Towards a Reusable Process Model Structure for Higher Education Institutions

by

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Dedication

To my husband Derick, without your love and support
this work would not have been possible.

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Abstract

One of the tools used during re-engineering of an environment is the process model as modelling tool. The identification of process models within an institution is a difficult and tedious task. A problem is that often process model structures is identified for one specific project and not stored for future reuse. The ideal for institutions is to reuse process model structures within the institution. This study focused on the generic structures within the higher education application domain where the hypothesis for this study was that *a generic educational process model structure for higher education institutions can be established; a process management flow procedure can be used to manage the flow within an educational process model; and that an educational process model can be stored and reused in re-engineering efforts.*

The study was divided into three research questions, where the first focused on the identification of generic process model structures, the second on the usability of the process model structures within a re-engineering effort, and the last on the preservation of a process model structure.

For the first research question, the identification of process model structures, three institutions were used for data collection. It was necessary to develop a requirements elicitation procedure for data collection. The structure derived was confirmed at a fourth institution. For the second research question, which focuses on the usability of process model structures, an ordinal measurement was defined to measure the usefulness of the process model structures in a re-engineering effort. A re-engineering procedure was developed for re-engineering the application domain, called the process management flow procedure, and used for a re-engineering effort at one institution. Lastly, for the third research question the preservation of the process model structures, the abstraction of the process model structure was investigated as well as the feasibility of implementing the process model structures physically using existing repository software.

The conclusion after the investigation of the three research questions was that the hypothesis was confirmed that there is indeed a set of process model structures within the higher education institution that are generic, preservable and reusable in a re-engineering effort.

Key words: Process model repository, higher education re-engineering, higher education process innovation, process models, process modelling, generic process models, reusable process models, process model structures, generic higher education process models, preservation of process model structures.

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Abbreviations

BPR	Business process re-engineering
CASE	Computer-aided software engineering
CD	Compact disk
DEU	Distance education university
HCI	Human-computer interaction
HE	Higher education
HEI	Higher education institution
HGP	Human Genome Project
IT	Information technology
MIT	Massachusetts Institutes of Technology
OO	Object-oriented
PERT	Program evaluation and review technique
PM	Process model
SAUVCA	South African Universities Vice-Chancellors Association
SE	Software engineering
TechPta	Technikon Pretoria
TOC	Theory of constraints
UFS	University of the Freestate
UNISA	University of South Africa
UP	University of Pretoria
WWW	World Wide Web

Preface – Notes on Writing Style

Scientists use different styles in presenting the thesis as a trustworthy document to the reader. For many years the preferred style was very formal where the researcher wrote the thesis in the third person passive voice and refrained from referring to him or herself as ‘I’. In recent years some researchers have preferred a more informal approach where the work is scientificically sound but the tone is fairly informal. In this thesis, I adopted an informal approach and ask the reader not to confuse a more relaxed writing style with inexactness.

As regards references to people, when referring to a specific person, the applicable gender was used. But in general, ‘he’ includes ‘he or she’, ‘him’ refers to ‘him or her’, and ‘his’ refers to ‘his or hers’.

With regard to the naming conventions for the institutions used in data-gathering, the institutions referred to include the University of South Africa, the University of Pretoria, Technikon Pretoria and the University of the Freestate. As a result of the merging of different institutions in South Africa, the name of Technikon Pretoria changed to Tshwane University of Technology. At the time of data-gathering the Technikon was known as Technikon Pretoria and I will use it in this study.

With regard to the referencing style for naming the processes, capitalization is used to refer to a process on the highest level of the process model structure (e.g. REGISTRATION). On the second level, subprocesses are written in italics with the first letters of each word in the process name capitalized (e.g. *Application Process*). For lower levels the subprocesses are written in italics with only the first letter capitalized.

A compact disk (CD) is included with the thesis that contains the Appendices and the articles published during the study.

1. Introduction

1.1 INTRODUCTION

This thesis focuses on the identification and preservation of process model structures for a class of structures in the education domain. The class of structures I shall be concerned with, falls within the 'higher education institution' (HEI) domain.

This study resides within the computer science and information systems discipline, but is multi-disciplinary in nature, addressing issues from software (method) engineering and process re-engineering applied to the educational domain.

Software engineering is 'the establishment and use of sound engineering principles in order to obtain economically viable software that is reliable and works efficiently on real machines' (Pressman, 2005:53). Process re-engineering (or process innovation) focuses on the functional view of the business where the process is discussed in terms of its activities (subprocesses) and the flows between the activities (Curtis, Kellner & Over, 1992). The core of process re-engineering is the process to be re-engineered (Hammer, 1990; Davenport, 1993). In re-engineering procedures, the identification of the process is described as one of the main activities. The re-engineering team uses different tools and techniques to describe the processes within the organization (Davenport, 1993; Hammer & Champy, 1993). One of the major tools used is the process model, which gives a graphic overview of the processes and the relationships between the processes (Curtis *et al.*, 1992). This thesis focuses on the use of process models as a tool during process innovation or process re-engineering in the HEI domain.

'Higher education' (HE) in the South African context means all learning programmes leading to qualifications higher than Grade 12, or its equivalent, in terms of the National Qualifications Framework, as contemplated in the South African Qualifications Authority Act, 1995 (Act No. 58, 1995), and includes tertiary education as contemplated in Schedule 4 of the Constitution (Higher Education Act 101, 1997). A 'higher education institution' means any institution that provides higher education on a full-time, part-time or distance basis and which is established, or deemed to be established, as a public higher education institution under this Act; declared as a public higher education institution under this Act; or registered, or conditionally registered, as a private higher education institution under this Act.

My hypothesis is that *a generic educational process model structure for higher education institutions can be established; a process management flow procedure can be used to manage the flow within an educational process model; and that an educational process model can be stored and reused in re-engineering efforts.*

The background to the research problem is given in Chapter 1, section 1.2, followed by the problem statement and purpose of the study in section 1.3. The three research questions that drive the study are defined in section 1.4 with some comments on the rationale from a personal, organizational and scientific perspective in section 1.5. The scope and potential contribution are discussed in sections 1.6 and 1.7 respectively. In section 1.8, an overview is given of the research method, with a summary of the research design in section 1.9. The Chapter concludes with a discussion on the thesis layout in section 1.10.

1.2 BACKGROUND

In the early 1990s process re-engineering was widely used in different application domains to change the way that organizations were doing business. Some success stories were recorded, but a number of failures tempered the process re-engineering wave in the mid-nineties (Davenport, 1995a). However, the tremendous growth of the Internet and the World Wide Web (WWW) stimulated new interest in the procedures and methods available to rethink the current processes and to introduce technological changes into the organization (Kalakota & Robinson, 1999; Hollander, Denna & Cherrington, 2000). In the HEI application domain, the way that educational institutions was 'doing business' was considered, and tools and techniques were introduced to manage technological changes during re-engineering (Allen & Fifield, 1999; Oblinger & Katz, 1999; Bates, 2000; Katz & Oblinger, 2000). The procedures used in both application domains employ process re-engineering methods available from the business application domain (Teng, Jeong & Grover, 1998; Carnevale, Berestka & Morrissey, 1999).

One of the reasons why HEIs are careful to introduce process re-engineering projects into the HEI application domain is the cost associated with the transformation. According to Spcier and DeBlois (2004), the funding of Information Technology (IT) projects is still the most important issue in strategic planning.

One way of reducing costs is to introduce the concept of reusability. Firesmith and Eykholt (1995:395) define reuse as the 'use of some pre-existing product (e.g. existing requirements, design, code, etc.)'. In programming languages, the reuse of program code is an innovative way of reducing costs, which not only reduces the cost of development, but also increases reliability and the effective use of specialists, and enforces standards (Sommerville, 2000). A function or piece of code developed for one application is stored and made available for reuse by programmers as part of other program developments. In the re-engineering of the application domain, researchers at the Massachusetts Institute of Technology (MIT) grasped the value of this concept and introduced it into the building of process repositories for the business application domain (Malone *et al.*, 1999a). MIT developed the abstract representation of the process repository in the early 1990s in the form of a Compass Explorer and in the mid 1990s commercialized the Phios software used for data access and manipulation of the process model structures (Phios, 1999) (discussed in more detail in section 2.5).

During the reuse of something such as an object or a process, the classification or identification of the generic concepts is a consideration (Malone, Crowston & Herman, 2003). In object-orientation, classification is used to group or generalize concepts that naturally belong together. For example, a truck and a car both belong to a group called 'vehicle'. Classification is used to reduce the number of components in the library or repository where the components are preserved.

As far as this study is concerned, I support the notion of Sanchez (1993) that there is a danger inherent in the generalization of the organizational taxonomy based on a diverse sample of organizations, and that the researcher should rather take one specific kind of organization and investigate its nature. Therefore, instead of focusing on the whole of the National Educational system in South Africa, the scope of this study is limited to the classification and preservation of the process model structures in the HEI application domain only. The HEI structure differs from other available structures in South Africa, for example the pre-primary educational system, which makes the scope manageable.

As indicated above, in a number of fields the classification of systems and the reusability thereof have proved to be an advantage. The identification of process model structures is not easy and is usually costly (Nikols, 2003). In the HEI application domain where change is inevitable to stay competitive, the identification of structures could be an advantage, as was stated in the early 1990s by Prupis (1992). If these structures can be reused across boundaries, this could not only benefit the internal structure of one HEI, but could also benefit organizations where it is not feasible to initiate expensive process re-engineering innovations. A reusable object is not worth much if the object is not available. The preservation and availability of objects are therefore important, through libraries in the case of objects (Budd, 1991), or repositories in the case of process models (Carr, 2003).

With regard to the identification of generic concepts, Rosch (1973) did some experiments on how people categorize and associate words with experiences and found that they rely on what is the best representative of the category designated by that word. Similarly, software engineers are involved in a categorization process during the identification of classes and subclasses in the object paradigm (Jacobson, Booch & Rumbaugh, 1999). In the business application domain, not much has been written on the *method* used to identify the generic process model structures to be used as reference models in future re-engineering efforts. For example, if one needs to duplicate the identification of the structures used in the MIT process repository for a different application domain, the product is available to look at, but no formal methodology or technique is available which the researcher may refer to in the identification and preservation of process model structures for his own application domain.

1.3 PROBLEM STATEMENT AND PURPOSE OF THIS STUDY

The focus of this study is to move towards the description of the HEI, with specific reference to process model structures. Some relevant work on the preservation of business process model structures has been done in the development of the MIT business process repository in the 1990s (Malone *et al.*, 2003). However, in moving towards the identification and preservation of the HEI application domain, the differences and similarities with the business domain constitute a key consideration. The HEI and the business application domain differ with regard to the goal associated with each. The educational domain is more service-orientated and financial systems are more market-oriented. The higher education domain encapsulates some activities that are prominent in the business world, such as financial structures and human resource issues. However, there is a set of processes that work together with the aim of providing the student with a learning environment that is unique to the educational application domain, such as the course development and registration activities. Therefore, although there are similarities in the techniques for identifying the structures, the nature of the business process structures differs and the process structures in the MIT process repository are therefore inadequate for representing the processes in the educational application domain.

In business re-engineering theory there are some methods available to guide the developer in re-engineering the business environment (Hammer, 1990; Davenport, 1993) or in the HEI application domain (Allen & Fifield, 1999; Scott, 2003b), but the theory is limited to the identification of the process model structures as an important step, without elaborating on the techniques used to identify the structures. Therefore, there is not only a need for a description of what the HEI process model structures are, but also a need to describe methods that developers may consider during the identification phase of the process model structures.

From the factors discussed above, the problem statement for this study is summarized to include the following issues:

- The HEI application domain is changing as a result of technological innovations. There is a need for process model structures within the HEI application domain to be used in process re-engineering efforts (Prupis, 1992).
- The current business process structures are inadequate for describing the educational application domain, and there are currently no generic process model structures available within the HEI application domain.
- There is a need for methods describing the way that generic structures can be derived in the HEI application domain. There is currently no literature available on the identification and preservation of the structures within the HEI application domain.
- Reusability is feasible in other application domains but has not been applied to the process model structures in the HEI application domain. There is a need to investigate the feasibility of reusing process model structures within this domain.
- Reusability is only possible if structures are preserved. There is currently no literature available on the preservation of the structures within the HEI application domain. There is a need to investigate the preservation of the process model structures and to investigate whether or not the current structures available are sufficient to support the HEI application domain.

The purpose of this study is to consider these problems and to focus on the construction and preservation of the generic process model structure for the HEI application domain.

1.4 RESEARCH QUESTIONS

Information systems can be viewed from three different perspectives, data, process or behaviour (Curtis *et al.*, 1992). The methodology used to derive a product in information systems is divided into four stages, planning, business analysis (or analysis), system design and construction design (Olle *et al.*, 1989). This study focuses on the second stage, the analysis of the environment from a process perspective with behaviour included in the graphical representation of process models. Techniques from software engineering (Pressman, 2005) and business process re-engineering (BPR) (Davenport, 1993; Hammer & Champy, 1993) are used to identify the generic process model structures. In the identification and definition of the generic process model structures we will move forwards in the path of what Sanchez (1993:73) calls 'the long and thorny way to an organizational taxonomy', applied to the educational domain.

The main issue addressed in this study is the approach used in the construction and preservation of the generic process model structure for the changing HEI application domain. The research questions defined for the study are as follows:

1.	What is the process model structure of the higher education institution?
2.	To what extent is the generic process model structure useful in a re-engineering effort?
3.	How can the educational process model be preserved and reused?

The HEI application domain is studied from a process or functional point of view and the objectives of the study are the following:

- The identification of the generic process model structure for the HEI application domain, including:
  - The identification of a procedure to derive the process model structure.
  - Data-gathering at different institutions to derive the process model structure.
  - The verification of the structure.
  - The verification of the procedure used to derive the process model structures.
- The investigation of the feasibility of the process model structures derived in a re-engineering effort, including:
  - The identification of a process management flow procedure for the HEI application domain
  - The identification of a measurement technique to establish how useful the process structures are.
  - Data-gathering during a re-engineering effort at one institution.

- An investigation into the feasibility of preserving the process model structures, including the:
  - Identification of a process model representation for preserving process models in repositories.
  - Identification of an environment in which process repositories can dynamically be preserved updated and retrieved.
  - Feasibility of presentation of the HEI in a process model representation and preserving it in a repository environment.

1.5 RATIONALE BEHIND THIS STUDY

The rationale is discussed from a personal, national, organizational and scientific perspective.

