencies not presented in the questionnaire or to elaborate on a specific competency already presented.

The goodness of measure of a research instrument is mainly evaluated in terms of reliability and validity (Saunders et al. 2009). Reliability is operationalised as internal consistency, which is the degree of inter-correlation, equivalence, and homogeneity among the items which comprise a scale. Face validity is established if the items in the questionnaire are identified and agreed on by literature. Content validity can be established by means of a pilot test. The purpose of the test is to refine questionnaires so that respondents will have no problems in answering the questions and that there are no problems in recording the data. In order to establish content validity, a pilot test of the ERP specialist questionnaire took place and involved structured interviews with five ERP experts. These ERP experts were managers at the selected ERP employer organisations and all had more than five years' experience in the ERP field. The ERP experts were required to complete a pen-and-paper version of the ERP specialist survey questionnaire as well as an additional pilot questionnaire which contained questions relating to the validity of the instrument.

Based on the results of the pilot test, six competencies were added to the competency set. All six of the competencies added related to the ERP technical level, of which four are in the ERP Management category and two in the ERP Programming category. Both of these categories are in the supplementary level (Table 2-1). The competencies identified by participants that should be included in the ERP management category are the:

- Ability to analyse the impact of integrated information on managerial decision making;
- Ability to analyse the impact of individual employee actions on other functional areas;
- Ability to improve controlling of business operating expenses through ERP; and
- Ability to prepare management reports from ERP.

Several participants were concerned that there could be some confusion regarding the type of programming competencies required. For this reason the programming competencies were adjusted to differentiate between the various types of programming, namely 3rd Generation language (3GL), 4th Generation language (4GL) and ERP programming. In order to eliminate this confusion two competencies were added to the programming category, namely: Ability to program in a 3GL; and Ability to program in a 4GL. After the six competencies, identified in the pilot study, had been added to the original set of forty two competencies, the final competency set included in the web-based questionnaire consisted of forty eight competencies.

2.5.2 Quantitative Results

The internal consistency of the data obtained from the quantitative responses to the web-based survey was measured using Cronbach's alpha (Table 2-3). The instrument can be considered internally consistent as all of the values for Cronbach's alpha were in the range of 0.69 to 0.94, which is well within the acceptable range (Cavana et al. 2001). The statistical analysis performed on the web-based survey as well as the pilot study confirmed the sound psychometric properties of the data collection instrument in terms of its validity and reliability.

Table 2-3 Cronbach's Alpha for ERP Competency Categories

Competency Category Description	Code	Cronbach's Alpha (α)
Business	BUS	0.69
Business Processes	BPM	0.86
ERP Theory	ES	0.84
ERP Transactions	TR	0.94
ERP Implementation and Configuration	IMP	0.90
Programming	PRG	0.91
ERP Security	SEC	0.89
General Management	GMG	0.80
ERP Management	ERM	0.89
Information Systems	IS	0.87
Interpersonal	INT	0.88

The Pearson Product-Moment Correlations test (Rosenthal and Rosnow 2008) is performed in order to measure the strength of the linear relationship between the eleven competency categories (Appendix C, Table C.1). This test returns a correlation coefficient called Pearson's *r*. The value of Pearson's *r* ranges from 1.00 to -1.00. When the value is 0, it means that there is no linear relationship between the variables. If the value is -1.00 then it suggests a negative relationship between the two variables. In other words, any specific increase in the scores of one variable will perfectly predict a specific amount of decrease in the other variable. When the Pearson's *r* value between two variables is 1.00 then there is a positive relationship between them. That is, any increase in the scores of one variable will perfectly predict an increase in the scores of the other variable. Correlations are significant ($r > r_{Crit}$) at the .05 level, and practically significant where $r_{Crit} > .30$. All of the eleven categories were significantly positively correlated except for the Programming and Interpersonal categories ($r = 0.094$).

The demographic profile of the participants is summarised in Table 2-4. Three types of demographic details were considered that could possibly affect the participants' perceptions of the importance of the competencies required for ERP specialists. These were the responsibility or role of the participant (either manager or consultant), the geographical area in which the participant resides (Port Elizabeth, Cape Town or Johannesburg) and the participants' years of experience (0-5 years, 6 to 10 years or < 10 years). The majority of the respondents were ERP consultants (72%, *n* = 76) whilst the remaining 28% of respondents (*n* = 29) were ERP managers.

Table 2-4 Demographic Profile for ERP Specialists

Demographic Information		**n**	**%**
Role	ERP Consultant	76	72
	ERP Manager	29	28
	TOTAL	**105**	**100**
Geographical Area	PE	40	38
	Cape Town	23	22
	Johannesburg	42	40
	TOTAL	**105**	**100**
Experience	0-5 years	53	50.5
	6- 10 years	20	20
	More than 10 years	32	30.5
	TOTAL	**105**	**100**

The different profile groups may differ in their perception of the importance of the competencies for an ERP graduate. The multivariate ANOVA (MANOVA) was calculated to determine if there were differences between the scores for the eleven competency categories between the participant profiles (role, area or experience) (Cavana et al. 2001; Hair et al. 2006). The results of these tests show that there are no significant differences between the groups for either role, area or experience for the competency categories (Appendix C, Table C.2). For this reason they can be combined and the mean for each competency examined for the group as a whole.

A *t* test for differences was performed and Cohen's *d* was calculated to determine the significance of differences between the mean ratings of competency categories. The practical significance interpretation intervals used in the statistical analysis of the different surveys is shown in Table 2-5 and will be used to explain the significance of certain research findings (Gravetter and Walnau 2009).

Table 2-5 Practical Significance Interpretation Intervals (Gravetter and Walnau 2009)

		Practical Significance Interpretation Intervals		
Inferential Test	**Statistic**	**Small**	**Moderate**	**Large**
t test:	Cohen's *d*	$0.2 < d < 0.5$	$0.5 < d < 0.8$	d > 0.8
ANOVA:	Eta squared	$\eta^2 < .09$	$.09 < \eta^2 < .25$	$\eta^2 > .25$
Correlation:	*r*	$.10 < r < .30$	$.30 < r < .50$	$r > .50$

All categories of competencies are listed in Table 2-6 in descending order of importance as rated by respondents. The highest rated category was Interpersonal (μ = 6.35) and the second highest rated category was Business Knowledge (μ = 5.43). The lowest rated category was ERP Programming (μ = 4.35) and the second lowest was ERP Security (μ = 4.39). Analysing the ERP technical level competencies only, the highest rated category is Business Process Management (μ = 5.34), second ERP implementation (μ = 5.29) and third is ERP Transactions (μ = 5.23).

The significant differences (Cohen's *d*) are listed in italics and in red. Four significant groupings (Rank 1 to 4) were identified and a border is drawn around each significant group. Full details of the results of the *t* test for differences between competency categories are listed in Appendix D. Throughout this study any reference to a p-value being significant means that there is statistical significance as well as practical significance (Cavana et al. 2001). Any p-value less than 0.0005 will be reported as zero.

Table 2-6 ERP Competency Categories (In order of importance)[3]

Competency Category	Rank	n	Mean	SD	Min	Median	Max	p-value	Cohen's *d*
Interpersonal	1	105	6.35	0.66	4.20	6.40	7.00	.000**	*0.81 (Large)*
Business	2	104	5.43	1.15	1.50	5.50	7.00	.207	0.08
Business Process Management	2	105	5.34	0.94	3.00	5.33	7.00	.112	0.12
ERP Implementation & configuration	2	105	5.29	1.03	2.38	5.38	7.00	.051	0.16
ERP Transactions	2	104	5.23	1.20	2.00	5.00	7.00	.016*	0.21
ERP Management	2	105	5.18	1.03	2.33	5.17	7.00	.002*	*0.30 (Small)*
General Management	3	105	5.03	1.32	1.00	5.00	7.00	.365	0.03
Information Systems	3	105	4.99	1.07	1.83	5.17	7.00	.060	0.15
ERP Theory and Concepts	3	105	4.81	1.28	1.00	5.00	7.00	.000*	*0.42 (Small)*
ERP Security	4	105	4.39	1.62	1.00	4.33	7.00	.401	0.02
ERP Programming	4	105	4.35	1.60	1.00	4.50	7.00		

* p-value ≤ 0.05 ** p-value ≤ 0.01

Figure 2-4 illustrates the frequency distribution of the eleven ERP technical and supporting competency categories (Table 2-1) according to three groups, Negative, Neutral and Positive. The lower and upper values[4] selected for the three groups are negative [1 to 2.71), neutral [2.71 to 5.29], and positive (5.29 to 7].

The Interpersonal category had the highest frequency count in the positive range (n = 96). ERP Programming had the lowest frequency count in the positive range (n = 30). The lowest frequency count in the negative range was Interpersonal and BPM which both had a count of zero. The competency with the highest frequency count in the negative range was Security (n = 20). Descriptive statistics were calculated for each competency item and the full list of ERP competencies with descriptions is included in Appendix E (Table E.1) together with their mean scores.

[3] Core Technical; Supplementary Technical; Supporting

[4] [Greater than or equal to;) Less than

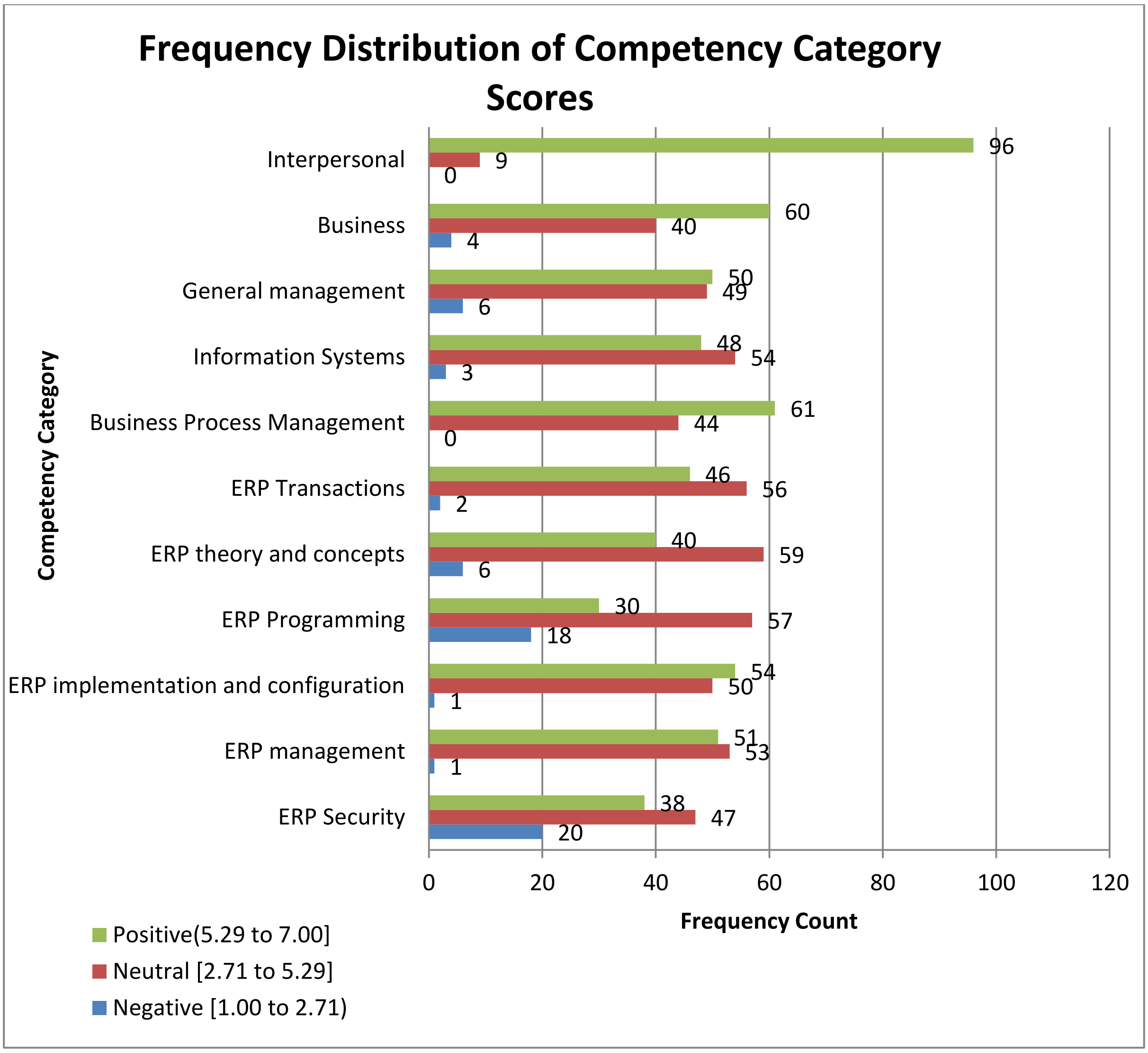

Figure 2- 4 Frequency Distribution of Competency Categories

A *t* test for differences was performed on each of the competency items to determine significant differences between them (Appendix E, Table E.2). The p-value was Bonferroni adjusted since more than one comparison is made for this test. Eight significant groups were identified. Significant groups are grouped in their own boxes and colour in Table 2-7 which lists the three significantly highest rated groups of competencies in the ERP technical level in order of importance from most important (Rank = 1) to least important (Rank = 3). The competency that rated the highest in the ERP technical level was "*Knowledge of the importance of the integrated nature of business processes",* which is in the BPM category. The top three competency items all fall into the BPM category, whilst the next four competency items are all in the ERP Implementation category.

Table 2-7 Significantly Highest Rated Groups for ERP Technical Competency Items [5]

Rank	Competency		Mean	Std Dev	Category
1	5.2	Knowledge of the importance of the integrated nature of business processes	5.87	1.12	Business Process Management (BPM)
	5.1	Knowledge of the typical business processes and activities in an organisation (e.g. fulfilment, procurement)	5.83	1.2	
2	5.3	Ability to map organisational business processes with those in ERP	5.70	1.18	
	8.8	The ability to configure ERP for implementing the relevant module	5.46	1.31	ERP Implementation
	8.5	Ability to determine the appropriate approach for implementing ERP	5.45	1.27	
	8.7	Ability to map the organisational structure with the ERP elements	5.44	1.41	
	8.1	Implementation knowledge (the knowledge of activities associated with installing, testing & training ERP software)	5.44	1.33	
3	13.6	Ability to prepare management reports from ERP	5.36	1.38	ERP Management

2.5.3 Qualitative Results

The questionnaire included several open-ended questions, which gave participants the opportunity to identify any interpersonal or technical competencies that were not included in the list. The responses were summarised and classified into categories and the frequency of these categories counted (Saunders et al. 2009). Several additional interpersonal and technical competencies were listed by respondents. The top two most popular categories are listed in Table 2-8 together with the respective frequency counts. The top two most frequently identified additional interpersonal competency listed was *"The ability to listen"* (*n* = 14), whilst the competency item *"Problem solving"* had the second highest frequency count (*n* = 12). The technical competency with the highest frequency count (*n* = 11) was *"Report design and writing skills"*, followed closely by *"Excel skills"*. These top two items in the Interpersonal category and Technical category were added to the set of competencies required for ERP specialists (Table 2-9).

5 Core Technical; Supplementary Technical; Supporting

Table 2-8 Additional Key Competencies for ERP Specialists

Competency Category	Frequency Count	%
InterPersonal Competencies		
Ability to listen	14	70
Problem solving	12	60
Technical Competencies		
Report Design and Writing skills	11	55
Excel skills	8	40

Several respondents identified the need for an ERP specialist who is versatile and possesses a broad range of competencies. One response which was typical of the versatility requirement stated that:

> *"It is desirable for ERP graduates to acquire an holistic view of how businesses operate; they will talk to many different people in a customer organisation, each person possibly a specialist in his field; they need to know enough about each area of business to inspire a reasonable level of confidence".*

2.6 Conclusion

A demand for industry-relevant ERP skills and knowledge exists globally. Based on a review of the literature, a set of competencies required for ERP specialists was compiled (Table 2-1). Eleven categories of competencies are identified of which four are supporting competencies and seven are ERP technical 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 seven ERP technical competencies are:

- Business Process Management (BPM);
- ERP Transactions;
- ERP Theory and Concepts;
- ERP Programming;
- ERP Implementation and Configuration;
- ERP Management; and
- ERP Security.

The set of 42 competencies in the 11 categories (Table 2-1) was evaluated in a pilot study where participants had the opportunity to identify additional competencies not listed. The final key competencies for ERP specialists were then included in a web-based survey of ERP specialists at South African organisations. This survey confirmed that there is a problem in obtaining these skill and knowledge competencies. The survey results also confirmed the competency set, although several additional competencies were identified from the open-ended questions of the survey and added to the final set of ERP specialist competencies (Table 2-9). The two additional competencies added to the Interpersonal category were *Ability to listen* and *Problem solving.* Two additional supporting ERP technical competencies, identified from the survey, were *Report design and writing skills* and *Excel skills.*

The highest rated significant group consisted of the Interpersonal category. From this it can be deduced that interpersonal competencies are extremely important for ERP specialists, in spite of the fact that the majority of studies have not addressed this area of competencies. The second most significant group of competency categories included Business, Business Process Management (BPM), ERP Implementation and Configuration, ERP Transactions, and ERP Management.

The competency categories of General Management, Information Systems, and ERP Theory and Concepts all formed part of the third most significant group of competency categories. The fourth and least most significant group included the categories of ERP Programming and ERP Security. The survey results confirmed research identifying the importance of business process management competencies for ERP specialists, since the two highest rated ERP competencies were:

- Knowledge of the importance of the integrated nature of business processes; and
- Knowledge of the typical business processes and activities in an organisation.

Table 2-9 Final Set of Competencies for ERP Specialists[6]

Rank	Competency Category	Competency
1.	Interpersonal	Communication skills Ability to work co-operatively in a team Ability to interact with various groups Time management skills Understanding of organisation culture Ability to listen Problem Solving
2.	Business	Knowledge of business functions Financial accounting ability
3.	Business Process Management (BPM)	**Knowledge of the importance of the integrated nature of business processes** **Knowledge of the typical business processes and activities in an organisation** Ability to map organisational business processes with those in an ERP software Process modelling knowledge Ability to use process modelling techniques Process modelling tool technical skills (e.g. Visio or ARIS)
4.	ERP Implementation and Configuration	Implementation knowledge Knowledge of ERP implementation methodologies Interface knowledge General configuration knowledge The ability to determine the appropriate approach for implementing an ERP The ability to evaluate different ERP software products The ability to map the organisational structure with the ERP elements The ability to configure an ERP for implementing the relevant module
5.	ERP Transactions	The ability to create master data and perform transactions in finance The ability to create master data and perform transactions in sales The ability to create master data and perform transactions in procurement The ability to create master data and perform transactions in other modules
6.	ERP Management	Knowledge of the nature and role of maintenance and upgrades of ERP Ability to analyse the impact of ERP on organisations **Ability to analyse the impact of integrated information on decision making** **Ability to analyse the impact of individual employee actions on other functional areas** **Ability to improve controlling of business operating expenses through ERP** **Ability to prepare management reports from ERP**
7.	General Management	General IT management skills Project management skills
8.	Information Systems	Database knowledge and skills Networking knowledge and skills Knowledge of general IS concepts Business analysis skills Systems analysis and design skills e-business knowledge and skills Report design and writing skills Excel skills
9.	ERP Theory and Concepts	Knowledge of ERP theory and concepts Knowledge of ERP architectures
10.	ERP Security	Internet and e-business security knowledge The ability to setup application security The ability to evaluate the current security of an organisation
11.	ERP Programming	Knowledge of good programming techniques **Ability to program in a 3rd Generation language (e.g. C#)** **Ability to program in a 4th Generation language (e.g. SQL server)** Ability to use good general programming techniques using your ERP

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[6] Core Technical; Supplementary Technical; Supporting

Bold = Most important competency; **Purple** = Added from pilot study; Red = Added from survey

This chapter has successfully addressed the first research question regarding *"What competencies (skills and knowledge) are required for an ERP specialist by ERP consulting companies in South Africa?".* The findings in Table 2-9 are a major contribution to both government and academic initiatives in South Africa to address both the e-skills problem as well as the need for ERP specialists, since they provide a standardised and comprehensive set of industry-relevant competencies required for ERP specialists which is the starting point of any skills improvement program. In addition, when designing ERP systems or ERP learning tools, designers should take into account the industry-relevant competencies required of ERP specialists.

IS departments are encouraged to consider the requirements for these competencies when implementing an ERP programme in order to ensure that they are meeting industry needs. For IS departments that already have an ERP programme in place, the set of competencies can be used to determine how well the programme is meeting the needs of industry. The next chapter will therefore address the tools, approaches, environments and frameworks that can be used for designing, developing, classifying or evaluating ERP education programmes.

Chapter 3: ERP Systems in Higher Education

3.1 Introduction

The trend towards ERP systems in large, medium and small organisations has had a significant impact on IS career tracks (Barnes and Ferguson 2008). One of these career tracks is that of the ERP specialist. ERP specialists are highly sought after globally and ERP consulting organisations in South Africa have problems recruiting ERP specialists with industry-relevant competencies (Section 2.4.2). Each of these competencies must be attained by graduates who wish to be employed as ERP specialists (Venakatesh 2008).

The demand for ERP specialists has led to pressure for ERP education to be included as an important part of IS curricula in higher education (Antonucci et al. 2004; Peslak 2005; Boyle and Strong 2006; Boyle 2007; Ask et al. 2008; Kreie et al. 2010). Consequently, more and more universities are beginning to implement some type of ERP system into business degree programmes (Willems and Bhuiyan 2006). The adoption of ERP systems is not an easy process and Antonucci et al. (2004) report that, whilst some HEIs have successfully incorporated ERP systems into their business or IS curriculum, others are struggling with the process. The changing demand patterns necessitate life-long learning skills not only for IT practitioners but also for the educators who teach them (Gallivan et al. 2004).

It is clear that there is a need for ERP education in IS curricula in higher education. However, the extent to which the competencies are taught will depend upon the nature of the programme into which the ERP system is adopted (Boyle and Strong 2006). Educators struggle to respond to dynamic changes in business environments (Grandzvol 2004).

Researchers and educators are unclear on the degree to which ERP systems should be integrated into curricula. Boyle (2007) believes that educators need an approach that ensures that the ERP content which is taught as part of an IS programme is complete, current, relevant and adequately prepares the student for entry level positions in organisations. The demand for ICT professionals also applies pressure for relevant programmes, however educators are also faced with a decline in enrolment for Computer Science and IS programmes (Mashaw 2009).

According to Boyle (2007), despite the demand for ERP specialists worldwide, HEIs have been slow to incorporate the technical competencies of ERP systems (Section 2.3.2) into IS curricula. This delay in incorporating ERP technical competencies into the IS curriculum has increased the gap between the competencies required by industry and the content of IS programmes in HEIs (Wang and Chen 2006). The question that must therefore be addressed is how well ERP programmes of HEIs meet the needs of organisations (Jensen et al. 2005; Boyle and Strong 2006). The complexity and the immense range of functions of ERP systems, as well as the extensive theoretical learning content of the underlying theory, places high demands on students (Eicker et al. 2007).

Jensen et al. (2005) state that in order to ensure that ERP programmes meet the needs of industry, it is important first to empirically identify the key competencies expected from IS graduates who will work as ERP specialists (Table 2-9). In order to attain these competencies, it has been proposed that educators of ERP systems must bring the issues and practices of industry to the classroom (Antonucci et al. 2004). One of the goals of an ERP programme is to prepare students for their career by giving them exposure to the various ERP systems available on the market (Strong et al. 2006; Peters and Haak 2010; Winkelmann and Leyh 2010). It is necessary therefore for HEIs to offer appropriate systems, strategies and suitable courses for their students. There is no standardised approach to ERP education. The choice and number of ERP systems adopted, as well as the competencies addressed and structure of courses, vary from institution to institution (Seethamraju 2007). The research question that this chapter will address is *"What frameworks and approaches can be used to adopt ERP systems into the IS curricula?" (RQ2).*

ERP education frameworks must consider industry requirements for ERP competencies (Chapter 2), and they also need to take into account the educational context of these requirements. Educational context includes the higher education policies, standards and influences of a country as well as international educational influences (Section 3.2). Instead of exposing students to the complexity of ERP systems, some studies have proposed using other, simpler, learning tools such as ERP simulators for developing ERP competencies (Section 3.3).

The adoption of ERP systems into a curriculum is a challenging process and several decisions need to be made by educators regarding the type of learning tool to be adopted, the level of adoption and the competencies that must be attained. Several studies have proposed ERP education frameworks that provide guidance to educators regarding the decisions with which they are faced when designing curricula (Sections 3.4). These frameworks should provide a set of beliefs, ideas or rules that can be used as the basis for making decisions (Chapter 1).

Studies of ERP system adoption into the curricula internationally (Section 3.5) and in South Africa (Section 3.6) have reported an improvement in several competencies but less significant improvement in others has been cited. The majority of these adoptions used ERP systems, such as SAP R/3, designed for large organisations, which are feature-rich, complex and not designed for learning (Shtub 2001; Winkelmann and Matzner 2009). Winkelman and Matzner (2009) propose that ERP systems designed for smaller organisations can achieve similar results with less frustration. Lessons learned from various experiences of ERP adoption can provide criteria for the selection of an ERP learning tool (Section 3.7).

3.2 Educational Context

Since 1996 there have been a number of policy documents defining critical outcomes of acceptable qualifications in HEIs (Dearing 1997; AQF 2010; NQF 2010). Defining qualifying learning outcomes, rather than objectives, classified in a National Qualifications Framework (NQF) has become the trend of higher education policy for a number of countries, for example Australia (AQF 2010), the United Kingdom (Dearing 1997), New Zealand and South Africa (NQF 2010). The implementations of an outcomes or qualifications-based education framework can provide a much more flexible approach to higher education.

In South Africa in 2005 Higher Education South Africa (HESA) was formed from the merger of two statutory representative organisations for universities and universities of technology (HESA 2010). HESA represents all public universities and Universities of Technology in South Africa and its mandate is to strengthen research and innovation in higher education. In 2007 the Higher Education Qualifications Framework (HEQF) was introduced to regulate all higher education programmes, curricula and qualifications in South Africa. Higher education institutions and specifically computing-related departments will need to adhere to the HEQF guidelines when designing curricula (Van Koller 2010).

In 1998, the South African Qualifications Authority (SAQA) published the regulations for the establishment of a NQF and procedures for the accreditation of qualifications (SAQA 2010). SAQA has recognised the need for ERP specialists in South Africa and for this purpose have registered a National Certificate in Business Consulting Practice (Enterprise Resource Planning). The competencies outlined in the SAQA ERP qualification (SAQA 2010) are in line with those identified as key to an ERP specialist (Table 2-9). All education programmes in South Africa need to adhere to the NQF and SAQA guidelines.

South African education organisations, SAQA and NQF, propose the use of an outcomes or competency-based curriculum (AQF 2010; NQF 2010). This concept of a competency-based curriculum is supported by other international studies in education (Dearing 1997) and for computing sciences curricula (Pinto 2010). Pinto (2010) proposes that curriculum designers need 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.

According to Pinto (2010), designers of new Computer Science curricula must articulate intended learning outcomes that align with competencies. Academic administrators must ensure that academic programmes deliver on the student performance in the expressed competencies. More recent studies of ERP education (Ask et al. 2008; Wang et al. 2009; Peters and Haak 2010) also support a competency-based education approach and emphasise 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 and this approach has been recommended for ERP courses in higher education by some studies (Choi et al. 2007; Jeyaraj 2010). A learner-centred teaching approach allows a more active and participatory role for students and has been incorporated into research studies of ERP systems in education (Peters et al. 2010). This development is happening because traditional educational systems are not considering the student's needs. The Wang et al. (2009) study incorporated the competencies needed for ERP specialists and implemented a learning-by-doing approach and the results showed that this motivated students to learn new materials by themselves.

The concept of a competency-based curriculum is also supported by the international IS 2010 curriculum (ACM 2010). This curriculum has addressed the demand for ERP specialists with industry-relevant competencies (Chapter 2), by the incorporation of an "*ERP specialist"* as one of several IS career tracks. This curriculum provides guidelines for undergraduate degree programmes in IS, which are published by the Association for Computing Machinery (ACM) and the Association for Information Systems (AIS). The IS 2010 report is the latest output from model curriculum work for IS that began in the early 1970s. The major difference between this and previous versions of the curriculum is that the curriculum is structured so that it separates the core of the curriculum from electives and introduces the concept of career tracks. Each career track requires both core and elective content.

The IS2010 curriculum includes a course entitled *"Enterprise Architecture"* which is now included as core for all IS graduates (ACM 2010) and one of the objectives of Enterprise Architecture is to understand ERP systems. An additional course called "*Enterprise Systems"* is listed as an elective for the IS curriculum but recommended for the ERP specialist career track. The Enterprise System course objectives state that the hands-on use of an ERP system is not prescribed, but is strongly recommended, and *"The importance of actual use is clear. Enterprise system software is in place in a majority of large organisations and increasing in use in small and medium-sized organisations."*

A competency metric with five levels is used in the IS2010 curriculum, of which only the first four are applicable to undergraduate curricula. These four levels are the focus of this study. Postgraduate curricula are therefore outside the scope of this study (Section 1.8). The four levels for undergraduate curricula are listed in Table 3-1, and are Awareness, Literacy, Concept/Use Skill and Detailed Understanding/Application.

Table 3-1 IS2010 Competency Metric for Undergraduate Programmes

ACM (2010)	Bloom (1956)	Description	Application
Awareness (Level 1)	Knowledge (Level 1)	Introductory Recall and Recognition	Class presentations, discussion groups, reading, watching videos, structured laboratories. Involves only recognition, but with little ability to differentiate. Does not involve use.
Literacy (Level 2)		Knowledge of Framework and Contents, Differential Knowledge	Continued lecture and participative discussion, reading, team work and projects, structured labs. Requires recognition knowledge as a prerequisite. Requires practice. Does not involve use.
Concept/Use Skill (Level 3)	Comprehension (Level 2)	Comprehension and Ability to Use Knowledge *when Asked/Prompted*	Requires continued lab and project participation, presentation involving giving explanations and demonstrations, accepting criticism; may require developing skills in directed labs.
Detailed Understanding/ Application (Level 4)	Application (Level 3)	Selection of the Right Thing and Using It *without Hints* Semi-structured team	Semi-structured team-oriented labs where students generate their own solutions, make their own decisions, commit to and complete assignments, and present and explain solutions.

The IS2010 levels of knowledge are based on, but not identical to the work of Bloom (1956) who describes a six-level metric of which the first three are applicable to undergraduate curricula, namely: Knowledge, Comprehension and Application (Bloom 1956). The IS model curriculum levels differ from Bloom's levels in that the IS curriculum levels 1 and 2 are mapped to Bloom's knowledge level (level 1) and IS curriculum levels 3 and 4 are mapped to Bloom's levels 2 and 3 respectively. The knowledge levels of IS 2010 are designed to give guidance to educators in planning as well as in the analysis of outcomes. IS educators should take cognisance of these four levels of knowledge for designing and implementing programmes that adopt ERP systems in IS undergraduate curricula.

3.3 Selecting ERP Learning Tools for HEIs

International curricula and education standards can assist educators with guidance regarding course content, however educators also need to decide what ERP system, if any, to adopt in the curriculum. There are many different ERP vendors in the market today (Section 2.2) and each offers different ERP solutions (Baltzan and Phillips 2009). According to Baltzan and Phillips (2008) customers sometimes find that their chosen ERP systems do not meet their expectations. For this reason it is important to ensure that adequate planning is done and to study ERP implementation problems and how to avoid them.

Several ERP systems have been used in IS education and studies have shown the benefits of the hands-on use of ERP systems for instructional purposes. IS graduates with hands-on experience of ERP systems will have a stronger and more desirable set of work skills (Kreie et al. 2010; Scholtz 2011). However, Shtub (2001) believes that these ERP systems are typically designed for use in industry and are not specifically designed for learning. Other authors agree and believe that ERP simulators can achieve equal or better results (Noguera and Watson 2004; Scott and Walczak 2009; Lindoo and Wilson 2010) with less frustration than the hands-on use of an industry ERP system (Shtub 2001). One study (Léger et al. 2011) of the use of an ERP simulation game called ERPsim as well as the hands-on use of an ERP system in a business course, reported improvements in student motivation and student competence. In this study, the term ERP learning tools will be used to refer to both industry ERP systems and ERP simulators.

The ERP learning tool, adopted into a curriculum, must support the attainment of industry-relevant competencies for ERP specialists (Table 2-9). Curricula must also incorporate more abstract, formal knowledge in accordance with the aims of higher education (Surendran et al. 2006). In contrast, courses offered to industry by ERP vendors provide vocational training and are therefore often not viable for direct use in curricula courses. ERP knowledge can be divided into three types, namely: Procedural, Application Conceptual and Business Context Knowledge (Sousa and Goodhue 2003). Procedural knowledge is described as "the understanding of the syntax and semantics of the application commands, how to combine them, and how to use them to complete a job task".

Application conceptual knowledge of ERP systems is the understanding of the business processes' workflow mapped in the application. Knowledge of how all the modules work together in the ERP system is also included in application conceptual knowledge. Business context knowledge is the understanding of the processes specific to the business, their goals and their interdependencies across the organisational functions.

Studies (Umble et al. 2003; Ngai et al. 2008) of ERP implementations have reported that training and education are among the most frequently cited critical factors for the successful implementation of ERP systems. ERP training has become a large business in itself, since if employees do not know how to use the ERP system effectively, the overall success of the system will be diminished (Dowlatshahi 2005). End-user training has therefore been the focus of much research in order to improve ERP implementation success (Coulson et al. 2003; Motwani et al. 2005; Choi et al. 2007; Seymour et al. 2007). A study (Coulson et al. 2003) of end-user training in industry found that conceptual training improves the end-user's ability to recall and articulate ERP concepts.

It is a challenge to ERP educators to design a programme that assists students with attaining the ERP competencies relevant to industry, and also find a balance between the attainment of procedural knowledge and skills, and conceptual knowledge of management theory and practices (Jensen et al. 2005; Wang et al. 2009; Peters and Haak 2010). Step-by-step ERP exercises are not always adequate to convey to students business process concepts embedded in ERP systems (Rienzo and Han 2010). The instructional use of ERP learning tools by students creates several challenges for educators as students do not always obtain the required levels of both conceptual knowledge and procedural skills. One of the challenges encountered is that students do not always understand why tasks are performed (Wang et al. 2009).

Additional challenges to educators include the shortage of suitably trained academics (Becerra-Fernandez et al. 2000; Guthrie and Guthrie 2000; Cameron 2008) as well as a shortage of educational resources (Becerra-Fernandez et al. 2000; Bradford et al. 2003; Seethamraju 2007; Barnes and Ferguson 2008).

The resource costs of hardware, software, instructors and instructional content for ERP systems are often too high for academic budgets (Guthrie and Guthrie 2000; Seethamraju 2007; Barnes and Ferguson 2008; Cameron 2008; Kanthawongs 2011). Instructional content also includes the availability of demonstration data which illustrates the key concepts to be taught and is also an important factor for selecting an ERP system to adopt in the curricula (Ask et al. 2008). In addition several usability problems with the user interface (UI) of ERP systems, when used for instructional purposes have been reported (Nelson 2002; Surendran et al. 2006; Scholtz et al. 2010). The challenges faced by educators need to be taken into account when making a decision regarding what ERP learning tools to adopt in the curricula.

In an effort to address the challenges faced by educators, ERP vendors (for example, SAP, Microsoft, Oracle) have formed strategic academic alliance programs with HEIs around the world (Surendran et al. 2006; Springer et al. 2007; Kreie et al. 2010). SAP, Peoplesoft and JD Edwards are leading in this initiative with SAP having the greatest adoption rate of any other ERP vendor in HEIs (Sager et al. 2006; Seethamraju 2007). These strategic alliances provide a university with completely functional industry ERP systems for teaching and research. The SAP University Academic Alliance Program provides educators with the tools, resources and model data necessary to teach students how technology can enable integrated business processes and strategic thinking (SAP 2010). These alliances provide an active learning environment and can provide an opportunity to bridge the gap between competencies of university graduates and those required by industry (Barnes and Ferguson 2008).

3.4 ERP Education Frameworks

Several ERP learning tools are available to educators for instructional purposes in an ERP programme. Educators need to decide which of these tools they will use in their ERP courses and to what degree or level they will adopt them into the curriculum. An ERP education framework should support decisions regarding the level of adoption of ERP tools into the curriculum and the competencies to be attained. A framework for IT education was proposed by Mashaw (2009) which supports the changing needs of IT graduates. However the focus of this framework is on general IS qualification where ERP is just one area of specialisation and it does not analyse the specific competencies required for ERP specialists.

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 breadth and depth (Section 3.4.1). Other studies proposing ERP education frameworks (Peslak 2005; Boyle 2007; Wang et al. 2009) complement the classification by providing guidance in terms of the courses that should be provided (Section 3.4.2). Boyle (2007) proposes an ERP Technical Knowledge classification framework for education (Section 3.4.3). Wang et al. (2009) propose a framework which supports the teaching of ERP/SAP implementation (Section 3.4.4). Although there are many advantages to existing ERP education frameworks, there are still several shortcomings (Section 3.4.5).

Several frameworks for ERP education are not investigated since they are considered outside the scope of this study (Section 1.8). These include those designed for postgraduate courses which focus on advanced ERP competencies (Pellerin and Hadaya 2008), as well as those which are designed for mature organisations considering implementing ERP systems in more than one discipline in the curricula (Antonucci et al. 2004). Studies of collaborative e-learning frameworks for ERP systems (Rusu et al. 2008) are also not included in the scope of this study.

3.4.1 Breadth and Depth of Adoption

A framework proposed by Guthrie and Guthrie (2000) describes five levels of ERP adoption into the business curriculum (Table 3-2). These levels can be introduced into a curriculum incrementally, and are referred to by Rosemann and Watson (2002) as the depth of adoption. 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 they are not required to actually use an ERP system. At the tutorial level, students simulate transactions using a Web browser, or CD-ROM, simulation tool or tutorial.