1.5.1 Personal rationale

In the mid 1990s, I became involved at UNISA in the conversion of existing courses to e-learning[1] courses. At that time there were only a few e-learning courses available, usually developed and presented by individuals interested in the topic. Similarly, the conversion from traditional courses to e-learning courses at institutions was limited. Research on the inclusion of technological approaches in the HEI was first presented at conferences and published in conference proceedings. At these conferences, academics reflected on the tools and techniques used in presenting courses over the web, similar to the work published in 2000 (Van der Merwe & Cloete, 2000). As a lecturer in software engineering at the University of South Africa (UNISA), I was interested in the techniques used to convert traditional processes to include technological innovations. I found that there were many publications on the conversion from the educational perspective, but only a few on the inclusion of technology from a software engineering perspective.

1.5.2 The changing educational landscape in South Africa

In South Africa, the first university was the University of the Cape of Good Hope (established in 1873). The University of London used to act as an external examining university for the candidates in the Cape Colony. Later, this university assumed the name the University of South

[1] Also commonly called virtual learning, telematic learning or teleteaching

Africa (UNISA) and moved to Pretoria. UNISA was restructured as a distance learning university in 1946 (Gillard, 2004).

The higher education system in South Africa, which was based on very simple principles, became more complex as time passed. New universities have been added to the system starting with the University Act of 1916, which gave full university status to the University of Cape Town and the University of Stellenbosch. The Extension of the Universities Act of 1959 resulted in creation of 'tribal colleges' for different ethnic groups located in rural areas. These colleges were under the trusteeship of UNISA and the Minister of Bantu Education. Colleges were created, particularly for 'Indian' and 'Coloured' citizens, in urban centres (Gillard, 2004).

After the 1923 Higher Education Act, the Technical Institutes became Technical Colleges which were focusing on training up to matriculation level. Technical colleges progressively started expanding post-matriculation qualifications and by 1958 some colleges were producing three-year post-matriculation national diplomas. An Act of Parliament in 1967 created four urban Colleges of Advanced Technical Education with three-year national diplomas being their core qualifications. Such colleges were renamed in 1977 as technikons. Parallel to the growth in the university sector, more technikons were created.

On 27 July 1999, Professor Kader Asmal, the Minister of Education, announced his intention to review the institutional landscape of higher education. The minister subsequently requested the Council on Higher Education (CHE) to advice him on the reconfiguration of the higher education system to meet the high-level human resource needs of South Africa (CHE, 2000).

In late January 2000, the Minister of Education tasked the CHE to conduct an investigation into the future of the educational system in South Africa. The CHE formed the 'Size and Shape Task Team' to conduct this investigation. In June 2000, they published a report in which they gave concrete proposals on the reconfiguration of the higher education system and recommended some issues for future investigation (CHE, 2000). In the report, the Task Team states that 'the problems and weaknesses of the higher education system will not disappear on their own or be overcome by institutions on their own. They must be confronted and overcome in a systemic way' (CHE, 2000:4).

The team relied on the outline defined by the 'Education White Paper 3: A Programme for the Transformation of Higher Education 1997' (Education White Paper 3, 1997), which:

- Identifies the various and diverse social purposes higher education must serve.
- Sets various goals for the higher education system and for institutions.
- States the principles and values that must be promoted.

In this white paper, one of the goals stated was to ‘diversify the system in terms of the mix of institutional missions and programmes that will be required to meet national and regional needs in social, cultural and economic development’ (Education White Paper 3, 1997:9). This motivated the announcement, by Education Minister Professor Kader Asmal at the end of 2001, that different types of institutions in South Africa, such as UNISA and Technikon Southern Africa, will merge. The restructuring of higher education on national level will impact each institution involved. As stated by the CHE, it will require the restructuring of the institution at different levels (CHE, 2000).

This restructuring emphasizes the importance of this study from a national level, where different institutions are busy with merger initiatives and it is inevitable that internal processes will be affected by the change. Institutions that merge will have to rethink administration and academic processes. For example, two institutions merging will need to consider registration systems previously used at the different institutions and select one of the two or develop a new registration system to register students in future. This will inevitably lead to the use of re-engineering principles within the HEI, which is closely related to the focus of this study.

1.5.3 Organizational rationale

On an organizational level, advances in information technology, the Internet and evolving e-learning strategies have led to the rise of many new learning organizations offering ‘virtual’ certification programmes to geographically dispersed students over the past few years (Singh, 2000). These types of *virtual universities* are often based on co-operation between different educational institutions, courseware specialists and course brokering companies, and most of them offer formal, as well as informal programmes (Belmiro & Pina 2001). However, there is also a trend towards including e-learning programmes in the formal curricula of traditional universities and colleges. Indeed, traditional higher education institutions that have already incorporated e-learning into the curricula often claim to have a competitive advantage in serving a wider audience of students.

The incorporation of technologies such as e-learning and e-commerce facilities into the traditional HEI is not simple. It involves many complex issues such as strategic management decisions, strategic information technology implementation strategies, change management to enhance the willingness to participate and commitment of stakeholders, training and retraining, selection of suitable learning strategies, partnership strategies, development of courseware, and so forth (Young 2001). When dealing with technology implementation strategies and change management, developers use functional decomposition of the organizational structure to view the flow between processes.

Different tools and techniques borrowed from the business application domain are available to assist in the investigation of the current process model structures. Methods are used from process re-engineering, as defined by authors within the business application domain such as Hammer (1990) and Davenport (1990). The focus of these methods is to derive the process model structures and from them identify the constraint processes (discussed in section 6.2). The data-gathering involved in the identification of the process structures is tedious and not easy.

On an organizational level, the study expands on the available requirements elicitation procedures for the identification of the process model structures in HEI. Some of the work related to the identification of process model structures is reported on in Van der Merwe (2003) and Van der Merwe, Pretorius & Cloete (2004b).

The availability of generic structures within a process repository can lower costs involved in the identification of process model structures. In similar fashion to reusability in the software engineering application domain, it can increase the effective use of specialists in other application domains and assist in the move towards a standard set of process reference models. For any HEI structures of this nature the identification of new processes and knowledge sharing is useful in process re-engineering.

1.5.4 Scientific rationale

The scientific rationale refers to the current limitations of the theory, which the study can help overcome. With regard to this specific study, there is a lack of procedural descriptions related to the identification and preservation of useful process model structures. Hammer (1990) and Davenport (1990) described some methods for process re-engineering in the business application domain. In the HEI application domain, Bruno *et al.* (1998) used adapted procedures and included some change management guidelines. In examples found in the HEI domain, the procedures include identification of the processes as a step, with limited information on how these processes should be identified (Carnevale *et al.*, 1999). Nikols (2003) confirms that the identification of processes is not an easy task, mainly because they are essentially unknowns. In the business application domain a number of authors have realized the value of generic process model structures and focused on their identification and preservation (Malone *et al.*, 1999a; Carr, 2003). Prupis (1992) emphasizes the importance of the identification of process structures in HEI.

However, there is a gap in the literature related to the tools and techniques used in the identification and preservation of generic process model structures. For example, during the study it was necessary to identify a set of characteristics as a measurement tool for requirements elicitation procedures (Van der Merwe, Cronje & Kotze, 2004a). This confirms that the scientific contribution pertains to the methods, tools and techniques used to establish the generic process model structures for future reuse.

1.6 THE SCOPE AND CONTEXT OF THE STUDY

It is not possible to do a study of this magnitude without limiting the scope. Section 1.6.1 gives an overview of what is included in this study and in section 1.6.2 the limitations are addressed.

1.6.1 Scope of the study

This study was a Type I study in method engineering where the intent is to ‘standardize on best practices in systems development’ (Avison & Fitzgerald, 2003:101). Type II to Type V methods relates to more advance topics such as the change of an existing approach to be more ecumenical (Type II) or the identification and linking of method fragments (Type III). The added value for Type I method engineering is to bring order to chaos where the methodological approaches add to the scientific knowledge in this application domain. The scope was limited to the higher education application domain, taking the following considerations into account:

- Within the HEI application domain, the driving force is the rapid change of information technology (IT) and the effect that it has on the process flow within the HEI. According to Curtis *et al.* (1992), the process can be viewed from four perspectives: functional, organizational, behavioural and informational. The focus of this study was on the functional view defined as ‘what process elements are being performed, and what flows of informational entities (e.g. data, artefacts, products) are relevant to these process elements’ (Curtis *et al.*, 1992:77). The concept of different views is illustrated in Figure 1.1.

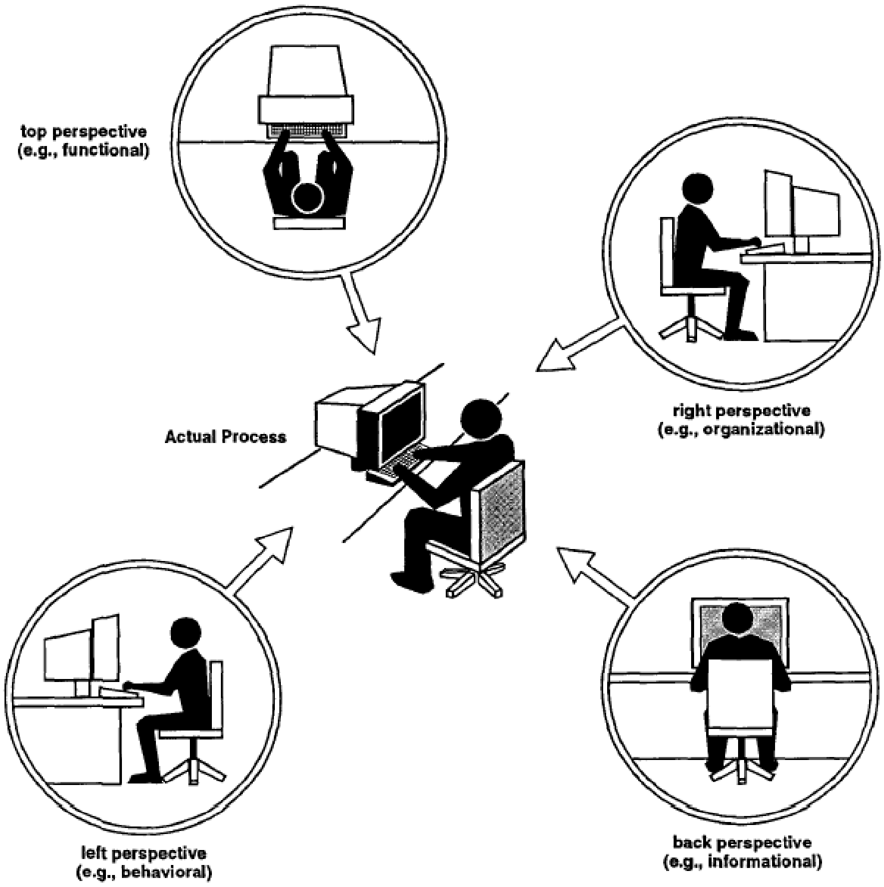

Figure 1.1: Different views of the actual process (Curtis *et al.*, 1992:78)

- With regard to the definition of primary processes and secondary processes, the focus of this study was on the identification of the high-level process model that includes the primary processes of the institution. Porter (1985) developed the concept of a value chain in which he distinguishes between the primary and secondary process. For the purpose of this study, primary processes are those critical activities responsible for (or involved in) the design and construction of the student's learning environment. Support processes are those processes that provide sustenance for the primary processes playing a secondary role in accomplishing the defined goal.
- With regard to the usability of the process model structures, I focused on the usability within a re-engineering effort. In other application domains, process model structures proved to be useful in re-engineering, the invention of new processes, and software generation (Malone *et al.*, 2003). Although I hinted at the creation of new processes in using the process management flow procedure, I did not focus on these activities.
- The reusability and preservations were tested through the creation of a process model representation that is an abstraction of the process models. The feasibility was investigated

using an established environment developed by the Phios software company supporting the MIT process repository (Phios, 2005).

1.6.2 Limitations of scope

The study is limited to the HEI application domain and although tools and techniques from the business application domain are used, the focus of the research is not on the business application domain. The objectives of this study relate to the change in the HEI application domain. Within this application domain the following aspects were not dealt with as major consideration in this study:

- The investigation into Computer-aided software engineering (CASE) tools supporting the requirements elicitation process. Tools such as Rationale Rose (Rational, 2002) or System Architect (Popkin, 2005) are very expensive and owing to financial constraints it was not feasible to use them in this study to support the analysis process. The focus was not on the software tools available but on the methods and techniques needed to establish the usability and reusability of process models.
- The data, behaviour and informational view of the organization. The process is viewed from a functional perspective and therefore observations were included from the other views such as the behavioural view, but that did not constitute the major thrust of this study.
- An investigation into why re-engineering projects fail within the HEI application domain. I used the theory based on reasons why re-engineering projects fail in business applications (Bergey *et al.*, 1999; Davenport *et al.*, 2003) but did not do a specific study to determine the reasons for the HEI application domain. It is indeed necessary to investigate the problems in this specific application domain with regard to the failure of process re-engineering and I suggest it as a project for future research in Chapter 9.
- The preservation of the process models focuses on the abstract representation related to the elements and the relationship between the elements. Coordination theory is not considered in this study.
- The implementation of the suggested prototype in section 6.2.4. I investigated the feasibility of the implementation but excluded the implementation itself. An implementation of this magnitude was beyond the scope of this thesis because it involves large development teams, management involvement and change management strategies.

1.7 SIGNIFICANCE AND POTENTIAL CONTRIBUTION OF THE STUDY

As previously mentioned, the rationale for this study is to investigate the reusability of generic structures within the HEI. The establishment of methods and techniques to derive generic process model structures enables the HEI to share process knowledge within the organization and expand on the structures identified in this study. The structures may also enable other institutions to share knowledge on process model structures if the repository is accessible. This can be valuable for institutions that do not have the capacity to be involved in a full requirements elicitation cycle during re-engineering efforts. ‘Reinventing the wheel is very expensive’ and for financially strained institutions, every tool and technique that is available may contribute towards the successful use of process re-engineering in the HEI.

Another contribution lies in the techniques used to investigate the reusability of process model structures. Teams involved in the identification of generic structures need guidelines during data-gathering to ensure a complete data set. Measurements and techniques are necessary to confirm that the process structures are generic, useful and are a representative of the target environment. The techniques in this study assist teams involved in the identification and preservation of structures in HEI and potentially in different application domains.

1.8 RESEARCH METHOD

The study is mainly a qualitative study, with some elements of quantitative research. According to Fraser (2003), it is appropriate to use a combination of both in a research study. The quantitative research elements in this study were incorporated through the identification of measurement tools during the use of a qualitative research approach called development research, which supports the building of theory through practice.

Myers (2004), a well-known author on research issues in information systems, describes qualitative research as the ‘use of qualitative data, such as interviews, documents and participant observation data, to understand and explain social phenomena’. In qualitative research, the researcher selects an approach that describes the way in which the research will be conducted.

I used a cross-matrix table (Van der Merwe, Kotze & Cronje, 2005) to investigate the nature of the research and categorized the research approaches needed as a combination of action research and case study research. The identification of generic structures requires a cyclic procedure of data-gathering and theory building. Development research, or action research, is defined by Van den Akker (2004) as research that aims to make both a practical and a scientific contribution. In this case, the tools developed constitute the practical contribution and the methods used are the scientific contribution. The case study environments used during the data collection included UNISA, the University of Pretoria (UP) and Technikon Pretoria[2] (TechPta), with verification done at the University of the Freestate.

1.9 RESEARCH DESIGN

The research design refers to the tools and techniques used during the data-gathering activities in the study. The issues that are of importance include the population, data collection, data analysis, trustworthiness and authentication.

1.9.1 Population and sampling

For the first research question, the identification of the process model structure, it was necessary to select different HEI organizations for the data-gathering. My goal was to investigate the generic structures of the HEI. Three institutions were selected as participants in the case study. The three institutions represented a distance education university (DEU), a residential university and a residential technikon. A distance institution is an institution that provides mechanisms for students to obtain qualifications while not physically attending classes at the institution. At a residential institution the institution provides lecturing physically at the institution that the student attend. According to the National Plan for Higher Education, the ‘traditional distinction between contact and distance institutions and modes of delivery is becoming increasingly blurred’ (National Plan for Higher Education, 2001). Irrespective of this change, I decided to use the three different types of institutions in order to verify that the structures are applicable in more than one type of environment.

A fourth residential university was selected at which to carry out data verification. All the units (departments, institutes, bureaux, etc.) within each organization were included in the initial data sample for each institution. A key person was identified in each unit for discussing the processes within the unit and the way that they interact with one another.

[2] After the merger known as Tshwane University of Technology, but during the study was still Pretoria Technikon.

For the second research question, the investigation of the usefulness of the process model structures in a re-engineering effort, UNISA was selected as the research environment. UNISA was selected because it is involved in all the activities available at the other institutions, and more. The focus was on the usefulness of the structures in an HEI environment and the type of HEI environment did not influence the results. The key persons used during the first research question were used again during this research cycle.

For the third research question, UNISA was once again used as the research environment. After two cycles of data-gathering, the environment was familiar and less time was needed for the decomposition of the process model structure. Although this was not the intention, the reuse of the process model structures in this research question confirmed the results of the second research question, i.e. that the process model structures are reusable.

1.9.2 Data collection

The main data collection technique used in all three research questions was the interviews conducted with key persons in units at the institutions during data-gathering. Data collection also included non-participant observation and participant observation. Two data-gathering tools were developed during the study, including the requirements elicitation procedure to derive the process model structures and the process management flow procedure for process re-engineering at UNISA for the second research question.

1.9.3 Data analysis

Data analysis can be defined as 'the systematic study of data so that its meaning, structure, relationships, origins, etc., are understood' (Data Warehouse Glossary, 2005). In this section, a brief description of the data analysis pertaining to the different research questions is given:

- For data analysis pertaining to the first research question, the data-gathering tools discussed in section 1.9.2 were used to investigate the structures in the HEI. The requirements procedure was defined using best practices from requirements elicitation. Development research is cyclic (Van den Akker, 1999) and after each cycle of using the requirements elicitation procedure, the results were used to investigate the theory and to add what had been learned from using the procedure in practice. The theory available on the classification of structures was used to discuss the generic nature of the structures derived. Comparison tables were used to compare the results from the different HEIs and to report on the generic nature of the structures on different levels of the HEI. In more complex structures, a more formal measurement method than comparison tables may be necessary, but in this study, where the structures included not more than 10 to 15 processes per level, the use of comparison tables was sufficient. According to Davenport (1993), the number of key processes inside an organization is rarely more than 20.

- For the second research question, where the usefulness of the process model structures was investigated, the different approaches involved in process re-engineering were considered and a process management flow procedure based on best practices was described. The procedure includes theory from process re-engineering and also Goldratt's (1992) theory of constraints (TOC)[3]. The focus was on the usefulness of the process model structures and an ordinal measurement tool was defined in which usefulness is described in terms of comparative objects (section 4.3.2.3). The usefulness of the process model structures can be defined as high, medium, low or non-existent. These measurements were used in discussing the usefulness of the process model structure in a process re-engineering effort at UNISA (results in section 6.3).
- The preservation of the process model structures was considered in the third research question and for the analysis, the current preservation methods available were investigated. The MIT process repository was selected and the feasibility of using it in an HEI for abstract representation of the structure was investigated. Some adaptations were suggested after the analysis indicated that the notation used is not purely object-oriented. In the adapted model, a limitation was placed on the functionality changes within subprocess inheritance to enforce polymorphism, where the child may inherit the functionality but not change it. The feasibility of using the adapted abstract representation was investigated using the process model structures for the REGISTRATION process at UNISA. It was also confirmed as a triangulation exercise in discussion with specialists who use Unified Modelling Language (UML) for analysis and design (more on this in Chapter 2).

1.9.4 Trustworthiness and authentication

Trustworthiness and authentication in research refer to the validity of the research done by the researcher. In quantitative studies the results are often measurable statistically, which simplifies the measurement of the success or failure of the study. Qualitative studies are built on words and

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[3] Note that although the first publication on TOC was done by Goldratt and Cox (1992), later publications only give credit to Goldratt and it is known as Goldratt's theory of constraints.

do not involve any formal measurement such as statistical analysis, but support analysis of the concepts found in the theory and practice (Leedy, 1993). To ensure trustworthiness and authenticity in this study, the measurements put in place for the different research questions are summarized in Table 1.1.

Table 1.1: Trustworthiness/authenticity for research questions

Technique used to ensure trustworthiness/authenticity	Research Question		
	1	2	3
Characteristic list	√		
Feasibility study	√	√	√
Case Study	√	√	√
Member checking / peer reviews	√	√	√
Triangulation	√	√	√
Publications	√		
Research projects	√		

As a summary, in Research Question 1, a characteristic list, feasibility study, case study, member checking, triangulation, publications and research projects were techniques used to ensure the trustworthiness and authentication of the research conducted. For Research Questions 2 and 3, feasibility studies, case studies, member checking and triangulation were used as instruments of trustworthiness and authentication.

1.9.5 Role of the researcher

In the HEI application domain, no other study could be found that relates directly to the goal of this study. Some HEIs were involved in the re-engineering of processes and reported on best practices (Penrod & Dolence, 1991; Olson, 1993; Bergey *et al.*, 1999), but none of them were involved in the identification of generic educational structures.

For the identification of the generic structures, related work was done by Porter (1985) in the identification of primary processes for the business application domain. With regard to the reusability of process model structures, the work done by MIT (Malone *et al.*, 1999a) on the preservation of business process model structures could be used from a product point of view.

The theory, however, only hints at the important aspects in the identification of process model structures, with a gap in the identification of the generic structures. In this study I was the responsible researcher for the project and my role in this study was to study the existing concepts from different disciplines, and to use what is known about the identification of the generic process model structures in such a way that the structures are useful and preservable.

During this study, I acted as project manager, analyst, re-engineer and theory builder in the development and use of the different tools and techniques used during the research project. These activities are summarized in Table 1.2.

Table 1.2: Role during research

Roles during research	Description	Activities	Research Question		
			1	2	3
Project leader	The researcher is involved as project manager in the different activities during the research.	Define problem statement Compile project plan Identify data-gathering techniques Time management Identify measurements.	√	√	√
	Quality control.	Identification of characteristics that the requirements elicitation procedure adheres to.	√		
		Identification of the ordinal measures for investigation of the usability of the process model structures.		√	
System analyst	The researcher is involved in the analysis of existing systems.	Do the requirements elicitation of existing systems.	√		
	The researcher is involved in feasibility studies.	Investigate the feasibility of using process models in process re-engineering.		√	
		Investigate the feasibility of implementing an HEI process model representation.			√
Developer	The researcher is involved in product development.	A requirements elicitation procedure.	√		
		A process flow procedure.		√	
		A process model representation.			√
	The researcher is involved in the building of a prototype.	Solutions during process re-engineering.		√	
Re-engineer	The researcher is involved in a process re-engineering effort.	Identify constraints. Define problems. Identify potential solutions.		√	
Theory builder	The researcher is involved in theory building.	Methods used for the identification of generic process model structures.	√		
		Methods used during process re-engineering in the HEI application domain.		√	
		Methods used for the preservation of the HEI process model structures.			√
	Scientific contribution	The procedures and techniques summarized in Chapter 9 that form part of the scientific contribution of the project.	√	√	√

The different roles that the researcher played included the following:

- As project leader, the researcher was involved in the definition of the problem statement, the compilation of the project plan, the identification of the different data-gathering techniques and measurement techniques to be used as authentication. The researcher was also involved in the authentication and verification of the research results using the measurements identified.

- As systems analyst, the researcher was involved in the requirements elicitation for the third research question, the investigation of the usability of process model structures during the second research question and the investigation of the feasibility of the implementation of the HEI process model representation.
- As developer, the researcher was involved in the development of the requirements elicitation procedure, the process management flow procedure and the abstract model for the process repository.
- In Research Question 2, the researcher acted as re-engineer during the identification of constraints and reasons for the constraints. The researcher also acted as developer in suggesting a prototype as a solution during this phase.
- Lastly, the researcher added to theory related to the identification of process model structures, the usability thereof and the preservation of the structures. The scientific value that the researcher contributed as theory builder was the tools and techniques that the researcher used in deriving the generic process model structures and the conclusions based on the methods involved in preservation of the structures.

1.10 OUTLINE OF THIS STUDY

The study is divided into nine chapters. Chapter 1, the introduction, provides an overview of the research including its scope, limitations and the research questions. In Chapter 2 an overview is provided of the theory related to the research questions and there is further elaboration of the rationale for the study from the theory. Chapter 3 is a contextualization in which background is given on the activities in which I was involved before the scope of the research was conceptualized. Chapter 4 contains descriptions of the research tools and techniques used during the research, including the research approach, the data-gathering tools, and the data-gathering tools developed for use during the data-gathering activities for the three research questions.

The three research questions are addressed in Chapters 5, 6 and 7 respectively. Chapter 5 consists of a discussion of the educational process model structures and an overview of how the requirements elicitation procedure adheres to the characteristics identified. In Chapter 6 the usability of the process model structures identified in Chapter 5, is investigated. The ordinal measurement tool described in Chapter 4 is used to give an indication of the level of usability. In Chapter 7 the educational process model repository is described, first on an abstract level where the different components and relationships between the components are discussed, and this is then followed by the discussion of the feasibility of implementing the process model structure in a repository similar to the Phios process model repository (2005).

In Chapter 8, the contribution of this thesis from the perspectives of the three research questions is discussed, both from a product and scientific viewpoint. Chapter 9 concludes with a summary of the findings of this research, including a summary of this study and an overview of the contribution of this study from a methodological, substantive and scientific view. Lastly, the possible future research identified during this study is discussed. The Thesis Map is graphically illustrated in Figure 1.2 and is included between each chapter as guideline.

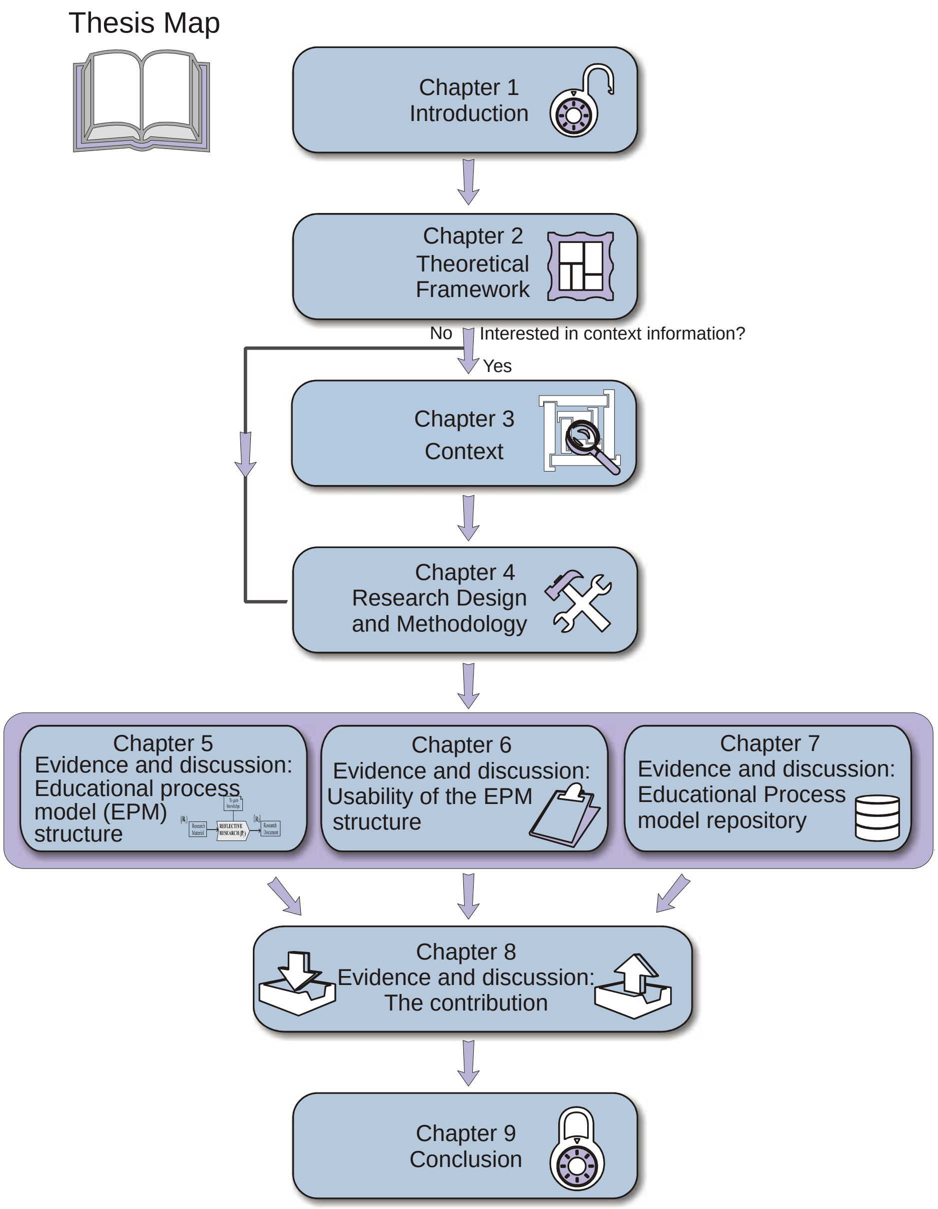


Figure 1.2 Thesis map

2. Theoretical framework

2.1 INTRODUCTION

The goal of Chapter 2 is to discuss the motivation for the research questions on the basis of the existing theory and to give an overview of the building blocks related to the research. This is accomplished through a literature review at the beginning of the study and also references to existing work during this study to complement the research project.