Table 3-2 Summary of Depth of Adoption of ERP Systems (Guthrie and Guthrie 2000)

Level of Adoption Depth	Description
Integrated Practicum	Integrated term-long project in which students use ERP systems as they would in industry
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
Enterprise Model	Exposure to ERP through class lectures and demonstration (PowerPoint Approach)

In the hands-on approach, which is 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. 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 and Guthrie 2000).

Rosemann and Watson (2002) describe ERP education as being characterised by the *Breadth of the solutions used* in the programme. The breadth of the educational experience will increase as the involved team grows from a single-faculty member to a team of faculty from different departments. Four different levels of breadth are described (Table 3-3), and include 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 usage 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 and show true business process integration between modules.

Table 3-3 Summary of Breadth of Adoption of ERP systems

<table>
<tr><th colspan="2">Level of Adoption Breadth</th><th rowspan="2">Description
(Rosemann and Watson 2002)</th><th colspan="2">Tier
(Springer et al. 2007)</th></tr>
<tr><th>Name</th><th>Level</th><th>Tier</th><th>Lab Type</th></tr>
<tr><td>Integration</td><td>III</td><td>Teaching the entire ERP core where more than one sub-module is used and examples of integration are examined.</td><td>Tier III</td><td>Configure</td></tr>
<tr><td>Modules</td><td>II</td><td>Students are exposed to an entire sub-module (for example, accounts payable).</td><td rowspan="2">Tier II</td><td rowspan="2">Master data, transactions</td></tr>
<tr><td>Transactions</td><td>I</td><td>Only selected transactions are executed (for example, entering a purchase order).</td></tr>
<tr><td>Browsing</td><td>0</td><td>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.</td><td>Tier I</td><td>Display Only</td></tr>
</table>

Springer et al. (2007) propose a similar approach to implementing ERP in a curriculum consisting of three-tiers, where Tier II can be linked to Levels I and II proposed by Rosemann and Watson (2002) and adopted in this study. However in addition to the levels of adoption, Springer et al. (2007) allocates additional course properties onto one of the three tiers (Table 3-4). Students at Tier I do not have much experience navigating the ERP interface and time for practical sessions is usually limited, therefore in order to make the laboratory session run smoothly, tasks at this tier should be display only. Transactions can be entered into the system prior to a session by an instructor, and the session tasks can then instruct students on how to navigate through the transactions and related master data. At this level a single client can be used and all students then access the same data.

Table 3-4 Properties of Courses in Each Tier (Springer et al. 2007)

Tier	Knowledge Objective	Course Level	Course Type	Lab Content (as % of course)	Lab Type
III	Integrative	Advanced	Cross-functional	75-100%	Configure
II	In-depth	Advanced	Functional	10-50%	Master Data/ Transactions
I	Exposure	Introductory	Functional	5-10%	Display Only

At Tier II students gain specific, in-depth knowledge of the ERP components related to the course. It therefore needs a larger time investment. At Tier III, students will focus on the cross-functional and integrative nature of ERP. A course in Tier III will focus on implementation, configuration and integration issues and students should therefore develop competencies in the ERP implementation and configuration category (Table 2-9). Tier I and Tier II must be completed before students can progress to Tier III. The Springer et al. (2007) approach provides a good starting point as a framework for making decisions regarding the Lab Type (Display Only; Master Data/Transactions; or Configure) to adopt based on the knowledge objective.

The Springer et al. (2007) approach has two limitations. Firstly at Tier II the Lab 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 levels, resulting in four levels (Table 3-3) as described by Rosemann and Watson (2002). A second limitation of the Springer approach is that no link is provided from the level of adoption to ERP specialist competencies, or to the type of ERP learning tool and the approach to use.

The level of breadth and depth can be combined into an ERP Adoption Levels Matrix for IS Higher Education (Table 3-5) in order to provide a complete view of all the options of levels of ERP adoption into the curricula. The Enterprise model (lectures-only) is outside the scope of this study (Section 1.8). 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.

Table 3-5 ERP Adoption Levels Matrix for IS Higher Education

	Level of Breadth (% of Practical content)					
Level of Depth	**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		Hands-On	ERP System
Laboratory Project	X	X	X		Hands-On	ERP System
Tutorial	X				Tutorial	ERP Simulator

The tutorial approach (Table 3-5) 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 content. 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 content, 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 3-5) provides a good structure for classifying the level of adoption, and is the most comprehensive to date. 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 link between the level of adoption selected and the competencies required for ERP specialists.

3.4.2. Peslak's Multiple-Course Approach

A multiple-course approach is recommended, using an incremental three course approach to teaching ERP in 12 steps (Peslak 2005) (Table 3-6). This framework maps 12 steps onto three courses. The three courses recommended are:

1. A Business Process Course;
2. A Core ERP course; and
3. A Supplementary ERP course.

Table 3-6 Multiple-Course Approach to ERP Education

Multiple-Course Approach to ERP education (Peslak 2005)		ERP Specialist Competency Category	Level of ERP Adoption Depth (Guthrie and Guthrie 2000)
Course	**Activities**		
Supplementary ERP	Company Setup	ERP Implementation and configuration	Dedicated Course/Integrated Practicum
	Setup of all major actors in SAP		
	Implementation and configuration		
	Reporting for SAP	ERP Programming	
	Programming skills (ABAP)		
Core ERP	ERP theory and concepts	ERP theory and Concepts	Laboratory Project OR Dedicated Course
	Hands-on teaching of SAP R/3	ERP transactions	
	Module Exploration		
Business Processes	Exposure to SAP R/3	ERP transactions	Enterprise Model OR Tutorial
	Business process knowledge	BPM	None
	Business functions and management	Business	

The Business Process Course involves business function and process knowledge as well as a short exposure to SAP R/3. Exposure to ERP involves screenshots or tutorials only and no hands-on use of an ERP system. Since no hands-on use of an ERP system is required, the course only needs Guthrie and Guthrie's (2000) Enterprise Model or Tutorial level of Adoption Depth (Table 3-2). The Business Process Course must also include knowledge of business functions and business management, which addresses the *Business* category of competency (Table 2-9). Peslak's (2005) model proposes that the business process course must be taught before the ERP courses. This is supported by other studies (Boyle and Strong 2006; Seymour et al. 2006; Seethamraju 2007; Barnes and Ferguson 2008) which have shown that a knowledge of business and business processes is required for the hands-on teaching of ERP systems.

The Core ERP Course uses hands-on teaching of ERP and therefore needs at least a Laboratory Project or Dedicated Course level of adoption (Table 3-5). This course includes lectures on ERP theory and therefore addresses the ERP competency category *ERP Theory and Concepts* (Table 2-9). The Core ERP course also includes some hands-on teaching of SAP R/3 and this addresses the *ERP Transactions* competency category identified as a key category for ERP specialists (Table 2-9).

The last of the three courses is the Supplementary ERP Course, which relates to the setting up of a new company, implementation and configuration issues as well as programming skills. The Supplementary ERP course is aimed at teaching supplementary ERP concepts and thus addresses the *ERP Implementation and Configuration competency* (Table 2-9). The Supplementary ERP course would require the hands-on use of an ERP tool and therefore a Dedicated or Integrated Practicum level of adoption (Table 3-3).

The Peslak (2005) study is limited since no empirical evidence on the results of the application of the framework is provided. However, all levels of Guthrie and Guthrie's level of ERP adoption depth are accounted for by Peslak's framework. Seven of the eleven competency categories are addressed by Peslak's (2005) framework. The competencies not addressed in Peslak's framework are: Interpersonal; IS; ERP Security; ERP Programming; and ERP Management.

3.4.3 ERP Technical Knowledge Framework

A five stage ERP technical knowledge framework was proposed by Boyle (2007) which educators can use to incorporate the technical aspects of ERP systems into IS education (Figure 3-1). The technical aspects are those not included in general IS programmes (Section 2.3.2). The framework can be used to determine gaps in existing ERP programmes or to design new ERP programmes. The framework was successfully applied to a four-year IS undergraduate degree programme in ERP at the St. Francis Xavier University in Canada (Boyle 2007). The first stage of the model includes the knowledge of business functions and IS which are not specific to ERP but more general to other IS and business degree programmes. Stages 2 to 5 address the ERP specific knowledge and skills which are labelled as ERP technical skills.

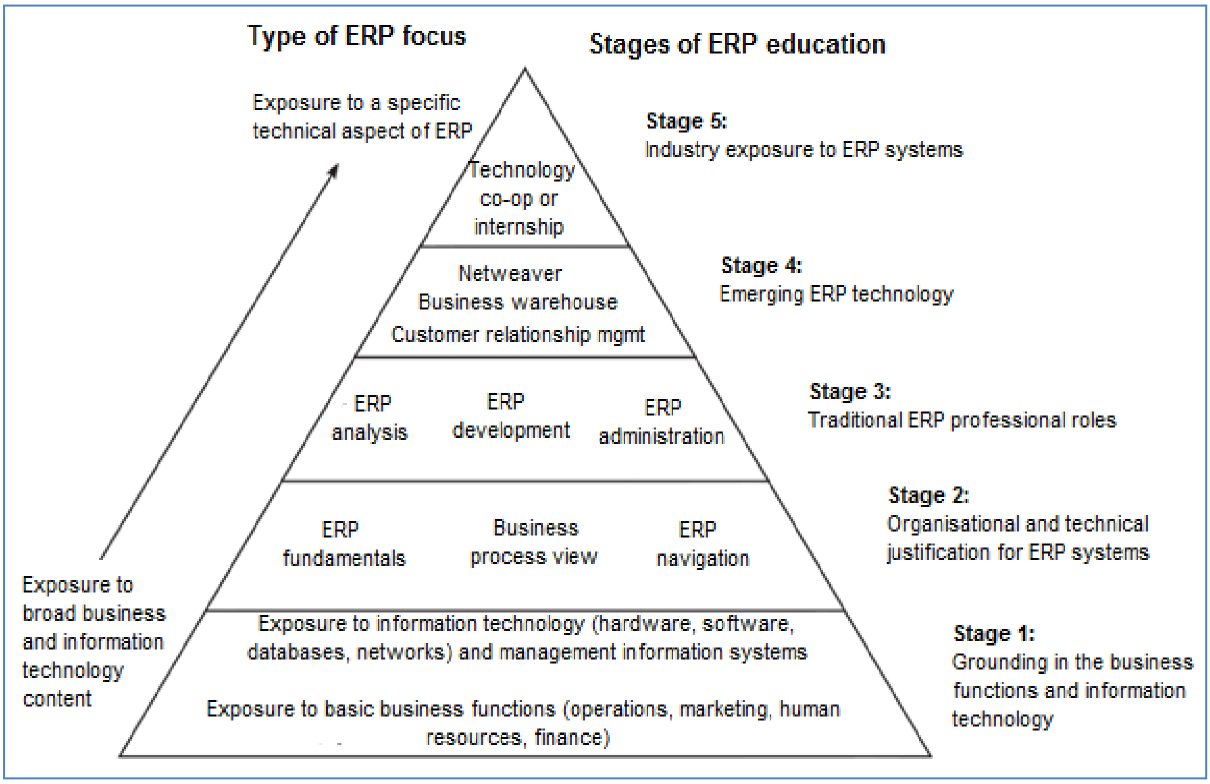

Figure 3-1 ERP Technical Knowledge Framework (Boyle 2007)

In Stage 3, students take courses in ERP implementation to prepare themselves for the three potential roles of an ERP specialist (Table 3-7), namely: ERP analyst; ERP developer and ERP administrator. These roles can be mapped to some of the competencies required of an ERP specialist (Table 2-9).

Table 3-7 ERP Specialist Roles and Competencies

ERP Specialist Roles (Boyle 2007)	ERP Competency Category (Table 2-9)
ERP analyst	Business, IS, ERP management; ERP Implementation and configuration
ERP developer	ERP programming
ERP administrator	ERP Transactions; ERP security

The ERP analyst is a critical position and is involved in implementing an ERP system. Graduates must have the required competencies to carry out this role. These competencies include the Business, IS and ERP management competency categories (Table 2-9). IS and ERP management competencies are important as graduates must also have a good understanding of methodologies used for IS and ERP implementations. The graduate who works as an ERP developer will have to be able to create management reports and screens and be able to write programs to configure or enhance the ERP system. The ERP administrator is responsible for the day-to-day functions and administration of the ERP system, which therefore includes the competency category of ERP transactions.

The Boyle (2007) ERP Technical Knowledge Framework adheres to the definition of a framework because it can assist with making decisions regarding the competencies for ERP specialists which educators wish to adopt as well as at what stage of education an ERP course is aimed at. However since it is a technical knowledge framework it only addresses the technical competencies of ERP graduates and does not include interpersonal and general management competencies identified as one of the most important competencies for ERP specialists in Chapter 2. Other ERP competencies omitted from this framework include ERP security and ERP management. An additional limitation of the Boyle ERP Technical Knowledge Framework model is that, since the degree programme discussed used SAP R/3, all software products for each of these levels were SAP products. It is a competency-based framework but does not provide any mapping to the appropriate level of adoption of the ERP system in the curriculum, or to the type of learning tool required.

3.4.4 ERP/SAP Implementation Framework

A framework for teaching ERP/SAP implementation was proposed by Wang et al. (2009). The proposed framework includes a methodology of mapping hands-on activities in SAP with each of nine learning outcomes (Table 3-8). The topics included in the Wang et al. (2009) framework are: ERP infrastructure and components; ERP core business processes; Business Process Reengineering (BPR); Implementation methodology roadmap; Enterprise model and organisation structure; General ledger and controlling; Organisation structure; ERP landscape systems; and Integrated business operations. The purpose of Wang et al.'s (2009) framework is to shift the teaching focus of ERP systems from ERP technical issues to organisation process issues. The proposed framework takes into consideration the different types of competencies needed to effectively transform business processes in an organisation.

Table 3-8 A Framework to Teaching ERP/SAP Implementation

Topic (Wang et al. 2009)	Hands-on Activity	ERP Specialist Competency Category (Table 2-9)
Integrated business operations	ERPSim Simulation game	ERP Implementation and Configuration
ERP landscape systems	Testing Fitter Snacker configuration	
Organisation structure	Business area customization	
General Ledger and controlling	Fitter Snacker Configuration: financial accounting	ERP Transactions
Enterprise model and organisaton structure	Fitter Snacker Configuration: Implementation Guide (IMG)	ERP Implementation and Configuration
Implementation methodology roadmap	Accelerated SAP	
Business Process Reengineering (BPR)	Application modules Process modeling diagrams	BPM
ERP Core business processes	Application modules & business process procedures implementation	Business
ERP infrastructure and components	SAP interface navigation	ERP Transactions

The Wang et al. (2009) framework incorporated learning-by-doing which motivates students to learn new materials by themselves, and the results show that the students achieved positive learning outcomes from the course. This learning-by-doing approach is also described as active learning and it supports the concept of learner-centred education proposed by other studies (Section 3.2).

However, although the Wang et al. (2009) framework is a good starting point, it does not assist educators with providing the detailed competencies required by industry. The framework is limited since no mapping to the level of adoption or the type of ERP learning tool is provided. Not all of the competencies identified as relevant for ERP specialists (Table 2-9) are addressed in Wang et al.'s (2009) framework. The supporting competencies not directly referred to are Interpersonal and IS. The technical competencies not addressed by Wang et al.'s framework are ERP Programming; ERP Management; and ERP Security.

3.4.5 A Comparison of ERP Education Frameworks

Several frameworks have been proposed for assisting educators with the adoption of ERP systems in the curriculum, but these frameworks do not satisfy the requirements for a comprehensive ERP education framework as they do not consider all decisions relating to this adoption (Table 3-9). Three ERP education frameworks (Guthrie and Guthrie 2000; Rosemann and Watson 2002; Springer et al. 2007) provide guidance, relating to decisions of the level of ERP system adoption which are suitable for undergraduate, single discipline ERP programmes. However these frameworks do not link these levels of adoption with the required ERP specialist competencies that will be addressed by the programme, nor do they provide assistance with the type of ERP learning tool that would be appropriate to use at that level of adoption. In addition none of the frameworks investigated provided criteria for selecting a suitable ERP learning tool.

Table 3-9 A Comparison of ERP Education Frameworks

Author / Decision	Guthrie and Guthrie (2000)	Rosemann and Watson (2002)	Springer et al. (2007)	Peslak (2005)	Boyle (2007)	Wang et al. (2009)
Level of Adoption Depth	Yes	No	Yes	No	No	No
Level of Adoption Breadth	No	Yes	Yes	No	No	No
Competencies to address	No	No	No	Yes	Indirectly	Indirectly (Outcomes)
ERP Adoption approach	No	No	No	No	No	No
Type of ERP learning tool	No	No	No	No	No	No
Selection criteria for ERP learning tools	No	No	No	No	No	No

Three ERP education frameworks (Peslak 2005; Boyle 2007; Wang et al. 2009) provide the greatest coverage of the required competencies for ERP specialists (Table 3-10). However, whilst they address many of the competencies, several are omitted and in addition the frameworks do not address other decisions faced by ERP educators and do not provide any link between these competencies and the level of ERP system adoption or the type of ERP learning tool that could be used.

Table 3-10 Comparison of Competencies Addressed by ERP Frameworks[7]

Competencies	Peslak (2005)	Boyle (2007)	Wang et al. (2009)
BPM	Yes	Yes	Yes
ERP Theory and Concepts	Yes	Yes	Yes
ERP Transactions	Yes	Yes	Yes
ERP Management	No	No	No
ERP Configuration and Implementation	Yes	No	Yes
ERP Programming	Yes	Yes	No
ERP Security	No	No	No
Interpersonal	No	No	No
Business	Yes	Yes	Yes
Information Systems (IS)	No	Yes	No

3.5 Evaluation of ERP Adoption in HEIs

Several frameworks for classifying and adopting ERP systems in the IS and business curriculum of HEIs have been proposed and two levels of ERP adoption are identified, namely the tutorial approach, and the hands-on approach (Section 3.4). The tutorial approach (Table 3-2) includes the use of ERP simulators, tutorials and multi-media and therefore does not include the hands-on use of an ERP system. The hands-on approach involves the hands-on use of an industry ERP system by the students.

[7] Core Technical; Supplementary Technical; Supporting

The tutorial approach to ERP system adoption can enhance learning about process flow (Shtub 2001; Lindoo and Wilson 2010) and can have a positive effect on computer self-efficacy (Scott and Walczak 2009). The use of simulators in the tutorial approach can take away the need for a student to know the details of how to perform a transaction and process-centric education is enhanced (Shtub 2001; Davis and Comeau 2004). Another advantage of simulators is that processing can be accomplished more efficiently with fewer errors and frustration than the hands-on approach (Lindoo and Wilson 2010). However, Lindoo and Wilson (2010) also discovered that the use of simulators can negatively impact the learning process. Another shortcoming of the tutorial approach is that students can become frustrated as a result of the quirks of simulators and can get confused as simulators often oversimplify the process flows and as a result omit steps in the business process (Lindoo and Wilson 2010). In addition the use of simulators removes the requirement of industry that students should learn more about the features and operations of an actual ERP system (Davis and Comeau 2004).

A web-based ERP-simulated environment was implemented in Taiwan and the results revealed that online learning with a web-based ERP-simulated environment, as a single approach, may not be suitable since students felt the systems too complex to learn on their own (Kanthawongs 2011). Another study of e-learning combined with face-to-face learning was proposed in a blended learning approach for ERP (Daun et al. 2006). This approach was successfully implemented at a university in Germany, but this success is reported with limited anecdotal evidence. In addition, e-learning is outside the scope of this study, therefore these two studies will not be evaluated further (Section 1.8).

In contrast to the tutorial approach, the hands-on approach involves use of the ERP system by students who perform navigating and processing tasks (Section 3.4.1). Various studies (Strong et al. 2006; Ragan et al. 2009) on ERP education in non-IS curricula, such as accounting, have reported success in the hands-on use of ERP systems for instructional purposes. However the focus of this study is on ERP system adoption in the IS curricula. The hands-on approach consists of three possible levels of depth of transactions, namely the Laboratory Project, Dedicated and Integrated Practicum (Table 3-5).

The level of breadth in the hands-on approach can vary from Browsing (Level 0) to Integration (Level III). Studies of the hands-on approach to ERP adoption have shown that students enjoy performing exercises using ERP systems and that by completing exercises within each business process, they are able to gain a better understanding of the various business processes and how they relate to each other. They also gain a better understanding of ERP concepts (Nelson 2002; Seymour et al. 2006; Surendran et al. 2006; Seethamraju 2007).

A summary of studies reporting on the hands-on approach to ERP adoption is provided in Table 3-11 and these are categorised in order of the country in which they took place and then chronologically within the country of origin. The majority of these studies took place in the U.S., reported using SAP R/3 or mySAP, and were implemented in undergraduate degree programmes. A rating from 1 to 5 is allocated to each study where 1 = Poor, 2 = Good, 3 = Very Good, and 4 = Excellent. These ratings were based on the comprehensiveness of the study reviewed in terms of the competencies addressed and the quality of evidence provided, where 1 = just named them; 2 = anecdotal discussion; 3 = empirical evaluation of competencies; and 4 = empirical evidence provided.

Several studies reported the improved motivation of students (Nelson 2002; Wang et al. 2009; Hustad and Olsen 2011), and the study performed by Davis and Comeau (2004) found that students enjoy the hands-on use of an ERP system. Surendran et al. (2006) reported that students valued getting exposure to an ERP product that has a high market share. A large percentage of studies exposing students to the hands-on use of an ERP system reported an improvement in knowledge by the students and positive learning outcomes (Nelson 2002; Davis and Comeau 2004; Surendran et al. 2006; Wang et al. 2009; Winkelmann and Leyh 2010). The hands-on adoption of the ERP system was viewed favourably by students and by industry (Seymour et al. 2006; Seethamraju 2007; Wang et al. 2009; Winkelmann and Leyh 2010).

Table 3-11 Summary of Hands-on ERP Adoption

Country	Authors	Institution	ERP system	Competency Categories	Problems	Rating[8]
U.S.	Nelson (2002)	School of Business at Penn State Erie	SAP	BPM; ERP Transactions; ERP Theory and Concepts	Lack of navigation guidance	2
	Surendran et al. (2006)	Southeast Missouri State University	SAP	BPM; ERP Transactions; ERP Implementation	Complexity of product; UI rated poorly	3
	Wang et al. (2009)	California State University	SAP	BPM; ERP Transactions; ERP Theory and Concepts	Learning underlying processes	4
	Rienzo and Han (2011)	Western Michigan University	Navision	BPM	No significant improvement in knowledge	3
Canada	Davis and Comeau (2004)	University of New Brunswick	SAP	ERP Transactions; ERP Theory and Concepts; BPM	BPM knowledge gain lower than expected	3
Australia	Hawking and McCarthy (2000)	Victoria University	SAP	BPM Yes (qualitative)	Anecdotal evidence only. Specific competencies not specified.	2
	Seethamraju (2007)	University of Sydney	SAP	BPM; ERP Transactions; ERP Implementation; ERP Management	Students struggled to understand information flow of processes	4
Scandinavia	Ask et al. (2008)	3 Universities	Several including Navision	Not specified	Faculty is not aware of available ERP systems	2
Germany	Winkelmann and Leyh (2010)	University of Dresden, Koblenz-Landau and Muenster	Several	BPM; ERP Transactions; ERP Theory and Concepts	Students said workload was very high	4
South Africa	Seymour et al. (2006)	University of Cape Town	SAP	BPM; ERP Theory and Concepts; ERP Transactions	Students wanted more SAP help	4
Norway	Hustad and Olsen (2011)	University of Agder	SAP, Navision and others	Not specified	Reduced learning curve of Navision	3

[8] 1 = Poor, 2 = Good, 3 = Very Good, and 4 = Excellent

The four most comprehensive studies (Seymour et al. 2006; Seethamraju 2007; Wang et al. 2009; Winkelmann and Leyh 2010) are those which provided the most comprehensive, empirical evidence of the attainment of ERP competencies in education, and for this reason these four studies were rated a 4 in Table 3-11. These studies all addressed the majority of the industry-relevant technical ERP competency categories (Table 2-9), namely: BPM, ERP Theory and Concepts, ERP Transactions, ERP Management, and ERP Implementation and Configuration. Only one study (Seethamraju 2007) addressed ERP Security competencies.

An improvement by the students in several categories of core technical ERP competencies (Section 2.3.2) was cited, namely business process management and ERP Theory and Concepts (Nelson 2002; Peslak 2005; Seymour et al. 2006; Surendran et al. 2006; Seethamraju 2007) as well as ERP transaction skills (Seethamraju 2007; Wang et al. 2009). An improvement in one of the supplementary ERP competencies, namely ERP implementation knowledge was also reported in the Seethamraju (2007) study. In spite of the improvement in many of the ERP competencies by students, some studies did not achieve a significant gain in three key technical competencies required for ERP specialists, namely: business process knowledge (Davis and Comeau 2004), management knowledge (Seethamraju 2007) and SAP customising and interface knowledge (Seethamraju 2007).

The majority of studies of ERP adoption reviewed used SAP, which supports studies reporting that SAP is widely implemented in higher education worldwide (Sager et al. 2006; Seethamraju 2007). However, recent studies (Ask et al. 2008; Rienzo and Han 2010; Winkelmann and Leyh 2010; Hustad and Olsen 2011) have reported benefits to implementing medium-sized systems in ERP courses for educational purposes rather than large, complex ERP systems. Winkelmann and Matzner (2010) argue that the policy of adopting one popular large ERP system into the curriculum provides a one-sided education and students are not exposed to smaller and possibly better fitting alternatives. These medium-sized ERP systems are designed for small to medium-sized organisations in Tier 2 and Tier 3 of the market (Section 2.2).

Allowing students to work with medium-sized ERP systems that are less complex than large scale systems such as SAP can still provide an understanding of the basic capability of an ERP system (Ask et al. 2008; Winkelmann and Leyh 2010; Hustad and Olsen 2011) and avoid the problem of student frustration which was identified by other studies (Noguera and Watson 2004; Scott and Walczak 2009). The Hustad and Olsen (2011) study reported that students were more satisfied with the lower learning curve of the Microsoft Navision ERP laboratory assignments compared to the SAP lab. Microsoft Navision is a Tier 2 ERP system (Figure 2-1) and therefore classified as a medium-sized ERP system. Anecdotal evidence only is provided in the Hustad and Olsen (2011) study, and the ERP competencies, addressed by the course, are not specified. In addition the course was aimed at business administration post-graduate students, so may not be suitable for undergraduate IS students in South Africa.

The Ask et al. (2008) study also reported the adoption of a medium-sized ERP system, Microsoft Navision, at three Scandinavian universities. This study also reported the use of other medium-sized ERP systems and proposed that educators do not lock themselves into one ERP vendor. However, this study does not specify the competencies addressed and is therefore rated as a 2 in Table 3-11. The Rienzo and Han (2011) study investigated the adoption of a medium-sized ERP system, Microsoft Navision, in a course to teach business processes. This study showed that, whilst there was no significant improvement in knowledge regarding the detailed sub-process coordination, students did report an increased awareness and understanding of business processes and business process integration. A study of ERP system use in industry (Koh et al. 2009) has shown that medium-sized ERP systems require less formal training and are less daunting to new users because of the familiar Windows interface. Since this study took place in industry and not in higher education, it is not included in Table 3-11.

3.6 ERP Adoption in South African HEIs

A number of studies of ERP adoption into the IS and business curricula have been reported internationally (Section 3.5). However, only two studies (Seymour et al. 2006; Scholtz et al. 2010) of ERP adoption in IS curricula have been reported on in South Africa. A survey of universities in South Africa was conducted in order to determine the status of ERP courses in their business or IS curricula. Universities of technology as well as colleges were excluded from the survey as these were out of the scope of this study (Section 1.8).

Questionnaires (Appendix G) were sent to the twelve universities in South Africa and five of these were identified as teaching ERP in their courses, whilst the other seven were not considered as teaching ERP as they had not yet introduced ERP into more than one lecture and did not use any ERP system for instructional purposes. Table 3-12 summarises the status of the ERP system adoption at the five institutions where ERP outcomes are implemented in IS courses.

The University of the Witwatersrand and NMMU are both redesigning their curricula in order to increase their exposure to ERP systems. The University of Cape Town (UCT) has already undergone such a process and in 2006 a study performed at UCT confirmed that increased ERP exposure in a course increased the student's perceived understanding of ERP concepts and business processes (Seymour et al. 2006).

Table 3-12 Universities in South Africa that have ERP Outcomes in their IS curriculum

University	Adoption Level (Section 3.4.1)	ERP System Adopted	Course	% ERP of Lectures	% ERP of Pracs
University of the Witwatersrand (Wits)	Enterprise	None	Information Systems III	25	0
University Of Kwazulu-Natal	Enterprise	None	Business Reengineering Course	25	0
Nelson Mandela Metropolitan University (NMMU)	Laboratory	SAP R/3	Management Information Systems	30	50
University of Cape Town (UCT)	Laboratory	SAP R/3	IT Applications	50	50
University of the Western Cape (UWC)	Dedicated	SAP R/3	ERP Basics and SAP	100	100

The seven HEIs that, at the time of the survey, did not offer ERP programmes in the IS curricula are:

- Central University of Technology;
- Rhodes University;
- University of Johannesburg;
- University of Fort Hare;
- University of Pretoria;
- University of the Free State; and
- North West University.

Forty-two percent of the respondents, therefore, provide ERP programmes, but only three of these HEIs provide students with hands-on exposure to an ERP system (25%), and only one HEI (less than 10%) provides a dedicated approach. This finding reveals that in spite of a need for ERP specialists in South Africa and internationally (Chapter 2), HEIs in South Africa are not adequately addressing this need. It can thus be deduced that HEIs in South Africa need to increase their exposure to ERP systems as recommended in the IS2010 guidelines and other research.

3.7 Conclusion

The need for ERP education in South Africa was confirmed by a survey of employers of ERP specialists (Chapter 2) and a need for quality ERP education programmes in IS curricula is evident (Section 3.1). The importance of ERP competencies was confirmed by the new IS curriculum (IS2010) which identified a special career track for the ERP specialist. The adoption of ERP systems into a curriculum is becoming more popular and several international HEIs have introduced the educational use of ERP systems in their business or IS curricula.

Educators are faced with several challenges with adopting ERP systems (Section 3.3). ERP education frameworks should assist educators in addressing these challenges and with decisions regarding what competencies to address, the level of ERP system adoption to implement and the ERP learning tool to use. There are many choices of ERP learning tools and several criteria can be used to select such a tool to use in IS education. These criteria include the following:

1) The cost of the related hardware and software required for the ERP system;
2) The available staff trained to support and teach the software;
3) The available training material suitable for academic purposes; and
4) The availability of demonstration data.

Several frameworks for the adoption of ERP into the IS curriculum have been proposed. These frameworks are not comprehensive as they do not consider all the factors relating to ERP system adoption decisions. An ERP Adoption Levels Matrix for IS higher education (Table 3-5) is proposed which can provide guidance to educators regarding the levels of both depth and breadth of ERP system adoption.

Several of the frameworks do not map to the competencies required for ERP specialists, whilst others do provide a list of competencies but do not map these to the appropriate level of adoption and ERP learning tool. In addition they do not take into account the usability problems encountered by the hands-on approach to ERP adoption and the impact on competencies. The hands-on approach to adopting an ERP system in a curriculum is critical to understand the more complex and deeper ERP concepts.

ERP simulators can be used to teach ERP competencies but studies on this approach are limited and have not achieved the same benefits as the hands-on approach. Recent studies (Winkelmann and Matzner 2009; Hustad and Olsen 2011; Rienzo and Han 2011) of ERP systems for educational purposes have reported success with the adoption of a medium-sized ERP system. These medium-sized ERP systems are less complex than large-scale ERP systems but can still support the teaching of ERP and business process concepts. A comprehensive, competency-based framework is required which also caters for medium-sized ERP systems designed for the mid-market.

Only 25% of South African HEIs have adopted the hands-on use of ERP systems in an IS curriculum (Section 3.6) and only two research studies on the adoption of ERP systems in education in South Africa have been performed. It can be deduced that HEIs in South Africa are not adequately addressing the need for ERP specialists and that research on studies of ERP adoption in South Africa is required.

The contributions of this chapter include an evaluation of ERP education frameworks into how comprehensive they are in assisting educators with the adoption of ERP systems and with addressing the industry-relevant competency levels. The comparison of these frameworks can assist with decisions regarding the design of a new ERP programme. This chapter has answered the second research question of *"What frameworks and approaches can be used to adopt ERP systems into the IS curricula?"*. The adoption of the hands-on approach where students use complex, industry ERP systems has introduced several usability problems. The following chapter will investigate the proposal of a comprehensive, competency-based ERP education framework that addresses the shortcomings of the frameworks evaluated in this chapter.

Chapter 4: A Competency-based ERP Education Framework

4.1 Introduction

An ERP Adoption Levels Matrix for IS Higher Education is proposed (Table 3-5 in Section 3.4.1). This matrix can assist educators with decisions regarding the level of breadth and depth of adoption of an ERP system in the IS curriculum. However, this matrix does not take into account the industry-relevant competencies required in an ERP course and does not provide a mapping between these competencies and the ERP system adoption level and type of ERP learning tool to adopt (Chapter 3).

In addition to the many decisions facing educators with the adoption of ERP learning tools, the usability of these tools further provides many challenges (Shtub 2001; Nelson 2002; Theling and Loos 2005; Surendran et al. 2006; Scholtz 2010). Users have encountered usability problems with ERP systems in industry which can interfere with a user's productivity and make achievement of goals difficult (Topi et al. 2005; Babaian et al. 2006). A need exists in HCI research to further understand the nature of ERP usability problems and methods for evaluating the user interfaces of ERP systems (Topi et al. 2005).

In education research, empirical studies regarding the usability of ERP systems for instructional purposes are limited (Chapter 3). Existing studies of ERP in education and ERP education frameworks have not considered the impact of usability on educational outcomes. A framework for ERP education is required which also considers the impact of the usability of the ERP learning tool on educational outcomes. Empirical studies of the relationship between usability and ERP educational outcomes can address gaps in HCI and education research studies.

This chapter will address the third research question of this study, namely "*What comprehensive education framework can be used in an ERP course in higher education institutions in South Africa?".* In order to address this, a comprehensive, competency-based education framework is proposed which will assist educators with decisions regarding the adoption of an ERP learning tool into an IS curriculum (Section 4.2).

Once the framework for ERP adoption has been implemented, it is important to measure the impact of this adoption. This leads to the fourth research question, "*How can the impact of ERP system adoption in a curriculum be measured?",* which will also be addressed in this chapter. Several studies (Davis and Comeau 2004; Noguera and Watson 2004; Scott and Walczak 2009) have proposed pedagogical measures for evaluating the success of the adoption of ERP systems into education (Section 4.3).

An evaluation of the success of ERP adoption in education should include usability measures (Section 4.4). One of the goals of this research is to address the gaps in ERP education research by providing academic performance measures, usability measures and ERP system adoption measures (Section 4.5). The proposed measures will assist educators with assessing the impact of ERP system adoption on student competencies in IS curricula, and can ultimately also be used to evaluate the ERP education framework.

4.2 ERP Education Framework

Several frameworks have been proposed for adopting ERP systems into higher education, however, they are not comprehensive as they do not address all the decisions faced by educators (Section 3.5). The ERP Adoption Levels Matrix for IS Higher Education (Table 3-5) can provide educators with assistance regarding the level of adoption of the ERP system into the curriculum. However the matrix neglects to provide mapping to the required ERP competencies. It is important to include the ERP specialist competencies in an ERP education framework in order to assist educators with the design of a competency-based curriculum. A model has been designed by Worley et al. (2005) which maps the competencies of an individual to the competencies required by an activity in an industrial environment, but no similar model has been proposed for ERP education.

A comprehensive Competency Framework for ERP System Adoption in IS higher education (ERPEd) is proposed (Figure 4-1). A competency-based curriculum is used in the framework in accordance with more recent education approaches (Section 3.2). The framework was derived from the ERP Adoption Levels Matrix for IS higher education (Table 3-5) which is extended by incorporating eleven industry-relevant competency categories for ERP specialists (Table 2-9) onto the appropriate levels of breadth (Browsing, Transactions, Modules and Integrated) and depth (Laboratory Project, Dedicated and Integrated) of ERP system adoption.