In this Chapter, section 2.2 provides background information on the rationale for the three research questions caused by new interest in the re-engineering of HEI environments after the introduction of the Internet as an innovation.

Sections 2.3, 2.4 and 2.5 each address the theory related to the three different research questions. In section 2.3, the theory related to the process model structure is discussed. In section 2.4, a discussion follows on re-engineering concepts in general, the role of re-engineering in HEI and the different re-engineering approaches available in the HEI and business application domain. Section 2.5 focuses on the existing structures available for the preservation of process model structures. The Chapter concludes with a summary in Section 2.6.

2.2 BACKGROUND INFORMATION

In May 2002, the number of Internet users worldwide was estimated at 580.7 million (NUA, 2002). At the beginning of 2005, this number nearly doubled to an estimated 888 million users (Internet World Stats, 2005). The estimated growth for Internet users over that three year period was a stupendous 300 million users. Since the introduction of the Internet as a technological innovation, it emerged in a number of disciplines as a tool to enhance service or support current structures such as healthcare systems (Ballas, 2001), business systems (Gebauer, Beam & Segev, 1998; Clague, 1999; Timmers, 2000) and knowledge sharing (O'Leary, 1998). It is inevitable that this technological innovation should also influence the HEI (Laurillard, 1993; Oblinger & Katz, 1999; Bates, 2000; Bates, 2003). The introduction of the Internet as a new technology will alter the ways in which colleges and universities conduct the business of higher education, how professors teach and how students learn (Clague, 1999).

2.2.1 The impact of the technological revolution on HEI

Day & Schoemaker (2000:2) refer to emerging technologies as those in which 'the knowledge base is expanding, the application to existing markets is undergoing innovation or new markets are being tapped or created.' For *established* environments the technology, infrastructure, customers and industry are well defined, which is in contrast to *emerging* technologies where these are not yet on solid ground.

The Internet is still an emerging innovation in higher education. Educause (2003) reported an increase in the number of institutions that use the Internet to provide web-based campus portals from 21.2 per cent in 2002, to 28.4 per cent in 2003. Online registration facilities grew from 20.9 per cent in 1998, to 70.9 per cent in 2003. In this report, Green commented that even if there is growth in a number of key e-commerce[4] and e-service[5] measures across all sectors of higher education, the campus community is still playing catch-up on e-commerce and e-service issues: 'Considering the wide array of e-commerce and e-service options routinely available to students and faculty in the consumer and corporate sectors, it's clear that the campus community is still roughly two years behind in its e-commerce and e-service offerings' (Educause, 2003).

The main reason for the slow implementation of technological innovations such as the Internet in HEI is the cost associated with this change (Spicer & DeBlois, 2004). However, HEIs should reposition themselves in the market where competition for student numbers is growing fiercer and a rising frustration is experienced with the slow transformation (Barone, 2004). Both the institution and the student community can gain by the use of more advanced technological innovations in HEI. Some of the advantages of using technology in HEI include the improvement of quality of learning, the provision of everyday technological skills for students and the improvement of the cost-effectiveness of education (Bates, 2000). On the administration side, the use of information technology (IT) and access through the Internet to student services give the students access to

[4] E-commerce refers to transactions done electronically through the Internet.

[5] E-service refers to any service provided electronically through the Internet.

educational opportunities that are unlimited by factors such as space, time and location, immediate feedback on rapid and continuous assessment, and virtual access to remote locations and expertise (Blurton, 2002).

Students are exposed to technological innovations at an early stage in life and the technological revolution is creating an 'expectation for operational efficiency and student-centred services' (Mills & Pumo, 1999:288). Therefore, HEIs cannot rely solely upon the traditional way of doing things (Mercer, 1999) and ignore the need to introduce more technologically advanced systems into the current way of doing things (Bates, 2000; Luker, 2000).

Over the last fifteen years, HEIs have reacted differently to the introduction of technological innovations. Senge (1990:4) claims that 'the organizations that will truly excel in the future will be the organizations that discover how to tap people's commitment and capacity to learn at all levels in an organization'. To excel includes keeping up with the rapidly emerging technologies and implementing changes that are advantageous for both the student (Blurton, 2002) and the institution (Luker, 2000). To handle this challenge successfully, the HEIs need to develop new competencies (Day & Schoemaker, 2000) and to introduce a disciplined approach to ensure that the implementation of new technologies is economically feasible, while maintaining the quality of learning (Laurillard, 1993; Bates, 2000; Ryan *et al.*, 2000).

In order to adopt the use of technology successfully with the emphasis on doing so efficiently and cost effectively in the learning domain, the organization needs to reorganize the current modus operandi, including the way in which HEIs are planned, managed and organized (Bates, 2000). The system surrounding the implementation of new technology trends needs to adjust to the new technology (Laurillard, 1993) in order to remain competitive while renewing the current way of doing things (Oblinger & Katz, 1999). This should be done in an informed and strategic fashion with the focus on both 'what' changes and 'how' it changes (Scott, 2003b).

HEIs need a well-organized re-engineering approach towards implementing changes, understanding the need to assess the quality of their teaching and research, and the efficiency of their service (Oblinger & Katz, 1999; Luker, 2000).

2.2.2 Re-engineering the processes in an HEI application domain

In the few years since the Internet has gained prominence, thousands of businesses, educational institutions and government agencies have begun to exploit the opportunities offered by e-commerce. Although the HEI is not a business (Greenberg, 2004) it can benefit from innovative practices derived from business, education or government (Clague, 1999). The concept used in this study in introducing change is the concept of business process re-engineering (BPR) or process innovation (PI).

Hammer (1990:104) initially introduced his concept of re-engineering in business as 'to use the power of modern information technology to radically redesign our business processes in order to achieve dramatic improvements in their performance'. Davenport (1993) gave a more formal description with regard to process innovation. The term 'process innovation' encompasses the 'envisioning of new work strategies, the actual process design activity, and the implementation of the change in all its complex technological, human and organizational dimensions' (1993:2).

In later work, Davenport (1995a; 2003) warns against the misuse of the 'concept' of re-engineering, but for the purposes of this study, I agree with his view that there is enough proof that re-engineering can be implemented successfully if the development team considers the risks accompanying the notion.

In the business application domain, Hammer (1990) and Davenport (1990) both published work on the use of process re-engineering methods (more information on the methodologies is given in section 2.4). Some sources refer to Hammer as the 'father of re-engineering' (Heterick, 1995) while others give the credit to Davenport (Avison & Fitzgerald, 2003). Many methods and procedures have been developed in different application domains using the concept of process re-engineering. For example, Tait (1999) suggested nine steps to rethink the business processes in higher education and Bruno *et al.* (1998) introduced some steps relating to both on processes and change management (Bruno *et al.*, 1998). At the intersection of these methods is the process to be engineered.

In the early 1990s there was a move away from managing organizations from a hierarchical structure towards a more process-oriented approach (Ernst, Katz & Sack, 1994). This move towards a more process-oriented approach complements the process re-engineering approach introduced by Davenport (1990) and Hammer (1990) with the process as the focus.

In all the approaches to process re-engineering the procedures state that it is necessary to identify the problem process and re-engineer it. The methods do not give many guidelines on the identification of the processes, which, as many developers will confirm, is not an easy task (Nikols, 2003). It is assumed that the developers are familiar with the use of process modelling techniques used in environments such as software development for modelling the process flow (Denn, 1987; Scheer, 1999; Borja, Harding & Toh, 2000).

Re-engineering in the educational environment includes the use of process models, which are used both to identify the key activities and to visualize the flow between activities (Denn, 1987). Every HEI involved in re-engineering activities using a re-engineering methodology is inevitably involved in the identification of the process models for the institution to use in process re-engineering. This encompasses the identification of the process models through an in-depth analysis of the HEI, the flows and the way in which the institution works (Bruno *et al.*, 1998). The procedure of data-gathering for modelling can be very expensive in terms of human resources and the time needed to conduct the activity, as with any data-gathering initiative in modelling existing activities (Sommerville, 2000; Whitten, Bentley & Dittman, 2000).

In the business application domain, researchers at the MIT Sloan School of Management realized the importance of not only managing data in the company, but also managing the processes involved in the business (Phios, 1999). They developed a system through which the organization can share on process knowledge through a process handbook or process repository. They base their approach on the concept of reusability where previous maps of processes are reused to build new process maps. This is based on the notion that there are processes that are reusable.

The idea of reusability is supported in a number of systems, including the well-known object-oriented paradigm in programming, where objects are reused in different programs. The advantages of reusability in software environments are as follows (Sommerville, 2000):

- Increased reliability where components are exercised in a working system.
- Reduced process risk, due to less uncertainty in development costs.
- Effective use of specialists where we reuse the components instead of people.
- Standards compliance in reusable components.
- Accelerated development.

According to Malone *et al.*(2003), the use of the reusable processes in the Process Handbook enables the user to:

- Redesign existing business processes.
- Invent new processes.
- Organize and share knowledge about organization practices.
- Automatically generate software to support or analyze business processes.

In order to commercialize the results of their research, MIT has licensed the intellectual property from this project to Phios, a company which manages the software, repository contents and the patents covering the basic approach to process representation (Phios, 1999). Some businesses are already using software available for accessing the Process Handbook, including SAP, MIT and SMI (www.phios.com). The advantage of the software is that it has a repository of process models available that the businesses can use or expand on.

The biggest advantage of the repository is the reusability of the process models. In re-engineering tasks in the HEI, a process repository of this magnitude can assist in the process re-engineering activities if there is a set of generic processes that represent the structure of the HEI institution. Prupis (1992) emphasized the need for such a structure in an article on the reorganization of higher education through information technology in which she stressed that the following should be explored, the:

- Identification of the organizational structures that support computing on college campuses.
- Organizational structure of the academic and administrative units.
- Changes in university structures as a result of the introduction of computing into university life.

Prupis (1992) supports the argument that HEI structures are important and if we know what the structures are, this will simplify the reorganization of the institution that is subject to change. For the purposes of this study I want to emphasize this need identified by Prupis and claim that if we know what the generic structures are, we can use them not only for re-engineering in one institution, but also in others. This is the motivation for the first research question that focuses on the educational process model structure of the higher education institution and is stated as follows:

What is the process model structure of the higher education institution?

The purpose of this research question is to investigate the structure of a higher education institution and to comment on the generic nature thereof. Firstly the focus is on the nature of the structure at the highest level and then attention is paid to sub-levels. If the identification of processes in one institution is rated as a difficult task (Nikols, 2003), doing it for more than one institution is certainly more complex. It is therefore necessary to follow a structured methodology for data-gathering. An issue in this research is the identification and use of a procedure to derive the structure.

The second research question arises from the rationale behind this study and the deliverable of the first research question. If I know what the structure of an HEI is, how do I know that it is useful? And more specifically, how do I verify the proposition that the structure derived in the first research question can be used in re-engineering initiatives? This brings up the second research question, which is stated as follows:

To what extent is the generic process model structure useful in a re-engineering effort?

The purpose of this research question is to investigate the usefulness of the generic process model structures derived from the first research question. In order to comment on the usefulness of these structures it is necessary to use them in a process re-engineering exercise and comment on their usefulness using a predefined set of indicators. One has to consider the available procedures for process re-engineering and investigate the feasibility of using the procedure in the HEI application domain.

If there is proof that there are generic process model representations in the HE application domain and it is known that these structures are useful in activities such as process re-engineering, it is possible to deduce that this will not only be useful for sharing knowledge on process structures within one institution but could be used by more than one institution in process re-engineering through a process repository for HE. This leads us to the third issue: if we know what the process model structure is and that it is useful in process re-engineering, how can it be preserved and stored for future re-engineering? The third research question addressed in this study, is as follows:

How can the educational process model be preserved and reused?

The purpose of this research question is to investigate the feasibility of using process repositories for the preservation of process model structures. This includes an investigation into the representation of the process model structure and the physical storage thereof. The rationale is to reuse the process models in such a way that they not only represent knowledge within an organization but can be extended for use by other organizations. The three research questions and the issues related to each are summarized in Table 2.1.

Table 2.1: Issues addressed for each research question

	Research Questions		
Question	Research Question 1	Research Question 2	Research Question 3
	What is the process model structure of the higher education institution?	To what extent is the generic process model structure useful in a re-engineering effort?	How can the educational process model be preserved and reused?
Issues	- What is a process? - What is process modelling? - What is process notation? - How can one identify the HEI process model structure? - When is the process model structure generic? - What tools are available to support the process modelling task?	- What is re-engineering? - What is business process re-engineering (BPR)? - What is HEI process re-engineering? - What methodologies are available in the business environment? - What methodologies are available in the HEI application domain?	- What is reusability? - What is the role of classification systems in process reservation? - What are the components of the MIT process repository representation? - How does one preserve the data in a process repository?

For the literature review related to the three questions, an initial literature review that led to the formulation of the research questions discussed was performed. There was ongoing investigation of related topics in the literature after the research questions were formulated. The literature research was conducted using trusted resources. These include paper-based journals, conference proceedings, books, databases through digital library access (e.g. ACM, IEEE and Academic Source Premier) and reliable electronic resources. About 70 different journals and over 400 references that included work by nearly 460 different authors were used in this study.

The first research question, which refers to the identification of the process model structure of the HEI, focuses on the process model structure. In section 2.3 the relevant concepts in the process model structure are discussed, including what a process is, what process modelling is, what process notation is, how one identifies the process model structure, how one identifies the generic process model structure and what process modelling tools support the identification of the process model structure. The issues related to the second research question are discussed in more detail in section 2.4, with the issues related to the third research question addressed in section 2.5.

2.3 PROCESS MODEL STRUCTURE

A process model structure consists of processes and the flow between the processes diagrammatically depicted on a process model diagram. The procedure of constructing the process model using a standard notation is called ‘process modelling’. Curtis *et al.* (1992) identified four different perspectives to view process models. These perspectives are functional, behavioural, organizational and informational (section 1.6). This study is viewed from a functional perspective where the process is discussed in terms of its activities and the flows between the activities (Curtis *et al.*, 1992).The concepts related to process modelling are discussed in more detail in the remainder of this section.

2.3.1 What is a process?

Processes can be viewed from more than one perspective (Curtis *et al.*, 1992; Luo & Tung, 1999). The choice of perspective depends on the goal of the system or the environment in which the system is built. In the early 1970s as part of the software development life cycle, authors started to use process modelling to depict the concept of processes and the flow between them graphically. A process (sometimes also called a ‘task’) is defined as a set of partially ordered steps intended to reach a goal (Curtis *et al.*, 1992). In the context of this study the following are also definitions used by different authors for a process:

- Davenport (1993:5) defines a process as ‘simply a structured, measured set of activities designed to produce a specified output for a particular customer or market’. The most important difference between the process and the product is that the process focuses on ‘how’ to do work in contrast to the product, which focuses on ‘what’ to do (Davenport, 1993).
- Hammer and Champy (1993) define the process as ‘… a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer’.
- Harrington (1991) defines a process as ‘any activity or group of activities that takes an input, adds value to it, and provides an output to an internal or external customer’.

Although some authors in the business application domain claim that the concept of a process has evolved from the business domain, this is not true (Osborn, 1996; Snowdown, 2002). The concept of a business process evolved in the 1990s whereas the first conference on software processes took place in 1984 in Egham, Surrey in the United Kingdom.

There are a number of significant elements that are used to depict a particular process, and different process modelling methodologies suggest different significant elements, depending on the specific application domain. Wang (1999) describes different elements for a process model, including an activity, a task, input/output, roles and a user.

Eriksson and Penker (2000) provide a higher abstract of these elements to include the process itself, process resources and the goal description of the process. Process resources can either be *input* or *output* resources. An *input resource* is used to assist in the flow of process activities. For example, in a student registration process, the registration form (input) is used (initially) to capture the student information. An *output resource* is the resulting output of the activities in a specific process, and in turn might potentially serve as an input resource to another process. Each process has at least one input resource and one output resource associated with it.

2.3.2 Process modelling

Wilson (1990) defines a model as 'the explicit interpretation of one's understanding of a situation, or merely of one's ideas about that situation. It can be expressed in mathematics, symbols or words, but is essentially a description of entities, processes or attributes and the relationships between them'. Curtis *et al.* (1992) define a model as an abstract representation of reality that excludes much of the world's infinite detail. Models are used in different application domains. For example, an enterprise model describes the objectives pursued by an enterprise (Rolstadas & Andersen, 2000).

A *process model* is a *structure* that represents a group of processes and their relationship to one another, which together accomplish a specific goal. A *high-level process model,* is a process model that includes all the *primary processes* and their relation to one another, to accomplish the high-level objectives of the environment modelled (Van der Merwe *et al.*, 2004b). Process modelling is made unique within one area by the conceptual boundaries set by the area (Curtis *et al.*, 1992). In a process model more than one process is linked with one another through inputs and outputs, using a standard process notation (process notation is discussed in more detail in 2.3.3).

In software development, a software process model focuses on the issues involved in the creation and evolution of software (Curtis *et al.*, 1992). Kawalek and Kueng (1997:1) investigated the usefulness of process models in modern organizations where they found that 'process models are still best understood and most successfully used in traditional analysis and design'. They also claim that the process model is a prerequisite for the implementation of a new process or for the re-engineering of existing environments. In business environments the business process model is used to capture existing processes by using a structured approach to represent the activities and the related elements and to represent new processes in order to evaluate their performances (Lin, Yang & Pai, 2002).

Building a process model structure has several advantages. According to Cummins (1992) it allows all participants to look at the structure from another angle and see it globally. It acts as a blueprint in the communication between different stakeholders, who can see what their own role is in the chain of events. The participants can also view the picture neutrally without considering politics and personalities. For a process modelling initiative to be successful it should include user training, project championship and structured communication between the analyst team and the users (Sedera, Rosemann & Gable, 2001). The downside of using process models is that if the model does not reasonably represent the real-life situation, the re-engineering effort may not be successful.

According to Curtis *et al.* (1992), process models can be used to obtain high-level prescriptive processes representative of the institution and are also capable of producing precise, unambiguous and comprehensive descriptions of the relevant processes. The process models used in this study refer to the process models that describe the structure of the organization at the highest level and, on lower levels, the activities involved in performing the processes on a higher level.

2.3.3 Process notation

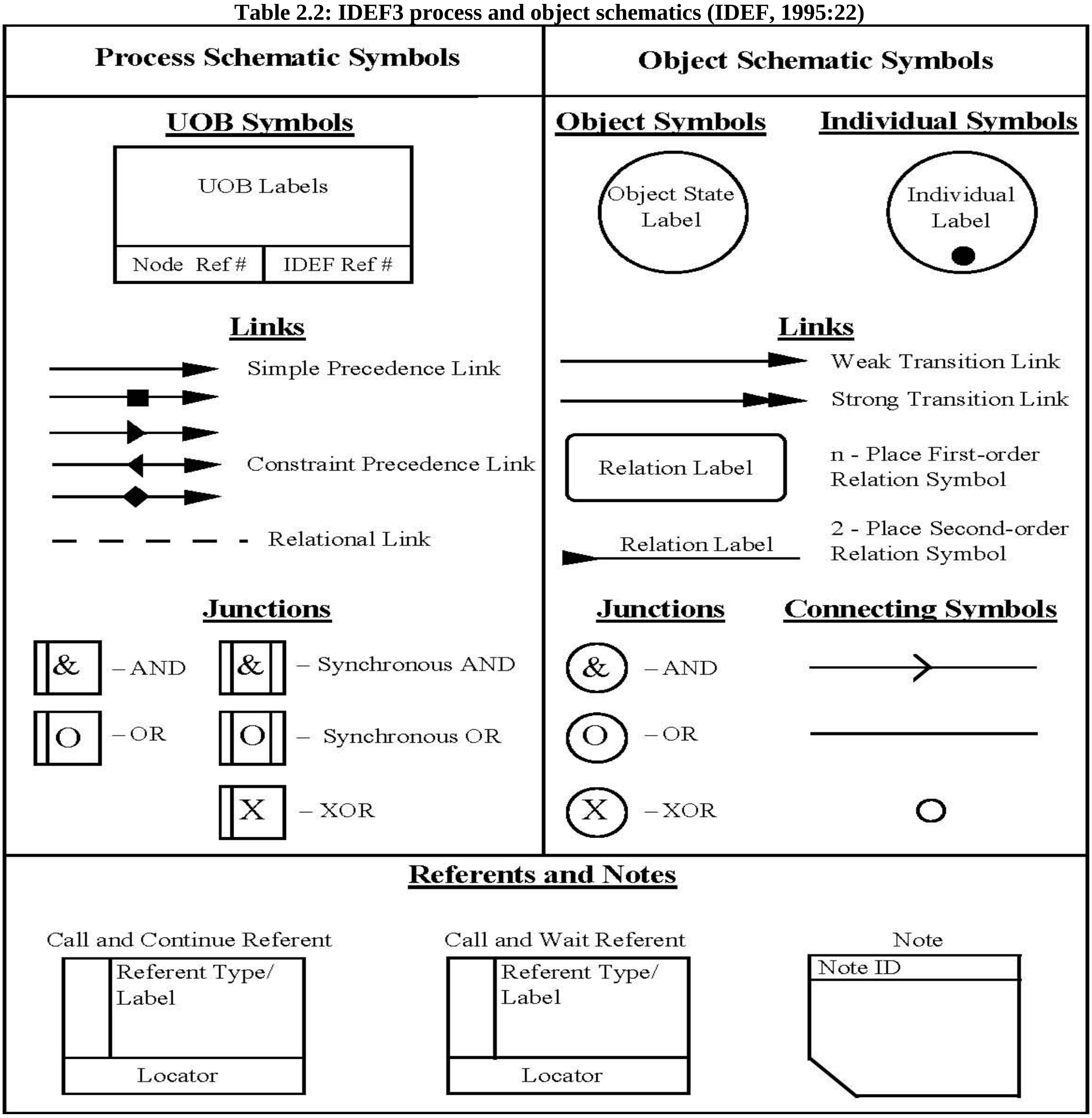
A process model has a notation that includes the symbols used in the models and the rules that govern the use of the symbols (Eriksson & Penker, 2000). A notation also dictates how the symbols should look and how they may be combined.

The two major modelling notations used in the 1990s include Integrated Computer-aided Manufacturing Definition (IDEF) and the UML, which came from the object-oriented software design paradigm (Moore, 2004). Business Process Modelling Notation (BPMN) was released in May 2004 as a process modelling notation and is seen by some as the next standard graphical notation for expressing business processes in a business process diagram (White, 2004).

The notation used for the three approaches differs markedly. For example, in the IDEF3 (1995) approach, which specifically focussed on the process modelling within the set of IDEF (2004) family of methods, different symbols are used for the use of Process Schematic Symbols and Object Schematic Symbols (listed in Table 2.2).

A process in IDEF distinguishes between an activity performed by people, an activity performed by a computer system and a process within the scope of the improvement project (or subprocess) (IDEF, 2004).

Table 2.2: IDEF3 process and object schematics (IDEF, 1995:22)



In contrast with the IDEF3 notation, the BPMN notation uses only three elements as the core of the notation, including an event, activity and gateway (White, 2004), as illustrated in Table 2.3.

In UML, a business process is defined as a stereotyped activity with a process, input, output, goal and resources associated with the process (Eriksson & Penker, 2000), as illustrated in Table 2.4.

Table 2.3: Core business process diagram objects for BPMN (White, 2004:2)

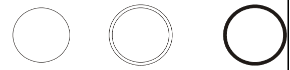
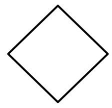
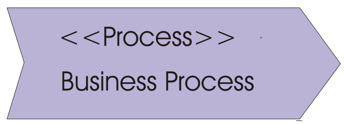
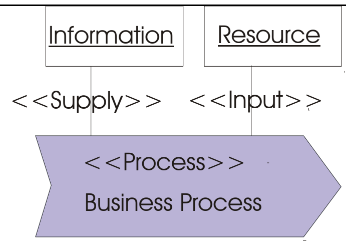
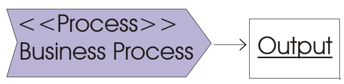
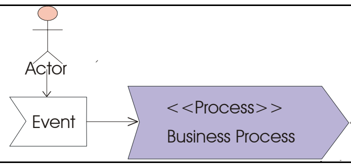
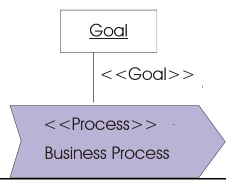
Object	Description	Element
Event	An event is represented by a circle and is something that 'happens' during the course of a business process. These Events affect the flow of the process and usually have a cause (trigger) or an impact (result). Events are circles with open centres to allow internal markers to differentiate between different triggers or results. There are three types of Events, based on when they affect the flow: *Start*, *Intermediate* and *End* (see the figures to the right, respectively).	
Activity	An activity is represented by a rounded-corner rectangle (see the figure to the right) and is a generic term for work that a company performs. An Activity can be atomic or non-atomic (compound). The types of Activities are: *Task* and *Subprocess*. The Subprocess is distinguished by a small plus sign in the bottom centre of the shape.	
Gateway	A gateway is represented by the familiar diamond shape (see the figure to the right) and is used to control the divergence and convergence of Sequence Flow. Thus, it will determine traditional decisions, as well as the forking, merging and joining of paths. Internal Markers will indicate the type of behaviour control.	

Table 2.4: UML stereotype process model (Sparks, 2000)

Object	Description	Element
Process/ Activities	'A business process is a collection of activities designed to produce a specific output for a particular customer or market. It implies a strong emphasis on how the work is done within an organization, in contrast to a product's focus on what is done. A process is thus a specific ordering of work activities across time and place, with a beginning, an end, and clearly defined inputs and outputs: a structure for action' (Sparks, 2000:4).	
Inputs/ Information	'Business processes use information to tailor or complete their activities. Information, unlike resources, is not consumed in the process - rather it is used as part of the transformation process. In formation may come from external sources, from customers, from internal organisational units and may even be the product of other processes. A resource is an input to a business process, and, unlike information, is typically consumed during the processing' (Sparks, 2000:4).	
Output	'A business process will typically produce one or more outputs of value to the business, either for internal use or to satisfy external requirements. An output may be a physical object (such as a report or invoice), a transformation of raw resources into a new arrangement (a daily schedule or roster) or an overall business result such as completing a customer order. An output of one business process may feed into another process, either as a requested item or a trigger to initiate new activities' (Sparks, 2000:5).	
Events	'An event is the receipt of some object, a time or date reached, a notification or some other trigger that initiates the business process. The event may be consumed and transformed (for example a customer order) or simply act as a catalyst (e.g. nightly batch job)' (Sparks,2000:5).	
Goals	'A business process has some well defined goal. This is the reason the organization does this work and should be defined in terms of the benefits this process has for the organization as a whole and in satisfying the business needs' (Sparks,2000:6).	

Any one of these modelling notations should be sufficient to model the flow of events in a process model. I selected the UML process model notation because UML is a standard modelling notation that supports the object-oriented paradigm (OMG, 1997) and for this research I am investigating reusability of concepts which is supported by the object paradigm. It is therefore appropriate to use a notation that supports the same concepts. The results of the research, however, are not dependant on the notation. Any one of the three notations would have been appropriate.

In grouping the elements together from the UML notation specified for business processes (as in Table 2.4), it is possible to build a coherent picture of the business process, as illustrated in Figure 2.1.