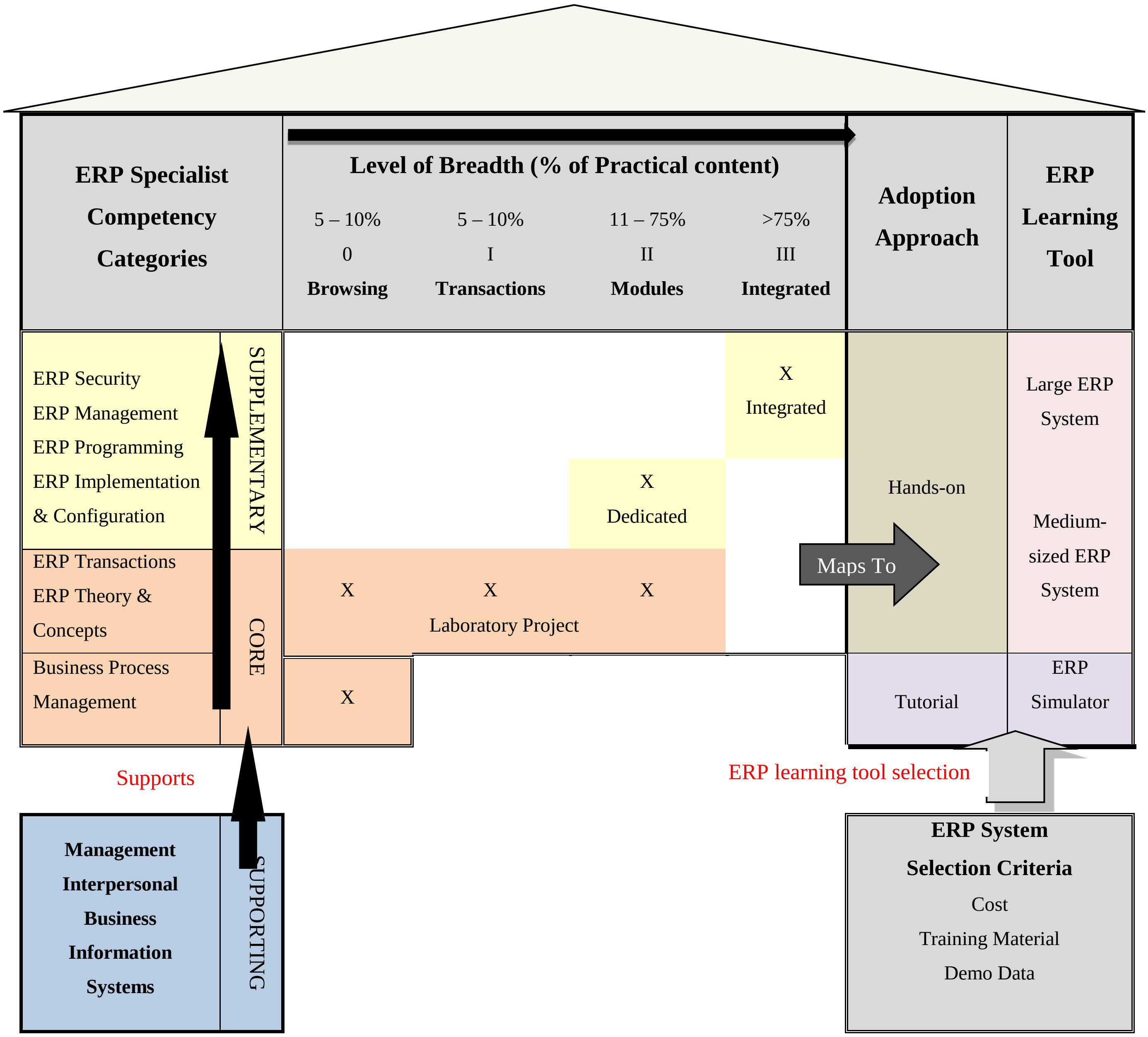

Figure 4-1 A Competency Framework for ERP System Adoption (ERPEd: Version 1)

Each of the eleven ERP specialist competency categories contains several competencies that are required of an ERP specialist (Table 2-9). The ERPEd framework can therefore assist ERP educators with decisions regarding the design of an ERP education programme. These decisions include what 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 (Section 3.7). 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 ERP specialist competency categories on the left of the framework are mapped onto the appropriate levels of adoption in the centre and an adoption approach and learning tool on the right. The cells that are not shaded indicate those where the combined levels would not be possible (Table 3-5).

At the base of the framework are two pillars. In the left hand pillar are the supporting ERP competency categories (Section 2.3.1), namely: Management, Interpersonal, Business and Information Systems. These supporting competencies are taught in other courses and do not necessitate the use of an ERP learning tool. At the next level are the core ERP technical competencies (Section 2.3.2), namely: Business Process Management (BPM), ERP Transactions and ERP Theory and Concepts. 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 (Section 3.5). However, all the other ERP core and supplementary competencies require the hands-on adoption approach. 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 (Section 3.5).

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 only in order to familiarise them with the complexity of the user interface (Section 3.4.1). After they are familiar with the navigation and interface of the system, they can do 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 or Integrated level.

At the highest level of the framework are the supplementary technical ERP competency categories. These include ERP Implementation and Configuration, ERP Programming, ERP Security and ERP Management. These 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 (Section 3.4.1). At this level a large ERP system is recommended.

The ERPEd framework assists educators with decisions regarding the selection of an ERP learning tool, since it provides criteria to use in this process. These criteria include the cost of the software, the training material provided and the quality and availability of demonstration data (Section 3.7). Consideration of these criteria can reduce the challenges faced by educators when implementing an ERP learning tool into the curriculum. These criteria are shown in the right hand pillar at the base of the framework. The ERPEd framework is competency-based and therefore learning outcomes, activities, tasks and assessments of ERP programmes using this framework should be linked to industry-relevant competencies.

4.3 ERP Education Measures

The ERPEd framework is proposed that can assist educators with the adoption of ERP systems. In order to ensure that the implementation of ERP systems in industry is a success and that the benefits are attained, the relevant measures, criteria and metrics should be established (O'Grady 2002). Similarly, in order to evaluate the success of ERP system adoption in education, it is necessary to identify appropriate methods, measures and metrics. Several methods, both internal and external, have been used for measuring the quality and success of ERP educational programmes. External methods include the ability of graduates to find employment after completion of a course of study (Guthrie and Guthrie 2000; Ask et al. 2008) and favourable reports from the employers of graduates or from successful internship programs (Guthrie and Guthrie 2000). The perceived importance of a course to industry is also an external measure which has been used in one study (Seymour 2006). This perceived importance of the course to industry has been shown to increase student enrolment numbers for that course (Rosemann and Maurizio 2005; McGinnis and Magro 2011). The focus of this study is on the adoption of the ERP system and the impact of this adoption, and therefore external methods are outside the scope of this study (Section 1.8) and will not be discussed further.

Internal methods used to evaluate the quality of ERP programmes and ERP system adoption success include student surveys (Surendran et al. 2006; Seethamraju 2007; Scott and Walczak 2009). Other methods used for evaluating IT-facilitated learning (Leidner and Jarvenpaa 1995; Choi et al. 2007) and in ERP education (Grandzvol 2004; Alshare and Lane 2011) include identifying and measuring well defined learning outcomes. In competency-based education learning outcomes should be aligned with the competency needs of the workplace (Section 3.4), and therefore in the case of ERP learning tools, on industry-relevant ERP specialist competencies (Table 2-9). The ERPEd framework (Section 4.2) is a competency-based education framework, which means that learning outcomes and evaluation measures are based on these competencies.

One popular measure used to evaluate the success of an ERP education programme is academic performance (Noguera and Watson 2004). Pinto (2010) also believes that academic programmes must deliver on student performance in the desired competencies. The difficulty that arises is that if there are errors in a transaction performed by a student in the ERP system, which could affect the performance of the student, it is difficult to know whether this was due to a system error or a student error (Davis and Comeau 2004; Peters and Haak 2010). For this reason, a clear distinction between academic performance of the student and the performance of the system needs to be made. In order to do this, measures of the usability of the ERP system should be examined and feedback regarding problems encountered should be provided and analysed. These usability measures are discussed in the next section.

It is argued that just examining performance is not sufficient to get a complete picture of the programme success (Compeau and Higgins 1995). Other studies have used the additional measures of self-efficacy (Choi et al. 2007; Scott and Walczak 2009) and user satisfaction with the ERP adoption approach (Noguera and Watson 2004; Kanthawongs 2010b; Alshare and Lane 2011) to evaluate ERP education. The perceived ease of use (effort expectancy) and perceived usefulness (performance expectancy) of ERP systems has also been used to evaluate attitudes toward ERP systems adoption (Alshare and Lane 2011).

Self-efficacy items should be based on the learning outcomes of the course and higher levels of self-efficacy should be achieved by students in addition to satisfying the performance outcome (Choi et al. 2007; Scott and Walczak 2009). Research has shown that low-efficacy beliefs are negatively related to subsequent task performance (Noguera and Watson 2004). Several studies (Davis and Comeau 2004; Seethamraju 2007) have included subjective self-assessments of self-efficacy based on learning outcomes in order to determine knowledge gain.

4.4 ERP System Usability Measures

Measures used to evaluate the success of ERP system adoption for educational purposes (Section 4.3) are similar to those used to evaluate the usability of ERP systems. Whilst several studies have investigated measures for ERP usability in industry, very few have addressed the usability of ERP systems in education. Measures for evaluating the usability of ERP systems in education are required. Research into the impact of usability on educational outcomes is also needed. In order to identify usability measures an investigation of usability problems is required. Several problems with the usability of ERP systems in industry and education have been reported (Section 4.4.1). An evaluation of system usability should consider usability measures identified by international standards and renowned usability experts (Section 4.4.2). Several usability measures for ERP systems in industry have been proposed (Section 4.4.3).

4.4.1 Usability Problems

The process of ERP system acceptance is seldom easy since ERP systems are extremely expensive to implement and require people to change the way they work (Calisir et al. 2009). One of the primary reasons for the non-acceptance of systems and the failure of these systems is the unusable user interface. Providing usability is a very important quality factor for the acceptance of interactive software applications (Seffah et al. 2006) and these applications include ERP systems.

Critical factors in ERP implementation success include perceived ease of use and perceived usefulness (Amoako-Gyampah 2004; Alshare and Lane 2011). Perceived ease of use is the extent to which a person believes that using a particular system will be free of effort (Davis et al. 1989).

Perceived usefulness is the degree to which a person believes that using a particular system will enhance his or her job performance. Studies of ERP implementations (Calisir et al. 2009; Youngberg et al. 2009) have shown that perceived ease of use significantly influenced participants' perceptions of system usefulness. Ease of use has also been shown to impact the behavioural intention to use an ERP system (Amoako-Gyampah 2007). User satisfaction with technology has also been used as a measure in studies (Zhang et al. 2005; Wu and Wang 2007; Longinidis and Gotzami 2009; Kanthawongs 2010a) to determine ERP project success in organisations.

Usability problems encountered while using ERP systems in industry have been found to make it harder to achiever user goals and impact the time taken to learn the system (Topi et al. 2005). The Aberdeen Group Report (2008) cites Ease of Use of the Software as the second highest priority for organisations in the ERP System Selection Criteria (Aberdeen 2008). Other reports (Pang 2008; Aberdeen 2010) have also identified usability and ease of use issues faced by ERP vendors. To exploit fully the capabilities of complex technologies like ERP systems, organisations must foster technology acceptance by end users (Youngberg et al. 2009).

A need exists to provide user interfaces for ERP systems which are easy to use, easy to learn and which support the user's tasks. However, in contrast, studies have shown that the complexity of ERP systems has resulted in user interfaces which suffer from poor usability (Babaian et al. 2006; Singh and Wesson 2009), and are frustrating to use (Ceaparu et al. 2004; Topi et al. 2005; Matthews 2008). The complexity of ERP resides in the unfriendly nature of the interface (Boudreau 2003; Yeh 2006). Usability issues, plaguing users of ERP systems, have been reported of which several were negative critical incidents or serious breakdowns in usability (Oja and Lucas 2010). The usability of ERP systems is often neglected and can be influenced by the different backgrounds of the users as this may affect how users interact with the software (Van Norren 2009).

A number of studies (Calisir and Calisir 2004; Topi et al. 2005; Singh and Wesson 2009) have shown that many of the usability problems in ERP systems that users are faced with relate to navigation and the completion of transactions. Users find the transaction interfaces too complex and users require an unreasonable amount of time and effort to find specific functionality quickly within the system. The main problems encountered with navigation, are the lack of help and guidance with determining the correct screens to access in the quickest possible way. Novice users, in particular struggle with this lack of guidance. Guidance should be provided by meaningful feedback from the interface when errors occur and context-sensitive user help facilities should be supplied (Sommerville 2010).

Usability problems with ERP systems, similar to those reported in industry, have also been encountered in education (Shtub 2001; Nelson 2002; Rosemann and Maurizio 2005; Surendran et al. 2006). The usability of the ERP system has an impact on the available time and workload of the students and should be considered when making a choice regarding which ERP system to adopt in the curricula (Winkelmann and Leyh 2010).

ERP systems are not designed to support teaching and therefore the amount of time required to learn the details of all the screens and functions of an ERP system is enormous (Shtub 2001). There is usually a steep learning curve in mastering the many menu paths (Nelson 2002; Theling and Loos 2005; Scholtz et al. 2010), data-entry screens and data elements within a single ERP application (Nelson 2002). ERP systems are challenging to learn to use and users will therefore focus on the completion of the practical exercises without understanding how these steps contribute to the bigger picture and the underlying business concepts (Davis and Comeau 2004; Wang et al. 2009; Rienzo and Han 2010; Winkelmann and Leyh 2010). As a result, navigation exercises must be structured to protect students from branching to unknown screens and becoming lost (Nelson 2002).

4.4.2 Usability Measures

Several problems with the usability of ERP systems in industry and education have been reported. Several benefits to organisations can be achieved by improving the usability of ERP systems which can, in turn, reduce the length of the training time and improve employee satisfaction (Babaian et al. 2006). Improved usability and user experience with ERP systems can lower training costs, improve productivity and provides business flexibility (Wang 2011).

Babaian et al. (2006) indicates that research into improving the usability of ERP systems is therefore required. In particular field studies which focus on users' perceptions of ERP usability can be used to improve our understanding of the factors that affect usability perceptions.

In order to improve the usability of ERP systems, studies are required that measure ERP system usability. The most common reasons for measuring usability in product development are to obtain a more complete understanding of users' needs and to improve the product in order to provide a better user experience (Bevan 2008). Measures for evaluating usability fall into two broad categories: namely subjective user-preference measures and objective performance measures (Rosson and Caroll 2002). Subjective performance measures assess how much users like the system, whilst objective performance measures assess how capable the users are to use the system.

There are several definitions of usability and several criteria, measures and metrics have been proposed for evaluating usability. The International Organisation for Standardisation (ISO) defines usability as the "*extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use"* (ISO 1997). The three factors or criteria of usability as identified by the ISO9241 standard are therefore effectiveness, efficiency and satisfaction. Seffah et al. (2006) also include effectiveness, efficiency and satisfaction in their model of ten usability criteria.

The ISO9241-11 standard (ISO 1997) states that the usability of any tool or system has to be viewed in terms of the context in which it is used, and its appropriateness to that context. This context of use includes the users, tasks, equipment or tools (hardware, software and materials), and the physical and social environments in which a product is used (ISO 1997; Preece et al. 2011). Preece et al. (2011) regard usability as ensuring that interactive products are easy to learn, effective to use, and enjoyable from the user's perspective. Usability involves the optimisation of the interactions which users have with interactive products, to enable them to carry out their activities in the workplace, at school and in their everyday life (Preece et al. 2011).

Effectiveness is defined as the ability of the system to accomplish the task (ISO 1997). Preece et al. (2011) concurs with effectiveness as being one of the criteria of usability and describes effectiveness as how good a product is at doing what it is supposed to do. Efficiency is defined as the accuracy and completeness of goals in relation to the resources expended (ISO 1997). It can also be viewed as the way that a product supports users in carrying out their tasks (Preece et al. 2011).

Performance is all about what the user actually does in interacting with the product and includes measuring the degree to which users can successfully accomplish a set of tasks. The last criterion of usability as defined by the ISO9241 (1997) standard is satisfaction, which is the '*comfort and acceptability of the system'*. Satisfaction has been defined as the extent to which the user believes an IS meets their requirements (Ives et al. 1983). User satisfaction has received widespread acceptance for measuring ERP impact in organisations and determining ERP success (Wu et al. 2002; Longinidis and Gotzami 2009).

Usability measures are determined by the purpose for which the product is being used (Bevan 2008). The primary purpose of the hands-on use of an ERP system in education is to improve the ERP competencies of the students. Satisfaction of ERP systems in education is therefore the measure or extent to which the expectations are met by the ERP system. This includes the students' satisfaction with the ERP adoption, which can be measured in terms of an improvement in competencies, as well as satisfaction with the usability of the ERP system.

Usability criteria must be measurable and should therefore consist of several measures and metrics (Faulkner 2000). In order to perform a usability evaluation, the details need to be specified and must include metrics and criteria for assessment. A metric is defined as a quantitative scale and method which can be used for measurement (ISO 1998). One metric of effectiveness is task completion rate (Faulkner 2000; Davis and Comeau 2004). Completion rate is a fundamental metric of usability and is a binary measure of pass and fail (Sauro 2011). An acceptable benchmark recommended for task completion rate in usability studies is 78% (Sauro 2011). When measuring effectiveness it is also advisable to include an analysis of the problems encountered by the users in order to improve the usability of such systems.

The efficiency of a system can be measured by task duration or time to accomplish a task (Faulkner 2000; Barnum 2001; Lazar et al. 2010) as well as accuracy (percentage completed correctly) (Barnum 2001). Some studies propose comparing task duration with goal time (Lazar et al. 2010). Other studies (Faulkner 2000; Tullis and Albert 2008) propose using effort as an additional measure of efficiency. Measuring effort can be very difficult and one way of doing this is to get subjective metrics of effort from the users (Faulkner 2000). These metrics can be obtained by means of a questionnaire and in this way provide a reasonably objective measurement of what would otherwise be a subjective response.

In an educational context, all the activities and assessments that require the use of an ERP tool are recognised as tasks. Task analysis comprises a list of all the tasks that the users would carry out using the system (Nielsen 1993). Competency-based education programmes should design these tasks based on learning outcomes derived from industry-relevant competencies for ERP specialists (Table 2-9), which should be assessed at the two levels of Bloom's Taxonomy of cognitive levels recommended for undergraduate programmes, namely Application and Analysis (Section 3.2).

Several studies cite the importance of specifying usability goals, measures and metrics, both quantitative as well as qualitative, when evaluating the usability of a system (Kirchenham 1996; ISO 1997; Tullis and Albert 2008). It is important to include qualitative goals (Faulkner 2000; Lazar et al. 2010) since quantitative data can determine if something is wrong whilst qualitative data can determine what is wrong from the user's point of view (Barnum 2001). In order to evaluate the usability of a system thoroughly, it is necessary to gain qualitative information as well as quantitative (Faulkner 2000). User preference questionnaires using Likert scales can provide a specific metric for the related usability attribute or metric (Kirchenham 1996). The use of both quantitative and qualitative data can support the triangulation of usability problems.

4.4.3 Measuring Usability of ERP Systems

The Technology Acceptance Model (TAM) has been used in several (Davis et al. 1989; Amoako-Gyampah 2007) studies to measure satisfaction of IS adoption in organisations. This model assumes that use of IS is discretionary and that user satisfaction with the system is a good predictor of success of such an adoption (Davis and Comeau 2004).

However, in many ERP-enabled work environments and in education, use of a particular system is mandatory, therefore Davis and Comueau (2004) argue that a TAM model may not be an appropriate measuring tool. One study (Kanthawongs 2011) however, successfully used TAM to evaluate the use of a simulated ERP system in an ERP course. This study showed that the greater the ease of use of the ERP system, the greater the students' satisfaction with the course. Another study of the hands-on approach to ERP systems for educational purposes (Rienzo and Han 2011) also used the TAM model to analyse student self-assessment.

Usability measures can be used to analyse the user experience and can help reveal patterns that may be hard or even impossible to see (Tullis and Albert 2008). Effectiveness, efficiency and satisfaction have been used as measures in testing the usability of ERP systems in industry (Costa 2010). Another study (Van Norren 2009) of the usability of ERP systems in industry used the measures of learnability, efficiency, memorability, errors and satisfaction. Five usability criteria which can be used as measures for ERP systems have been proposed by Singh and Wesson (2009), namely: navigation, presentation, task support, learnability, and customisation. The study successfully identified existing usability issues through the use of these criteria, which can be converted into related heuristics and measures (Figure 4-2).

The first ERP usability criteria proposed by Singh and Wesson (2009), is *Navigation. Navigation* has been reported as a design issue in several studies (Calisir and Calisir 2004; Topi et al. 2005; Singh and Wesson 2009). The related heuristic *Navigation and Access to Information* proposed by Singh and Wesson (2009) aims to determine the ability to identify and access appropriate information, menus, reports, options and elements accurately and effectively. The design of an ERP system's interface should enable easy navigation among different modules (Calisir and Calisir 2004). However one study (Rosemann and Maurizio 2005) of the hands-on use of SAP in education reported several problems with the navigation of user interface. Navigation problems have been identified as one of the main barriers that prevent ERP systems from delivering their potential benefits to organisations (Matthews 2008).

NAVIGATION

- *Navigation and Access to Information*

PRESENTATION

- *Presentation of Screen and Output*

LEARNABILITY

- *Degree of ease to learn how to use the system effectively*

TASK SUPPORT

- *Appropriateness of task support*

CUSTOMISATION

- *Ease of customising the system to ensure alignment between the system, the user and business processes*

Figure 4-2 ERP Usability Criteria and Heuristics (Singh and Wesson 2009)

Navigation aids can be provided to users to prevent disorientation (Calisir and Calisir 2004). To help users understand the logic flow of the system, broad and shallow menu structures should be preferred to narrow and deep ones. The depth, or number of levels, of a menu tree depends in part on the breadth, or number of items per level (Shneiderman and Plaisant 2005). If more items are put into the main menu, then the tree spreads out and has fewer levels. This shape may be advantageous, but only if clarity is preserved. Four to eight items per menu is recommended, but no more than three to four levels, and breadth should be preferred over depth (Norman and Chin 1988). When the depth is four or five levels, there is a good chance that the user will become lost or disoriented. Navigation problems (getting lost or using an inefficient path) become more likely as the depth of the hierarchy increases.

Several criteria for evaluating the navigation of ERP systems have been used in industry (Singh and Wesson 2009; Costa 2010) and in education (Scholtz 2010).These include the following:

- Information can be easily accessed;
- Functionality can be found quickly and easily;
- The user interface supports efficient and accurate navigation of the system; and
- There is a correlation between the searched item and the required item.

The second criterion proposed by Singh and Wesson (2009) is *Presentation* and its related heuristic is *Presentation of Screen and Output,* which aims to determine the appropriateness of the layout of menus, dialog boxes, controls and information on the screen for data entry and output generation. Issues identified in usability studies of ERP systems relating to presentation include problems with the complexity of the screen display and problems in understanding and interpreting output from the ERP system. The presentation criterion for ERP systems as described by Singh and Wesson (2009) includes consideration of how well the visual layout is designed. It is therefore related to the concept of attractiveness which is defined by ISO 2001 as the capability of the software system to be attractive to its user, such as the colour and nature of graphical design (ISO 2001). Studies of the evaluation of the presentation of ERP systems in industry (Singh and Wesson 2009; Costa 2010) and in education (Scholtz 2010) include the following criteria:

- The visual layout is well designed;
- The information provided by the system is timely, accurate, complete and understandable; and
- The layout of menus, dialog boxes and controls are easy to understand and interpret and are well structured.

Learnability is the criterion used to determine the degree of effort required to learn how to use the system efficiently and effectively (Preece et al. 2011; Singh and Wesson 2009). Learnability is one of the most important criteria of usability and refers to the capability of the system to enable the user to learn to use the application (Nielsen 1993). A system should be easy for the user to learn so that it is possible to use the system effectively and as quickly as possible (Faulkner 2000). Learnability is also defined as the ease with which new users can begin effective interaction and achieve maximal performance (Dix et al. 2004). Any interactive system should be easy to learn and easy to remember (Molich and Nielsen 1990).

When users encounter new systems, learnability is the first usability measure of which they will become aware since they will be attempting to learn to use the system (Faulkner 2000). A user’s attitudes towards a system can be affected by how easy it is to learn to use the system, which can be measured in terms of the user’s experience of learning how to operate it. A system that is easy to learn will enable the user to carry out a large number of tasks in a short space of time.

Some systems can be said to aim for zero-learning time and make use of the user's knowledge of the world so as to adapt the system to make them easy to learn. Systems that have good learnability build on what the user already knows and provides guidance or clues on what needs to be done. Learnability criteria used in other studies of ERP systems in industry (Singh and Wesson 2009; Costa 2010) and in education (Scholtz 2010) include:

- A user can learn how to use the system without a long introduction;
- The various functions of the system can be identified by exploration; and
- There is sufficient on-line help to support the learning process.

Seffah et al. (2006) also include learnability in their model of usability measures. Learnability has also been described as the magnitude of the users' task in learning to use the system (Newman and Lamming 1995). Features that make a system easy to learn for novice users might be cumbersome for experienced users (Molich and Nielsen 1990). Shortcuts should be provided for experienced users but unseen by novice users (Shneiderman 1998). Users should be able to tailor frequently used actions (Nielsen 1994).

Customisation relates to the ability of the system to be customised according to the specific needs of an organisation (Singh and Wesson 2009). Customisability is a measure of the extent to which the system can be adapted, either by the user or by the system. *Appropriateness of Task Support* aims to establish if there is an accurate alignment between the system and the real world, in order to ensure effective task support and efficient task completion (Singh and Wesson 2009).

The quantitative usability measures that can be used to evaluate ERP systems for instructional purposes include the three measures of usability of systems identified by ISO9241 (1997), namely: effectiveness, efficiency and satisfaction. Three additional measures proposed for evaluating ERP systems, used for instructional purposes (Scholtz 2010) and adapted from those used to evaluate ERP systems in industry (Singh and Wesson 2009), are navigation, presentation and learnability. These three measures were also used in other studies of ERP usability in industry (Costa 2010).

Figure 4-3 illustrates a summary of the usability measures for ERP systems used for instructional purposes. The two measures of customisation and task support are not included as they are more appropriate to users in industry than for students. The reason that the measure of task support is not included is because students are not in a position to evaluate whether or not the real world is reflected in an ERP system. Customisability is not included as a measure because students are not experts who have sufficient expertise to evaluate this aspect of the user interface.

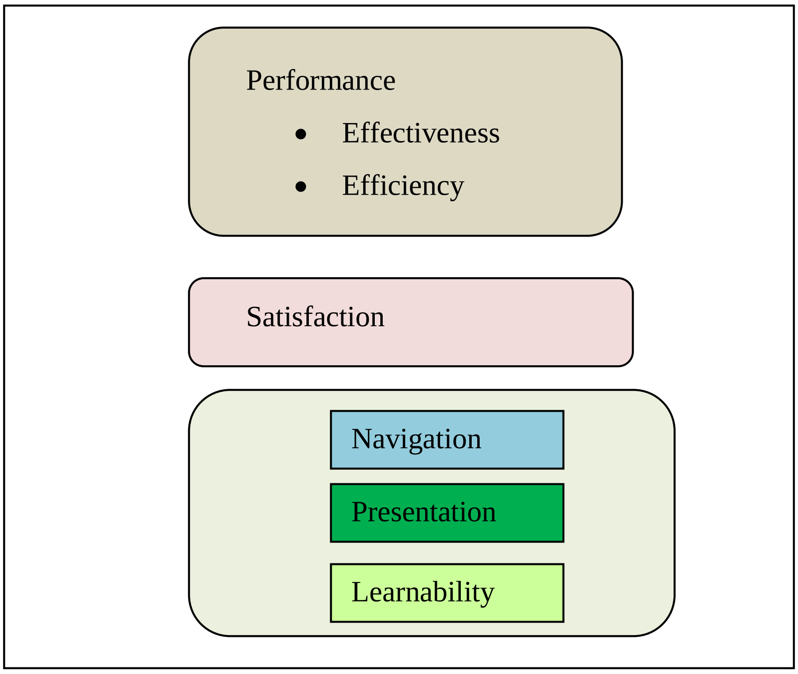

Figure 4-3 Usability Measures for ERP Systems Used for Instructional Purposes

4.5 Conclusions

The ERPEd comprehensive framework for ERP System Adoption for IS higher education is proposed (Figure 4-1) and visually refined (Figure 4-4) in this chapter. The ERPEd framework can assist ERP educators with decisions regarding the design of an ERP education programme. This framework addresses the limitations of other ERP education frameworks by including all ERP competencies relevant to organisations and mapping them to levels of adoption, an ERP system adoption approach, and a ERP learning tool (Section 4.2). ERPEd is a competency-based framework and identifies eleven competency categories required of ERP specialists which are relevant to consulting organisations. Three levels of competency are identified, namely: supporting competencies, core competencies and supplementary competencies.

The ERP competencies in conjunction with the level of breadth can also be used for designing the tasks that an ERP student should perform. The framework (Figure 4-4) also provides educators with criteria to support the selection of an ERP system to adopt in the curriculum. This chapter has therefore answered the third research question *"What comprehensive education framework can be used in an ERP course in higher education institutions in South Africa?"* .

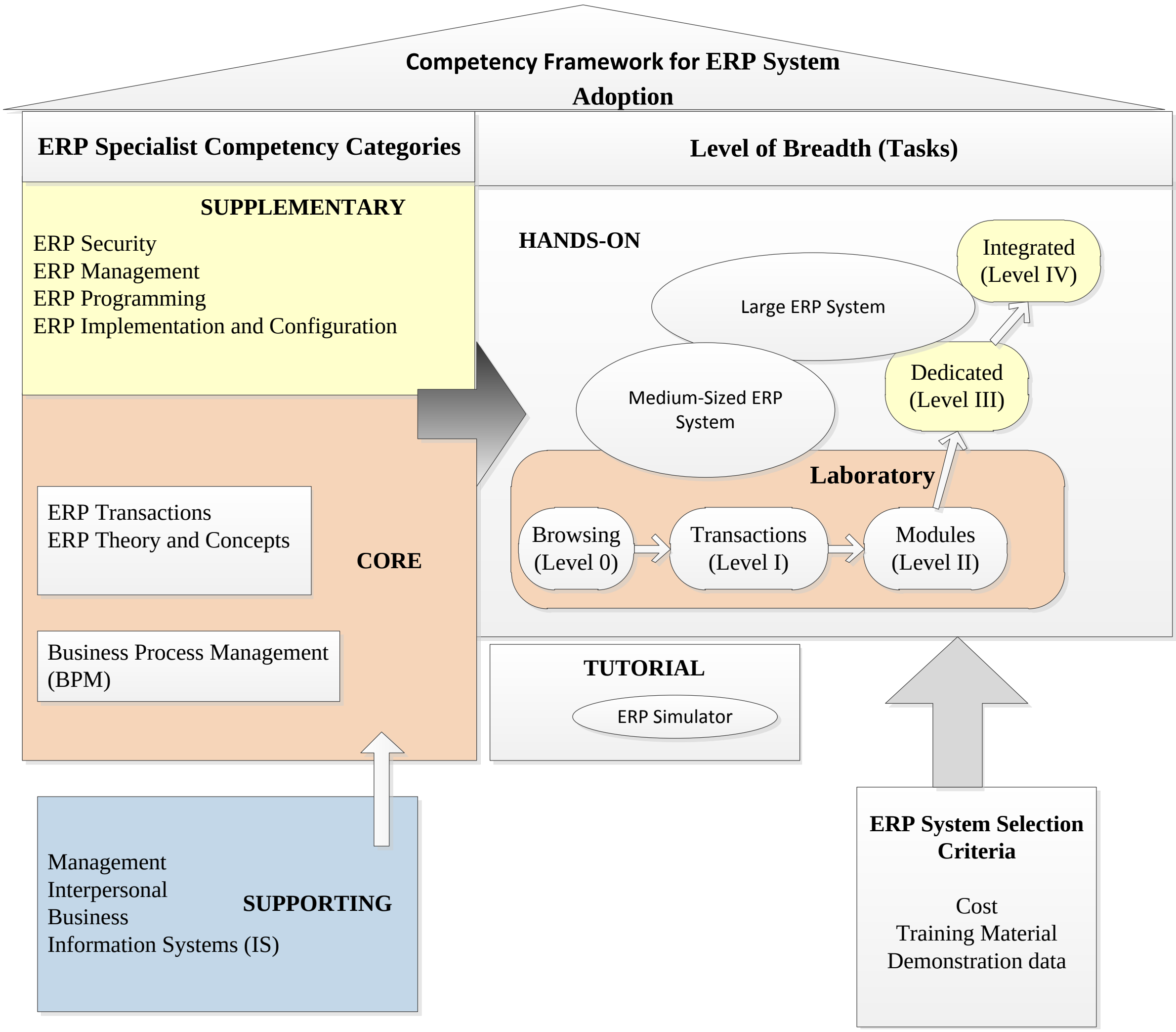

Figure 4-4 A Competency Framework for ERP System Adoption (ERPEd: Version 2)

The primary usability issues relating to ERP systems in education include the large amount of time taken to learn the details of ERP systems. These usability problems can hinder the learning process and students often achieve transactional competence but do not manage to understand the underlying concepts and therefore do not attain required levels of the other competencies.

In order to determine why and how these challenges impact the learning process, it is necessary to measure the academic performance of the student, the usability of the ERP system and the success of the ERP adoption approach. A summary of the relationship between these three categories is illustrated in Figure 4-5.

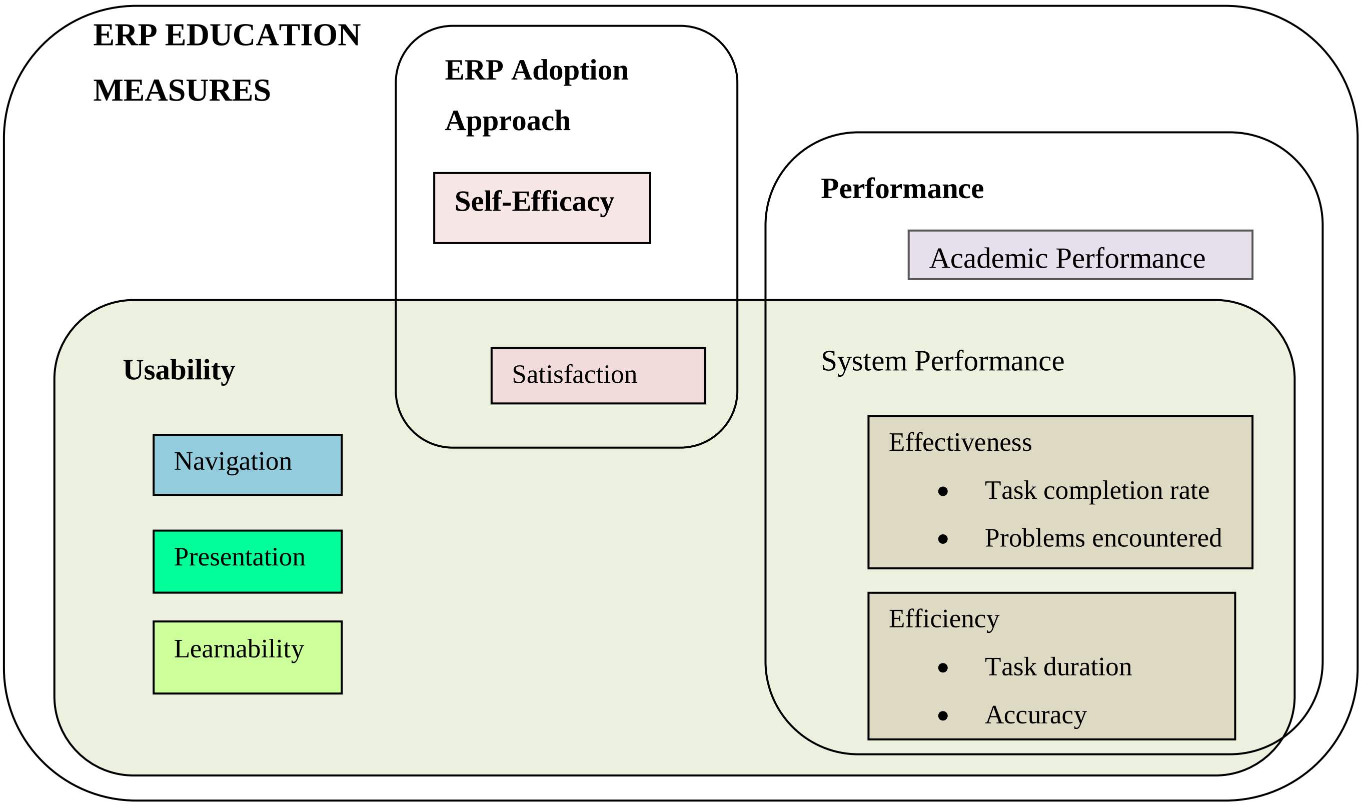

Figure 4-5 ERP Education Measures

The three categories of ERP education measures are therefore, usability measures, ERP adoption approach measures and performance measures. Measures of the success of an ERP adoption approach are self-efficacy and the satisfaction of the students (Section 4.3). In HCI studies system performance is used as a measure of the usability of a system. Therefore, in studies of the adoption of ERP systems in education, both the academic performance of the student and the performance of the ERP system should be measured (Section 4.3). Other usability measures identified as relevant in ERP system use in education are navigation, presentation and learnability (Section 4.4.3). Each of these measures is comprised of several related criteria which can be used to evaluate ERP systems used for instructional purposes (Table 4-1). Two measures used for system performance are effectiveness and efficiency (Section 4.4.2).

Table 4-1 Usability Criteria for ERP systems Used for Instructional Purposes

NAVIGATION	
1	Information can be easily accessed
2	Functionality can be found quickly and easily
3	The user interface supports efficient and accurate navigation of the system
4	There is a correlation between the searched item and the required item
PRESENTATION	
1	The visual layout is well designed
2	The information provided by the system is timely, accurate, complete and understandable
3	The layout of menus, dialog boxes, controls are easy to understand, interpret, and are well structured
LEARNABILITY	
1	A user can learn how to use the system without a long introduction
2	The various functions of the system can be identified by exploration
3	There is sufficient on-line help to support the learning process

This chapter has proposed a framework for ERP education and measures for how it can be evaluated. These measures include traditional academic measures as well as usability measures for evaluating the ERP system. This chapter has therefore answered the fourth research question "*How can the impact of ERP system adoption in a curriculum be measured?*".

This study provides a significant contribution to research in the fields of HCI and education as there are no known studies investigating the impact of the usability of the ERP system on the competencies and educational outcomes of ERP students. The following chapter will discuss the design of the application of the framework in a case study where the proposed educational outcomes and measures, as well as usability measures were used to evaluate an ERP course in an IS degree programme in South Africa.

Chapter 5: Application of the Competency-based ERP Education Framework

5.1 Introduction

A Competency Framework for ERP System Adoption for IS Higher Education (ERPEd) was proposed based on the theoretical framework derived in Chapters 2 – 4 (Figure 4-4). The theoretical framework also identified measures for evaluating ERP adoption in education (Figure 4-5). The primary research question of this study that needs to be answered is:

"What is the impact of the application of an ERP education framework at NMMU?"

In order to answer the primary research question, all five of the subsidiary research questions (Table 1-1) need to be answered, therefore these questions will be revisited here. The first research question, *"What competencies (skills and knowledge) are required for an ERP specialist by ERP consulting companies in South Africa?"* was addressed and answered in Chapter 2 by means of a survey of relevant literature and a survey of ERP employer organisations. The findings of these surveys were used to derive a set of competencies for ERP specialists.

The second research question *"What frameworks and approaches can be used to adopt ERP systems into the IS curricula?"* was answered in Chapter 3 by means of a survey of relevant literature and included an analysis of ERP adoption approaches and education frameworks. From this analysis an ERP Adoption Levels Matrix for IS higher education is proposed (Table 3-5), which considers both the level of breadth and depth of ERP adoption in IS curricula.

The third research question *"What comprehensive education framework can be used in an ERP course in higher education institutions in South Africa?"* was addressed in Chapter 4 by proposing a Competency Framework for ERP System Adoption for IS Higher Education (ERPEd). This framework was derived from related studies in ERP education as well as on a survey of employers of ERP specialists (Chapter 2) and a survey of educators of IS and ERP programmes in South Africa (Chapter 3).

The fourth research question *"How can the impact of ERP system adoption in a curriculum be measured?"* was addressed in Chapter 4 and several measures of ERP education and ERP system adoption are identified. Based on the findings of the first four subsidiary questions, this chapter addresses the design of an empirical investigation required to answer the last subsidiary research question, namely:

> RQ5 *"What is the impact of the adoption of an ERP system in the IS curriculum at NMMU on ERP educational outcomes?"*

A research design is used to describe the procedures for conducting a study and its purpose is to help find appropriate answers to research questions. Understanding and answering research question five means employing a research strategy and methods that would be deemed appropriate (Cohen et al. 2001), and should ensure that the requisite data can be gathered and analysed to arrive at a feasible solution (Cavana et al. 2001). A case study strategy was selected as the most appropriate research strategy to use to answer this research question. The research design elements for the case study include the case study purpose (Section 5.2), a discussion of the selection of a single case study and a motivation of why this strategy was used to answer research question five (Section 5.3). The research design of a case study should also include the case study protocol which describes how the case is to be studied in order to address the case study questions and to identify the aspects of the case to be studied (Section 5.4).

5.2 Case Study Purpose

This chapter discusses the design of a case study where the ERPEd framework (Chapter 4) was applied and an ERP system adopted in the IS curricula at NMMU. A summary of the relationship between the various factors of this design is provided in Figure 5-1.

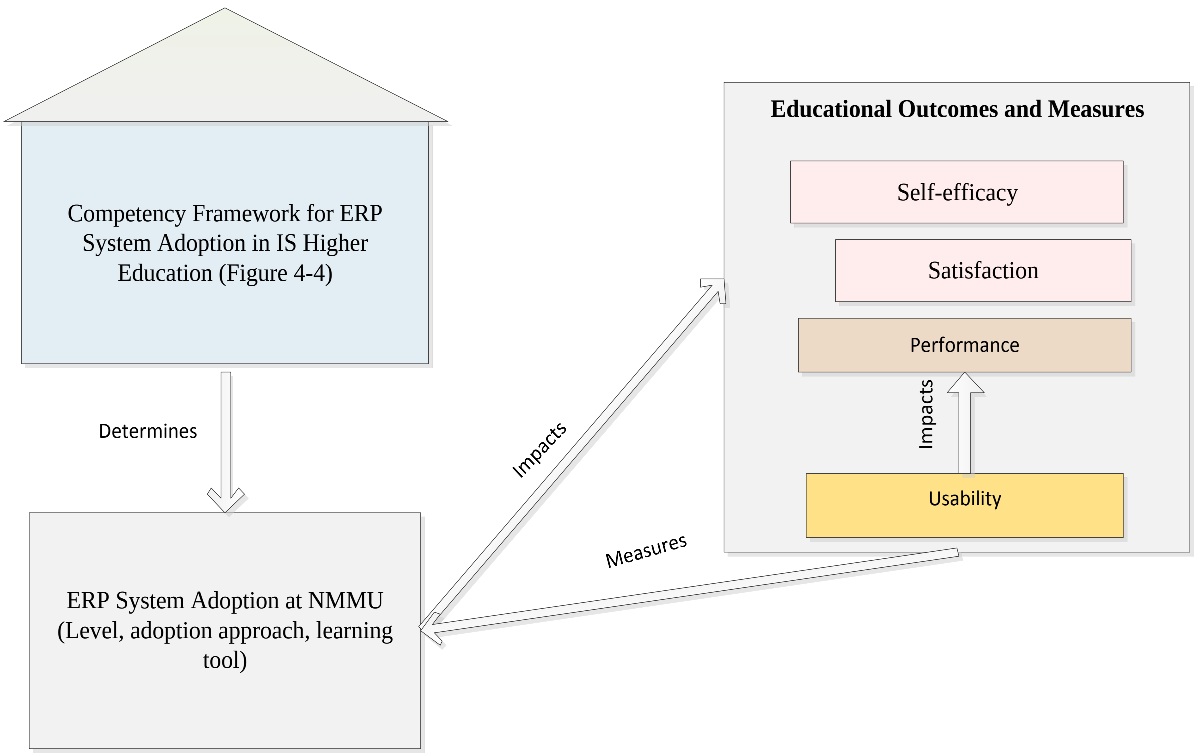

Figure 5-1 Case Study Purpose

The ERPEd framework determines the ERP system adoption, since it provides assistance with decisions regarding the adoption of an ERP system in the curricula. These decisions include which ERP competencies should be attained by students in the course, which adoption approach to use, which level of adoption to implement and which particular ERP learning tool to use. ERP learning tools include ERP systems (large or medium-sized) and ERP simulators (Section 4.5).

The success of ERP education and the ERP system adoption can be determined by measuring the educational outcomes of self-efficacy, performance and satisfaction (Section 4.2). In order to answer research question five, the impact of the ERP system adoption on educational outcomes will be explored. The usability of the ERP system also needs to be measured since it can impact ERP adoption success.

However, empirical studies on the impact of usability on educational outcomes are limited (Section 4.4). The impact of the usability of the ERP system on one of the educational outcomes, namely performance, will be examined in this case study. A quantitative analysis of the impact of usability on self-efficacy and satisfaction will not be examined since it is outside the scope of this study and is not included in the research objectives.

An exploratory study is undertaken when not much is known about a situation at hand (Sekaran and Bougie 2010) and can be useful for clarifying the understanding of a problem, or its precise nature (Saunders et al. 2009). Exploratory case studies in HCI allow researchers to understand novel problems or situations, often with the hopes of informing new designs (Lazar et al. 2010). The case study at NMMU will be exploratory since it is used to examine the nature of the problems encountered by students whilst learning to use the ERP system, and to understand better how users interact with ERP systems, in order to improve the design of future ERP systems for educational purposes.

Explanatory case studies are used to develop models that can be used to understand a context of technology use, or to examine causal relationships between variables (Lazar et al. 2010). The emphasis in explanatory research is on studying a situation or a problem in order to explain the relationships between variables. An evaluation of the usability of the ERP learning tool is required in order to analyse the impact of ERP adoption on educational outcomes, since usability is one of the proposed measures of ERP education (Section 4.6). Whilst the case study research at NMMU is exploratory it also involves explanatory research in that it seeks to examine relationships between the ERP system adoption approach used and educational outcomes.

A case study is an inductive approach where no hypothesis is formulated, but where certain expectations, theories or questions act to guide the empirical research (Saunders et al. 2009). Hofstee (2006) however states that case study findings can be useful in hypotheses generating and testing. Hypotheses will not be identified in this case study but instead the design process will be guided by provisional theories and case study questions (Section 5.4.1).

5.3 Case Study Selection

The goal of this study is to understand the impact of ERP systems on educational outcomes, including the benefits and problems encountered. This knowledge can be used to validate the proposed ERPEd framework and the lessons learned can also be used by other educators in similar education environments to improve the ERP adoption process. In particular, an increased knowledge of the usability problems encountered by students can assist educators to improve the design of practical tasks. Designers of ERP systems can also use this knowledge to improve the user interface of ERP systems.

Case studies opt for analytic rather than statistical generalisation, that is they develop a theory which can help researchers to understand other similar cases or situations (Robson 2002). A case study strategy can be used successfully in this study to answer research question five relating to the impact of the implementation of the adoption of an ERP system on educational outcomes. It can provide analytic rather than statistical generalisation, since although the results may only be applicable to the context at NMMU it can provide insights for the broader ERP education and HCI population. This ability to collect a variety of information is one of the major strengths of the case study method (Olivier 2009). Several factors justified the choice of using a case study as the research strategy to use in this study (Section 5.3.1). The case study selected was an ERP course presented in the Management Information Systems (MIS) course at the NMMU (Section 5.3.2).

5.3.1 Motivation of Case Study and Survey Strategy

The case study strategy and methods used are seen as being compatible with the wider objectives of this research. The methods aimed at giving the optimal data required to investigate comprehensively the research questions posed. Care was taken to select methods that could complement each other and that were feasible, given the constraints of resources. Research strategies are not mutually exclusive (Saunders et al. 2009), and could incorporate a survey strategy as part of a case study, as was done in this research study. The use of a combined case study and survey strategy was used to achieve the objective of applying and validating the ERPEd framework and revealing hidden evidence within a real-life phenomenon.

The survey strategy is usually associated with the deductive approach, and is most often used to answer “who”, “what” and “how many” questions (Saunders et al. 2009). The data is often collected by using a questionnaire administered to a sample of the population, and then standardised, allowing easy comparison. In this study the survey strategy is used by administering questionnaires to students in order to gain empirical feedback.

Several factors justify the choice of using a case study as the research strategy to use in this study, namely:

- Case study strategy is particularly well-suited to IS research (Benbasat et al. 1987; Lee 1989) because new technologies are continually introduced and interest has shifted to organisational rather than technical issues (Benbasat et al. 1987). The research of this study relates to ERP systems which fall into the broader field of IS.
- Case studies can provide invaluable feedback when a study is in the early stages of understanding the problem and the merits of possible solutions (Benbasat et al. 1987). In South Africa, ERP education is still in its early stages (Section 3.8.3) and the use of a case study can provide meaningful feedback to the academic community regarding ERP adoption in South African curricula.

This section explores the general characteristics of case studies and compares these with the selected case study to confirm that the selected strategy is a suitable one to use for this research. There are four characteristics of case studies (Lazar et al. 2010), namely:

- In-depth investigation of a small number of cases;
- Examination in context;
- Multiple data sources; and
- Emphasis on qualitative data analysis.

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. Case studies are useful when detailed knowledge of any particular case is required. Experiments need a large number of participants to perform specific, well-defined tasks, leading to results that can be interpreted to a broad range of users, In contrast, case studies use an in-depth, broad examination of a small number of cases in order to address a broad range of concerns (Mouton 2001; Lazar et al. 2010).

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. The application of the ERPEd framework covers a broad range of concerns since it encompasses the fields of business, education and HCI. It is of relevance to business due to the industry based competency set, to HCI research since the usability of the ERP system will be explored and to the educational community due to its context in a higher education institution.

The use of a case study strategy can be a useful tool for gathering requirements, evaluating interfaces and understanding how users complete tasks (Benbasat et al. 1987). The case study strategy is therefore a suitable strategy to use for this study where the impact of ERP system adoption is explored and the process of learning to use an ERP system to complete business process tasks will be evaluated. Laboratory based usability studies and controlled environments of usability labs have the advantage of removing undesired external influences (Lazar et al. 2010). However, they do not provide a very realistic picture of how people really work. It is difficult to control the environment of students using the ERP systems in computer laboratories.

Case studies often rely on multiple data sources and collection techniques to act as sources of corroborating evidence which can increase confidence in the data (Yin 2003; Lazar et al. 2010). The use of multiple sources and different data collection techniques in a single study in order to provide corroborating evidence is known as data triangulation (Saunders et al. 2009). Multiple data sources can also help alleviate any concerns regarding the quality of data provided by a single source. The impact of the application of the ERPEd framework needs to be explored by examining several different aspects regarding the usability of the ERP system as well as the impact on the performance of the students using the system. In order to get a detailed picture of the experiences of the students, it is necessary to collect and analyse both quantitative and qualitative data from multiple sources. A case study approach suits this form of mixed methods data collection approach. Qualitative data and data analysis is usually emphasized in case studies, and the focus is primarily on questions that help describe or explain behaviour and have considerable ability to generate answers to the 'Why?', as well as the 'What?' and the 'How?' questions (Yin 2003).

Case studies are therefore particularly suited to answer questions relevant to this study such as, "*What problems were encountered with the ERP system interface?*" and *"Do these problems impact educational outcomes?"*. Case studies can, however, also include quantitative components measuring traditional metrics such as task completion time, but these are not the sole focus of a case study as with experiments. Case studies can penetrate situations in ways that are not always susceptible to numerical analysis (Benbasat et al. 1987). Qualitative data collected may be a valuable way of triangulating quantitative data or vice versa (Saunders et al. 2009).

5.3.2 Selection of a Single Case Study

Case studies can examine single or multiple cases (Saunders et al. 2009). A single case may or may not be representative and in the case that it is not representative, multiple cases may provide increased confidence in the observed results. However, single organisation and single technology studies are common in IS research (Amoako-Gyampah 2004) and specifically in ERP research (Seethamraju 2007; Krigsman 2011). A single case study approach was used for this research and the case study selected is the NMMU, where a Management Information Systems (MIS) course aims to establish a sound theoretical knowledge of management information systems and ERP systems, as well as the attainment of transactional competency of ERP systems. The single case was selected on the assertion that it was well positioned to generate a variety of evidence, and therefore multiple cases were not required. The MIS course at NMMU forms part of the 3rd year undergraduate degree programme for IS students. This research study will examine the MIS course unit presented in 2010, which is one of five computing science courses taken by students in their 3rd year.

The ERPEd framework (Figure 5-2a) was implemented in the MIS course at NMMU in 2010. The competencies addressed by the course included the three ERP core competencies of the framework, namely Business Process Management; ERP Theory and Concepts; and ERP Transactions. The framework recommends that ERP programmes addressing any competencies other than business process management should include an industry ERP system rather than just an ERP simulator (Section 3.5).

The ERPEd framework also proposes that courses addressing the core ERP competencies require a hands-on approach with a medium-sized ERP system as the ERP learning tool. Three criteria for selecting ERP systems in the IS curriculum are identified by the ERPEd framework, namely: the cost of the ERP system, the cost and quality of training material, and the quality and availability of demonstration data (Section 3.7). SYSPRO Version 6 ERP system was selected as the most suitable, medium-sized ERP learning tool to use in the MIS course. SYSPRO has been identified as one of the top 10 ERP systems (erpfacts.com 2010) and one of the best ERP solutions in the Tier 3 category (Kristine 2011).

The SYSPRO software was supplied free of charge to NMMU on an educational license basis, therefore the cost criteria was satisfied. In addition SYSPRO provided a dedicated consultant to assist NMMU with the modification of the training material to suit the purposes of the course and demonstration data was included with the SYSPRO system. All three criteria for ERP system selection were therefore met by SYSPRO. The extract of the framework applied at NMMU resulted in the hands-on approach with SYSPRO as the medium-sized ERP system to use.

The application of the ERPEd framework applied at NMMU (Figure 5-2b) maps onto the core competencies addressed by the MIS course. In accordance with this, a Laboratory breadth of ERP system adoption is applied (Section 4.2), using an incremental approach whereby students will progress from Level 0 (Browsing level) to Level II (Modules level) in the course. A Modules level includes tasks which enable students to experience the integrated nature of processes in one or more modules.

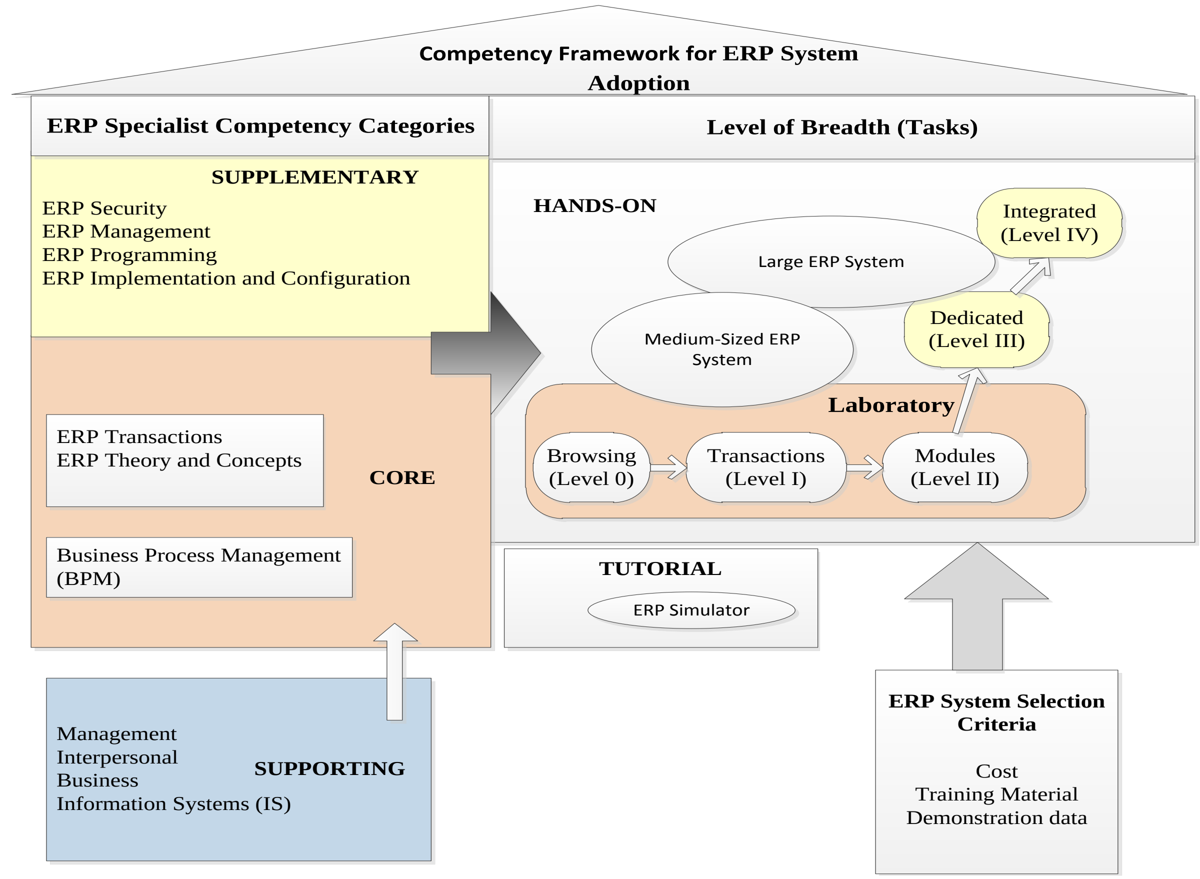

Figure 5-2a) Competency Framework for ERP System Adoption (ERPEd)

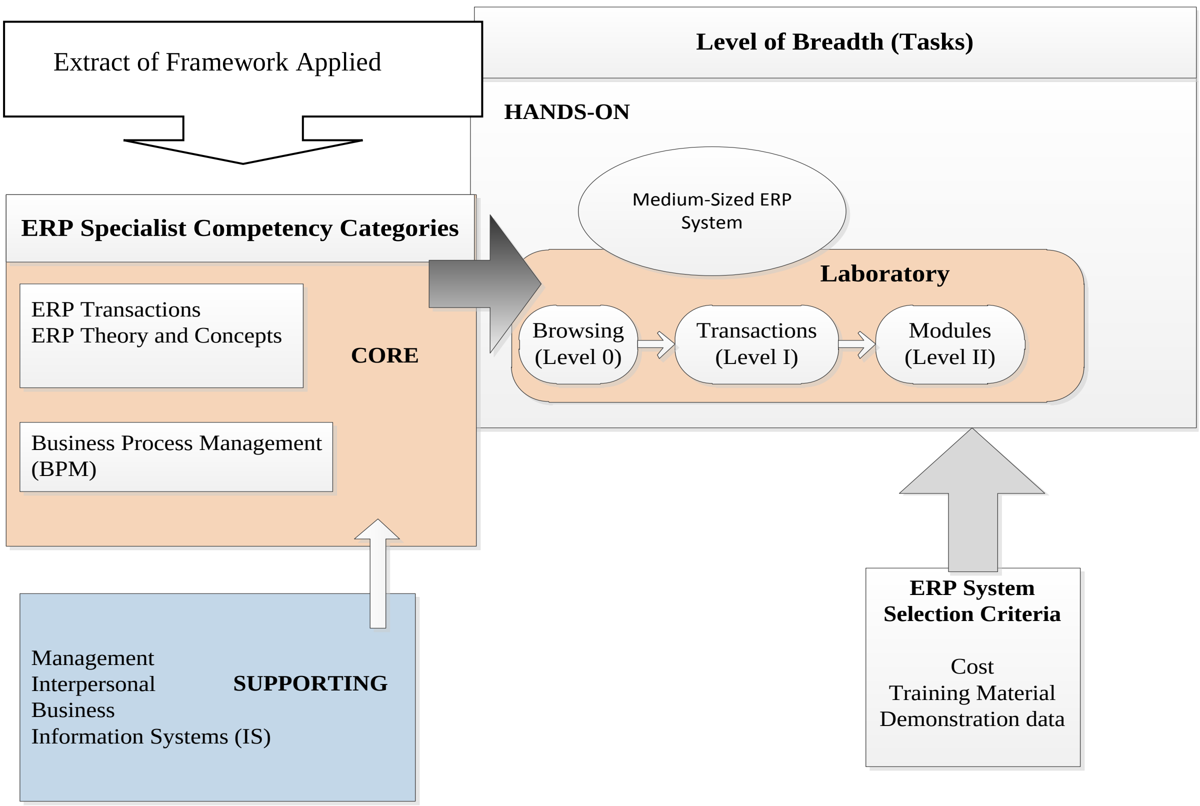

Figure 5-2b Application of ERPEd at NMMU

5.4 Case Study Protocol

The case study protocol describes precisely what is to be studied in the selected case(s) and how these aspects are to be studied (Olivier 2009) and is a powerful tool for establishing reliability (Yin 2003). The protocol should explain exactly what is expected to be learnt from the case, namely: the case study questions (Section 5.4.1) that need to be answered, and any questions to be asked of participants described in terms of the research instruments used (Section 5.4.2). The protocol also lists the aspects of the case that are observed and the design of the pilot study, if applicable, as well as data collection processes (Section 5.4.3). The rules and procedures for data preparation and analysis are described (Section 5.4.4) and risks and constraints of the study identified (Section 5.4.5).

5.4.1 Case Study Questions

The case study strategy aims to answer research question five relating to the impact of the adoption of an ERP system in the IS curriculum at NMMU on ERP educational outcomes (RQ5). The specific factors that are explored are ERP system usability and ERP educational outcomes. Research question number five can therefore be refined into the following three case study questions:

1. What is the impact of the adoption of the SYSPRO medium-sized ERP system on ERP educational outcomes at NMMU?
2. What is the impact of the usability of the SYSPRO ERP system impacts on ERP academic performance at NMMU?
3. What perceptions do NMMU students have of the SYSPRO ERP system?

The educational outcomes that will be investigated include performance, self-efficacy and satisfaction, which can also be used to measure usability (navigation, presentation and learnability.

5.4.2 Case Study Research Materials and Measuring Instruments

A number of different types of measurement instruments and materials are used in the investigation (Table 5-1) in order to address the three case study questions and collect data accordingly. The materials are classified into one of four types, namely: demographic material (Section 5.4.2.1); instructional material (Section 5.4.2.2), assessment instruments (Section 5.4.2.3); and evaluation instruments (Section 5.4.2.4).

Table 5-1 Case Study Measuring Materials and Instruments

Identifier	Material Description	Measures	Type Classification
D_1	Informed Consent Form		Demographic
D_2	Background Questionnaire		
D_3	Pen-and paper Prior Knowledge Profiling Test		
L_1 - L_3	Lecture Notes		Instructional Material
T_1 - T_4	Training Material		
P_1 - P_4	Practical Assignment Forms 1 to 4 (Four weekly documents)	**Performance** • Task Completion rate • Number of Problems • Task Duration or time • Accuracy (Informal) • Problem detail	Assessment
A_1	Test of ERP competencies (Pen-and-paper theory and practical)	**Performance** • Accuracy (Formal)	
SE_1 - SE_8	Self-efficacy (SE) Questionnaires 1 to 8	**Self-efficacy of competencies** • BPM • ERP Theory and Concepts • ERP transactions Satisfaction of ERP adoption • Competency improvement	Evaluation
U_1 – U_4	Usability Questionnaires 1 to 4 (Four weekly documents)	**Usability** • Presentation • Navigation • Learnability Qualitative usability • Positive features • Negative features	

5.4.2.1 Demographic Materials

The demographic instruments included the three materials administered at the start of the course unit, namely: an informed consent form (D_1), a background questionnaire (D_2 - Appendix H) and a prior knowledge profiling test (D_3 - Appendix I). The informed consent form is used to adhere to standard ethics procedures (Section 1.9.3).

The purpose of the background questionnaire is to collect background demographic data of the participants and consists of some demographic details such as gender, language, experience of IT, experience of accounting and ERP systems and prior accounting knowledge. The prior knowledge profiling test is a 15-point multiple-choice quiz that tests basic concepts about business, ERP theory and ERP transactions relating to the procurement cycle. The assessment is similar to the one used in the Noguera and Watson (2004) study to form a baseline of the knowledge levels of each participant.

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. Students are classified into one of two ERP expertise groups (Novice or Experienced) based on their experience of ERP systems (including accounting systems) obtained from the background questionnaire and their prior knowledge. The classification of ERP users according to Novice or Experienced was adapted from the one used by Rusu et al. (2008) and is calculated as follows:

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

5.4.2.2 Instructional Materials

The competencies addressed in the lectures and practical sessions are those as recommended by the ERPEd education framework (Figure 5-2), namely: ERP Theory and Concepts; business process management; and ERP Transactions. Students are required to attend weekly lectures and practical sessions. The sequence of the three ERP lectures (L_1, L_2, and L_3) and the four interventions which are the practical sessions (Prac 1, Prac 2, Prac 3 and Prac 4) are listed in Table 5-2. The lectures are traditional theoretical lectures, one hour in duration, which take place in a lecture room. Three lectures can sufficiently cover the core conceptual knowledge of these three competency categories (Section 2.3.2.1) and therefore no lecture is given in Week 4.

These theoretical concepts have to be 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 for the core ERP competencies are time consuming and therefore one more practical session than lecture is provided.

Table 5-2 ERP Lectures and Practical Sessions in the MIS Course

ERP Specialist Competency Category	Lecture	Lecture Week	Practical Session	Training Material
ERP Theory and Concepts	L_1	Week 1	Prac 1	T_1
Business Process Management (BPM)	L_2	Week 2	Prac 2	T_2
ERP Transactions	L_3	Week 3	Prac 3	T_3
	-	Week 4	Prac 4	T_4

The practical sessions, 70 minutes in duration, take place in the computer laboratory where students are required to perform learning activities on the SYSPRO ERP system for four concurrent weeks. Each practical session takes place in the same department laboratory each week. Training material (T_1 - T_4) includes notes on the scenario used in the practical session, an outline of the business process covered, as well as a brief introduction to that section of the SYSPRO ERP system. This training material must be read before completing the tasks in SYSPRO which are allocated a goal time of 50 minutes in duration to complete.

The learning activities require students to perform hands-on transactions in SYSPRO. Each practical session comprises several tasks that are linked to the three relevant ERP competency categories (Table 5-3), and these are included in the practical assignment forms (P_1 – P_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 (Section 4.2). 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 (Level II).

Assistance is in the form of answering questions to clarify misconceptions or to encourage students in the formulation of solutions. At no time are solutions provided during a practical session, except verbally in broad terms. The tasks are also designed in order to address Level 3 (concept/use skill) of the IS2010 competency metric (Section 3.2).

Table 5-3 ERP Practical Sessions and Tasks

Practical Session	Week	Tasks (Included in $P_1 – P_4$) 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	

5.4.2.3 Assessment Instruments

During the practical sessions, students are required to follow the steps to complete the transactions in SYSPRO and complete a practical assignment form (P_1 - P_4), each of which consists of a description of the practical tasks as well as a pen-and-paper assessment testing transactional and conceptual knowledge. All students are required to submit their solutions on the practical assignment forms (Appendix M1 – Appendix M4) before the end of the practical session.

The practical assignment mark, awarded for each session is used as the metric for accuracy. The solutions to the practical sessions submitted by students are marked by the same marker to ensure consistency and reliability.

The test of ERP competencies (A_1), 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 (Appendix J). The practical part of the assessment (Appendix J, Section A) is out of a maximum of 35 marks and requires the student to use the SYSPRO ERP system to complete tasks similar to the tasks performed in the four weekly 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. The theoretical part of the test (Appendix J, Section B) consists of 15 multiple-choice questions that test conceptual knowledge of the three core ERP competency categories relating to the procurement cycle. A multiple choice assessment was considered sufficient for evaluating students at the Literacy level (Level 2) of the IS2010 competency metric.

5.4.2.4 Evaluation Instruments

The evaluation instruments administered include eight self-efficacy questionnaires SE_1 - SE_8 (Appendix K) and four usability evaluations questionnaires, U_1 – U_4 (Appendix L). The self-efficacy questionnaires are administered at various key points (Figure 5-3) 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. Only the relevant competency categories addressed in a particular lecture and/or practical session are referred to in a specific questionnaire.

Self-efficacy questionnaires were administered directly prior to lectures L_1, L_2 and L_3, and these were SE_1, SE_3 and SE_5 respectively (Figure 5-3). A questionnaire was administered after each of the three lectures and before the related practical session, Prac 1, Prac 2 and Prac 3, and these were SE_2, SE_4 and SE_6 respectively. A self-efficacy questionnaire was also administered between Prac 3 and Prac 4 (SE_7) and after Prac 4 (SE_8). The criteria and scales used in the self-efficacy questionnaire were adapted and replicated from those used in similar ERP education studies (Nelson 2002; Seethamraju 2007; Wang et al. 2009).

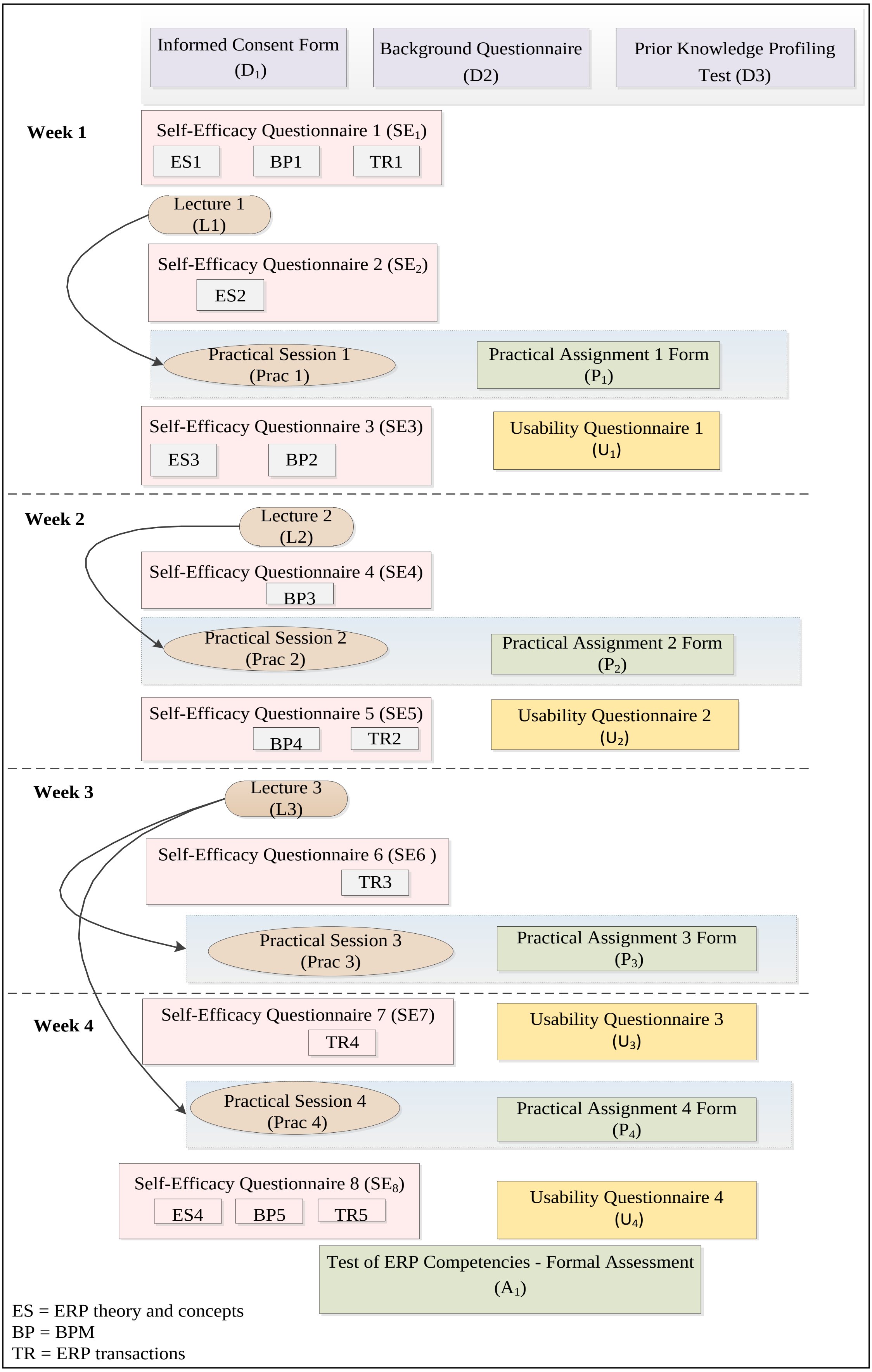

Figure 5-3 Sequence of Administration of Research Materials and Instruments

The first part of the questionnaire (Appendix K, Section A) consists of a list of industry-relevant ERP competencies for each of the three core ERP competency categories, and participants are 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 part of the self-efficacy questionnaire (Appendix K, Section A) consists of a discrete selection regarding whether or not the ERP system had contributed towards the achievement of competency of specific tasks performed in each practical session. Satisfaction of ERP systems in education can be measured by the students' subjective satisfaction with the ERP adoption. This measurement is in terms of satisfaction of whether the use of the SYSPRO ERP system resulted in an improvement in competencies (Section 4.4.2).

A usability questionnaire is administered after each practical session in order to obtain quantitative and qualitative feedback regarding the usability of the SYSPRO ERP system, and consists of two sections. The first section (Appendix L, Section A) requires the participant to rate the usability criteria (Table 4-1) on a 5-point Likert scale. The usability criteria are grouped into the three categories of usability identified as being relevant to ERP systems used for instructional purposes, namely: navigation (NAV), presentation (PRES) and learnability (LEARN). A 5-point Likert scale is used in the usability questionnaire since this scale was used in other ERP usability studies (Singh and Wesson 2009; Costa 2010). The second section (Appendix L, Section B) includes several open-ended questions, which enable the students to report on problems encountered as well as their perceived positive and negative features of the SYSPRO system.

5.4.3 Data Collection Procedure and Quality

A mixed methods data collection approach is used, whereby both quantitative and qualitative data is collected. A questionnaire survey data collection method is used 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 questionnaires are administered to all consenting students enrolled in the MIS course unit. Quantitative data in the form of performance metrics is obtained throughout the course and are those specifically recommended by the ERPEd framework (Section 4.6).

Several methods are used for testing the reliability and validity of the self-efficacy and usability questionnaires. Quantitative and qualitative data analysis techniques are used since the questionnaires include closed and open-ended questions. Quantitative criteria used for assessing research quality and rigor include internal and external validity, reliability and objectivity (Saunders et al. 2009). Face validity is established since both questionnaires were derived from literature, whilst content validity is confirmed by a pilot test where the purpose is to refine the research instruments. This is also in line with guidelines for good case study design (Olivier 2009). A pilot study conducted at NMMU (Scholtz 2010) established content validity and contributed to the refinement of the final research instruments.

Qualitative research quality criteria include: credibility, transferability, dependability and confirmability (Anfara et al. 2001). Evidence of credibility includes triangulation, member checks and/or 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 (Figure 5-4) to provide reliability and validity to qualitative data (Lazar et al. 2010). Multiple, independent pieces of data pointing in a common direction will confirm and validate the findings.

Triangulation of data is achieved by the collection of data from the usability evaluation, self-efficacy surveys and subjective user opinions of the usability of SYSPRO which will validate the findings (Figure 5-4). Responses from the questions relating to satisfaction with the ERP adoption approach and a perception by participants, if competencies are improved, can validate the self-efficacy ratings. Performance data relating to problems encountered can confirm or refute the findings of the self-efficacy data. Qualitative performance data can validate quantitative performance data. Qualitative data from the open-ended questions regarding the positive and negative features of SYSPRO can validate measured usability ratings. Problems encountered can confirm negative feedback of the features of SYSPRO and vice versa.