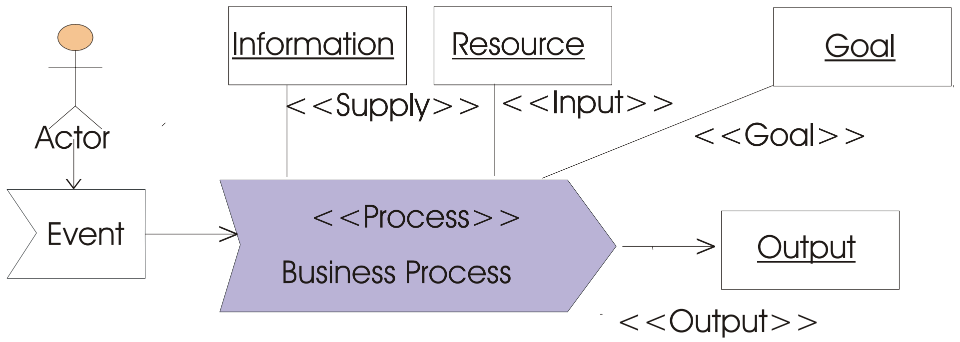


Figure 2.1 : Coherent business process model

The process is usually in the middle of the diagram with the inputs on the left-hand (or at the bottom or top of the process) with an arrow showing towards the process. The goal and output is on the right-hand side with arrows showing from the process towards the goal and the output.

A process model may consist of more than one activity to achieve a desired result. For example, a product is first built and then delivered to the customer according to an order. There are two activities or processes involved in the selling of the product. Putting the two processes together in one diagram and linking them through a resource that acts as an output for one process and input to the other, results in a process model as illustrated in Figure 2.2.

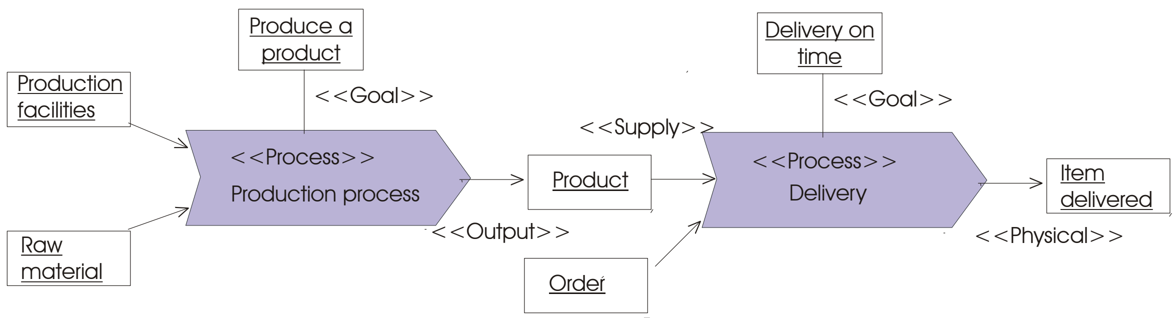


Figure 2.2: Production and delivery of an item

In this example the product is first produced using raw material and the production facilities as input. The product is the output for the production process as well as the input for the delivery process, together with the order. The output for the delivery process is the physical item that is delivered.

2.3.4 Identification of the process model structure

To identify the processes and flow between process models is not an easy task. As mentioned previously in section 2.3.2, the process model structure can be used in different application domains, for example during software development (Sommerville, 2000; Whitten *et al.*, 2000; Pressman, 2005) or in re-engineering where the goal is to enhance a single process or a number of processes (Davenport, 1993; Hammer & Champy, 1994). In these application domains different methodologies or procedures have evolved to assist in the procedure of software development or re-engineering.

The focus of this section is on the identification of the process model structure. The identification of the process model structure is usually a single step in the procedures for software development or re-engineering. How the process model structure is used in activities such as re-engineering is discussed in more detail in section 2.4.

There are two steps in the identification of the process model structure, the process model components elicitation and the construction of the process model structure.

2.3.4.1 Process model components identification

The identification of the components in an application domain forms part of the requirements elicitation process. A requirement is a function that is necessary so that a system can work to satisfy an organization's objectives (Christel & Kang, 1992). A set of processes that fullfill a function within the institution is also a requirement and requirements elicitation procedures can be used to identify the processes within the institution. Requirements elicitation includes the use of different techniques to gather data. Table 2.5 gives a summary based on the text from Kotonya and Sommerville (1998) and Suzanne and James Robertson (1999) on some of the techniques used in requirements elicitation to find the data that one is looking for.

Table 2.5: Data-gathering techniques used in requirements elicitation

Technique	Description
Interviews	The most commonly used technique is interviews where the analyst discusses the system with different stakeholders.
Scenarios	Scenarios are used where the system stakeholders are shown real-life situations which are easier to relate to than abstract representations.
Soft systems	In understanding the problem, soft systems are used where there is uncertainty about the kind of system to implement. It is concerned with human-related issues such as people, procedures and policies.
Observation / apprenticing	Lastly, observation is used where the analyst observes how people are carrying out work and this is then used in defining the processes.
Business event workshop	The business event workshop is a social interaction between the user and the analyst where the user describes his work in relation to a specific event.
Brainstorming	During a brainstorming session, a group of people together form ideas on the problems and solutions related to a specific scenario.
Electronic requirements	Mail, discussion forums and documents available on the web are useful to the analyst in discovering information on a topic related to his data-gathering.

The Volere Process model is one example of a process for gathering and testing requirements (Robertson & Roberson, 1999). It includes the following activities:

1. Project blastoff.
2. Trawl for knowledge.
3. Write the requirements.
4. Quality gateway.
5. Prototype the requirements.
6. Do requirements post mortem.
7. Take stock of the specification.
8. Domain analysis.
9. Reusing requirements.

2.3.4.2 Construction of the process model structure

After the identification of the elements involved in the process model structure, the analyst proceeds with the construction of the process model.

The process of elicitation and structuring the process models is usually guided by a requirements method. Requirements methods are systematic ways of producing system models such as process models (Kotonya & Sommerville, 1998).

Depending on the type of process model structure, there are different procedures available. The strategy for event-driven process modelling as described by Whitten *et al.* (2000:333) includes the following activities:

- Construct the context data flow diagram.
- Draw the functional decomposition diagram to partition the system into logical subsystems and/or functions.
- An event-response is compiled to identify and confirm business events.
- Add an event handler to each event or construct the event diagram for each event.
- Construct one or more than one system diagram to show the bigger picture.
- Construct primitive diagrams for those events that need more processing details.

For the construction of the UML process model, Eriksson & Penker (1998) mention the considerations as illustrated in Table 2.6, when specifiying the business processes with reference to the diagrams used in UML:

Table 2.6: Identification and specification of the business process

Consideration	How addressed?
Which activities are required?	Processes
When are the activities performed, and in what order?	Control flow
Why are the activities performed; what is the goal of the process?	Goal object
How are the activities performed?	Break down into subprocesses
Who or what is involved in performing the activities?	Resources
What is being consumed or produced?	Resources
How must the activities be performed?	Control flow
Who controls the process?	Owner
How is the process related to the organization of the business?	Swimlanes
How does the process relate to other processes?	Interaction modelling

The only procedure that I could find in the higher education domain on identification of process model structures is the work done by Bruno *et al.*(1998). The procedure is discussed in more detail in section 2.4. In the procedure suggested by the team for re-engineering the HEI, Step 1 relates to the identification of the process model structure. A process map is suggested by the authors with no indication of how the map was derived.

This indicates a gap in the theory where procedures are described on the construction of business process models and software models, but not on process models in the HEI. In answering the first research question: *What is the educational process model structures of the higher education* *institution?* it will therefore be necessary to either adapt one of the existing process identification procedures or construct a new procedure.

However, the question does not only concern the process model structure of a single institution. The focus is on the generic process model structure for the HEI. It is therefore also necessary to ask how it will be possible to identify the process structure that is generic.

2.3.5 Establishing a generic process model structure

According to Mauer & Holz (1999), a generic process model is a reusable description of the workflow of software development processes. Our interest is in the generic nature of process model structures in the HEI application domain. According to the Merriam-Webster Dictionary (2005), something is generic when it is 'general, applicable to any member of a group or class'(Merriam-Webster, 2005). To determine the generality of something, one needs to test whether it applies to a number of cases. The number of cases depends on the type of research that one is involved in.

In object-oriented programming it is easy to determine the generic object for a function because the output is easily measurable. For instance, the 'save' option in any program is suppose to save a file to the path supplied. Most applications use a save option, including word processors, databases, spreadsheets, etc. One can say that the save option is generic to applications on the computer. In contrast, a function such as 'draw line' may be generic only in certain programs, for instance drawing packages. A medical application storing data on patients is unlikely to have a draw line function. It is therefore only possible to comment on the generic nature of the draw line function within drawing packages.

But how does one determine whether or not a structure is generic? Unfortunately there are no guidelines for determining this, except to comment on the repeating nature thereof. Porter's (1985) value chain concept is probably the best known generic diagram used in business models. Every business consists of a set of activities that work together to design, produce, market, deliver and support its product. All these activities can be represented by using a value chain. The 'value' is the amount buyers are willing to pay for what a firm provides. In the value chain model proposed, the purpose was to display the total value by defining the value activities and their margins (illustrated in Figure 2.3).

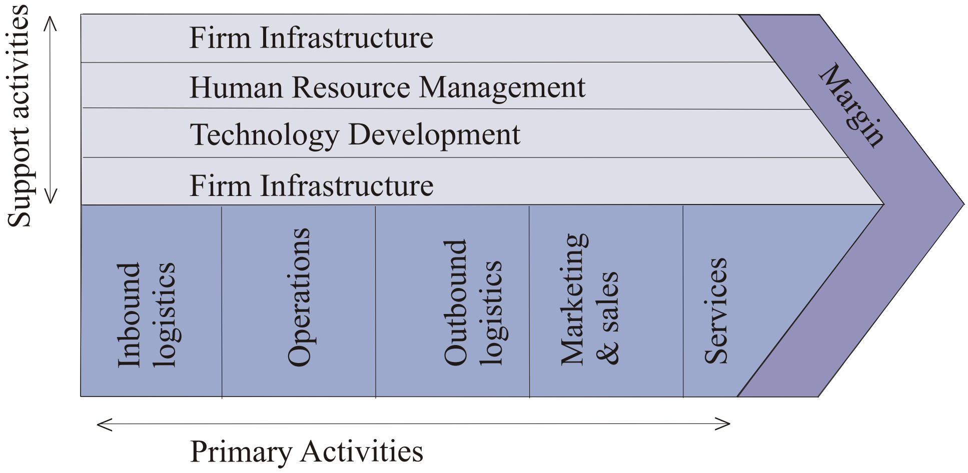


Figure 2.3: The generic value chain (Porter, 1985)

The model consists of nine activities, which are sub-divided into five primary activities and four sub-activities. The primary activities are inbound logistics, operations, outbound logistics, marketing and sales, and services. A short description of each follows (Porter, 1985)**:**

- *Inbound logistics* include activities associated with the receiving, storing and disassembly of the product, e.g. material handling, warehousing, inventory control, etc.
- *Operations* are the activities involved in the transformation of the product from the input product to the finished product, e.g. machining, testing, packaging, equipment maintenance, etc.
- *Outbound logistics* are the activities involved in the storage of the product and the distribution to the customer, e.g. warehousing, delivery vehicle operations, order processing, etc.
- *Marketing and sales* are the activities involved in introducing the ‘value’ to the buyer, e.g. advertising, sales force operations, etc.
- *Service* is the activities which enhance or maintain the value such as installation, repair and parts supply etc.

The secondary activities include procurement, technology equipment, human resource management and firm infrastructure. A short summary of each follows (Porter, 1985):

- *Procurement* refers to the function of purchasing, not the raw material, e.g. temporary office staff, hotel and travel expenses, office equipment, etc.
- *Technology equipment* includes engineering and process development, e.g. office automation, telecommunication, etc.
- *Human resource management* includes the recruitment, hiring, training, development and compensation of personnel.

- *Firm infrastructure* includes general management activities, finance, accounting, quality management, etc.

Although Porter (1985) gives a description of all the elements in his value chain and a discussion on the rationale, there is no procedure given on how he determined the generic nature of the structure. The generic nature of the structures in this case comes from the worldwide acceptance and use of the model, and the fact that it corresponds to the activities in a business.

In scientific research, a hypothesis can be tested through experiments that are repeated in a controlled environment, from which deductions can be made. An experiment is defined as an operation carried out under controlled conditions in order to discover an unknown effect or law, to test or establish a hypothesis, or to illustrate a known law (Merriam-Webster, 2005). A casual relationship is based on observations such as the repetitive nature of the phenomena and is not necessarily measurable.

For process models, it is possible to derive the generic structure from the repeating nature of the processes. If a process repeats in a specific application domain, it is possible to deduce that it is generic for the domain (similar to the 'save' and 'draw line' commands mentioned above). Before any process structure can be deemed generic, it is necessary to determine the repeating nature of the process. For the first research question it is therefore necessary to investigate if the structure identified repeats at different institutions before it can be claimed to be generic. In section 2.5.2 an overview is given of the classification of systems related to the preservation of systems.

2.3.6 Process modelling tools

There are a number of tools available that can assist the analyst in the modelling of process model structures. The tools that the developer wants to use depend on the approach or technique that he is using and the financial resources that he has available. Examples of tools are given in Table 2.7. Some of the tools support more than one technique. For example, Popkins Systems Architect (Popkin, 2005) can be used for both Yourdan's technique (Whitten, 2000) and IDEF (2004). This is not an extensive list, but only gives some of the popular approaches and tools available. For more information on these and other tools, the Delft University of Technology website provides an extensive list that also provides links to the tools (http://is.twi.tudelft.nl/~hommes/toolsub.html#15).