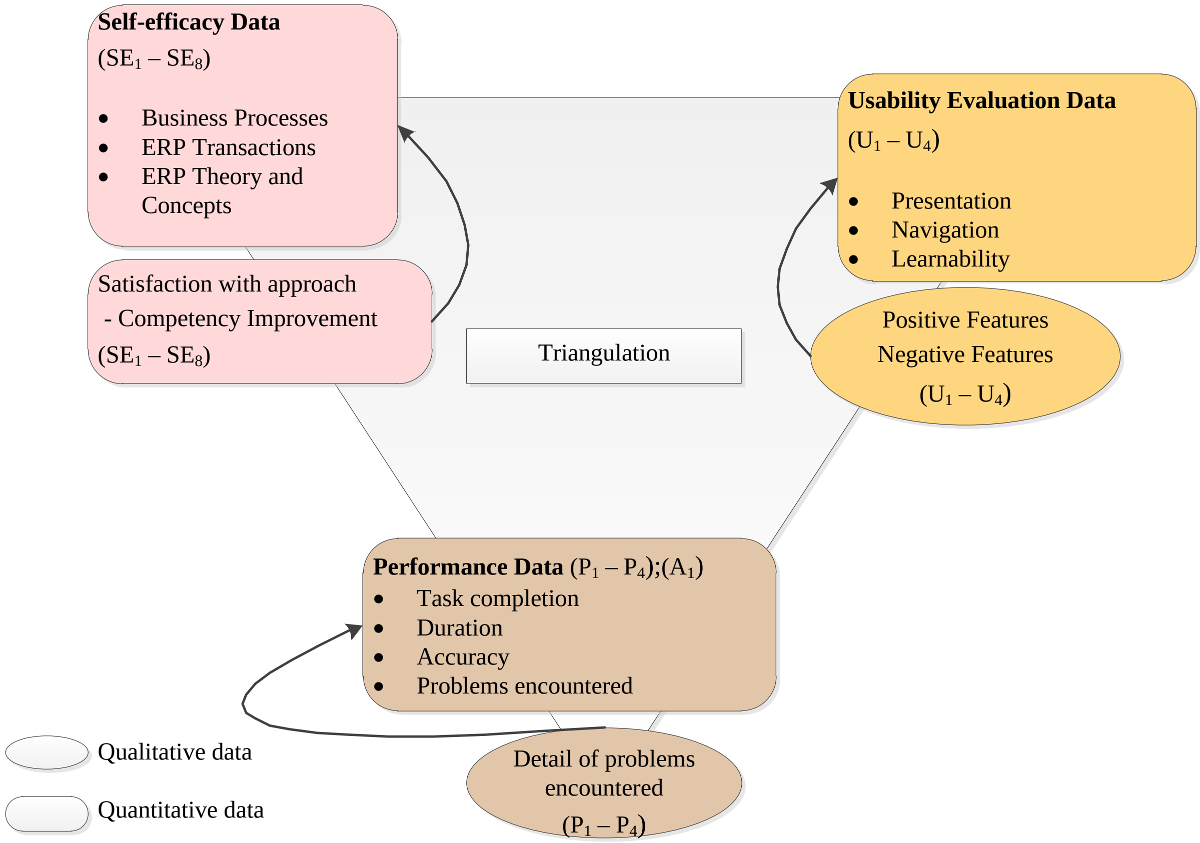

Figure 5-4 Data Triangulation and Map to Materials

In addition to the credibility provided by data triangulation, other methods such as transferability, dependability and confirmability are used in this study to ensure the quality of the case study research. Transferability includes providing detailed descriptions of all steps taken, whilst dependability includes the creation of an audit trail, triangulation and peer examination (Anfara et al. 2001). Yin (2003) also recommends keeping an audit trail in order to trace the analytic results back to the raw data. Throughout this research study, an audit trail is kept which documents chains of evidence tracing the results back to the raw data.

Qualitative research requires a detailed explanation of the decisions and steps taken throughout the research process in order to improve validity. In order to eliminate bias in the content analysis, specific procedures are followed during the coding process (Lazar et al. 2010).

The procedures followed in the NMMU case study are clearly specified in the case study protocol (Section 5.4). Confirmability includes triangulation and reflexivity (Anfara et al. 2001). Reflexivity reflects on the research process and the decisions taken and requires that a researcher is not biased and considers other possibilities or alternative explanations for findings (Creswell 1994).

5.4.4 Data Preparation and Analysis

Four types of data are collected throughout the course, namely: Participant background demographic data, student assessment data (formal and informal), ERP usability evaluation data and ERP adoption evaluation (self-efficacy) data (Section 5.4.2). Sequential numbers are recorded on each questionnaire in order to monitor for missing or duplicate questionnaires. The data is then captured into a Microsoft Excel spreadsheet, cross-checked and verified by an independent person and analysed for inconsistencies and errors. Participant data is considered missing data and discarded: *if a participant does not submit more than 50% of the practical sessions. Students cannot submit a practical session if they have not attended the session.*

A combination of quantitative (Section 5.4.4.1) and qualitative (Section 5.4.4.2) data analysis is used. Qualitative data is required to answer the subsidiary research questions regarding the behavior of students whilst learning to use the SYSPRO ERP system. Quantitative data answers statistical questions relating to the performance of the students. Using a combination of quantitative and qualitative data analysis techniques can therefore address both of these types of questions and is a valuable method to use in IS research and can eliminate potential inconsistencies in results (Kaplan and Duchon 1988).

5.4.4.1 Quantitative Techniques

Two evaluation instruments, the self-efficacy (SE_1 – SE_8) and usability questionnaires (U_1 – U_4), are examined for internal consistency by calculating Cronbach’s alpha coefficients (Nunnally 1978), in order to establish the reliability of these instruments. Validity is established by means of face validity, since all the items in both questionnaires are identified and agreed on by literature (Saunders et al. 2009). Content validity is established by means of a pilot test of both questionnaires (Scholtz 2010).

There are a number of quantitative test statistics applicable to the current study. These statistics can be categorised into those analysing the measures of academic performance, self-efficacy, satisfaction and usability. Academic performance includes the metrics of task completion rate, problems encountered, task duration and accuracy. Task completion rate and task duration measure the performance of the ERP system. The task duration scores are calculated from a manual record of the start and stop times and are compared against goal times in order to measure usability performance (Lazar et al. 2010). The task completion rates and frequency of problems encountered are analysed using the Chi-square goodness of fit test and Cramer's V is used to determine practical significance (Rosenthal and Rosnow 2008).

The accuracy metric includes the grades obtained from the informal assessments during the practical sessions from the practical assignment forms (P_1 – P_4) as well as the formal assessment (A_1). The formal assessment consists of a pen-and-paper theory test and practical test at the end of the course unit (Section 5.4.2.3) after all lectures and practical sessions have been completed. These grades are scores that fall in the range between 0% and 100%. Academic performance makes use of a computed mean obtained by participants for the pen-and-paper and practical assessments. A high score indicates a high level of achievement and a low score indicates a low level of achievement.

Self-efficacy and usability data analysis includes calculating descriptive statistics for the responses to the closed-ended questions. A 5-point Likert scale is used for rating of criteria in both the self-efficacy and usability questionnaire, and therefore the following interval ranges apply: Negative = [1 to 2.6); Neutral = [2.6 – 3.4]; and Positive = (3.4 – 5]. One sample *t* tests are performed (Rosenthal and Rosnow 2008) to calculate the significance of positive or negative scores.

The Mann-Whitney test is a non-parametric test that can be used when two independent groups need to be compared based on a single variable and is the non-parametric equivalent of the independent-samples *t* test (Rosenthal and Rosnow 2008). It is useful to apply this test rather than the *t* test when the samples from the populations are small (less than 30) and it cannot be assumed that the study variable is normally distributed in the populations. Mann-Whitney tests and independent-samples *t* tests are performed to compare two independent ERP expertise groups (Novice and Experienced) to ensure a homogeneous group of participants.

The differences between competency categories for self-efficacy ratings and the differences between the usability measures of learnability, presentation and navigation are analysed using *t* tests. The Pearson Product-Moment Correlations test is performed in order to measure the strength of the linear relationship between usability and accuracy (Rosenthal and Rosnow 2008). The practical significance interpretation intervals used in the statistical analysis of the different surveys is shown in Table 5-4 and will be used to explain the significance of certain research findings (Gravetter and Walnau 2009). Practical significance will be labelled as being small, moderate or large (Table 5-4).

Table 5-4 Practical Significance Interpretation Intervals (Gravetter and Walnau 2009)

		Practical Significance Interpretation Intervals		
Inferential Test	**Statistic**	**Small**	**Moderate**	**Large**
Chi^2 Test:	Cramér's V			
	df* = 1	$.10 < V < .30$	$.30 < V < .50$	$V > .50$
	df* = 2	$.07 < V < .21$	$.21 < V < .35$	$V > .35$
	df* ≥ 3	$.06 < V < .17$	$.17 < V < .29$	$V > .29$
t test:	*Cohen's d*	$0.2 < d < 0.5$	$0.5 < d < 0.8$	$d > 0.8$
Correlation:	*r*	$.10 < r < .30$	$.30 < r < .50$	$r > .50$

5.4.4.2 Qualitative Techniques

One of the goals of usability studies is to identify areas of the system which are problematic for users (Preece et al. 2011). The responses to the open-ended question in the practical assignment forms (P_1 – P_4) are collected as qualitative data. These questions asked participants to record any problems encountered while using SYSPRO. Other qualitative data collected relates to the positive and negative features of SYSPRO. The first step in qualitative data analysis is the reduction of data by summarising and categorising it (Saunders et al. 2009). Qualitative data analysis of the open-ended responses from the two evaluation instruments, the self-efficacy and usability questionnaires, is performed using content analysis (Kolbe and Burnett 1991). Content analysis includes categorisation of data where data is analysed using conceptual analysis and/or relational analysis.

Creswell (1994) also recommends data analysis for generating categories and building theories and this method is also proposed for case study research strategies (Merriam 1988). Conceptual analysis is used to establish the existence and frequency of concepts such as words or themes in a text and to interpret the text by coding the text into manageable content categories.

Constant comparative analysis, which is a technique which occurs as the data are compared and categories and their properties emerge or are integrated together, is used (Glaser and Strauss 1967). Categories may be derived from the data or from a theoretical framework or a combination thereof and then attached to meaningful chunks of data (Saunders et al. 2009). Relational analysis is then used on the qualitative data to build on conceptual analysis by examining the relationships between concepts in a text. Data display is a technique which involves taking reduced data and displaying it in an organised, condensed manner (Sekaran and Bougie 2010). It can also include assembling qualitative data into summary visual displays (Saunders et al. 2009). Data display and analysis are suited to an inductive strategy to analyse qualitative data, but are also compatible with a more deductive strategy (Section 1.9.2).

The usability questionnaire collects self-reported metrics which is subjective data. Self-reported metrics provides the most important information about users' perception of the system and their interaction with it, and can also provide insight into the opinions of users regarding the system (Tullis and Albert 2008). These self-reported metrics record user reactions and are very important for usability analysis.

5.4.5 Risks and Constraints

The risks and constraints of this case study are typical of case studies and include the difficulty of keeping the case study focused and obtaining unbiased results that can be confidently generalised (Mouton 2001; Hofstee 2006). The case study strategy is thus a difficult approach to use, especially on its own, and is often combined with other techniques such as the survey strategy (Hofstee 2006) as evident in this study.

One constraint of surveys is the limit to the number of questions that any questionnaire can contain if the goodwill of the respondent is not to be compromised. The other limitations of case studies include non-standardisation of measurements and the time-consuming process of data collection and analysis (Mouton 2001). These risks and constraints are addressed in the case study protocol by ensuring research quality and rigour in the research process (Section 5.4.3).

Case studies are by their nature a time consuming process and require substantial time commitments from researchers and the participants (Lazar et al. 2010). These constraints consequently allowed only a single case study to be explored. Considering that the primary objective of this study is not to produce generalisations, but rather to uncover problems and issues with the adoption of ERP systems and with the proposed framework, a single case study approach could be considered a constraint but can still provide the ability to focus on the critical issues in a single setting. Single case studies have been successfully used in HCI (Lazar et al. 2010) and other IS research studies (Law et al. 2010).

5.5 Conclusions

A case study was selected as the most appropriate strategy to answer research question five, namely: *"What is the impact of the adoption of an ERP system in the curriculum at NMMU on ERP educational outcomes?"* A survey strategy was also used in conjunction with the case study strategy in order to achieve the goals of this study. The case study strategy is particularly well suited to IS and ERP research and can provide detailed analysis of a small number of cases which cannot be provided with a numerical analysis.

A case study is therefore a suitable strategy to use for studying the process of learning to use an ERP system and to examine usability issues encountered as a result of adopting an ERP system into the curriculum. However, case studies are a very time consuming process and have limitations regarding bias which can be overcome by ensuring the quality and rigour of the research process.

The selected case is an established HEI in South Africa, the NMMU, where the ERPEd framework is implemented in an MIS course. Based on the framework, a hands-on approach is adopted in the course using a medium-sized ERP system, SYSPRO version 6. Several tasks are performed by students during four practical sessions using SYSPRO where the Laboratory level of breadth, using an incremental approach, is used. In the first practical session students only do Browsing transactions (Level 0) in the ERP system, and then move on to simple transactions (Level I) and then progress to completing a full business process in an ERP module (Level II).

Data from the case study is collected by means of two types of instruments, namely: assessment and evaluation instruments. The assessment instruments include informal and formal assessment instruments. The informal assessment instruments are the practical assignment forms, whilst the formal assessment instrument is the pen and paper test of ERP competencies at the end of the ERP course. These assessment instruments collect quantitative performance data which includes task completion data, problems encountered, task duration and accuracy (for formal and informal assessment) as well as qualitative data relating to details of problems encountered by students. Data triangulation is used to eliminate bias and ensure quality of research.

The evaluation instruments are the self-efficacy questionnaire and the usability questionnaire which are administered at various points in the course. The self-efficacy questionnaire is used to obtain students' subjective opinions of their knowledge and/or expertise of the three core ERP competency categories (ERP Theory and Concepts, BPM and ERP Transactions) in order to measure knowledge improvement.

The usability evaluation data includes quantitative data relating to student ratings of the presentation, navigation and learnability of SYSPRO. The usability evaluation data also includes the responses to the qualitative questions relating to the positive and negative features of SYSPRO. A variety of quantitative and qualitative data analysis and statistical techniques are used (Table 5-5) in order to address the identified case study questions. These questions relate to the impact of the adoption of the SYSPRO ERP system on the educational outcomes at NMMU. The educational outcomes are performance, self-efficacy and satisfaction, including usability, and therefore data is collected and analysed accordingly.

Table 5-5 Evaluation Instruments and Data Analysis Techniques

	Instrument	Measures	Analysis and Statistical Techniques
P_1 - P_4	Practical Assignment Forms 1 to 4 (Four weekly documents)	**Performance** • Task Completion rate • Number of Problems	Frequency counts Chi-square goodness of fit
		Task Duration or time	Means and standard deviations
		Accuracy (Informal)	Percentage grade Descriptive statistics
		Problem detail	Content analysis and conceptual analysis
A_1	Test of ERP competencies	**Performance** • Accuracy (Formal)	Percentage grade
SE_1 - SE_8	Self-efficacy (SE) Questionnaires 1 to 8	**Self-efficacy of competencies** • BPM • ERP Theory and Concepts • ERP transactions • Satisfaction of ERP adoption (Competency improvement)	Cronbach's alpha Means and standard deviations Mann-Whitney test Independent-samples *t* test One sample *t* test
U_1 – U_4	Usability Questionnaires 1 to 4 (Four weekly documents)	**Usability** • Presentation • Navigation • Learnability	Cronbach's alpha Means and standard deviations Independent-samples *t* test One sample *t* test Pearson Product-Moment Correlations test
		Qualitative Usability (Perceptions)	Content analysis and conceptual analysis

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The findings of the NMMU case study can make a positive contribution to knowledge on the effectiveness of ERP system adoption in higher education in South Africa. The following chapter will report on the analysis and interpretation of the case study results in order to determine answers to the research questions identified.

Chapter 6: Case Study Results

6.1 Introduction

The ERPEd framework (Figure 4-4) is proposed for the adoption of an ERP system into the IS curricula. This framework includes the competencies required for an ERP specialist which are relevant to industry and maps these onto a recommended ERP system adoption approach, an ERP learning tool as well as the appropriate level of adoption. This chapter reports on the results of the application of the ERPEd framework at NMMU, according to the prescribed case study protocol (Section 5.4).

The ERPEd framework was applied at NMMU to assist educators with decisions regarding the adoption of an ERP system into the MIS course. The application resulted in the adoption of the SYSPRO medium-sized ERP system into the course with the hands-on approach and at a Laboratory level of breadth (Section 5.3.2). The competencies addressed by the ERP section of the MIS course were the three core ERP specialist competency categories, namely: ERP Transactions, BPM and ERP Theory and Concepts.

The purpose of the case study was to explore the impact of the hands-on approach to ERP system adoption using a medium-sized ERP system on educational outcomes. In order to investigate the impact of the application of the ERPEd framework at NMMU, an analysis of the impact of the ERP system adoption must first be examined. The research question that this chapter will therefore answer is "*What is the impact of the adoption of an ERP system in the IS curriculum at NMMU on ERP educational outcomes? (RQ5)*".

In order to answer this research question, three case study questions on which data is collected and analysed, have been posed (Section 5.4.1), namely:

- *What is the impact of the adoption of the SYSPRO medium-sized ERP system on educational outcomes at NMMU?*
- *What is the impact of the usability of the SYSPRO ERP system on educational outcomes at NMMU?*
- *What are the positive and negative perceptions of NMMU students of the SYSPRO ERP system?*

The participants in the study (Section 6.2) were consenting undergraduate IS students registered for the third year Management Information Systems (MIS) course at NMMU which included a unit on ERP systems. Results are reported according to the measures used to evaluate the data (Table 5-5), namely performance (Section 6.3), self-efficacy and satisfaction (Section 6.4). Qualitative and quantitative data was collected and analysed in order to measure the usability of the SYSPRO ERP system (Section 6.5). The data triangulation process contributed to improving the quality of the research process (Section 6.6). Several conclusions and recommendations are made based on the impact of the adoption of the hands-on use of the SYSPRO ERP system on educational outcomes reported from the case study (Section 6.7).

6.2 Selection of Participants

The participants of this study are students registered for the MIS course during 2010. 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 (Section 5.4.4). Less than half the participants have English as their home language (Table 6-1) with the majority of participants (79%) being in the age group 21 to 25 years and having more than five years of experience using a computer (91%). A large proportion (70%) of the students had some accounting theoretical knowledge but only a small percentage had some experience of using an accounting software package (12%) or an ERP system (12%) (Table 6-2).

The participants were assessed according to their prior knowledge level by a multiple-choice prior knowledge profiling test (D_3) which was administered to the participants at the start of the course (Section 5.4.2.1). Based on the results of the prior knowledge profiling test a student was classified as having Low or High prior knowledge (Section 5.4.2.1). The majority of participants (67%) were classified as having Low prior knowledge. The knowledge and experience profile together with the prior knowledge of the participants were used to classify participants according to an ERP expertise level of either Novice or Experienced (Section 5.4.2.1). A total of 61% (n = 20) were classified as having a Novice ERP expertise level.

Table 6-1 Demographic Profile of Actual Participants

		n	**%**
Gender	Female	7	21
	Male	26	79
	TOTAL	**33**	**100**
Age	< 21	3	9
	21-25	26	79
	26-30	2	6
	> 30	2	6
	TOTAL	**33**	**100**
Home Language	English	16	49
	Afrikaans	4	12
	Xhosa	7	21
	Other African	6	18
	TOTAL	**33**	**100**
Years Computer Experience	0-1 Yrs	0	0
	2-3 Yrs	1	3
	4-5 Yrs	2	6
	5+ Yrs	30	91
	TOTAL	**33**	**100**

Table 6-2 Knowledge and Experience Profile of Actual Participants

		n	%	Competency Category
Accounting theoretical knowledge	No	10	30	BPM
	Yes	23	70	
	TOTAL	**33**	**100**	
Accounting Software Experience	No	29	88	ERP Transactions
	Yes	4	12	
	TOTAL	**33**	**100**	
ERP System Experience	No	29	88	ERP Transactions
	Yes	4	12	
	TOTAL	**33**	**100**	
Prior Knowledge	High	11	33	ERP Theory and Concepts; and BPM
	Low	22	67	
	TOTAL	**33**	**100**	

6.3 Performance Results

Performance is one of the measures required to evaluate ERP education quality and measures the performance of the student and the ERP system (Section 4.5). Performance consists of the measures of effectiveness and efficiency. Effectiveness of ERP systems in education is measured by task completion rate and problems encountered (Section 6.3.1). The efficiency of ERP systems in education is measured by task duration (Section 6.3.2) and accuracy (Section 6.3.3).

6.3.1 Task Completion Rate and Problems Encountered

Data collected from the practical assignment forms (P_1 – P_4) include task completion rate and the number of problems encountered, which are metrics of the effectiveness of the student and the usability of the ERP system (Section 5.4.2). A Chi-Square goodness of fit test conducted on task completion rate (Section 5.4.4.1) and the results (Table 6-3) showed that in all four practical sessions the number of participants which completed the tasks was statistically significant ($\alpha \leq 0.05$). Cramer's V was calculated for all sessions which had a statistically significant completion rate in order to determine if the number of participants who completed a practical session was practically significant. Prac 1 and Prac 2 had a 100% completion rate with the results for both of these sessions being statistically significant and having a large practical significance ($Chi^2(1) = 33.00$, $p < .0005$, $V = 1.00$). In Prac 3 84% ($n = 27$) completed all the tasks in the session showing statistical significance with a large practical significance ($Chi^2(1) = 15.13$, $p < .0005$, $V = 0.69$). The percentage of students who managed to complete Prac 4 decreased to 69% ($n = 20$), which is statistically significant with a moderate practical significance ($Chi^2(1) = 4.17$, $p = .041$, $V = 0.38$).

Table 6-3 Task Completion Rate

Practical Session	# Participants	Completion Rate		Chi-square	p-value (d.f. = 1)	Cramer's V	Practical significance
		n	%				
Prac 1	33	33	100	33.00	.000**	1.00	Large
Prac 2	33	33	100	33.00	. 000**	1.00	Large
Prac 3	32	27	84	15.13	. 000**	0.69	Large
Prac 4	29	20	69	4.17	.041*	0.38	Moderate

* $\alpha \leq 0.05$ ** $\alpha \leq 0.01$

Prac 1 and 2 had the highest completion rate (100%), which is expected, since the tasks in these sessions were of a low level of complexity due to the Browsing level of breadth which was implemented (Section 5.3.2). In Prac 3, a Transaction level of breadth was implemented and participants were required to enter simple transactions in the SYSPRO ERP system for the first time. This could account for the 16% drop in completion rate from Prac 2 to Prac 3. Prac 4 had the lowest completion rate, which is to be expected since the complexity of the tasks increased from Prac 3 to Prac 4 and a Modules level of depth was implemented. The completion rates of the first three practical sessions are higher than the benchmark of 78% recommended for usability studies (Section 4.3), whilst Prac 4's rate of 69% is lower than the benchmark. One of the purposes of measuring task completion rate is to determine the performance of the students and of the SYSPRO ERP system (Section 5.5). Since a significant majority of participants could complete the tasks in all four sessions, it can be deduced that the educational outcome of academic and system performance in terms of task completion rate was met.

Participants who did not manage to complete all the tasks in Prac 3 and Prac 4 were asked to provide reasons for non-completion. Eleven responses (n_r = 11)[9] were submitted and the content analysis (Section 5.4.4.2) revealed that similar categories emerged from responses for both Prac 3 and 4. The majority of reasons for non-completion related to the usability (n_r = 8) of the SYSPRO system (Table 6-4). Responses relating to usability were allocated to pre-defined categories for each usability measure, namely navigation, presentation and learnability.

[9] n_r The frequency count of responses

Table 6-4 Reasons for Non-completion Related to Usability

Usability Measure	Category	Frequency Count	Example of reason for non-completion
Navigation	Finding screens	3	*I couldn't get to the screens as displayed in task 3.*
	Finding data	2	*Could not find my postings*
	Affordance	1	*I was not getting the expected dialog boxes and had to repeat tasks*
Learnability	Ease of learning	1	*I find it difficult when working with Syspro, it is difficult to understand. I think I need a detailed introduction.*
	Recovering from error	1	*Task 8 did not work correctly and there was no way in which to go back and correct it*
TOTAL (n_r)		**8**	

Since the problems encountered prevent users from completing tasks these are regarded as critical usability incidents and are related to those encountered with ERP systems reported by Oja and Lucas (2010). The responses cited as examples (Table 6-4) reflect the most detailed or typical response in a particular category.

Of the eight usability problems identified as reasons for non-completion, six were directly related to navigation, and the main problem which emerged was the difficulty with finding required screens and data. This observation supports the findings of Topi et al. (2005) that users require an unreasonable time and effort to find functionality quickly in an ERP system. Two of the reasons related to learnability and of these one specified a problem with not being able to recover or undo an error. This problem is related to the concept of the recoverability of a system (Newman and Lamming 1995; Sommerville 2010), where recoverability is described as the characteristic of a system being able to recover from user error (Nielsen 1993) and is classified as an attribute of learnability (Dix et al. 2004).

The ten participants who did not manage to complete at least one practical session, or had problems in a particular session are referred to as extreme cases (Table 6-5). All participants completed Prac 1 and Prac 2. Only Prac 3 and Prac 4 had participants classified as extreme cases. Eighty percent of the extreme cases experienced problems in more than one practical session. Five of the participants who did not complete had problems in 75% or more of the other practical sessions. It appears that participants who have problems in one session tended to have problems in other sessions.

Table 6-5 Extreme Cases in Practical Sessions (*n* = 10)

	DID NOT COMPLETE		PROBLEMS IN SESSIONS			
Participant	**Prac 3**	**Prac 4**	**Prac 1**	**Prac2**	**Prac 3**	**Prac 4**
P01		✗				
P03		✗			✝	✝
P04	✗	✗	✝		✝	✝
P10		✗		✝	✝	✝
P14	✗	✗	✝		✝	✝
P17	✗	✗	✝		✝	
P22		✗				
P23	✗	✗	✝	✝		✝
P34	✗		✝	✝		✝
P35		✗	✝			✝

✗ Participant did not complete session ✝ Participant had a problem in session

A further metric of the effectiveness of the ERP system is to identify any problems encountered (Section 4.4.2). All participants, regardless of whether they completed or not, were requested to record any problems they had experienced while using SYSPRO to do their tasks in the practical session. A Chi-Square goodness of fit test (Section 5.4.4.1) conducted on this data indicated that the results for problems in tasks in Prac 2 and Prac 3 were significant (Table 6-6). Cramer's V was calculated for significant items, but is not applicable (n/a) for the non-significant items and therefore practical significance was not determined.

In Prac 1 45% (*n* = 15) of the participants had problems with performing the tasks in SYSPRO (Table 6-6). This, however, is not significant ($Chi^2(1) = 0.27$, $p = .602$). In Prac 2, the number of participants who had problems decreased to 12% (*n* = 4). This result is statistically significant with a large practical significance ($Chi^2(1) = 18.94$, $p < .0005$, $V = 0.76$). Thirty-one percent (*n* = 10) of the participants had problems with the tasks in Prac 3, which is statistically significant with a moderate practical significance ($Chi^2(1) = 4.50$, $p = .034$, $V = 0.38$). In the last session, 41% of the participants (*n* = 12) had problems with using SYSPRO, but this is not significantly or practically significant ($Chi^2(1) = 0.86$, $p = .353$).

The practical session which had the highest percentage of problems experienced (45%), was Prac 1 (Table 6-6), which is to be expected since, even though the tasks are at a Browsing level of breadth and therefore have the lowest complexity, it is the first time students were exposed to the SYSPRO ERP system. Prac 2 had the lowest percentage of participants experiencing problems (12%), which can possibly be attributed to the fact that the level of tasks was still Browsing, which has a low level of complexity. In addition the users had become familiar with the user interface since it was the second time they had used SYSPRO. In Prac 3, a Modules level of breadth was implemented so students entered actual transactions in SYSPRO for the first time and this can possibly account for why the percentage of participants encountering problems increased from Prac 2 (12%) to Prac 3 (31%). In Prac 4 the tasks were more complex than in previous sessions and this could account for the increase from Prac 3 (31%) to Prac 4 (41%) in the percentage of participants experiencing problems.

Table 6-6 Problems in Practical Sessions

Practical Session	# Participants	Participants Experiencing Problems		Chi-square	p-value (d.f. = 1)	Cramer's V	Practical significance
		n	%				
Prac 1	33	15	45	0.27	.602	n/a	-
Prac 2	33	4	12	18.94	.000**	0.76	Large
Prac 3	32	10	31	4.50	.034*	0.38	Moderate
Prac 4	29	12	41	0.86	.353	n/a	-
TOTAL ***(n_r)***		**41**					

* $\alpha \leq 0.05$ ** $\alpha \leq 0.01$

The data relating to the types of problems experienced underwent a data reduction process and were summarised and grouped into categories by means of content analysis (Section 5.4.4.2). Each problem was classified into one of the three pre-defined categories relating to the usability measures, namely, navigation, presentation or learnability (Section 5.4.2). In addition any new categories that emerged were allocated to each response. The frequency count of all responses (n_r) allocated to each usability measure and category identified in all four practical sessions is listed in Table 6-7.

From the 41 affirmative responses related to problems encountered in one or more of the four practical sessions, details were obtained regarding the specific problems encountered (n_r = 37). The findings of the qualitative analysis revealed that the majority of problems were usability problems (n_r = 34) whilst the remaining three problems related to running out of time. The majority of usability problems reported related to the navigation of the SYSPRO user interface (n_r = 28), and of these the most frequent category related to the finding of data fields (n_r = 9). Finding the correct functions (buttons, menus) required to perform the tasks was the second most common problem (n_r = 6). These problems relating to the navigation of the ERP system user interface confirm the findings in studies reporting similar usability problems with ERP systems in industry (Calisir and Calisir 2004; Topi et al. 2005; Singh and Wesson 2009) and in ERP education (Surendran et al. 2006).

Table 6-7 Usability Problems Encountered During Practical Sessions

Usability Measure	Category	Frequency	Example of response
Navigation	Finding data	9	*Location of supplier name and number not easy to access*
	Finding Functions and buttons	6	*At times, there was confusion as to where to add warehouses and branches as everything is normally in the main menu and not part of the taskbar.*
			Couldn't find the find button.
	General Navigation	5	*When logging out I was unsure of who to log out as there were many options.*
	Utility/Tasks	4	*There was some confusion with the postings.*
	Clutter	2	*All the menus panes are one into each other.*
	Adding records	2	*I forgot that after typing the primary key one has to press enter*
	TOTAL (n_r)	**28**	
Learnability	Lack of guidance	3	*Difficult to determine where to go and what to do the first time I used the system. Asked for assistance.*
	Recoverability	1	*When adding a user as an admin and you press enter in the subgroups popup you get an error.*
	Error prevention	2	*There should be warnings before completing a task which would be final*
	TOTAL (n_r)	**6**	

Several learnability problems (n_r = 6) were identified by participants as problems. Three of these problems related to the lack of guidance provided by the user interface of the SYSPRO ERP system. As one participant stated, it was "*Difficult to determine where to go and what to do the first time I used the system*".

The frequency of this type of problem confirms the findings of related studies which identified navigation problems and a lack of guidance provided by ERP systems in industry (Topi et al. 2005; Babaian et al. 2006) and in education (Nelson 2002) It also confirms the navigation criteria recommended by Singh and Wesson (2009) of "*There is a correlation between the searched item and the required item"* for ERP systems (Table 4-1). No problems relating to the presentation usability measure emerged.

The categories of recoverability and error prevention (Table 6-7) had low frequency counts but are considered important usability issues since they are regarded as critical incidents. Two of these critical incidents related to problems which were encountered with SYSPRO, where the user interface did not provide warnings to prevent errors. They were allocated to the category of error prevention which is the ability of a user interface to prevent a problem from occurring in the first place by either eliminating error-prone conditions or checking for them and presenting users with a confirmation option before they commit the action (Nielsen 1994). Error prevention is an attribute of learnability (Dix et al. 2004). The third critical incident related to problems with SYSPRO when the interface violated the principle of recoverability of a system (Newman and Lamming 1995; Sommerville 2010).

6.3.2 Task Duration

Task durations were calculated from the start and end times of each practical session which were recorded on the practical assignment forms (P_1 – P_4). The detailed task duration of each participant is listed in Appendix N (Table N.1) where a blank entry indicates non-attendance by a student for that particular practical session. The descriptive statistics for task duration are illustrated in the box plot in Figure 6-1.

In order to determine performance of the student and of the SYSPRO system, task duration should be compared against a goal time. All four practical sessions had a mean duration of less than the goal time of 50 minutes (Figure 6-1). The session with the highest mean duration was Prac 1 (μ = 43 min) which is to be expected since it is the first time the participants encountered the SYSPRO system. The session with the lowest mean duration was Prac 2 (μ = 8 min). The level of breadth for tasks in Prac 2 was still Browsing, and the participants had previously experienced the SYPRO system in Prac 1, so it is to be expected that it would have the shortest mean duration.

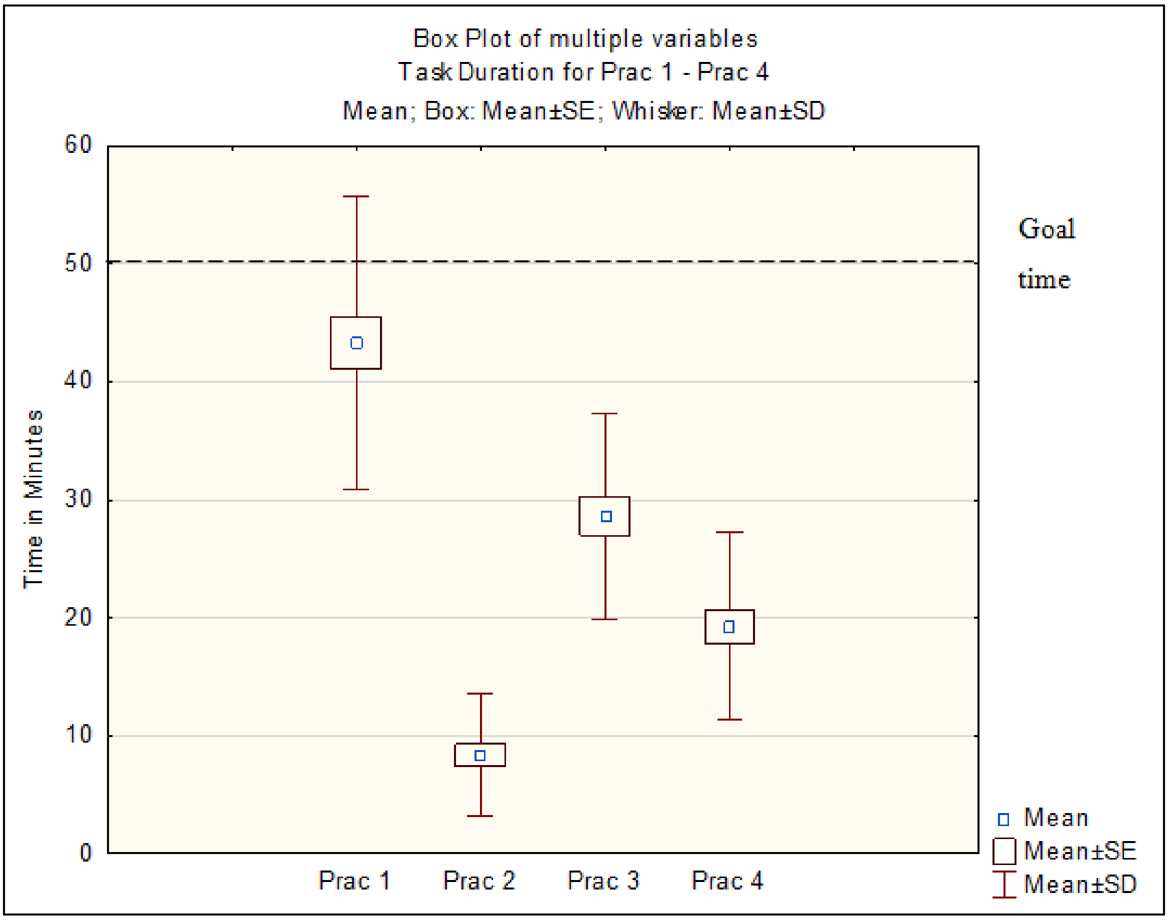

Figure 6-1 Task Duration for Prac 1 to Prac 4

6.3.3 Accuracy

Task accuracy is measured by the marks awarded for tasks attempted (Section 5.4.2.3). Accuracy data collected and analysed included results of the informal assessment in the form of the four practical sessions (Section 6.3.3.1) as well as the results of the formal assessment (Section 6.3.3.2).

6.3.3.1 Accuracy in Informal Assessment

Practical assignment forms (P_1 – P_4) were submitted by each participant and marks were awarded for accuracy (Section 5.4.2.3). The comprehensive report of the marks awarded for accuracy for each participant is included in Appendix O, with associated descriptive statistics shown in Figure 6-2.

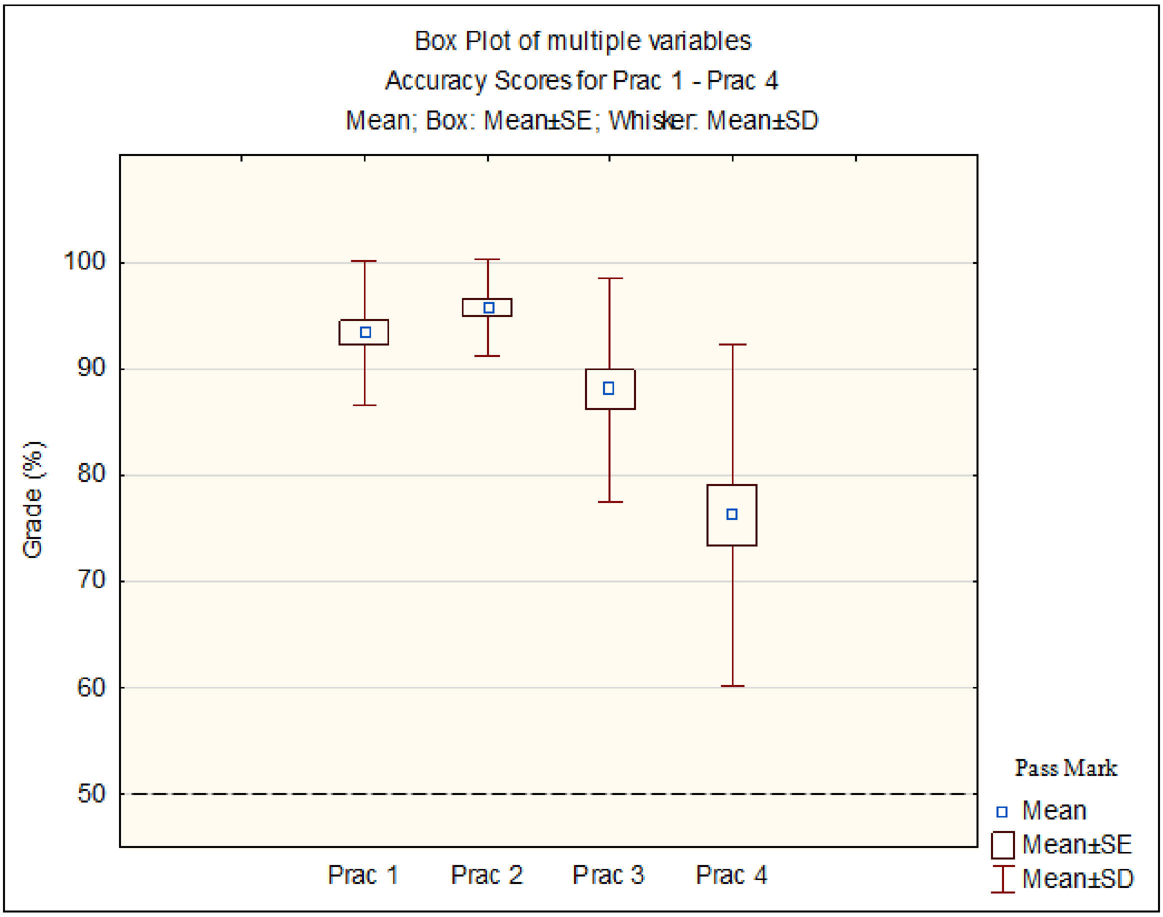

Figure 6-2 Box Plot of Accuracy for Prac 1 to Prac 4

The mean marks for accuracy are high for all four sessions as they are all above 75%, which is considered a distinction at NMMU. 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 (Section 5.3.2). The lowest mark obtained across all four sessions was 29% for a participant in Prac 4 who did not manage to finish all the tasks in the allocated session time (Table 6-5).

The second lowest mark in all four sessions was for participant P03 who obtained a 40% mark in Prac 4, and also did not complete all the tasks. The same participant P03 had problems in 75% of the practical sessions (Table 6-5).

6.3.3.2 Accuracy in Formal Assessment

Students were administered a formal assessment in the form of a controlled test of ERP competencies (Section 5.4.2.3 - A_1) which consisted of an assessment of both their transactional skills (Appendix J – Section A) and their conceptual knowledge (Appendix J – Section B). The detailed results of accuracy for the formal assessment appear in Appendix P with associated descriptive statistics shown in the box plot in Figure 6-3.

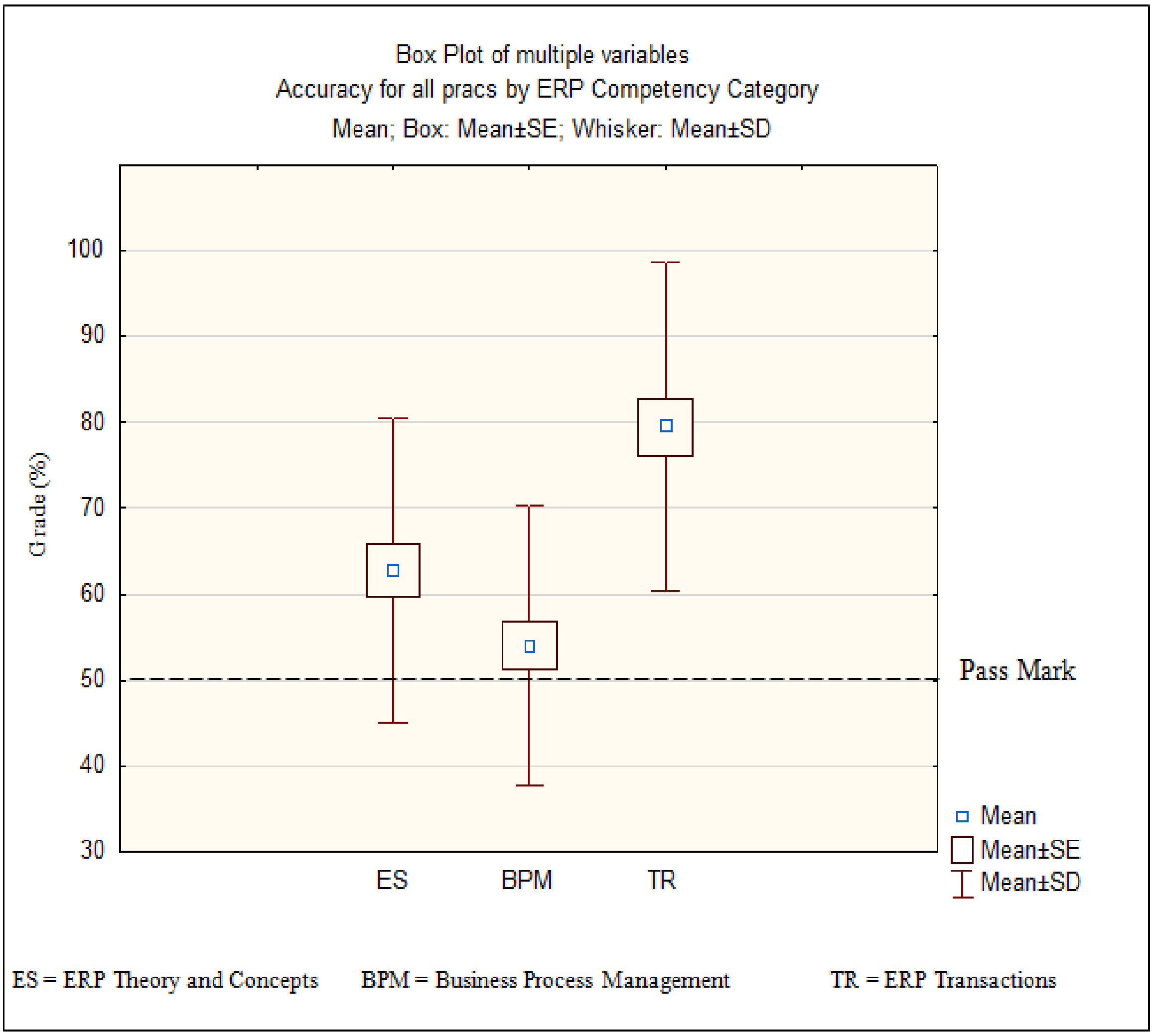

Figure 6-3 Box Plot of Accuracy per Competency Category (Formal Assessment)

The competency category in which participants performed the best in the formal assessment was ERP Transactions (μ = 79%). 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. Therefore the educational outcome for accuracy has been met.

The pass rate 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 (Davis and Comeau 2004; Wang et al. 2009; Rienzo and Han 2010; Winkelmann and Leyh 2010) reporting that students struggle to understand the underlying business processes when using an ERP system.

6.4 Self-Efficacy Results

Self-efficacy questionnaires (SE_1 - SE_8) were completed by the participants at various stages throughout the application of the ERPEd framework (Section 5.4.2.3). These questionnaires consisted of two sections. The first section comprised closed-ended questions where participants had to give subjective ratings of their self-efficacy in the three ERP competency categories (Section 6.4.1). The second section contained open-ended questions relating to the participants' satisfaction with the use of SYSPRO to attain the ERP competencies (Section 6.4.2).

6.4.1 Self-Efficacy Ratings

Cronbach's alpha coefficients for the summated scores derived from the self-efficacy questionnaires were calculated (Table 6-8). All of the Cronbach's alpha coefficients for self-efficacy were close to 1 ($0.83 <= \alpha <= 0.96$) which implies that internal consistency of the self-efficacy questionnaire is very high (Cavana et al. 2001).

Table 6-8 Cronbach's Alpha for Self-efficacy Questionnaires

Competency Category	Instrument	Code	Cronbach's Alpha (α)
Business Processes	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

A Mann-Whitney test, as well as an independent *t* test between groups (Section 5.4.4.1), was performed on the self-efficacy quantitative data in order to compare the Novice group with the Experienced group. The Mann-Whitney test (Appendix Q, Table Q.1) showed no significant differences between these groups except for one item in the very first practical session, namely ERP transactions. The results of the Mann-Whitney test were confirmed by the *t* test of independence (Appendix Q, Table Q.2). 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 Tables 6-9. A one sample *t* test was also performed (Section 5.4.4.1) to determine if the post-intervention results of positive self-efficacy were significant. From the results it can be seen that the mean for self-efficacy measured, after completion of Prac 4 (post-intervention), is positive for all three competencies (Section 5.4.4.1), 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 (Section 5.4.4.1) to determine if the post-intervention results of positive self-efficacy were significant. The results of this showed that only BPM's score was significantly positive ($p = .044$).

Table 6-9 Descriptive Statistics for Self-efficacy

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	.186
SD	1.43	1.30	1.21	1.23			
Minimum	1.00	1.00	1.00	1.00			
Median	3.00	4.00	4.00	4.00			
Maximum	6.50	6.00	6.00	6.00			

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	.216
SD	1.21	1.55	1.04	1.18	1.32			
Minimum	1.00	1.00	1.00	1.00	1.00			
Median	1.50	3.00	3.00	4.00	4.00			
Maximum	5.00	7.00	4.00	6.00	7.00			

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+	2.11	28	.044*
SD	1.26	1.02	1.06	1.09	1.20			
Minimum	1.00	1.50	1.17	1.00	1.00			
Median	4.17	4.08	3.42	3.67	4.00			
Maximum	5.83	5.83	5.50	6.00	6.33			

+ Positive rating

* $\alpha \leq 0.05$ ** $\alpha \leq 0.01$

An independent-samples *t* test for differences between means was performed (Section 5.5.4.1) to determine if the difference in self-efficacy for the competency categories measured before commencing Prac 1 (pre-intervention) and post-intervention, is significant (Appendix Q, Table Q.3). The results show that there was a significant growth in knowledge as measured by self-efficacy from pre-intervention to post-intervention, in two of the three competency categories, namely ERP Theory and Concepts and ERP Transactions (Table 6-10). ERP Theory and Concepts had a significant ($p = .001$) knowledge growth ($\mu = 1.02$). ERP Transactions had the highest knowledge growth of 1.91 which is significant ($p = .000$).

Table 6-10 Growth in Self-efficacy from Pre-intervention to Post-intervention

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**

* $\alpha \leq 0.05$ ** $\alpha \leq 0.01$

The only competency category that did not have any growth in self-efficacy was BPM, and this actually decreased slightly from Prac 1 to Prac 4 ($\mu = 0.04$), but this is not statistically significant ($p = .455$). Although BPM's self-efficacy ratings did not increase from Prac 1 to Prac 4, it was the competency category which had the highest positive self-efficacy rating at the end of the course ($\mu = 3.87$).

6.4.2 Satisfaction of Competency Improvement

Satisfaction of ERP systems in education is the measure of the degree to which the educational outcomes are met by the ERP system, and includes the students' satisfaction with the ERP adoption (Section 5.4.2.3). Satisfaction with the ERP adoption can be measured in terms of an improvement in competencies of students. The second section of the self-efficacy questionnaire (SE_1 - $SE_{8;}$ Appendix K, Section B) contained questions related to how the SYSPRO system contributed to the improvement in the competencies of students (Section 5.4.2.4). The competencies and question numbers are listed in Table 6-11 together with the frequency counts of participants who improved or did not improve their related competency.

The original responses related to competency improvement are listed in Appendix U. In seven of the eight questions relating to competency improvement (Table 6-11), a significant majority stated that the use of SYSPRO in the practical sessions improved their competencies. In Prac 1, 83% (*n* = 25) of the participants stated that they improved their knowledge of the competency ($Chi^2(1) = 13.33$, $p < .0005$, $V = 0.67$). After Prac 2, 79% of the participants (*n* = 26) said the practical session assisted with their understanding of the procurement process ($Chi^2(1) = 10.94$, $p = .001$, $V = 0.58$).

Table 6-11 Improvement in Competencies for Prac 1 to Prac 4

Prac	Item	Competency	Improved		Chi-square	p-value (d.f.=1)	Cramer's V	Practical significance
			n	%				
Prac 1 (N = 30)	Q1	ERP Theory and Concepts (general ERP concepts, features, modules)	25	83	13.33	.000**	0.67	Large
Prac 2 (N = 33)	Q1	Procurement process activities and documents eg Purchase Orders and types of data	26	79	10.94	.001**	0.58	Large
Prac 3 (N = 33)	Q3-1	Purchase orders in an ERP	28	85	16.03	.000**	0.70	Large
	Q3-2	Procurement and ERP	19	58	0.76	.384	n/a.	n/a
	Q3-3	Procurement process activities, documents eg Purchase Order and the types of data	28	85	16.03	.000**	0.70	Large
Prac 4 (N = 29)	Q5-1	Receiving Goods in an ERP system	26	96	18.24	.000**	0.79	Large
	Q5-2	Procurement Process	26	96	18.24	.000**	0.79	Large
	Q5-3	Understanding of Posting Invoices process in an ERP	23	88	9.97	.002**	0.59	Large

* $\alpha \leq 0.05$ ** $\alpha \leq 0.01$

In Prac 3, 85% (*n* = 28) participants stated that they significantly ($Chi^2(1) = 16.03$, $p < .0005$, $V = 0.7$) improved their knowledge of the purchase orders competency (Q3-1) as well as the procurement process activities and documents competency (Q3-3). In the last practical session 96% (*n* = 26) of participants significantly ($Chi^2(1) = 18.24$, $p < .0005$, $V = 0.79$) improved their knowledge of receiving goods in an ERP system (Q5-1) and the procurement process (Q5-2), whilst 88% (*n* = 23) improved their knowledge of posting invoices in an ERP system (Q5-3) ($Chi^2(1) = 9.97$, $p = .002$, $V = 0.59$).

In Prac 3, the *Procurement and ERP competency* (Q3-2), was the only competency which did not have a significant majority ($Chi^2(1) = 0.76$, $p = .384$) of participants who stated that the use of SYSPRO assisted with improving the competency. The practical session which had the highest percentage of participants, stating an improvement in competencies was Prac 4, with a large practical significance.

Participants in each practical session who felt that the use of SYSPRO did not improve their competencies were asked to cite their reasons in each practical session. Approximately 80% of participants in Prac 1 to Prac 4 provided reasons and the majority of these reasons related to the usability of the SYSPRO system (n_r = 13). The frequency counts per category for all four practical sessions were calculated and are provided in Table 6-12. The category with the highest frequency count was button pushing (n_r = 7). By this, they meant that they felt they were just following instructions and not understanding any of the underlying processes. The second highest category (n_r = 3) was related to the participants' wanting more practical sessions using SYSPRO. Two participants stated confusion with the posting tasks as reasons for not improving their competencies.

Table 6-12 Reasons for not Improving Competencies in Prac 1 to Prac 4

Category	Frequency Count	Example
Button pushing	7	*Did not learn anything, was just following instructions but still do not know why we did that.*
		We were given a prac and instructions on exactly how to complete it - the SYSPRO prac assisted with the learning of the software but not the actual concepts of ERP - I know how to get to accounts payable and see supplier info but I'm still not too sure what those things are.
Need more practicals	3	*To an extent yes, but since we have not done much yet, it has not increased dramatically. With more practicals and exploration of the SYSPRO program I'm sure it will.*
Confusion	2	*It makes more sense but it was more confusing.*
		It made me more confused because some things would not show.
Learning curve	1	*Well I am still trying to get a hang of the system as the ordering of information is still new to me.*
TOTAL (n_r)	**13**	

The majority of participants (70%) provided reasons for improving competencies (n_r = 71) when using SYSPRO in Prac 1 to Prac 4. A content analysis of the reasons for the improvement of competencies (Table 6-13) revealed that the majority of reasons related to the benefit of practical application of the theory (n_r= 27).

This finding confirms the benefits of learner-centred education reported by other studies of the hands-on use of ERP systems for educational purposes (Choi et al. 2007; Wang et al. 2009; Jeyaraj 2010; Peters and Haak 2010). The second most frequently cited reason for improving competencies was due to the visual aspect of seeing the documents processed **(**n_r= 19). This enabled some participants to *"make it easier to grasp the ERP concepts more than the lecture did"*. The visual aspect is a new theme which emerged with studies in ERP education identifying this aspect of the use of an ERP system.

Table 6-13 Reasons for Improving Competencies in Prac 1 to Prac 4

Category	Frequency Count	Example
Practical	27	*Because I could see what happens in real life situations and this made me feel that the practical part is better than the theoretical part.*
		The prac helped because I physically did the posting of invoices and I learn better doing than reading theory.
Visual	19	*I find that actually working in an ERP application makes it easier to grasp the ERP concept as I now have a visual image of the application in my mind. When doing just the theory it was more difficult to grasp the overall concept.*
		By being able to view posted invoices one could get the understanding of what transactions are recorded in the various reports. Had we only learnt the concepts theoretically, I do not think I would have understood the Invoices, Receipts, and other documents generated.
Understanding of processes	9	*I now know what an ERP system looks like. Secondly, I know that the first level in SYSPRO show the different modules. I learnt what a chart of accounts is and I learnt about the types of accounts. So using SYSPRO has, to some extent, helped to shed some light on some concepts that I did not understand.*
		It showed me all the details that need to go into documents e.g. purchase orders. Therefore my knowledge of them is more nows
Integration	5	*Using the system showed how all business functions can be integrated into one system and be accessed from it which is helpful to understand ERP and such systems*
Impact and Complexity of ERP	5	*Gave me another perception of how complex ERP systems are and how important they are for improving business processes.*
		Working and struggling with SYSPRO has made discover main modules and how they affect the business
		The ease of navigation and functionality helped me understand why and what features of ERP there are and how they can improve business functions.
Learnability	3	*The prac was much easier to complete as i'm getting used to the system and I can navigate much easier through the menus*
		A brief understanding was all I needed and therefore Syspro did. still a little confused but with time, I think I'll be able to grasp everything
Navigation	2	*Easy navigation throughout the system and steps*
Tasks	1	*Learned howto view and retrieve data on purchasing and also how to add a supplier.*
TOTAL (n_r)	**71**	

The third highest frequency of reasons for improving competencies was for the category of understanding of business processes (n_r = 9). Participants felt that the hands-on use of SYSPRO contributed to their understanding of concepts that they did not previously understand. One participant stated that *"It showed me all the details that need to go into documents eg purchase orders, so my knowledge is more now."* The benefits of the hands-on use of ERP systems to improve understanding of business processes has been reported in several other studies (Peslak 2005; Seymour et al. 2006; Surendran et al. 2006; Wang et al. 2009). Several participants mentioned that using the SYSPRO system made them realise just how complex ERP systems are. The responses in the top three categories were all very similar and no sub-categories emerged.

6.5 Usability

After each of the four practical sessions, the participants completed a usability questionnaire (Section 5.4.2.4). Data from the closed ended questions were analysed quantitatively (Section 6.5.1). Qualitative analysis techniques were performed on the responses for the open-ended questions relating to the positive and negative features of the SYSPRO ERP system (Section 6.5.2).

6.5.1 Quantitative Usability Ratings

Cronbach's alpha coefficients for the summated scores derived from the usability questionnaires (U_1 – U_4) were calculated (Table 6-14). Of the 12 summated criteria, nine were within the acceptable range for Cronbach's alpha which means the internal consistency is high (Nunnally 1978). Learnability in the usability questionnaires U_1 (α = 0.55) and U_2 (α = 0.6) obtained values in the range 0.50 to 0.69, the interval deemed acceptable in the early stages of basic research (Nunnally 1978). The only item which had a low Cronbach's alpha was presentation in U_1 (α = 0.45), and the related results should therefore be treated with caution, and may need to be redesigned in future research.

The first section of the usability questionnaires required the participants to rate the usability of the SYSPRO ERP system on a 5-point Likert scale. This section consisted of three sub-sections related to the usability measures of learnability, presentation and navigation. Each usability measure comprised a number of metrics based on the related usability criteria (Section 5.4.2.3). The descriptive statistics for each of the criteria for all four practical sessions are listed in Table 6-15.

Table 6-14 Cronbach's Alpha for the Usability Questionnaires

Criteria	Practical Session	Instrument	Cronbach's Alpha (α)
Navigation	Prac 1	U1	0.76
	Prac 2	U2	0.80
	Prac 3	U3	0.89
	Prac 4	U4	0.87
Presentation	Prac 1	U1	0.45
	Prac 2	U2	0.67
	Prac 3	U3	0.70
	Prac 4	U4	0.86
Learnability	Prac 1	U1	0.55
	Prac 2	U2	0.6
	Prac 3	U3	0.81
	Prac 4	U4	0.91

Table 6-15 Descriptive Statistics for the Usability Criteria for all Practical Sessions

	n	Mean	SD	Min	Median	Max
NAVIGATION						
Information can be easily accessed	26	3.28	0.80	0.75	3.50	4.50
Functionality can be found quickly and easily	26	3.23	0.73	1.50	3.38	4.50
The user interface supports efficient and accurate navigation of the system	26	3.35	0.66	1.75	3.38	4.50
There is a correlation between the searched item and the required item	26	3.83 +	0.65	2.50	3.75	5.00
PRESENTATION						
The visual layout is well designed	26	3.25	0.70	1.50	3.25	4.50
Information provided by the system is timely, accurate, complete and understandable	26	3.75 +	0.55	2.50	3.75	4.50
The layout of menus, dialog boxes, controls are easy to understand, interpret, and are well structured.	26	3.50 +	0.55	2.50	3.50	4.50
LEARNABILITY						
A user can learn how to use the system without a long introduction	27	3.22	0.88	1.75	3.25	4.50
The various functions of the system can be identified by exploration	27	3.42 +	0.80	1.25	3.50	4.50
There is sufficient on-line help to support the learning process	27	3.31	0.63	1.75	3.25	4.50

+ Positive range

None of the ten usability criteria were in the negative range, six were in the neutral range and four were in the positive range (Section 5.4.4.1). The highest rated criteria was *"There is a correlation between the searched item and the required item"* (μ = 3.83), and the second highest was *"Information provided by the system is timely, accurate, complete and understandable"* (μ = 3.75). A one-sample *t* test was performed (Section 5.4.4.1) on the four positive usability criteria to determine if they were significantly positive (Table 6-16). Only the highest rated criteria (p = .002) and the second highest (p = .003) were significantly positive.

Table 6-16 Positive Usability Criteria for SYSPRO

Usability Criteria	Mean	t	d.f.	p-value
NAVIGATION				
There is a correlation between the searched item and the required item	3.83	3.37	25	.002**
PRESENTATION				
Information provided by the system is timely, accurate, complete and understandable	3.75	3.24	25	.003**
The layout of menus, dialog boxes, controls are easy to understand, interpret, and are well structured.	3.50	0.93	25	.363
LEARNABILITY				
The various functions of the system can be identified by exploration	3.42	0.13	26	.898

* $\alpha \leq 0.05$ ** $\alpha \leq 0.01$

The descriptive statistics for each set of aggregated usability criteria and each practical session are listed together in Appendix R (Table R.1), and illustrated in Figure 6-4. An analysis of the scores from the usability questionnaire data (U_1 – U_4) for each practical session, revealed that the highest rated usability measure was navigation in Prac 2 (μ = 3.86), which is significantly positive (p = .000). Prac 2 also had the highest presentation score (μ = 3.77) which is significantly positive (p = .001). The highest learnability score (μ = 3.73) for all four practical sessions was in Prac 2 and this is significantly positive (p = .006). The practical session with the lowest rating was learnability in Prac 4 (μ = 2.87), which is in the neutral range. There were no negative mean ratings for any of the three usability measures.

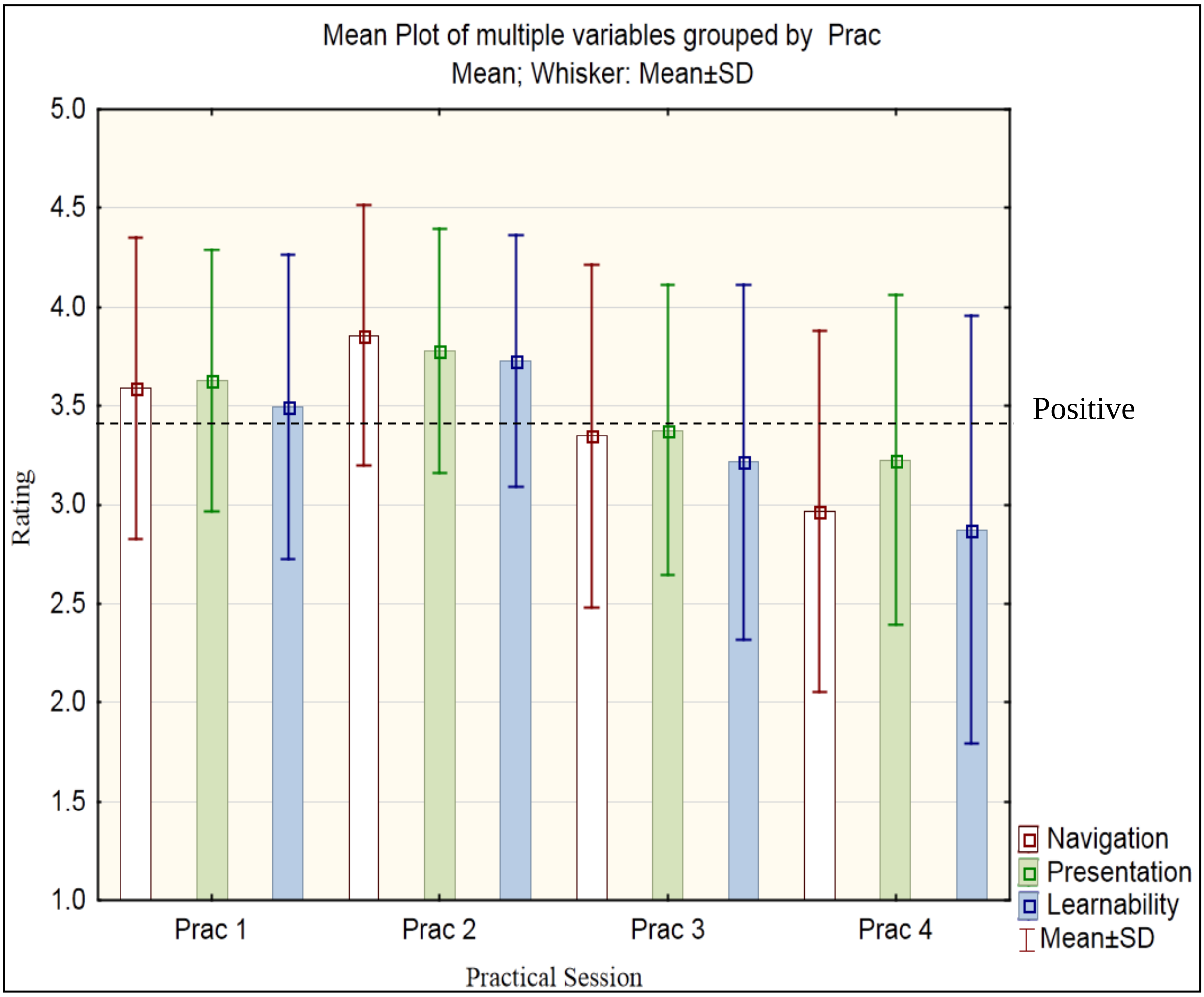

Figure 6-4 Mean Plot of Usability Ratings for SYSPRO

Considering the overall usability ratings for all four practical sessions (Figure 6-5), presentation had the highest score (μ = 3.51), with navigation second (μ = 3.44) and learnability lowest (μ = 3.33). Presentation and navigation both had scores in the positive range, whilst the learnability score was in the neutral range. This result confirms studies reporting that ERP systems are not designed for learning (Shtub 2001; Winkelmann and Matzner 2009).

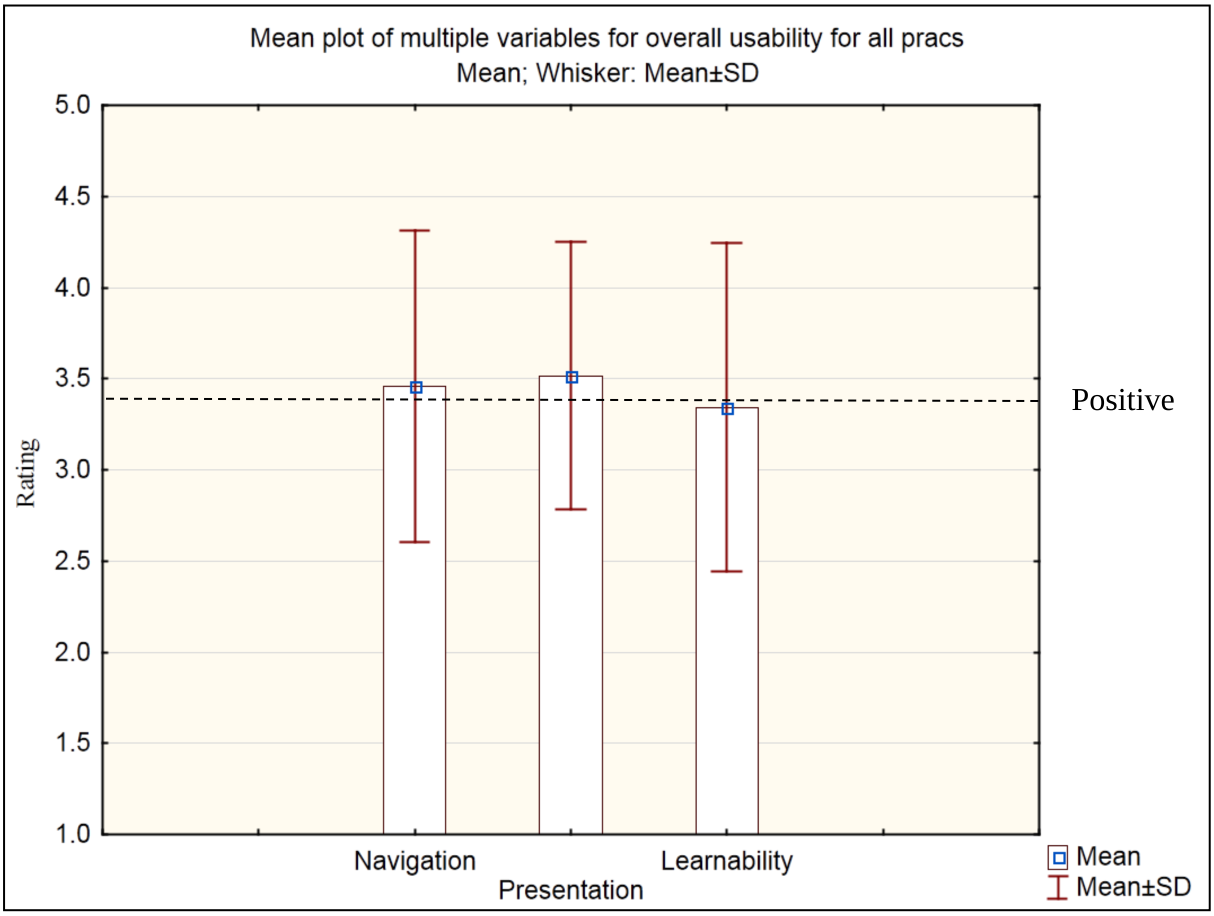

Figure 6-5 Mean Plot of Overall Usability for all Practical Sessions

Tests to calculate significant differences between scores for each of the usability ratings were performed (Table 6-17). The findings show that there is an increase in the usability ratings from Prac 1 to Prac 2 for all measures of usability, namely navigation, presentation and learnability. It can be deduced that as the participants became familiar with the system, they tended to rate it higher. However, there is a drop in mean ratings from Prac 2 to Prac 3 and from Prac 3 to Prac 4 for all three usability measures. This could be due to the increased complexity of tasks.

Overall there is a significant drop from pre-intervention to post-intervention for all three usability measures, navigation ($p = .009$), presentation ($p = .038$) and learnability ($p = .003$). This could be due to the increased complexity of the tasks from browsing in Pracs 1 and 2, to the entering of transactions in Prac 3 and 4, where an understanding of the underlying business processes is required in order to complete the tasks successfully. The results suggest that as the complexity of the tasks increases, the rating of usability decreases.

Table 6-17 Differences between Usability from Pre-intervention to Post-intervention

Difference				Inference			
	n	Mean	S.D	*t* value	d.f.	p-value	Cohen's *d*
NAVIGATION							
Prac 1 to Prac 2	33	0.27	0.74	2.05	32	**.048***	**0.36**
Prac 2 to Prac 3	31	-0.52	0.91	-3.16	30	**.004****	**-0.57**
Prac 3 to Prac 4	26	-0.46	0.76	-3.11	25	**.005****	**-0.61**
Prac 1 to Prac 4	28	-0.57	1.07	-2.82	27	**.009****	**-0.53**
PRESENTATION							
Prac 1 to Prac 2	33	0.15	0.70	1.24	32	.224	n.a.
Prac 2 to Prac 3	31	-0.40	0.85	-2.61	30	**.014***	**-0.47**
Prac 3 to Prac 4	26	-0.21	0.71	-1.48	25	.151	n.a.
Prac 1 to Prac 4	28	-0.44	1.07	-2.18	27	**.038***	**-0.41**
LEARNABILITY							
Prac 2 to Prac 1	33	0.23	0.74	1.81	32	.080	n.a.
Prac 3 to Prac 2	31	-0.52	0.93	-3.08	30	**.004****	**-0.55**
Prac 4 to Prac 3	27	-0.28	0.92	-1.60	26	.122	n.a.
Prac 4 to Prac 1	29	-0.64	1.05	-3.30	28	**.003****	**-0.61**

* $\alpha \leq 0.05$ ** $\alpha \leq 0.01$

The Pearson Product-Moment Correlations test was performed in order to measure the strength of the linear relationship between usability and accuracy (Section 5.4.4.1). According to the results of this test, some of the relationships between accuracy scores in the informal assessment and usability are significant, implying that high/low accuracy performance scores correlate with high/low usability (navigation, presentation and learnability) scores (Table 6-18). This means that there was a positive relationship between the accuracy of the student and the usability of the ERP system. Accuracy and learnability for Prac 1 (Accuracy 1 and Learnability 1) are significantly correlated (r = .441). Accuracy and navigation for Prac 3 (Accuracy 3 and Navigation 3) are significantly correlated (r = .546), as well as accuracy and presentation for Prac 3 (Accuracy 3 and Presentation 3) (r = .441). In Prac 4, accuracy 4 and all three usability attributes, navigation (r = .392), presentation (r = .490) and learnability (r = .515) are all significantly correlated.

The correlation results indicate that students who score high for accuracy also rate the usability of SYSPRO high. Similarly those who have low accuracy scores rate SYSPRO's usability low. This implies that those who rated the usability low also had low accuracy scores, which means that the usability of the system could have impacted their performance in terms of accuracy.

Table 6-18 Pearson Product-Moment Correlations Test Results for Accuracy and Usability

Practical Session	Comparison		n	r_{Crit}	r
Prac 1	Accuracy 1	Navigation 1	33	.345	.236
		Presentation 1			.055
		Learnability 1			.441*
Prac 2	Accuracy 2	Navigation 2	33	.345	.200
		Presentation 2			-.022
		Learnability 2			.134
Prac 3	Accuracy 3	Navigation 3	31	.355	.546*
		Presentation 3			.441*
		Learnability 3			.260
Prac 4	Accuracy 4	Navigation 4	28	.374	.392*
		Presentation 4			.490*
		Learnability 4			.515*

* Significant ($r > r_{Crit}$) at the .05 level, and also practically significant because $r_{Crit} > .30$

6.5.2 Qualitative Usability Ratings

The usability questionnaire ($U_1 – U_4$) included a section with open-ended questions regarding self-reported metrics of the usability of the ERP system (Section 5.4.4.2). These metrics are the user perceptions of the positive features of the SYSPRO user interface, as well as the negative features of the SYSPRO user interface (Section 6.5.2). The response rate for these questions was high (> 90% of participants). Analysis of the qualitative data led to the identification of four main categories describing the positive features of the SYSPRO system on the participants. A summary of the categories, together with their frequency counts appears in Table 6-19. The full list of categories and responses is listed in Appendix S.

Table 6-19 Top Positive Perceptions of SYSPRO

Usability Measure	Category	Frequency Count	Example of response
Navigation	Main Menu	49	*The menu structure is logically laid out and easy to navigate, though the names can sound the same at times.*
			The main menu is easy and is at the middle of the screen, so it makes it easy to see what's on there and to click upon.
			The treeview on the left. It shows the programs that is used often(because of recently used items)
			The tree view menu let's you drill down to specific information very quickly.
			All options (Accounts Payable, Accounts Recievable) are grouped into folders and tree structures, making navigation of the companies accounting records easy to obtain
			The main menu came in handy when switching between the different `journals.`
			Clicking on menus and using toolbars.
	TOTAL (n_r)	**49**	
Presentation	Layout	21	*I liked how structured all the relevant parts of the program are in relation to the different functions.e.g.purchasing, suppliers etc*
			Everything is grouped into group boxes, such as Main Menu which makes navigation easier.
			All information is grouped according to orders, suppliers and customer information, instead of having it all together.
			information can be hidden or visible and as such if i don't want to see it but don't want to close it I can just hide it
			All information relevant is displayed on one page
	Attractiveness	10	*There are groupings (navigation, main menu and program details) and colourful, unlike some accounting programs which are dull and make the works less stimulating.*
	TOTAL (n_r)	**31**	
Learnability	Familiarity	19	*Menu bars and menu items are easy to understand. They are similar to other familiar applications' menus.*
	TOTAL (n_r)	**19**	

The usability measure with the highest frequency count was navigation (n_r = 49). The highest rated feature identified by the participants was the main menu design and structure. The tree structure (Figure 6-6) was cited by several participants as a positive feature which enabled easy navigation. The usability measure with the second highest count of responses for positive features was presentation (n_r = 31). Presentation includes the layout of the SYSPRO interface, which was the second most popular feature overall cited by respondents (n_r = 21). In terms of layout, several participants liked the grouping of information and how structured various parts of the user interface are.