Table 2.7: Techniques and tools available for process modelling (Delft University of Technology, 2005)

Technique	Tool	Technique	Tool
IDEF	4Keeps, AI0 WIN , BPWin , Business Object Modelling Workbench, CORE, Design IDEF, Design Leverage IDEF Tools, Popkins Systems Architect, Pro CAP Pro SIM, Process Maker, SA/BPR Professional, Workflow Modeler	Yourdan (DFD)	4Keeps, BONAPART, GRADE Paradigm Plus, Popkins Systems Architect, Softwarethrough Pictures SE, With Class 98
UML tools	4Keeps, Class Designer , COOLJex, Innovator, Javision, j-vision, LOREx2 for Java, Magic Draw UML, Object Plant, Object engineering, Paradigm Plus, Pragmatica, Real-time Studio, Rhapsody, SDT, Soft Modeler Business, Softwarethrough Pictures UML, Together C, Together J, Visual UML, With Class 98	Object-oriented tools	BRWin A&D, Class Designer, ICONIXOOAamp D Power Tools, Kappa, Live Analyst, Mac Aamp D, Meta Edit, Object GEODE, Object Management Workbench, OMWtm, Object Modeler, Object Team, OODesigner, Paradigm Plus, Process Flo, Quick CRC, radical, Rhapsody SA/Object Architect, Select Enterprise, System Architect, The Electronic Workforce
Tools that support Booch	4Keeps, Class Designer, Paradigm Plus Softwarethrough Pictures Booch, With Class 98	Tools that support Rumbauch	4Keeps, Paradigm Plus, Select Enterprise
Tools that support meta-modelling	AWD and Workflow Analyzer, Meta Edit, Meta Edit Method Workbench, Meta Edit Personal Metaphase 2.0, Metaview FOLDERS, Power Designer, Process Maker, Softwarethrough Pictures Booch, Softwarethrough Pictures OMT, Work Flow	Tools that support flow chart	ABC Flow Charter 4.0, ABC Graphics Suite, ABT Project Workbench, AWD and Workflow Analyzer, Bench Marker Plus, BPM, Business Object Modelling Workbench, Cap Web-Flow, CLEAR, Suite, and more at http://is.twi.tudelft.nl/~hommes/toolsub.html#15

I selected UML as the notation for the process models in this thesis, which is supported by different tools. For example, Enterprise Architect supports the UML process stereotype as shown in Figure 2.4.

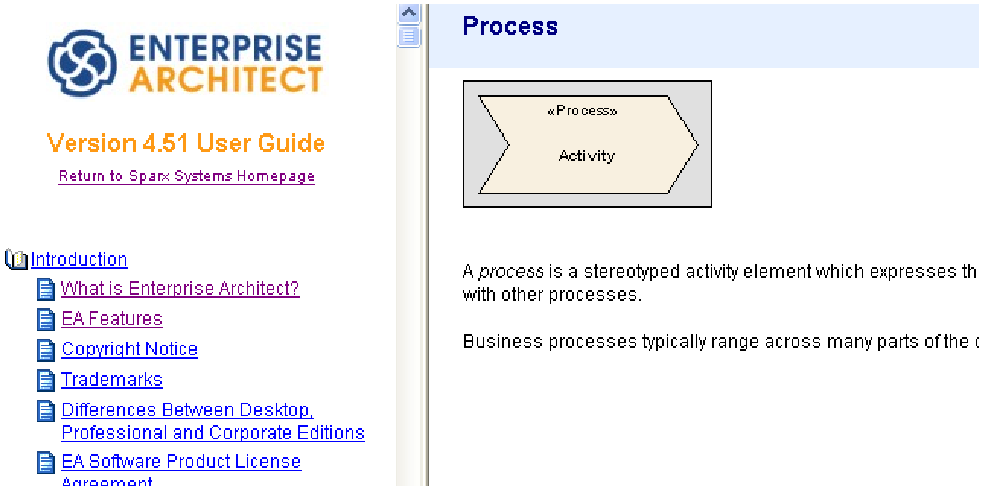


Figure 2.4: Enterprise Architect supports the UML process stereotype (Sparks, 2000)

2.3.7 Overview: process model structure

In section 2.2 the importance of the determination of generic process model structures was emphasized. To be able to investigate the educational process model structure of the HEI, it was necessary to investigate the concepts associated with the process model structure. The theory discussed in sections 2.3 gives an overview on the building blocks related to the building of process model structures, including what a process is, how process modelling is used and the notation used in process modelling.

Prupis (1992) mentioned the importance of the identification of structures that can be reused in the HEI application domain. In section 2.3.5 the concept of generic structures is addressed that relates to reusability. The problem is that although the theory provides us with the concepts on what a process is, how to model processes etc., there is a lack in procedures to identify the generic process model structures, which is the force behind the first research question. The identification of process model structures within the HEI application domain is discussed in more detail in Chapter 4.

2.4 PROCESS RE-ENGINEERING

The second research question focuses on the role of the process model structure during process innovation or re-engineering. In this section, the current status of process re-engineering in BPR and in the HEI are discussed (section 2.4.1), after which the different methodologies in BPR and in the HEI (section 2.4.2) are examined. Lastly, some remarks are made on the use of the theory of constraints in re-engineering (section 2.4.3).

2.4.1 What is re-engineering?

Re-engineering is the ‘fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed’ (CRF, 2005). In this section re-engineering is discussed first from a business perspective and then the focus is on re-engineering in HEI.

2.4.1.1 Business process re-engineering

Business process re-engineering is also known as business process redesign, process re-engineering, business transformation, or process change management. For the purpose of this thesis, the term that will be used is ‘business process re-engineering’ except when directly quoting other authors.

There is much controversy on who was really the father of the concept of business re-engineering, Davenport or Hammer. Both wrote their first articles on the concept in 1990 and both released a book in 1993. Davenport (1995a) claims that his book on process re-engineering had already been released in November 1992, whereas Hammer released his book on the re-engineering of the corporation in April 1993.

Davenport (1990:11) defined business process redesign in the Summer Edition of Sloan Management Review as 'the analysis and design of work flows and processes within and between organizations'. A few weeks later, Hammer (1990) wrote an article in the Harvard Business Review in which he maintains that it is necessary to drastically redesign or re-engineer the processes within the business in order to make dramatic improvements to the performance of the processes. In 1994 Hammer and Champy (1994:32) formalized this definition as 'the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed'.

The two approaches are both related to the redesign, with Hammer much more focused on starting with a clean slate. Davenport was more cautious and prescribed a slower approach where the problem process is identified and re-engineered through innovation. Although there were many success stories in the early 1990s about companies using these concepts, there were also many tragedies. Some companies used re-engineering to sponsor expensive projects. It even became part of downsizing projects where it was used as the motivation for layoffs in companies (Davenport, 1995a). Davenport wrote a few articles on the criticism that the concept of re-engineering received from businesses after some projects failed (Davenport & Stoddard, 1994; Davenport, 1995a; Davenport, 1995b; Davenport *et al.*, 2003). In 1994 he emphasized that there are some myths associated with the use of re-engineering (Davenport & Stoddard, 1994). In this article he warned against the 'clean slate' approach recommended by Hammer & Chumpy (1993). The support for re-engineering weakened and in 1995 Davenport published an article 'The Fad that Forgot People' in which he acknowledged the failure of re-engineering as it was initially intended (Davenport, 1995a).

With the introduction of the Internet in the early 1990s and the need for companies to introduce technological changes over the last ten years, new interest was evinced in the concept of re-engineering of the organization. Re-engineering was not totally doomed. Papers written in the late 1990s mentioned successes but also emphasized the pitfalls of re-engineering. For example, Teng *et* *al.* (1998:1) did a survey on 100 BPR projects and established that the ‘most successful re-engineering projects direct attention to social design and process transformation rather than analyzing existing procedures’. They also discovered that information system (IS) and BPR professionals neglected the later stages of re-engineering and that a project is more likely to be successful if the key elements of the organization are considered in the re-engineering effort.

In 2002, Mohamed Ziri, Head of the European centre for TQM wrote an editorial in the Business Process Management Journal, with the title ‘Bring back BPR – all is forgiven’ (2001:1). In this paper he emphasizes that all those who are in favour of re-introducing the concept of re-engineering are those who learned that ‘it should not be fixed if it is not broken’. According to him, it is best to eliminate processes that are wasteful and do not contribute to the effective working of the business.

As mentioned, re-engineering never died; those who used it as a guideline in rethinking processes and implemented changes with caution had success stories. Many authors gave guidelines after success stories. The following are some of the guidelines that a business should consider in a re-engineering effort (Weicher *et al.*, 1995; Zairi, 2001; Davenport, 2004):

- BPR should be part of the company plan and be included in strategic planning.
- Consider appointing someone responsible for the re-engineering effort, since adding to the existing tasks of existing jobs will not work.
- The IT group should be an integral part of the re-engineering from the start even if BPR is a business-driven and not an IT-led concept.
- Provide for regular process performance measurement.
- Management should be involved from the beginning.
- The company should consider both the processes within the company and the business functions.
- BPR should have a clear project plan with due dates so that the project don’t go on ‘forever’.
- Be careful of a clean slate approach where everything previously done is scratched and a totally new system is introduced. Consider what worked and include those concepts in the new process.
- The approach adopted during BPR should fit the company profile.
- BPR denotes change – the company should be prepared to make structural and infrastructure changes.

The six critical success factors given by the Comptroller iCenter (2005) for re-engineering include:

- Understand re-engineering.
- Build a business and political case.
- Adopt a process management approach.
- Measure and track performance continuously.
- Practise change management and provide central support.
- Manage re-engineering projects for results.

As Davenport (2001) reports in an article in Darwin, ‘we still don't know how to use IT to improve business processes on a reliable basis’. Re-engineering is not a word to be taken lightly and it needs careful planning with consideration of what the current processes are and why we need to implement change. If IT is the driver, remember to focus on the information and not the technology, institute re-engineering carefully and responsibly, and buy for stability and reliability in purchasing new systems (Davenport, 2001).

Taking all this into account, planning is the most important issue. According to the Carnegie Mellon Software Engineering Institute, the most common reason why re-engineering projects fail, is the adoption of a flawed or incomplete re-engineering strategy (Bergey *et al.*, 1999).

2.4.1.2 HEI process re-engineering

It was inevitable that the re-engineering hype would also affect the HEI application domain in the early 1990s. Following Davenport’s (1990) and Hammer’s (1990) introduction of the concept in the business domain, HEIs also introduced the concept to implement changes. In an article written by Grassmuck (1990), she claimed that it is necessary to implement radical changes in the institutions and to create new paradigms and models, including:

- Improvement in research and teaching.
- Globalization of the current campus programmes.
- Restructuring of the academic and administrative services.

Penrod and Dolence (1991) wrote one of the first articles giving an overview of the re-engineering concepts introduced in 1990. He emphasized the need for strong leadership and strategy, the lack of which many other authors later identified as one of the reasons why re-engineering failed (Bergey *et* *al.*, 1999). Twigg (1992) emphasized the fact that the problems faced in an HEI can only be confronted and driven by a paradigm shift towards higher quality, which enables the institution to move towards the solutions that information technology offers.

Porter (1993) argued, in a viewpoint article in CAUSE/EFFECT, that business re-engineering has not yet been successfully applied in a higher education application domain and will moreover not be implemented soon. Olson (1993), at the time Deputy Vice-President of Student Administrative Services at Columbia University, wrote a commentary on Porter's article in which he disagree with his statement. He had already been involved in a successful re-engineering effort at the University of Columbia. He admits that a HEI is not like the corporate world and that the core education and research mission will not change fundamentally. But HEIs are faced with new challenges such as competition and rising costs, which demand new responses offered by BPR.

Although this happened more slowly than in the business domain, the introduction of the Internet also sparked new interest in BPR in the late 1990s, and several papers with best practices and considerations appeared. Grotevant (1998) discussed some myths applicable to re-engineering, including the fact that business process engineering is not a new concept or a passing fad. She also warns against the syndrome where IT is the driver of BPR and later, if the transformation fails, IT is blamed for the problems that could occur within the business. Furthermore, she emphasized that no transformation is possible without some changes in the organization.

There are a number of case studies at institutions reported on in the literature. For the interested reader, some significant studies are listed as follows:

- Allen and Fifield (1999) report on experiences at Midland University, Highland University, North Eastern University, Yorkshire University and North Western University. According to them the efforts do not really constitute re-engineering but rather process re-engineering with the focus on wider access to existing systems.
- Bruno *et al.* (1998) applied the process engineering procedure suggested at Glendale Community College and Oklahoma City Community College. They do not draw a conclusion on best practices and it appears that this was an ongoing project at the time when the article was written.
- After a re-engineering project at Mount Holyoke College, the participants claimed that there are cultural changes that distinguished the HEI from the business application domain (Carnevale *et al.*, 1999).

- Jaacks and Kurtz (1999) report on a re-engineering effort at Western Iowa Tech Community College and claim that it is necessary to streamline processes, eliminate duplication of efforts and examine outdated or inefficient ways of doing business in implementing new systems or undertaking major system upgrades.
- In 1996 Rice University undertook a major re-engineering effort when they not only replaced the student system with a new system, but also successfully updated the existing undergraduate admission financial aid, student registration, student accounts, and overall record management (Hochstettler *et al.*, 1999).

2.4.2 Re-engineering methodologies

There is a range of procedures available that a company may consider in process re-engineering. Although the focus of this study is on re-engineering in the HEI application domain, the roots of re-engineering lie in BPR. The focus is therefore first on re-engineering methodologies in the business environment in section 2.4.2.1 after which attention is paid to the re-engineering of HEI application domains in 2.4.2.2.

2.4.2.1 Re-engineering in the business environment

As mentioned previously, BPR originated from writings both by Davenport (1990, 1993) and Hammer (1990, 1993). A brief overview of both procedures is given.

2.4.2.1.1 Davenport's process re-engineering procedure

Davenport (1990:11) defines process redesign as 'the analysis and design of work flows and processes within and between organizations'. He suggested the following steps to be included in business process redesign (Davenport, 1993):

1. *Develop business vision and process objectives*: The strategic vision is very important. The company should clearly identify the reasons for the redesign of the processes. Objectives include cost reduction, time reduction, output quality and quality of work life.
2. *Identify processes to be redesigned*: The processes in the company need to be studied and a decision is necessary on what will be re-engineered. There are two approaches: either identify all the processes and then prioritize or identify only the processes that pose a problem.

3. *Understand and measure existing processes*: It is necessary to understand the reasons why a process is a problem so that the problem is not repeated. In this case, accurate measurement can serve as the beginning of future process improvements.
4. *Identify IT levers*: The role of IT should be considered early in the redesign stages to garner the most from the opportunities it presents.
5. *Design and build a prototype of the process*: Davenport suggests that the key factors to consider during the design and the prototype of the process are to use IT as a design tool, understand the generic design criteria and create organizational prototypes.

Something worth mentioning that relates to the first research question in this study, is that Davenport (1993) supports the identification of key processes at the highest level of an institution, during Step 2 of his procedure.

Key processes, or main processes, are the processes during which the developer focuses on the main 'things' that are happening within the institution. According to Davenport (1993) it is unlikely that the list of key processes will involve more than 20 processes.