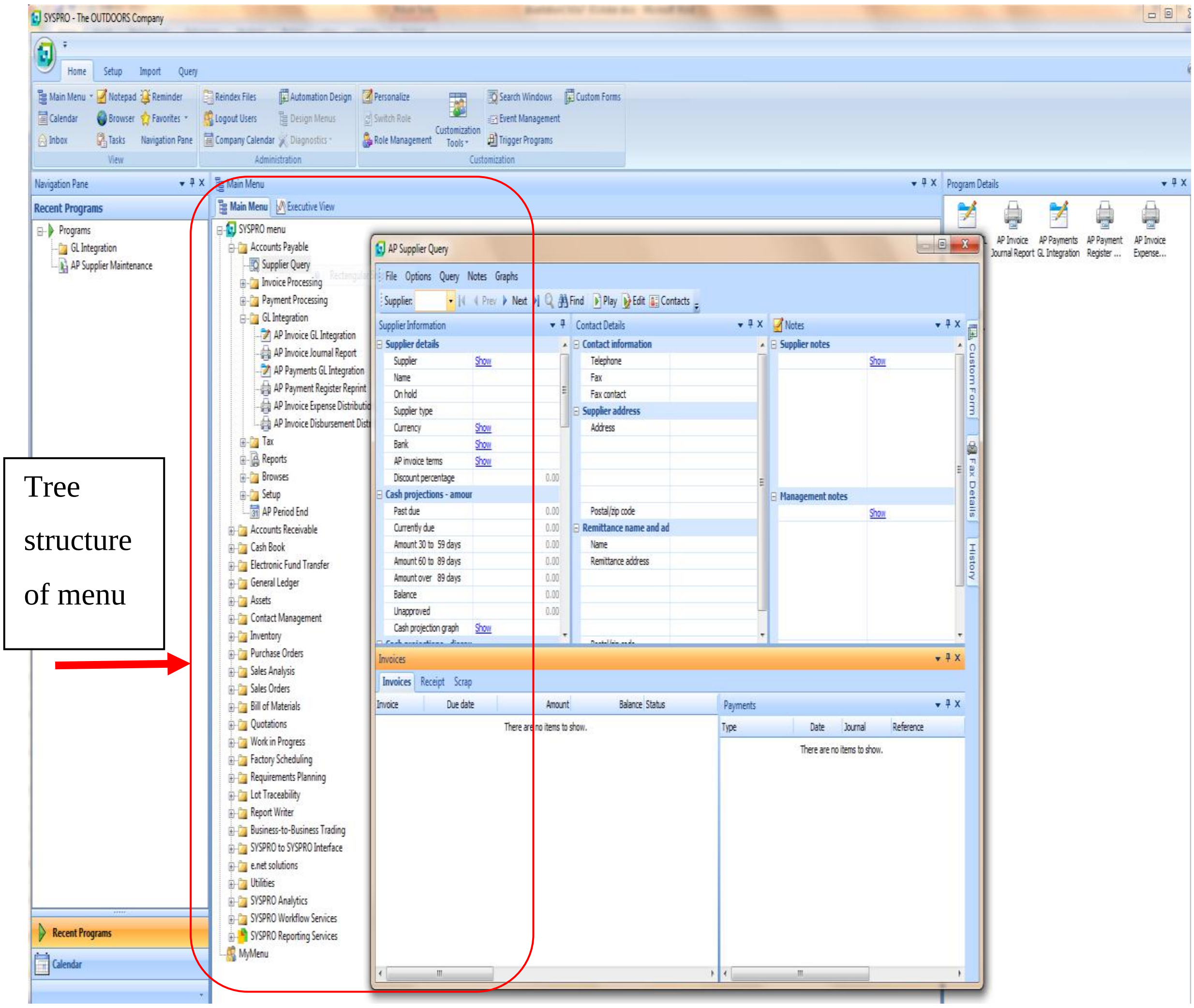

Figure 6-6 SYSPRO Main Menu Screenshot

Another aspect of the presentation criterion cited is the attractiveness of the interface (Table 6-19), which had the third highest number of responses related to it (n_r = 10). The concept of attractiveness is similar to the concept of aesthetic and minimalist design identified by Nielsen (1994), a key criterion for user interface design. The fourth most frequently cited positive feature relates to the familiarity of the SYSPRO user interface **(**n_r= 19). Students reported that they were familiar with the Microsoft interface as they had worked with it in other courses, and that they found SYSPRO's user interface similar to the Microsoft interface. The benefit of the familiar interface of SYSPRO reported by participants confirms studies reporting the importance of familiarity in improving reactions to ERP systems by new users (Koh et al. 2009; Hustad and Olsen 2011). Familiarity is a factor of learnability and is the extent to which a user's knowledge and experience in other real-world or computer-based domains can be applied when interacting with a new system (Compeau and Higgins 1995).

Due to the high frequency of positive responses relating to the navigation of SYSPRO menus, the responses were analysed further using data analysis and data display (Section 5.4.4.2). The data display of the analysis of SYSPRO's positive navigation features is illustrated in Figure 6-7. Here comments relating to the features were separated and linked to the resulting benefit of these features, and the benefits are listed in red. The main positive perceptions of participants relating to navigation were the tree view structure and drill down facility of the menu system in SYSPRO. One participant stated that "*The tree view menu let's you drill down to specific information very quickly*".

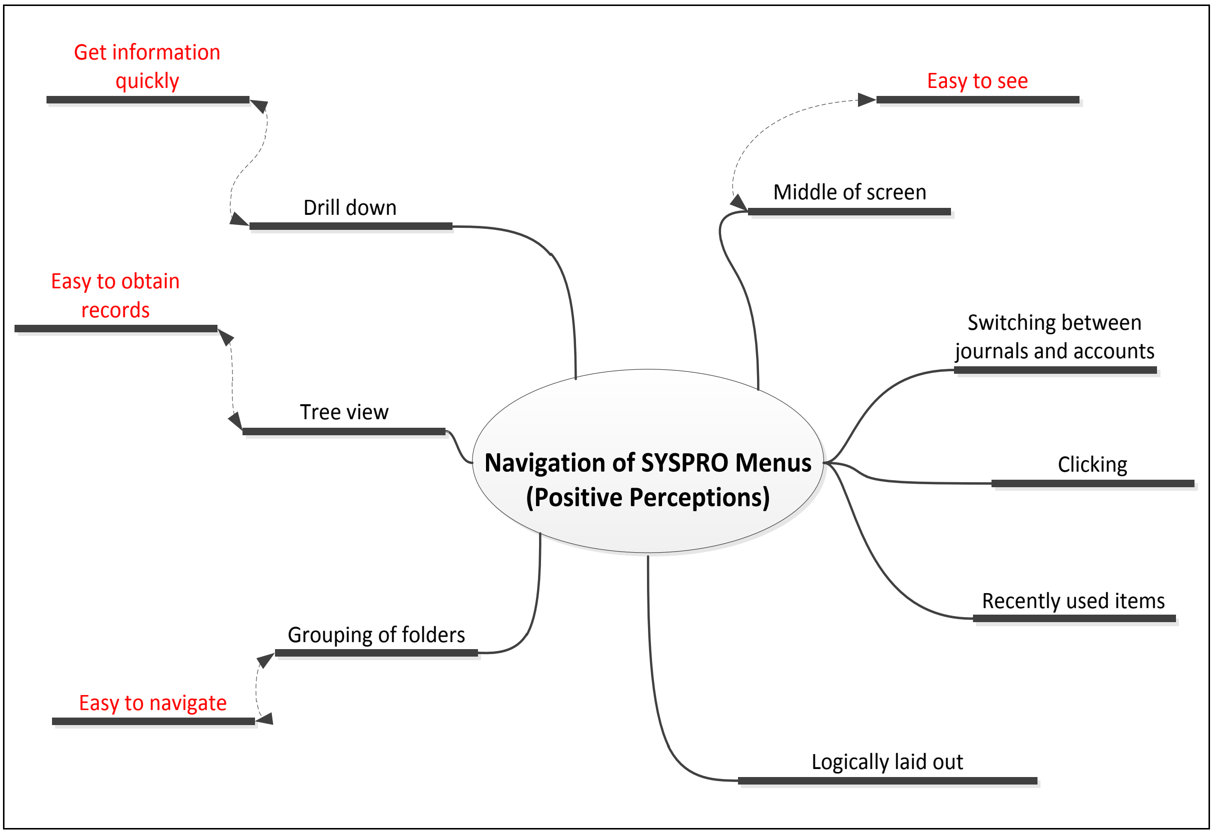

Figure 6-7 Data Display of Positive Perceptions of SYSPRO's Menu Navigation

The benefits of the SYSPRO menu system cited were the ease of navigation and ability to get information quickly. The responses revealed that SYSPRO adheres to the usability principle of grouping similar items in a tree structure into categories as recommended by Shneiderman and Plaisant (2005). This categorisation of menu items is particularly important when the number of menu items grows and becomes difficult to maintain under intellectual control (Shneiderman and Plaisant 2005).

Participants were asked to identify and describe one feature of SYSPRO that they like the least. The results of the conceptual analysis of these negative responses are summarised in Appendix T and the top categories are listed in Table 6-20. The most frequent negative feature cited by participants related to Presentation (n_r = 44) and was connected to the cluttered user interface and more specifically to too much information and clutter in the menus and windows. One participant stated that *"Too much information at once is overwhelming"*. One participant stated that "*For a first time user, the amount of menu/windows can be overwhelming, creating an introductory interface for first time users would assist the learning curve."* This observation supports other research reporting the problems with the complexity of the user interface and the need to cater for novice users (Topi et al. 2005).

Table 6-20 Top Negative Perceptions of SYSPRO

Usability Measure	Frequency Count	Examples of responses of Negative feature
Presentation (Clutter)	44	*Too much information at once is over-whelming*
		Hard to find something right in front of you.
		Too many windows, every action performed seems to open another window.
		Unnecessary options on the left and right side of the main menu (that you don't occasionally use) is distracting.
		The way the windows seem to overlap. Creates a cluttering sense of being lost
		There were initially too many features. For a first time user, the amount of menu/windows can be overwhelming, creating an introductory interface for first timers, would assist in the learning curve.
		The main window gets cluttered with all the open tabs. That will make a novice user of this program rather confused.
		it takes a little time to understand what each of the panels is for. Eg the inventory screen is divided up into: stock code details, distribution, production, and warehouse values
		every time i had to cancel what i had opened i found that irritating as i could have many pages open
Presentation (Adding records)	7	*Adding details to any new item. The system was inconsistent with the use of the enter key and the clicking to place the cursor*
		when creating new supplier. textbox would have been nicer
TOTAL (n_r)	**51**	
Navigation (Hidden controls)	13	*Can't always see the scrollbars*
		Having certain functions of the system hidden from the user, upon click will they appear, i.e. the automatic hide tabs.
		The tabs although useful for navigation sometimes, cause confusion when looking for specific information.
		The toolbar on the right side which is hidden when not used, I preferred it pinned.
TOTAL (n_r)	**13**	

Some of the problems identified can be seen in the screenshot in Figure 6-8 which represents the purchase order entry screen of SYSPRO. Several participants struggled to find the scrollbars in this screen, and therefore could not find relevant information in the purchase order task. The number of windows also overwhelmed some participants.

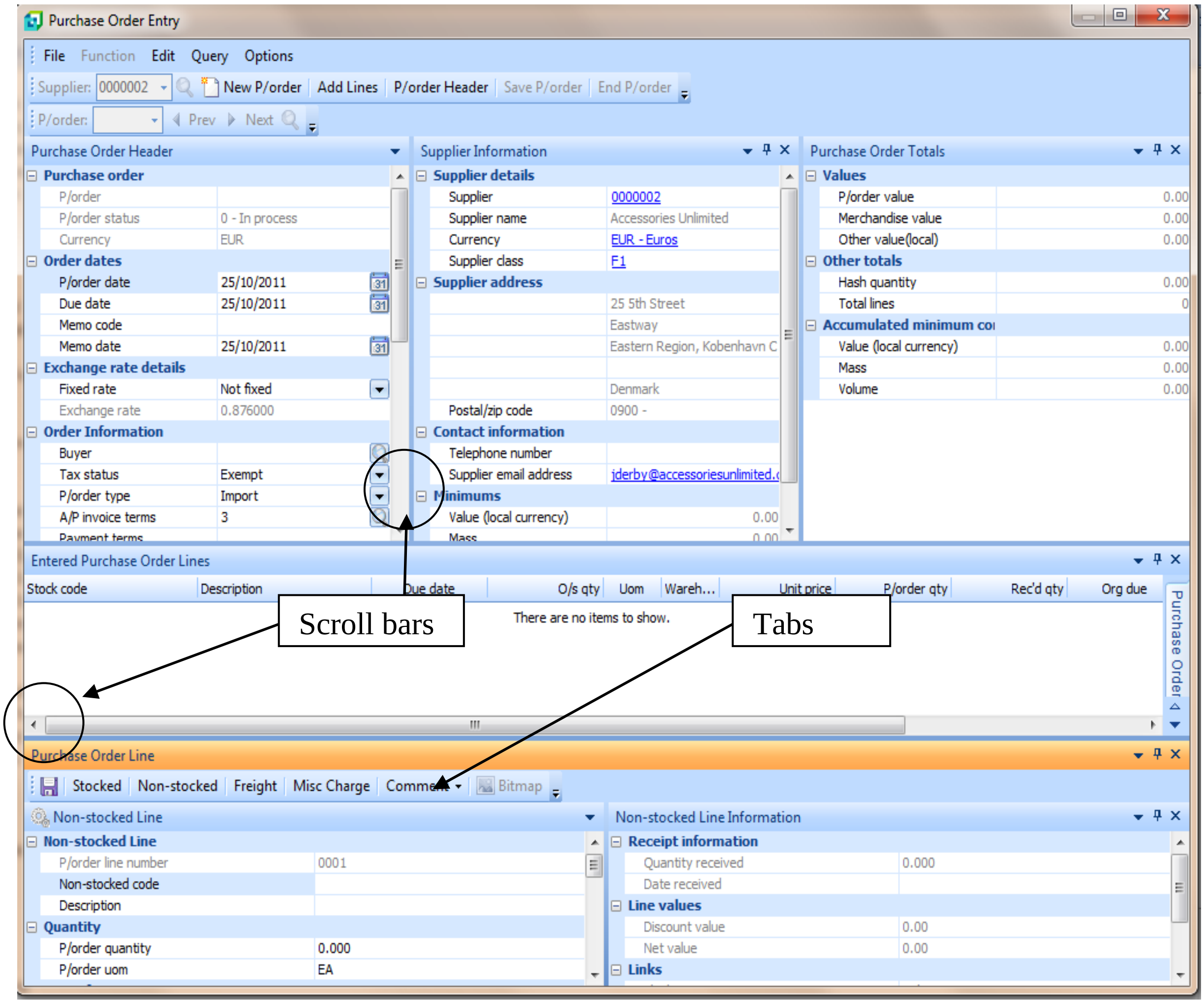

Figure 6-8 SYSPRO Purchase Order Entry Screenshot

The problem with too many menus and windows in SYSPRO reported by participants to cause confusion (Table 6-20) confirms Shneiderman and Plaisant's (2005) theory that the incorrect use of tree structures in menus can occasionally lead to confusion or disagreement. The reported experience of confusion by users of ERP systems has not been identified by any previously related studies of ERP use in education, but could however be related to the concept of frustration experienced by ERP users as reported by Topi et. al (2005). Some participants struggled to focus on more than one activity (screen, function, option), and reported confusion as a result of too many windows, features and open tabs (Figure 6-6).

As stated by one participant, *"The main window gets cluttered with all the open tabs. That will make a novice user of this program very confused."*. This observation confirms the findings of a study (Stone et al. 2005) which reports that users have difficulty focusing on more than one activity at a time.

Due to the high number of responses related to the presentation measure and the cluttered user interface, a more detailed data analysis of the problems relating to the cluttered interface was undertaken. This data analysis and display is illustrated in Figure 6-9. The responses were also analysed to determine participants' experiences of using the SYSPRO system. The text excerpts were categorised into features and user emotions or experiences as a result of these features. The user experiences cited included distracting, overwhelming, confused and irritated. One participant stated that the overlapping windows *"creates a cluttering sense of being lost"*.

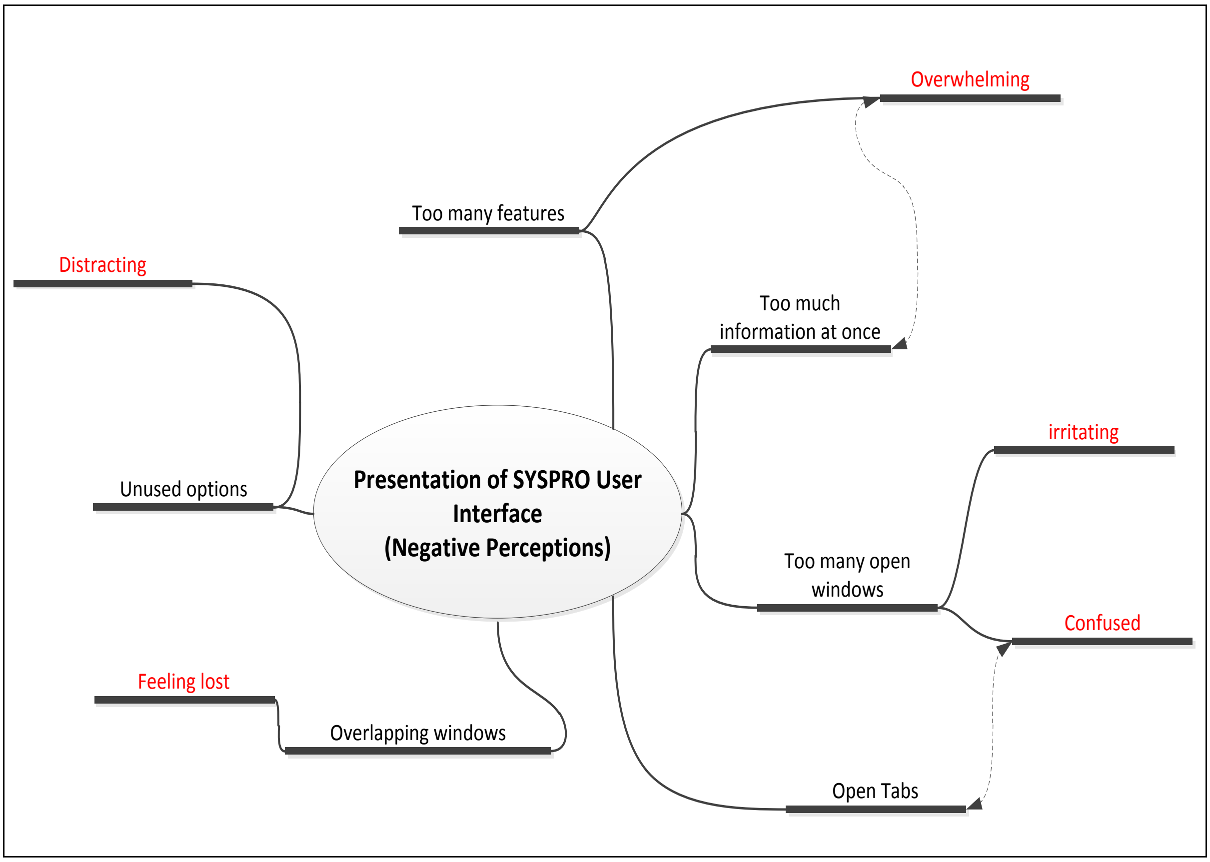

Figure 6-9 Data Display of Negative Perceptions with SYSPRO Related to the Presentation of the UI

The second most frequent negative feature was related to navigation and in particular consisted of problems with the hidden controls in SYSPRO such as the tabs and scrollbar (n_r= 13), which sometimes caused confusion of the users (Table 6-20). This problem in the SYSPRO user interface with hidden controls violates an important principle of usability which states that the functionality of an application should be accessible by seeing and pointing, rather than by remembering and typing (Johnson et al. 1989).

6.6 Discussion and Analysis of Results

The measures of ERP education include academic measures, ERP adoption approach measures and usability measures (Section 5.4.2). Educational outcomes evaluated with the academic measures of performance comprise task completion rate, problems encountered, task duration and accuracy (Section 6.6.1). Subjective ratings of self-efficacy including satisfaction of competency improvement are used to evaluate the ERP adoption approach (Section 6.6.2).

The usability of the ERP system is evaluated using the measures of navigation, presentation and learnability (Section 6.6.3). The data triangulation process is a key contribution of this research and provided insight into the problems encountered with learning to use the SYSPRO system (Section 6.6.4), and also contributed to ensuring the quality of the case study research (Section 6.6.5).

6.6.1 Performance Results

The majority of participants completed the tasks in all four practical sessions (Section 6.3.1), therefore it can be deduced that the educational outcomes of academic performance and performance of the SYSPRO system, in terms of task completion rate (Table 6-3), were met. Prac 4, however is a cause for concern since it had the lowest completion rate. The complexity of the tasks increased from Prac 1 to Prac 4, suggesting a possible reason for the finding. Although a majority of participants completed the tasks in Prac 4, the completion rate of 69% is below the acceptable benchmark of 78% for usability tests (Sauro 2011). This finding suggests that there are some challenges associated with the usability of SYSPRO for tasks in Prac 4, or with the complexity level of the tasks.

The analysis of the qualitative performance responses revealed that the primary reason for non-completion of practical sessions was due to difficulties encountered by participants with the navigation of SYSPRO's user interface and with finding the required data and functions (Section 6.3.1). These difficulties were also the most frequently reported problem encountered, confirming the findings in related studies reporting navigation problems with ERP systems in industry (Calisir and Calisir 2004; Topi et al. 2005; Singh and Wesson 2009) and in ERP education (Surendran et al. 2006).

Other reasons cited for non-completion of practical sessions related to problems with error handling and recoverability (Section 6.3.1). Since these problems affected the completion rate, they are considered critical incidents and can therefore impact the attainment of the educational outcome of performance. Even though the frequency of these reasons was not high, careful consideration needs to be paid to support for error handling and recoverability when designing the user interface of ERP systems. Designers of ERP systems should take this into account and ensure that the interface provides mechanisms which allow users to take corrective action (Section 6.7.4). In addition the interface should eliminate error-prone conditions, or check for them and present users with a confirmation option or warning before committing an action.

The analysis of the performance data (Section 6.3) revealed that Prac 1 had the highest percentage of problems experienced (45%) and the highest mean task duration. This observation suggests that despite the tasks being of a low complexity, first time use of the ERP system, SYSPRO, resulted in some learnability problems. Prac 2 had the lowest percentage of participants experiencing problems (12%), and the lowest mean task duration, which could be attributed to the fact that they had become familiar with SYSPRO and the level of the problem in the tasks. Prac 4 had the second highest percentage of participants experiencing problems (41%), reflecting a lower completion rate and could be attributed to the fact that it had the highest complexity of tasks. All four practical sessions had a mean task duration of less than the goal time.

The mean grade for informal assessment of accuracy is high for all four sessions as they are all above 75%, which is considered a distinction at NMMU. The results of the formal assessment of accuracy revealed that all three competency categories had a mean grade of greater than 50%. BPM was the competency category which had the lowest mean grade (54%). Additional ways of improving BPM understanding in ERP education should therefore be researched further.

6.6.2 Self-Efficacy Results

From the results it can be seen that the mean for the subjective rating of self-efficacy measured post-intervention is positive for all three competencies (Section 6.4), namely ERP Theory and Concepts (μ = 3.71), ERP Transactions (μ = 3.71) and BPM (μ = 3.87). However, the results showed that only BPM's score was significantly positive (p = .044). The results show that there was a perceived growth in knowledge as measured by self-efficacy between pre-intervention and post-intervention, in two of the three competency categories, namely ERP Theory and Concepts and ERP Transactions (Table 6-10). The only competency category that did not increase in self-efficacy was BPM, and this actually decreased between pre-intervention to post-intervention (μ = 0.04), but not significantly (p = .455). Despite this observation, the competency category was measured to have the highest post-intervention self-efficacy rating (μ = 3.87) (Section 6.4.1, Table 6-10).

In 88% of the competencies addressed, the majority of participants stated that the use of SYSPRO in the practical sessions improved their competency (Table 6-11). The majority of reasons given for improvement of competencies related to the benefit of practical application of theory. Participants felt that the hands-on use of SYSPRO contributed to their understanding of concepts that they did not previously understand. These observations suggest that the participants are satisfied with the use of SYSPRO for improving ERP competencies, and the educational outcome of satisfaction was achieved.

6.6.3 Usability Results

Four of the eleven usability criteria had mean ratings in the positive range, while six were in the neutral range and none had a mean rating in the negative range (Section 6.5.1). The highest rated usability criteria related to the finding of required items. This finding suggests that it is critical to consider this criterion when designing the interface for an ERP system for instructional purposes.

Overall the aggregated quantitative usability measures of presentation and navigation had mean ratings in the positive range (Section 6.5.1). Learnability rated in the neutral range and was the lowest measure, and was rated in the neutral range, indicating that system developers and designers need to consider these types of learnability criteria and problems when designing ERP systems used for instructional purposes. Analysis of qualitative responses from participants (Section 6.5.2) confirmed findings of a related study reporting that an introductory interface should be provided by the ERP system to cater for novice users learning to use the system (Topi et al. 2005), and that the ERP system should provide guidance for novice users in order to improve navigation (Shtub 2001; Surendran et al. 2006; Sommerville 2010).

The most popular features of SYSPRO related to navigation and the main menu design and structure. The tree structure of SYSPRO's menu (Figure 6-6) was cited by several participants as a positive feature which enabled easy navigation. This confirms the principle that user interfaces should provide a tree view menu that enables drilling down to specific information very quickly (Shneiderman 1998). When a collection of menu items grows and becomes difficult to maintain under intellectual control, a tree structure is recommended where categories of similar items are created. Designers of ERP systems should take into account the principle that broad and shallow menu structures should be provided, rather than narrow and deep ones (Norman and Chin 1988; Calisir and Calisir 2004).

Other popular features included the layout of the SYSPRO interface and the grouping of information, as well as the attractiveness of the interface. The familiarity of the SYSPRO interface was also identified as a feature that the participants viewed positively. It can be deduced that these principles should be incorporated into ERP systems used for instructional purposes.

This supports findings of related studies (Galitz 2007; Koh et al. 2009; Hustad and Olsen 2011) stating that ERP systems that employ familiar concepts and use a language that is familiar to the user can improve the ease of learning. Galitz (2007) also advises that application interfaces should be kept natural, and mimic the behaviour patterns of the user and real-world metaphors should be employed, such that users can get started quickly and become productive.

The least popular feature of SYSPRO cited by participants related to the presentation measure and was connected to the cluttered user interface and more specifically to too much information and clutter in the menus and windows (Section 6.5.2). This problem could be avoided by adhering to the user interface design principle of simplicity which states that a dialog should consist of the minimum and should be natural and logical for the user to use (Nielsen 1993). Another way of avoiding this problem is for ERP system designers to ensure the correct use of tree structures in menus (Shneiderman and Plaisant 2005). The classification and indexing of menus are complex tasks, and in many situations there is no single solution that may suit everyone. ERP systems like SYSPRO should have groupings at each level of menus that are natural and comprehensible to users and menu structures that are broad and shallow should be preferred to narrow and deep ones (Shneiderman and Plaisant 2005). If users know the target, menu traversal can be accomplished in a few seconds. On the other hand, if the groupings are unfamiliar and users have only vague notions of the items they are looking for, then they may get lost in the tree menus (Norman and Chin 1988). Good user interface design should also take into account the fact that users struggle to focus on more than one activity at a time (Stone et al. 2005).

Hidden controls such as scroll bars in several windows in the SYSPRO user interface, was another frequently reported negative feature. This supports the principle that functionality can be placed in context-sensitive controls or hidden user interfaces, but that this should not be the only way in which the function can be invoked (Johnson 2000). Less visible or hidden methods can be provided, but these should always be secondary methods, with more visible methods being primary. SYSPRO designers could therefore investigate other methods of offering the functionality provided by the hidden controls.

The quantitative analysis of the performance and usability data revealed that there is a positive correlation between accuracy and usability (Section 6.5.1). This implies that those students who rated the usability low also had low accuracy scores, which suggests that the usability of the system could have impacted their performance in terms of accuracy. From this it can be deduced that improving the usability of the SYSPRO ERP system can improve the accuracy results of students at NMMU.

6.6.4 Data Triangulation Results

The data triangulation process (Section 5.4.3) considered three primary aspects of results according to the related measures of ERP education, namely, performance, self-efficacy and usability (Figure 5-4). Performance showed a negative trend in learnability due to low completion rate and high frequency of problems in the first practical session compared with later sessions. This is confirmed by the usability ratings of learnability as the lowest measure of usability. Performance results also revealed some negativity in terms of navigation but this was contradicted by a positive qualitative evaluation of SYPRO navigation, particularly its menus and tree structure.

An analysis of the self-efficacy quantitative data revealed that two thirds of the competency categories addressed by the MIS course showed that students experienced a growth in subjective self-efficacy of the students. BPM was the only category that did not have any growth in subjective self-efficacy. The performance quantitative data agreed with this finding, since in the formal assessment, participants had the lowest grade for the BPM category. However, BPM had the highest post-intervention and pre-intervention self-efficacy rating. It was also the highest rated category pre-intervention.

The triangulation of the quantitative and qualitative self-efficacy and satisfaction data revealed that several participants stated that using the SYSPRO system made them realise just how complex an ERP systems is. This observation could account for the drop in self-efficacy ratings for BPM from pre-intervention to post-intervention, since students could have overestimated their knowledge at the start of the course, particularly for the BPM competency category. This observation suggests that once they started working with the ERP system they may have realised the complexity of ERP systems and business processes and then rated their self-efficacy lower than they did pre-intervention.

The qualitative performance data revealed that one of the frequent reasons cited for improving competencies was that SYSPRO assisted with the understanding of business processes. If the quantitative self-efficacy was considered on its own a skewed finding might have been obtained. The insights provided by the qualitative data analysis and the triangulation of data would not have been obtained without the collection of qualitative data and the data triangulation process.

The qualitative data analysis of performance, usability and self-efficacy data was successfully used to verify or refute the quantitative data within the same measure. In addition the data analysis of problems encountered verified the usability features and in this way performance and usability data were successfully triangulated. The performance data analysis provided the ability to view different alternatives for the findings of the self-efficacy data analysis, and was therefore successfully triangulated. Self-efficacy and usability measures are necessary to contextualize the findings of performance specifically regarding the learnability of SYSPRO. Learnability issues are an imperative aspect of the educational environment in order to increase student competencies. The data triangulation of all three aspects therefore contributed to the validity and reliability of the qualitative research.

6.6.5 Research Quality Ensured

Quantitative criteria used for assessing research quality and rigour included internal and external validity, reliability and objectivity (Section 5.4.3). Face validity and content validity of the research instruments were established through the literature review and the pilot study. Internal consistency of the questionnaires was established by the results of the Cronbach's alpha coefficients for the self-efficacy questionnaire (Section 6.4.1) and the usability questionnaire (Section 6.5).

Qualitative research quality criteria satisfied were credibility, transferability, dependability and confirmability (Section 5.4.3). Evidence of credibility provided included 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 was used for the case study analysis to provide reliability and validity to qualitative data.

The data triangulation process successfully contributed towards establishing the research quality since it is a factor of both credibility and dependability of qualitative research (Section 5.4.3). The time sampling used at various points throughout the research process also provides evidence of credibility. The case study protocol and audit trails tracing analytic data back to raw data, contribute to transferability which is another criterion for qualitative research. Alternative explanations are considered in the analysis of the qualitative results, thereby providing reflexivity which is the last criterion of qualitative research considered in this study.

6.7 Conclusions

This chapter has provided a report of a case study where a medium-sized ERP system, namely, SYSPRO ERP, was adopted into the IS curricula of a degree programme at a higher education institution in South Africa. The course involved was a 3rd year, Management Information Systems (MIS) course which includes ERP systems. The decisions regarding the type of system to be adopted in the course, the adoption approach and the level of adoption to implement were based on the ERPEd framework (Figure 4-4). The educational outcomes evaluated included performance, self-efficacy, and satisfaction. In additional to academic outcomes, the success of ERP system adoption was affected by the ERP system usability.

Performance of the system and of the student can be measured by task completion rate, problems encountered, task duration and accuracy. In terms of task completion rate, the majority of participants completed all four practical sessions in the allocated time. The mean task duration was acceptable as the majority of students finished all practical sessions in less than the goal time. In terms of accuracy of both the formal and informal assessments, students performed well. In the informal assessment all practical sessions had a mean grade greater than 75%. In the formal assessment the mean grade for all three competency categories was above 50% which is a pass at NMMU. In terms of academic performance therefore the results were positive.

The self-efficacy measure had positive mean ratings for all three ERP competency categories. The results also revealed that there was a growth in self-efficacy for the competency categories of ERP Transactions and ERP Theory and Concepts. However, there was no significant growth in self-efficacy for BPM from pre-intervention to post-intervention.

In spite of the lack of a significant growth of BPM from post-intervention to post-intervention revealed by the quantitative ratings of self-efficacy, the analysis of self-efficacy data related to the satisfaction of competency improvement revealed that the majority of students stated that the use of SYRPRO helped to improve seven out of the eight competency items addressed. It can be deduced that students felt that their competencies were improved and that they enjoyed using SYSPRO. The outcome of satisfaction was therefore successfully met.

The usability of the SYSPRO system was rated positively for the usability measures, navigation and presentation. The third usability measure of learnability was rated neutral. The most popular feature of the SYSPRO ERP system cited by participants is the main menu structure, which relates to the usability measure, navigation. The tree view structure of the main menu and the drill down facility enabled participants to find information easily and navigate through the user interface. Other positive features of the menus identified by participants included grouping of folders, the logical layout of the menu and the menu of recently used items. One aspect of learnability which emerged was the concept of familiarity which was cited by several participants as a positive feature of SYSPRO.

Several negative perceptions of SYSPRO related to the cluttered user interface. The top two problems related to finding of data and the finding of functions/buttons. Several participants felt that there are too many windows, tabs and features which resulted in users becoming confused, overwhelmed and irritated. In addition the problem with hidden controls was reported as a negative feature of SYSPRO. The experience of confusion was cited by several participants and is a new theme which has not been reported by other related studies. The usability of the ERP system was shown to have an impact on the educational outcome of performance, since accuracy and usability were positively correlated. The data triangulation process improved the quality of research and decreased the risk of bias, and is an important contribution of this study.

In some cases the results were verified by the data triangulation process and in others it provided the ability to view alternative scenarios or reasons for findings. The triangulation of the data provided in-depth insight into the context of the problems relating to learning to use an ERP system that would not have been possible with a pure quantitative or positivistic approach.

The students enjoyed the hands-on use of SYSPRO in the practical sessions. Overall, the impact of the adoption of the medium-sized ERP system, SYSPRO, in the IS curriculum at NMMU was positive. The findings of this study confirm those of Winkelman and Matzner (2010) who proposed that ERP systems designed for smaller organisations can achieve similar results to those obtained with a large ERP system. The most broadly applicable results from this section of the study lie in the lessons learned. It can be concluded that medium-sized ERP systems can be successfully adopted into an ERP course at NMMU and can have a positive impact on educational outcomes of performance, self-efficacy and satisfaction. The ERPEd framework was successfully applied at NMMU.

The qualitative responses provide important contributions to this study, even if the resulting findings cannot necessarily be generalised to other environments. However, additional research on ERP learning tools which can provide the user with even more guidance, especially for novice users, is recommended. Designers of ERP systems should take into account the results of the analysis of the usability related responses. The reviewing case study results reported in this chapter have details that might be of interest to a wide range of users, including HCI researchers, technology experts and academics.

The insights provided by this case study might be extremely valuable to others interested in conducting related research and can help researchers to understand other similar cases or situations. The use of multiple data sources and qualitative data analysis in the case study strategy provided insight into understanding how students complete tasks while learning to use an ERP system that would not have been possible with only a positivistic approach using quantitative data analysis. As can be seen by the evidence provided, the fifth research question, *"What is the impact of the adoption of an ERP system at NMMU on ERP educational outcomes?"* has been answered in this chapter. The next chapter will revisit the objectives of this research to determine how they have been achieved. Recommendations and conclusions are provided, as well as recommendations for future research.

Chapter 7: Recommendations and Conclusions

7.1 Introduction

Several reports predict a continued demand and growth for ERP systems in the global marketplace as well as in South Africa (Section 1.1.1). Even small to medium-sized organisations as well as organisations in developing countries, including South Africa, are implementing ERP systems. The demand for ERP systems globally has led to problems with obtaining quality ERP specialists who can effectively support the implementation and maintenance of ERP systems, and the high costs of ERP skills have also been reported (Section 1.1.2). These problems with obtaining ERP specialists with the appropriate competencies have impacted ERP project success (Section 2.3).

In order to address this demand for ERP specialists, several HEIs have adopted ERP systems in their business and IS curricula with varied success. There is still a gap internationally and in South Africa between the competencies of IS graduates and those required by organisations (Section 1.3). A similar gap exists between the competencies required by ERP consulting companies for ERP specialists and the ERP competencies of graduates. There is a need to address this gap and provide for competency-based curricula that are relevant to industry as well as meet the aims of higher education (Section 3.1). Existing frameworks for ERP education are not competency-based, are not comprehensive, and do not address the usability issues of ERP systems. In addition South Africa is a developing country and therefore frameworks designed for curricula in other countries may not be suitable for South African HEIs. South African IS departments need to incorporate ERP systems into their curricula and prepare their students for work in enterprise systems (Section 3.6). The current percentage of ERP content in IS curricula in South Africa is still relatively low when compared with that in other countries.

The purpose of this thesis was to propose a framework for adopting an ERP system in IS curricula for HEIs (Chapter 4). A secondary purpose was to apply and validate this framework at a HEI in South Africa. The goal of this chapter is to briefly revisit what was achieved in this research study and to make conclusions and recommendations based on the insights and knowledge gained. Research objectives for this study were identified and have been successfully achieved (Section 7.2). The significant contributions made by this research are both theoretical and practical (Section 7.3). A small number of problems and limitations were encountered during the research (Section 7.4), theoretical and practical recommendations are made (Sections 7.5) and opportunities for future research identified (Sections 7.6).

7.2 Achievement of Research Objectives

The following seven research objectives were identified at the start of this study and were all achieved successfully:

- RO1. To identify and compile a set of competencies for ERP specialists;
- RO2. To validate the ERP competency set according to the requirements of South African ERP consulting organisations;
- RO3. To compare frameworks and approaches which can be used to adopt ERP systems into the IS curricula;
- RO4. To propose an education framework which can be used for the adoption of ERP systems in an IS curriculum in HEIs in South Africa;
- RO5. To propose a set of educational measures for ERP system adoption in an IS curriculum;
- RO6. To apply the ERP education framework at the Nelson Mandela Metropolitan University (NMMU) to support the adoption of an ERP system in the IS curriculum;
- RO7. To evaluate the application of the proposed ERP education framework at NMMU.

The first and second research objectives identified were to compile a set of competencies for ERP specialists and validate them in a South African environment (Section 7.2.1). The third objective involved a literature study of frameworks and approaches which can be used to adopt ERP systems into the IS curricula (Section 7.2.2).

From this literature study a framework which can be used for the adoption of ERP systems in an IS curriculum in HEIs in South Africa was designed (Section 7.2.3). The fifth objective was to identify measures for ERP system adoption in a curriculum (Section 7.2.4). The sixth objective was to apply the ERP education framework at NMMU (Section 7.2.5), whilst the seventh and last objective was to evaluate the application of the proposed ERP education framework at NMMU (Section 7.2.6).

Several research questions were posed in order to address the relevant research objectives. The main research question was stated as:

"What is the impact of the application of an ERP education framework at NMMU?"

Several subsidiary research questions were derived from the main research question in order to achieve the objectives (RO1 - RO7) and were addressed in the various chapters (Table 7-1).

Table 7-1 Research Questions and Chapters Addressing the Questions

	Research Question	Chapter	Objective
RQ1	What competencies (skills and knowledge) are required for an ERP specialist by ERP consulting companies in South Africa?	2	RO1 & RO2
RQ2	What frameworks and approaches can be used to adopt ERP systems into the IS curricula?	3	RO3
RQ3	What comprehensive education framework can be used in an ERP course in higher education institutions in South Africa?	4	RO4
RQ4	How can the impact of ERP system adoption in a curriculum be measured?	4 & 5	RO5
RQ5	What is the impact of the adoption of an ERP system in the IS curriculum at NMMU on ERP educational outcomes?	6 & 7	RO6 & RO7

7.2.1 Competency Set for ERP Specialists in South Africa (RO1 and RO2)

A literature study of ERP competencies was undertaken in order to derive a set of competencies for ERP specialists (Section 2.3). This competency set was validated by a survey of the requirements of South African ERP consulting companies and an updated competency set relevant to the South African environment was compiled (Section 2.6).

The results of this industry survey confirmed international studies citing problems with recruiting ERP specialists. The first and second objective, related to the compilation and validation of a set of competencies for ERP specialists in South Africa, were therefore achieved.

7.2.2 Compare Frameworks and Approaches for ERP System Adoption (RO3)

Several frameworks for ERP education were compared to the competency set of ERP specialists in order to determine any shortcomings in the frameworks (Section 3.4). An ERP Adoption Levels Matrix for Higher Education was proposed which provides a more comprehensive breakdown of the levels of breadth and depth of ERP system adoption (Section 3.4). The status of ERP education in South African HEIs was examined (Chapter 3), and the results showed that the majority of universities that participated in the survey have not yet adopted ERP systems in the IS curriculum yet. Objective three, which was to compare frameworks and approaches for the adoption of ERP systems, was therefore successfully achieved.

7.2.3 Framework for ERP System Adoption in IS Curricula in South Africa (RO4)

The fourth objective was to investigate which framework could be used for the adoption of ERP systems in IS curricula in HEIs in South Africa. This objective was satisfied, since a comprehensive framework, ERPEd, is proposed (Section 4.5). This framework addresses the limitations of other ERP education frameworks by including all ERP competencies required by industry and maps them to the appropriate levels of adoption, an ERP system adoption approach, and an ERP learning tool. The ERPEd framework is a competency-based framework derived from industry-relevant competencies, and therefore meets the requirements of outcomes based education and the international IS 2010 curriculum.

7.2.4 Set of Educational Measures for ERP System Adoption in IS curricula (RO5)

Several usability problems with ERP systems in education were explored and a number of measures of ERP education were identified in Chapter 4 (Section 4.5). These measures include academic performance measures, usability, self-efficacy and satisfaction measures of the ERP adoption approach (Section 4.5).

Performance measures include effectiveness and efficiency. The usability of the ERP system consists of the measures of navigation, presentation and learnability and was evaluated to determine its impact on educational outcomes. The fifth objective of proposing a set of educational measures for ERP system adoption in IS curricula, was therefore successfully met.

7.2.5 Apply the ERP Education Framework at NMMU (RO6)

The sixth objective was achieved since the ERPEd framework was successfully applied in a MIS course at NMMU in 2010 (Chapter 5). The three competency categories addressed by the course were ERP Theory and Concepts, ERP Transactions and BPM. Based on the ERPEd framework a hands-on approach to the adoption of an ERP system was selected, and the medium-sized ERP system SYSPRO was used as the learning tool. Students were required to perform tasks using the SYSPRO system in four weekly practical sessions. The tasks were designed based on the framework, and the first session therefore consisted only of the first level of breadth (Browsing level) which involves browsing and navigation of the ERP system. In the second session more browsing activities were performed and then in the third practical session some simple transactions are entered in the ERP system. In the last practical session the complexity of the tasks was increased to show integration of business processes and data.

7.2.6 Evaluate the Application of the ERP Education Framework at NMMU (RO7)

Using the measures of ERP education proposed (Section 4.5), the analysis of the data revealed that all targeted educational outcomes for the course were met. In all four practical sessions the performance metrics of task completion rate, task duration and accuracy were satisfactory and the outcomes successfully met (Section 6.3). The most frequently reported reason for non-completion was difficulties with navigation of the SYSPRO user interface and the finding of functions and data.

These difficulties were also the most frequent type of problems encountered by participants in the practical sessions (Section 6.3.1). The findings confirm other related studies reporting navigation problems with ERP systems in industry and in education (Section 4.4.1).

All three ERP competency categories had mean positive subjective post-intervention ratings for self-efficacy. However only one category, BPM, had a significantly positive ($p = .044$) mean rating. The subjective ratings of self-efficacy of the three competency categories addressed by the course also showed a significant improvement in two of the three categories, namely: ERP Theory and Concepts, and ERP Transactions (Section 6.4). Whilst the self-efficacy ratings of the third competency category, BPM, did not show a significant improvement, responses to other questions showed that participants cited an improvement in competencies relating to the BPM category.

Qualitative data from several participants stated that the use of SYSPRO helped them to understand the underlying business processes. A significant majority of participants stated that the use of SYSPRO improved their competencies (Section 6.5). It can be deduced from the responses of the participants that they enjoyed working with SYSPRO and felt that it helped them to understand the theoretical concepts imparted in the lectures. The responses to the open-ended questions revealed that the students of the MIS course were strongly in favour of the adoption of the SYSPRO ERP system in their course.

The students rated the usability of SYSPRO postively, since there were no negative mean ratings for all three usability measures of navigation, presentation and learnability (Section 6.6). Two categories of usability, namely navigation and presentation were rated positively by the students, whilst the third measure, learnability was rated lowest and in the neutral range. This highlights the importance of addressing learnability issues for ERP systems designed for instructional purposes and of having an ERP system that is easy to learn (Section 3.3). Usability was also shown to have an impact on the accuracy metric of performance since there was positive correlation between accuracy and usability for the majority of practical sessions. As can be seen by the discussions in this section, all the objectives of this study were successfully met.

7.3 Research Contributions

Several significant contributions are made to the fields of HCI, business and education internationally and in South Africa. These contributions from this research can be categorised as theoretical contributions (Section 7.3.1) as well as practical contributions (Section 7.3.2).

7.3.1 Theoretical Contributions

This thesis has five main theoretical contributions, namely, the set of key competencies for ERP specialists (Section 7.3.1.1), the ERP Adoption Levels Matrix for higher education (Section 7.3.1.2), the ERPEd framework (Section 7.3.1.3) and a set of measures for ERP education (Section 7.3.1.4). The final contribution is a process of data triangulation that can be used for analysing quantitative and qualitative ERP education data (Section 7.3.1.5).

7.3.1.1 Set of Competencies for ERP specialists

The ERP competency set (Table 7-2) is one of the primary contributions of this study and is a comprehensive set of industry-relevant competencies for ERP specialists, which was compiled after an extensive literature study and a survey of ERP specialist employers in South Africa (Chapter 2). The survey showed that interpersonal skills and business competencies are ranked as the most important supporting competency categories for ERP consultants in South Africa, whilst BPM and ERP Implementation and Configuration competencies are the most important technical skills. The set of competencies for ERP specialists is a major contribution towards government efforts in South Africa to address the ICT skills shortage.

The ERP competency set provides a standardised and comprehensive set of industry-relevant competencies required for ERP specialists, which is a minimum requirement for any skills improvement programme. The competency set is based on empirical evidence from organisations in South Africa, whilst other related studies are based on educational objectives.

Table 7-2 Competency Set for ERP Specialists[10]

Rank	Competency Category	Competency
1.	Interpersonal	Communication skills Ability to work co-operatively in a team Ability to interact with various groups Time management skills Understanding of organisation culture Ability to listen Problem Solving
2.	Business	Knowledge of business functions Financial accounting ability
3.	Business Process Management (BPM)	**Knowledge of the importance of the integrated nature of business processes** **Knowledge of the typical business processes and activities in an organisation** Ability to map organisational business processes with those in an ERP software Process modelling knowledge Ability to use process modelling techniques Process modelling tool technical skills (e.g. Visio or ARIS)
4.	ERP Implementation and Configuration	Implementation knowledge Knowledge of ERP implementation methodologies Interface knowledge General configuration knowledge The ability to determine the appropriate approach for implementing an ERP The ability to evaluate different ERP software products The ability to map the organisational structure with the ERP elements The ability to configure an ERP for implementing the relevant module
5.	ERP Transactions	The ability to create master data and perform transactions in finance The ability to create master data and perform transactions in sales The ability to create master data and perform transactions in procurement The ability to create master data and perform transactions in other modules
6.	ERP Management	Knowledge of the nature and role of maintenance and upgrades of ERP Ability to analyse the impact of ERP on organisations **Ability to analyse the impact of integrated information on decision making** **Ability to analyse the impact of individual employee actions on other functional areas** **Ability to improve controlling of business operating expenses through ERP** **Ability to prepare management reports from ERP**
7.	General Management	General IT management skills Project management skills
8.	Information Systems	Database knowledge and skills Networking knowledge and skills Knowledge of general IS concepts Business analysis skills Systems analysis and design skills e-business knowledge and skills Report design and writing skills Excel skills
9.	ERP Theory and Concepts	Knowledge of ERP theory and concepts Knowledge of ERP architectures
10.	ERP Security	Internet and e-business security knowledge The ability to setup application security The ability to evaluate the current security of an organisation
11.	ERP Programming	Knowledge of good programming techniques **Ability to program in a 3rd Generation language (e.g. C#)** **Ability to program in a 4th Generation language (e.g. SQL server)** Ability to use good general programming techniques using your ERP

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10 Core Technical; Supplementary Technical; Supporting

Bold = Most important competency; **Purple** = Added from pilot study; Red = Added from survey

7.3.1.2 The ERP Adoption Levels Matrix for Higher Education

The ERP Adoption Levels Matrix for Higher Education (Table 3-5) provides a comprehensive classification of the breadth and depth of ERP system adoption in the curricula. This matrix fills a gap in related ERP education research since it classifies tasks according to both the breadth and depth of ERP system adoption in the curricula.

7.3.1.3 The ERPEd Framework

An analysis and comparison of studies of ERP education frameworks (Table 3-9 and Table 3-10) is provided as well as an evaluation of several studies of the hands-on approach to ERP system adoption (Table 3-11). The ERPEd framework (Figure 7-1) provides a comprehensive, competency-based framework for educators considering adopting an ERP system into the IS curriculum. It can assist educators by assisting them with decisions regarding the competencies to address, the level of ERP adoption, the type of learning tool to adopt, and the approach to use. Other ERP education frameworks are not comprehensive since they do not address all competencies for ERP specialists and do not consider all decisions relating to ERP adoption, or the usability of the ERP learning tool.

The application of the framework in the selected case study at NMMU was successful since the adoption of the SYSPRO ERP system had a positive impact on performance and self-efficacy. Usability was found to have an impact on the outcome of performance since there was a positive correlation between usability and accuracy which is one metric of performance.

The competency set for ERP specialists, as well as the ERPEd framework can provide a significant contribution to the work of the EARF in South Africa, which is addressing the demand for enterprise systems education in the country (Section 1.1.2). In addition it will contribute towards the e-skills effort in South Africa by providing a standard set of competencies upon which skills improvement programmes can be based (Section 1.1.2).

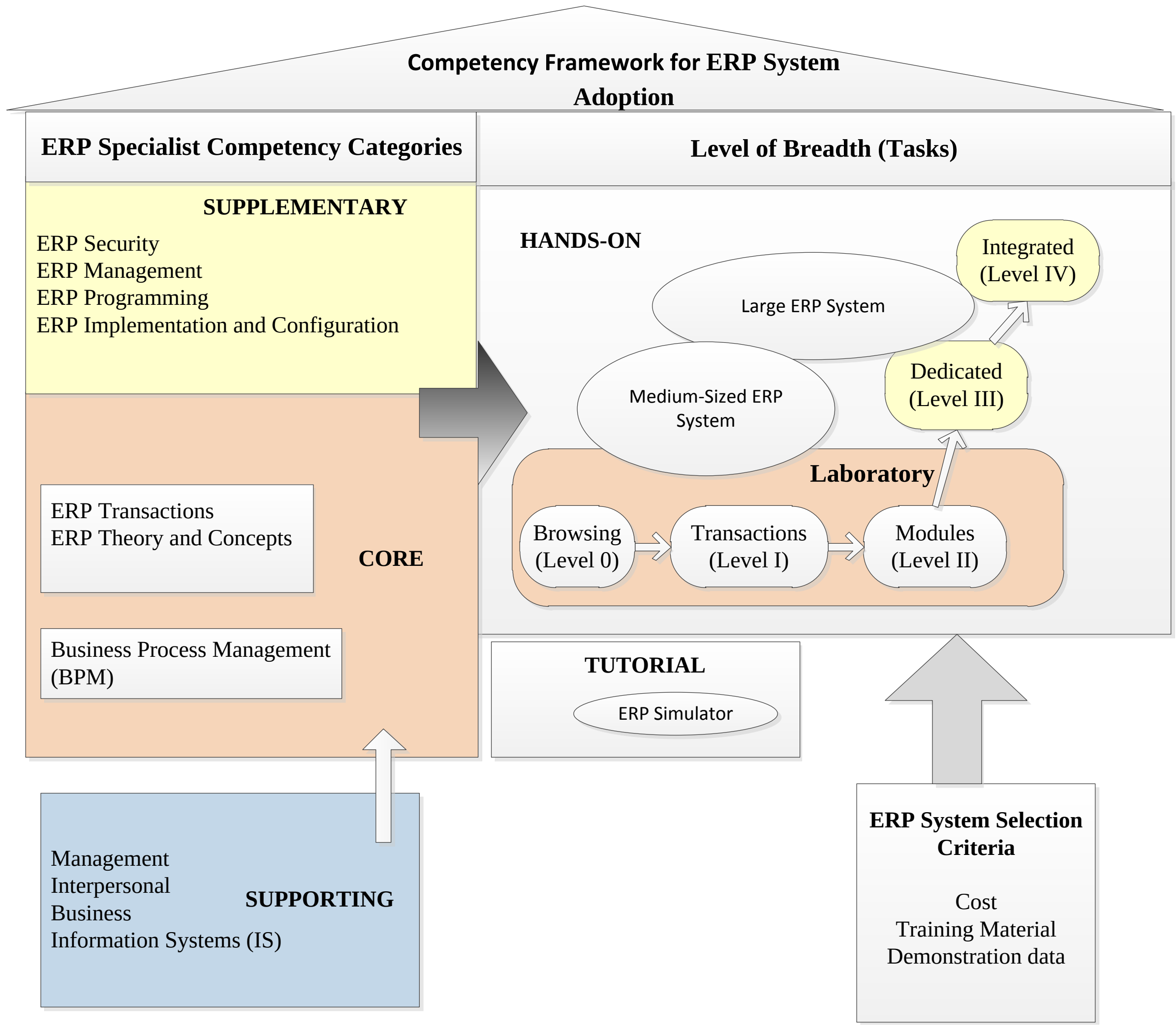

Figure 7-1 A Competency Framework for ERP System Adoption (ERPEd: Version 2)

7.3.1.4 A Set of Measures for ERP Education

The fourth contribution of this study is a set of measures for the hands-on approach to ERP education (Figure 7-2), which include traditional academic performance measures, measures of the ERP adoption approach as well as usability measures. Three usability measures for ERP systems in education were proposed, namely, navigation, presentation and learnability (Section 4.4.3). The qualitative data of the case study usability evaluation relating to the positive features of SYSPRO confirmed all three measures of usability, namely, navigation, presentation and learnability (Table 6-13).

Navigation of the user interface is a key factor during the ERP learning process as it was one of the most frequently cited reason for non-completion of tasks and also of problems reported by the students while using the ERP system (Section 6.4.1). Learnability and presentation problems were also reported by the students. The usability results of this study show that improving the usability of the SYSPRO system could improve the accuracy of the students, since usability and accuracy were positively correlated.

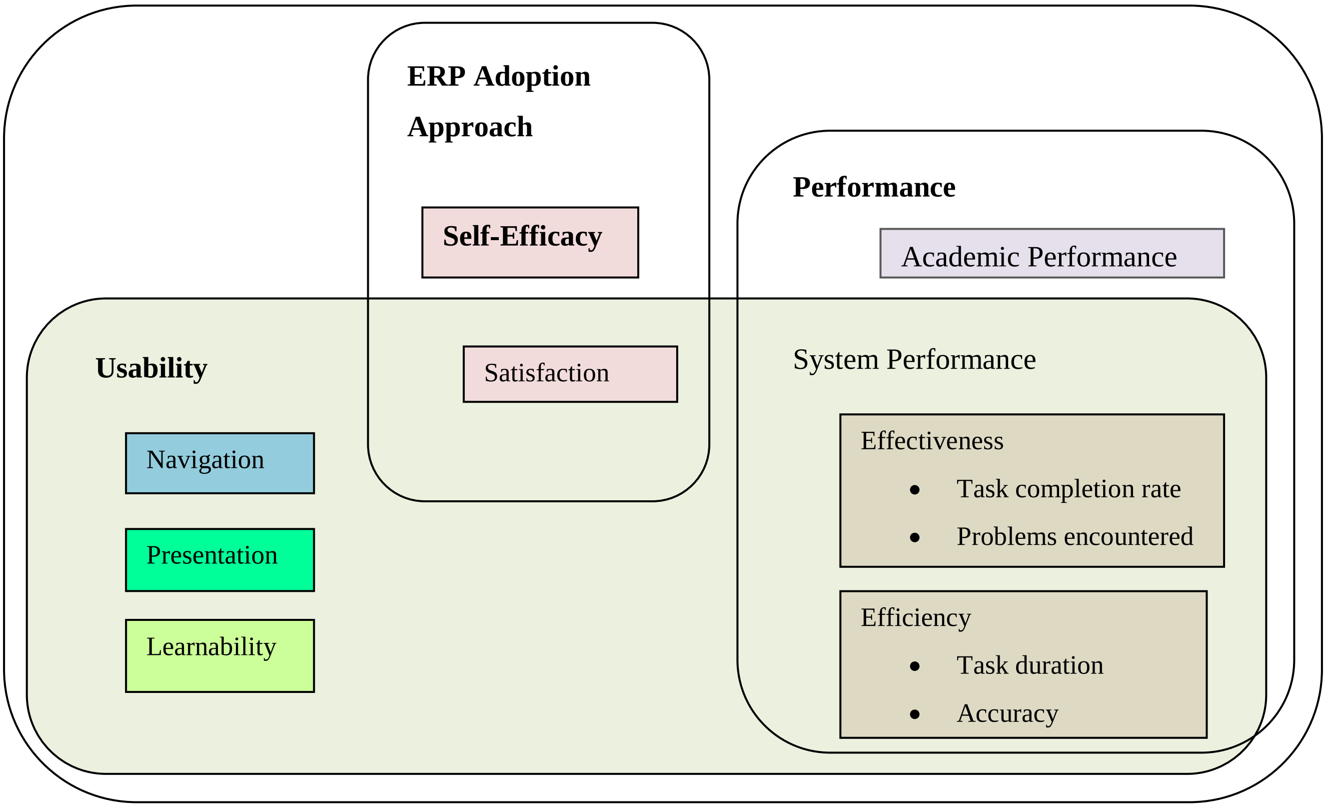

Figure 7-2 ERP Education Measures

7.3.1.5 Data Triangulation Process

The data triangulation process used in this study (Figure 7-3) has provided a significant contribution to the HCI and education research communities. It provides a means of evaluating quantitative and qualitative data in case studies with additional reliability by providing multiple pieces of corroborating evidence, using several measures of ERP education quality (Section 6.7). It can also remove the potential for bias which is one of the limitations of case studies. Competency improvement satisfaction data can be used to validate self-efficacy data.

Problems encountered when using the ERP system can be analysed and used to corroborate performance data. Qualitative data regarding the positive and negative features of the ERP system can be used to verify quantitative usability data and qualitative data relating to problems encountered. The qualitative data can refute or confirm the quantitative data and penetrate situations which are not possible using only numerical or quantitative analysis. In addition the study showed that in addition to performance data, self-efficacy data and usability data can be used as additional internal measures of ERP education.

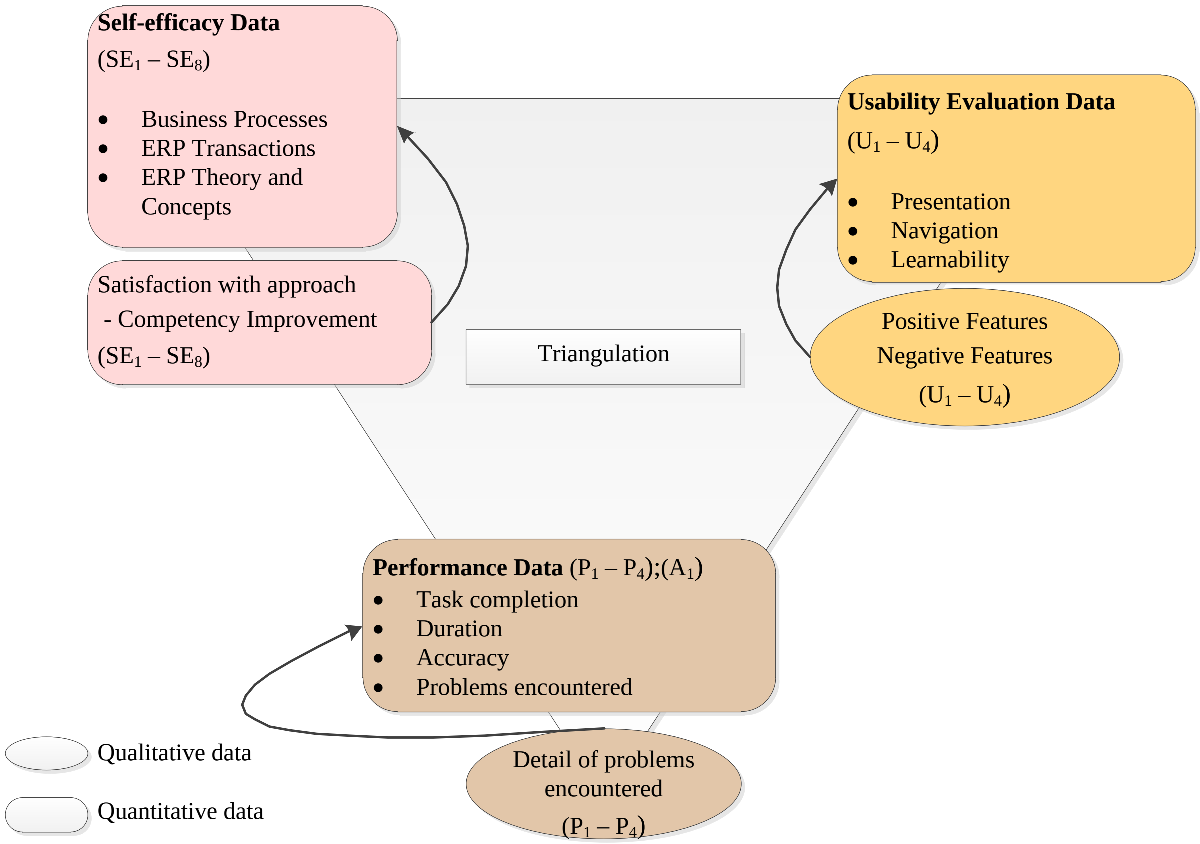

Figure 7-3 Data Triangulation

7.3.2 Practical Contributions

Several practical contributions are provided by this research study, for the business, HCI and education communities in South Africa and internationally. For the business community the demand for ERP consultants is addressed and a standardised set of industry-relevant competencies required for ERP consultants is provided (Table 2-9). The standardised set of competencies can be used as the starting point for the development of an appropriate skills improvement program.

Research into the competencies of ERP consultants can result in the improved skills and knowledge of employees of ERP consulting organisations and this in turn has the potential to improve the service and support of ERP systems in the marketplace. An additional contribution of this research is the potential use of the competency set for measuring the competencies of consultants during the recruitment process, for compiling job descriptions and for performance evaluations. The understanding gained from this research has provided an input to the ERP consulting industry in South Africa.

The qualitative research results, specifically in the areas of ERP specialist competencies and ERP system usability issues are significant practical contributions of this study. For the HCI community the problems identified with the user interface of the SYSPRO system can be used by designers of ERP systems to improve the usability of ERP systems in education. Likewise, designers should also take into account the positive features of the system identified by the participants. In particular the learnability issues with ERP systems must be addressed by designers of such software.

In education, the ERPEd framework can be used to assist educators with the process of adopting an ERP system into the IS curriculum. It can assist educators with the many decisions that need to be made regarding this ERP adoption. The decisions include the competencies to be addressed, the level of breadth and depth of adoption, as well as the adoption approach and the type of ERP learning tool to adopt. Educators can use the measures provided to evaluate the adoption of an ERP system in the IS curricula, and to evaluate the performance of the student and the ERP system. Several usability criteria have been validated and can be used to evaluate ERP systems used for instructional purposes. The framework can also narrow the gap between industry requirements for the competencies of ERP specialists and what higher education is providing.

7.4 Problems Encountered and Limitations Identified

Several problems were encountered during the course of this study. The first of the problems related to the actual sample size used in the both the industry survey and in the case study, which were too small in some cases for certain statistical tests.

Using students as participants in the case study exposed the study to the risk of the normal behaviour of students of missing lectures and practical sessions and this resulted in a further reduction of the sample size. In addition several participants who did participate in the practical sessions did not complete all of the evaluation forms distributed, which again reduced the sample size further. This study was also limited by a single case study and should ideally be repeated in other educational institutions in South Africa and other countries. The measures of ERP education used in the study are limited to internal measures and can be extended in future research to include external measures. The study was further limited in that the MIS course at NMMU only validated the ERPEd framework at one level of breadth, the Laboratory level. Further research is required to validate other levels of the framework.

7.5 Recommendations

Several recommendations can be made for theory (Section 7.5.1) and for practice (Section 7.5.2) in the business, HCI and education communities.

7.5.1 Recommendations for Theory

For the business community it is recommended that the ERP competency set can be used as a standardised model of competencies for ERP specialists. For education, the comprehensive, ERPEd framework is the first comprehensive, pedagogical ERP education framework which includes industry-based competencies. It also addresses decisions relating to the mapping of competencies to the level and type of adoption and also the type of ERP learning tool. It is also the only study to consider the impact of usability on educational outcomes. The measures for ERP education and the guidelines provided also add to the general body of knowledge for ERP education in South Africa and internationally.

The HCI community should consider the usability issues identified in the literature study, particularly those showing that usability is a critical success factor for ERP adoption in industry and education (Section 4.4). This was confirmed by the usability evaluation in the NMMU case study (Section 6.5). Currently the usability of ERP systems is not taken into account in any ERP education framework. The three usability measures of ERP systems each comprise several criteria which were used in the usability questionnaire to rate the usability of SYSPRO (Table 7-3).

The results of this study confirmed that these are criteria which affect the usability of ERP systems used for instructional purposes (Section 6.5). In addition several other criteria were identified which can be used to measure or evaluate ERP systems used for educational purposes.

Table 7-3 Usability Criteria for ERP systems Used for Instructional Purposes[11]

NAVIGATION	
Ease of Use	Information can be easily accessed
	Functionality can be found quickly and easily
	The user interface supports efficient and accurate navigation of the system
	There is a correlation between the searched item and the required item
Guidance	The ERP system provides navigation aids to prevent disorientation
	The ERP system provides guidance for novice users.
Flexibility	Shortcuts are provided by the ERP system for experienced users but are unseen by novice users
	Users should be able to tailor frequently used actions
PRESENTATION	
Layout	The visual layout is well designed
	The information provided by the system is timely, accurate, complete and understandable
	The layout of menus, dialog boxes, controls are easy to understand, interpret, and are well structured.
	The ERP system provides a tree view menu that lets you drill down to specific information very quickly.
	Broad and shallow menu structures are provided rather than narrow and deep ones
	Tabs are grouped effectively
	Functionality in the ERP system is placed in context-sensitive controls or hidden user interfaces, but this is not the only way in which the function can be invoked. Less visible or hidden methods are provided, but these are always be secondary methods, with more visible methods being primary
Simplicity	The dialog of the ERP system consists of the minimum, and is natural and logical for the user to use
LEARNABILITY	
Ease of learning	A user can learn how to use the system without a long introduction The various functions of the system can be identified by exploration There is sufficient on-line help to support the learning process
	An introductory interface is provided by the ERP system to cater for novice users
Recoverability	The ERP system provides mechanisms for allowing users to take corrective action
Error prevention	The ERP system eliminates error-prone conditions, or checks for them and presents users with a confirmation option or warning before committing an action
Familiarity	The ERP system uses a familiar language and interface

[11] Red = Added to original list (Table 4-1) based on qualitative analysis of usability evaluation

The usability criteria for ERP systems in educational environments proposed can assist educators and HCI practitioners to evaluate the usability of ERP systems. The measures of ERP education identified in this study can be used to increase understanding of the pedagogical factors in ERP education and of the usability issues with ERP systems used for instructional purposes. Reasons for critical incidents, which can impact task completion and therefore performance, included error prevention and recoverability (Section 6.3.1). For this reason error prevention and recoverability can be investigated as additional measures of usability for ERP systems in education. ERP systems should provide mechanisms for allowing users to take corrective action. In addition it should eliminate error-prone conditions, or check for them and presents users with a confirmation option or warning before committing an action.

A popular positive feature of SYSPRO was the familiarity of the SYSPRO user interface, which confirms other studies (Section 6.6.3) citing the benefits of a familiar interface for learning ERP systems. For this reason familiarity can be added to the usability measures for ERP systems used for educational purposes. The measure with the highest frequency of negative responses was navigation. Designers of ERP systems should provide navigation aids to prevent disorientation, and guidance for novice users (Section 4.4.3). In addition an introductory interface could be provided by the ERP system to cater for novice users

The category with the highest frequency of usability problems within the navigation measure was the clutter and complexity of the user interface. These problems could be avoided by adhering to the design principle of simplicity (Section 6.6.3), which states that a dialog should consist of the minimum and should be natural and logical for the user to use. Problems with the menu system can be avoided by designing a menu system with groupings at each level that are familiar, natural and comprehensible to users and broad and shallow menu structures should be provided rather than narrow and deep ones. The ERP system should provide shortcuts for experienced users but these should be unseen by novice users, and users should be able to tailor frequently used actions (Section 6.6.3).

Several problems were encountered with hidden controls in SYSPRO. These could be avoided if designers adhere to the principle of context-sensitive controls. This principles states that functionality in the ERP system is placed in context-sensitive controls or hidden user interfaces, but this is not the only way in which the function can be invoked. Less visible or hidden methods are provided, but these should always be secondary methods, with more visible methods being primary (Section 6.6.3).

The following guidelines for the ERP and HCI education community should be considered:

- ERP courses should address the supporting competencies identified in the ERPEd framework, namely interpersonal, business (including accounting) and management. The interpersonal competencies can be addressed in ERP courses by creating a cooperative learning environment that stimulates and encourages students to develop interpersonal skills. This can be done by requiring students to work in teams (McMurtrey et al. 2008; Tesch et al. 2008; Boyle and Peslak 2010) and to prepare presentations on ERP systems (Winkelmann and Matzner 2009; Hustad and Olsen 2011). Business courses should be included in an IS curriculum for ERP specialists.
- ERP courses should cater for novice and expert users in both the user interface of the ERP system and in the design of the course which uses the system. One way of achieving this in the course is through self-directed learning where students can work at their own pace (Hustad and Olsen 2011). The design of the UI should also allow for the different competence levels of students, as well as the usability criteria for ERP systems used for educational purposes (Table 7-1).

Several studies (Section 4.4.3) have shown that there is a need for an ERP learning tool which is designed specifically for learning and which provides improved navigation and guidance to the novice user. This was confirmed by the usability evaluation results of the case study (Section 6.3.1). The ERP system should also take into account the conceptual knowledge that students must acquire, as well as industry relevant competencies. Existing studies of ERP learning tools do not cater for the different levels of competencies, and this study can therefore assist in filling this gap.

7.5.2 Recommendations for Practice

Based on the results of this study HEIs are strongly encouraged to adopt a hands-on approach to ERP systems in their IS curriculum. In addition they should consider the benefits of implementing a medium-sized ERP system which may be less complex than the adoption of 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. HEIs that have succeeded with the adoption of an ERP system for introductory courses should consider adopting the supplementary ERP competencies into more advanced ERP courses. IS departments in higher education are also 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, proposed by this study, into their curriculum.

The South African government should consider including the ERP competency set for in the national ICT skills improvement program and should continue the process of collaborating with higher education. Management should consider the results of this study to assist the business community with working more closely with higher education, specifically regarding ERP competencies. In addition they should use the set of ERP competencies for evaluating the competency level of prospective or current employees. The usability results can be used by ERP system vendors such as SYSPRO to design systems that are more suited to a learning environment, and to address the usability problems identified in this research.

In order to encourage more school learners to enrol for IS degree programmes, the marketing of IS curricula, and the need for ERP specialists and ICT skills globally, should be undertaken. Awareness programs at schools can be provided which include educating parents, teachers and career counselors about ICT and ERP career opportunities.

The case study strategy is a time consuming one, particularly the recording of the results of the assessments, which in this study was done manually (Section 5.4.5). This could be improved by automating this process, as well as the mapping of the competencies to assessments and the acquired competencies of students. An ERP system which automatically assesses students and classifies their competency level could improve the research process.

7.6 Recommendations for Future Research

The findings of this research study provide several insights for possibilities and opportunities for future research. The study has provided the foundation for closer university and industry collaboration and provides a platform for future co-operation and liaison. A significant finding is that organisations participating in the industry survey indicated that they have a problem obtaining ERP specialists with the required competencies. The impact of the ICT skills shortage worldwide has been of great concern and most governments, including South Africa, have realised the importance of these skills and the support provided by ICT for modern businesses.

- Further research should be undertaken on the level of competencies of ERP specialists currently employed in industry, which could also include a gap analysis between what exists in the marketplace and what is required by organisations. Research studies could also be undertaken of a comparison of ERP competencies between countries.
- Additional studies could be undertaken which use external methods of evaluating education quality, for example, analysing reports from the employers of graduates or from successful internship programs (Guthrie and Guthrie 2000). The study of Seymour et al. (2006) could be expanded and updated to evaluate the perceived importance of ERP courses to industry (Seymour 2006).
- HEIs are experiencing rapid change in the ICT industry and there is increased pressure to equip graduates with the required competencies. The ERPEd framework is proposed for adopting ERP systems into the IS curriculum in HEIs, and was successfully applied at NMMU. This confirms the findings of those of Winkelman and Matzner (2010) who proposed that ERP systems designed for smaller organisations can achieve similar results to that obtained with a large ERP system. However the results cannot necessarily be generalised to all other cases (Section 5.4.5). It is therefore desirable that further research implement the framework at other HEIs in South Africa or in other countries. In addition, only one level of breadth was implemented using a medium-sized ERP system, SYSPRO. Other medium-sized ERP systems, or other levels of breadth, could also be adopted and evaluated.
- Insufficient empirical research has been done on the topic of the usability of ERP systems, particularly in education (Section 4.4). Future research should include additional studies on the impact of the usability of ERP systems on educational outcomes in other environments.

- In particular, future research of ERP systems that are specifically designed for learning and provides more guidance to users is required (Section 6.7.4). These ERP learning tools should address the usability problems and critical incidents identified in this study and adhere to the principles of good interface design (Section 6.7.4).

7.7 Summary

This research has produced four primary artefacts, namely:

- A set of industry-relevant competencies for ERP specialists;
- The ERPEd framework;
- A set of measures for ERP education; and
- Usability criteria for ERP systems used for instructional purposes.

The ERP competency set can be used by organisations to improve the quality of ERP specialists and thus the success of ERP projects. It can also be used by educators for designing ERP education courses and programmes for IS higher education. The comprehensive competency-based, ERPEd framework, is proposed for adopting ERP systems in the IS curricula. This framework was successfully applied at NMMU and the results of the case study have shown that the medium-sized ERP system, SYSPRO, can successfully attain the necessary competencies of introductory ERP courses at NMMU. The results of the case study also identified several usability criteria for ERP systems used for instructional purposes, which can be used by HCI designers to improve the usability of ERP systems and in this way contribute to improving the performance of students who are using these systems.

Studies that validate the ERPEd framework in other environments can improve the competencies of IS graduates and thereby narrow the gap between industry requirements and what HEIs are producing. There is a need for research into the improvement of ERP learning tools, as was confirmed by the usability evaluation results in the case study. Future research could explore the potential benefits of designing and implementing an improved ERP learning tool designed specifically for learning and for instructional purposes.

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