An example of a key process within different companies is marketing. According to an example on key processes (Table 2.8) listed by Davenport (1993), marketing is a key process at IBM, Xerox and British Telecom. Marketing being a key process at all three companies supports Porter's (1985) value chain notion that marketing is a primary or key process within the business application domain.

Table 2.8: Key business processes of leading companies (Davenport, 1993:29)

IBM	Xerox	British Telecom
Market information capture	Customer engagement	Direct business
Market selection	Inventory management and logistics	Plan business
Requirements	Product design and engineering	Develop processes
Development of hardware	Product maintenance	Manage process operation
Development of software	Technology management	Provide personnel support
Development of services	Production and operations management	Market products and services
Production	Market management	Provide customer service
Customer fulfillment	Supplier management	Manage products and services
Customer relationship	Information management	Provide consultancy services
Service	Business management	Plan the network
Customer feedback	Human resource management	Operate the network
Marketing	Leased and capital asset management	Provide support services
Solution integration	Legal	Manage information resource
Financial analysis	Financial management	Manage finance
Plan integration	Human resources	Provide technical R&D
Accounting	IT infrastructures	

Once again, there are no guidelines on how to determine the key processes. Porter's (1985) framework is mentioned as a reference to primary processes. Davenport (1993) mentioned that one guideline is to use Harrington's approach, in which the executives jot down the different processes for which they are responsible and derive from these the key list of processes.

2.4.2.1.2 Hammer's process re-engineering steps

In contrast to Davenport (1990), Hammer's (1993) definition of re-engineering is much more aggressive. Hammer (1993:32) defines re-engineering as 'the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed'. Note that the focus is on four key words: fundamental, radical, dramatic and processes. Lam (1995) maintains that these four concepts are fundamental in motivating the company to think about what it is that they are doing and why are they doing it. 'Radical' refers to the way that change should be implemented, ignoring what has been done previously and reinvented. 'Dramatic' refers to the kind of change: changes should not be small but should influence the way the company does things. Lastly, the focus should be on the processes. What are the processes and how should they be re-engineered?

Hammer defines the steps involved in re-engineering a business as:

1. Name the processes and state your goal.
2. Map the process.
3. Choose the process to re-engineer.
4. Understand each process.
5. Re-engineer the process.

A number of other BPR methodologies evolved during the boom period of BPR, including those of Furey (1993), Harrison (1993), and Manganelli (1994). In 1999 Muthu *et al.* (1999) provided a cross-reference table with some of these methodologies. They identified a consolidated methodology from five methodologies previously presented, in which some of these procedures were merged, and defined a consolidated methodology with the following activities (Muthu, 1999):

1. *Prepare for re-engineering*: During this stage the focus is on preparing for the re-engineering activity. An important question to address is whether or not BPR is necessary.

2. *Map and analyze As-Is process*: During this step the re-engineering team should understand the current processes.
3. *Design To-Be process*: The re-engineering team should consider more than one alternative to the problem. Benchmarking (in which the organization compares itself to competitors who have already implemented the solution) is a technique recommended by the authors.
4. *Implement the re-engineered process*: This is the step during which the most resistance is experienced. The re-engineering team needs to identify a list of activities to complete and implement the changes.
5. *Improve processes continuously*: The processes should be monitored and if there is any concern created by the implementation, it should be addressed by the team immediately.

Although it may seem as if the procedures differ radically, it is not the case. Some of the activities are encapsulated in other activities. I used a comparison table (Table 2.9) to compare the activities in the different approaches. The number in the columns refers to the step number in the associated procedure.

Table 2.9:Activities within re-engineering

Step/Phase	Davenport (1990)	Hammer (1993)	Muthu (1999)
Develop business vision	1	1	1
Identify processes to be redesigned	2	1	
Map the process		2	2
Choose the process to re-engineer		3	3
Understand the current processes	3	4	
Identify IT levers	4		
Design and build a prototype of the new process	5		
Re-engineer the process		5	
Implement the re-engineered process			4
Improve process continuously			5

Hammer (1993) does not include an implementation phase and only Muthu *et al.* (1998) included a step on the measurement of the process re-engineering. From this comparison it is possible to deduce that according to these authors a re-engineering activity should at least include a phase on building a strategy, steps on the identification of the process to be re-engineered, an understanding of what is wrong with the current processes, steps that address what the solution is, and the re-engineering of the process.

2.4.2.2 HEI re-engineering methodologies

In this section, the focus moves from re-engineering practices in the business application domain to the HEI application domain. Although many institutions were involved in re-engineering efforts

(Carnevale *et al.*, 1999; Hochstettler *et al.*, 1999), few re-engineering methodologies were introduced specifically for the HEI application domain. Most of the case studies hinted at the use of either Hammer’s (1990) or Davenport’s (1990) approach. Hartman and Zahary (1991) gave ten guidelines for re-engineering in the HEI application domain after a new upgrade was done of the integrated student information system at the California State University. The guidelines included:

1. Identify the mission, goals, and outcome targets.
2. Walk through the process as it exists.
3. Rediscover and redefine the rules and regulations.
4. Consider alternative ways of doing the work.
5. Look at the process through the eyes of the client.
6. Discuss what has just been said and heard while it is still fresh.
7. Recast the mission and goals of the unit within the bigger picture.
8. Redesign the process within the context of the new mission and information technology.
9. Look for flaws by testing the redesigned process in more than one way.
10. Review the re-engineered process with the unit director for flaws.

Although it was not claimed that these steps constituted a formal procedure, they could easily map to the steps introduced by Davenport (1990). In the mid 1990s re-engineering efforts in HEI were limited due to the bad publicity received after the failure of some projects, as discussed in section 2.4.1.1. However, the technological wave introduced by the Internet soon also exerted more pressure on the HEI application domain to change, and like the BPR application domain, the HEI institutions also returned to re-engineering, but this time more cautiously and with due emphasis on the lessons learned from BPR and from projects at different institutions. Bruno *et al.* (1998) introduced the concept of Process Engineering in an article ‘Practical Process Engineering for Higher Education’. The procedure focused on process engineering, with five steps being defined:

1. The selection of the process to re-engineer.
2. The analysis of the current processes.
3. The design of the new processes.
4. Implementation.
5. Quality assessment.

The procedure also provides for change management mechanisms on each level. During the first step, the task is to design a change management plan. This is followed by an effort to understand the staff who will be involved in the change. In the third step it is the responsibility of management to assist in the incorporation of the changes into the existing flow of the institution while the fourth step focuses on the training involved to provide the staff with the necessary capabilities to perform effectively in the new environment. The approach is illustrated in Figure 2.5.

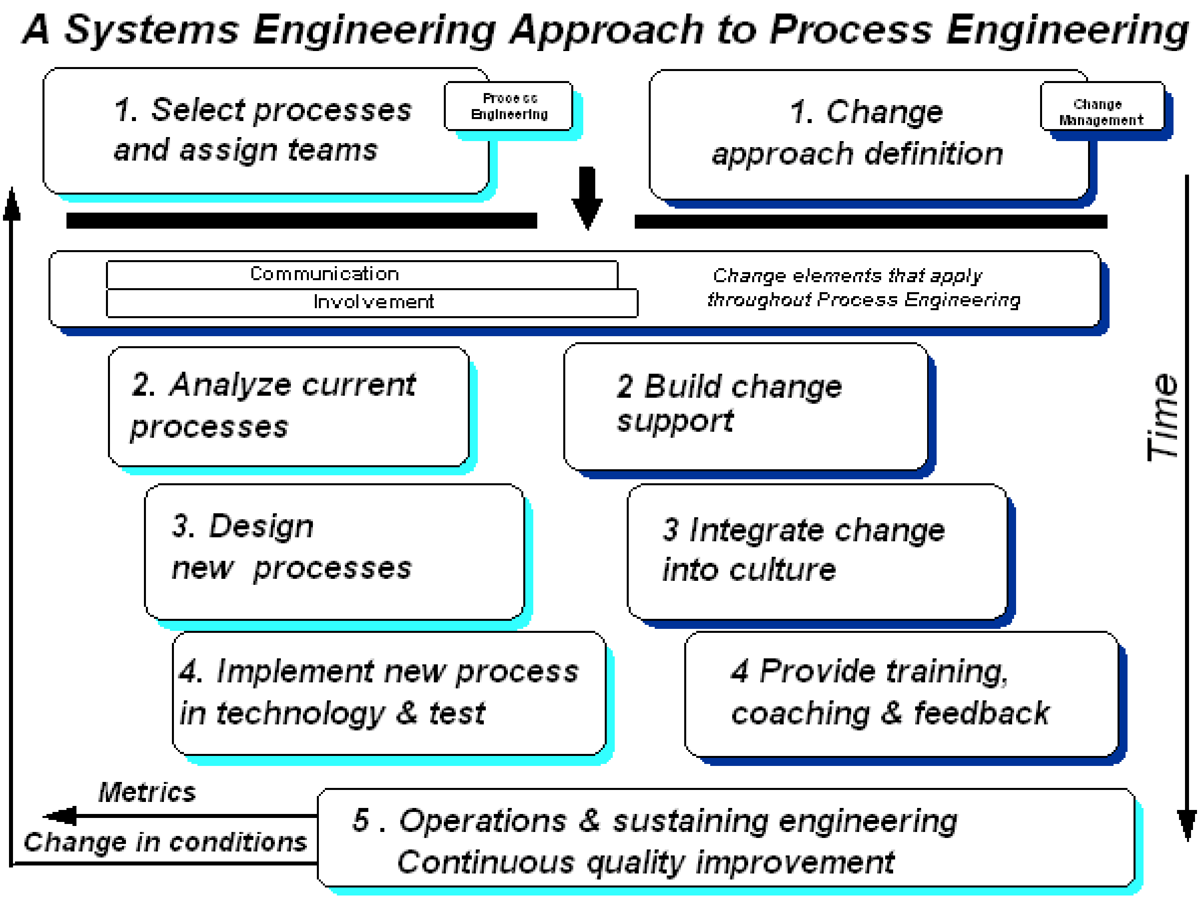


Figure 2.5: A process engineering approach in HEI (Bruno *et al.*, 1998)

In a study by Coopers & Lybrand in 1999, it was stated that half of the HEI income is spend on administrative tasks, which may not even add value to the organization (Tait, 1999). According to Tait (1999), for a re-engineering effort to be successful in HEI it should have management commitment, organization-wide ownership, an understanding of re-engineering and a recognition of the need for fundamental change. He elaborated on the five steps introduced by Bruno *et al.* (1998) and introduced nine steps in enterprise process engineering, including:

1. Identify strategic objectives.
2. Determine important metrics.

3. Implement a change-management programme.
4. Define processes.
5. Capture the current method.
6. Identify affected and involved parties.
7. Model business processes.
8. Apply best practices.
9. Review and refine outcomes.

Tait (1999) provides for change management in steps 3 and 6, while Bruno *et al.* (1998) include change management as a separate set of steps that is used simultaneously with the process re-engineering steps. Tait (1999) also includes the identification of metrics as an important step that is not included in the other procedures. Table 2.10 provides an integrated list of the steps/phases and indicates the inclusion of these in the three BPR and two HEI procedures discussed.

Table 2.10: Activities within BPR and HEI re-engineering

Step / Phase	BPR procedure			HEI procedure	
	Davenport (1990)	Hammer (1993)	Muthu (1999)	Bruno *et al.* (1998)	Tait (1999)
Develop business vision	1	1	1		1
Determine important metrics					2
Implement a change management plan				Separate	3
Identify processes to be redesigned	2	1			
Map the process		2	2		
Choose the process to re-engineer		3	3	1	4
Understand the current processes	3	4		2	5
Identify IT levers	4				
Identify affected and involved parties				Separate	6
Design and build a prototype of the new process	5			3	7
Re-engineer the process		5			
Implement the re-engineered process			4	4	8
Improve process continuously			5	5	9

From Table 2.10, it appears that human resource issues were included only in the HEI re-engineering procedures. This could be the result of widespread recognition of other failed re-engineering efforts and acknowledgement by developers of the reasons why the projects failed. Both the HEI procedures were defined after other re-engineering efforts failed and BPR received negative publicity in the mid-1990s (Davenport, 1995a; Bergey *et al.*, 1999). Some studies argued that academia are not ready for re-engineering and see it as a limitation of the academic freedom that allows them to do things as they seems fit. Allen and Fifield (1999) argue that change is smooth if it is done on the administrative side of the institution.

The five activities that are prominent in Table 2.10 for all the procedures include:

1. Definition of a goal statement.
2. Identification of processes.
3. Selection of process to be re-engineered.
4. Re-engineering activity.
5. Quality control.

The procedure should also make provision for some consideration of change management and quality control, e.g. the inclusion of metrics. Furthermore, re-engineering or process re-engineering is a complex task and should be supported by management; otherwise it is doomed to failure. There are a number of tools and techniques available to support the different steps in the re-engineering effort, such as METIS, DPA, Cosmo and Workflow Charter.

2.4.3 Theory of constraints

Re-engineering focuses on the process, and changes to the processes. A related field introduced by Goldratt 1992 is theory of constraints (TOC) (Goldratt & Cox, 1992). This section investigates the way that TOC can contribute towards the re-engineering of an environment.

2.4.3.1.1 Introduction to theory of constraints

Theory of constraints is a management philosophy introduced in 'The goal: A Process of Ongoing Improvement' (Goldratt & Cox, 1992). It is based on the notion that each organization has a goal and that everything works together to achieve that goal. TOC introduces the activities that work together as a chain of events where the chain is as weak as the weakest link. The purpose of TOC is to find the weakest link and to eliminate it. TOC was originally developed for the manufacturing environment and only later extended to the business environment. Goldratt and Cox (1992) proposed the five step process of on-going improvement as follows:

1. *Identify the constraint* where the analyst searches for the weakest link in the chain of events.
2. *Exploit* where the focus is on how to get more production with the existing capacity.
3. *Subordinate* include the channelling of the materials needed next from a non-constraint resource.
4. *Elevate* where other ways are investigated to increase the capacity if there is still a constraint.
5. Go back to step 1.

The TOC Center (2001) released an eleven-step TOC Performance Improvement Process for putting TOC into practice. The TOC Performance Improvement Process is built on 'the recognition that changing people's mindset and behaviour is the fundamental obstacle to any lasting improvement effort' (2001:3). The steps proposed by the TOC Center are as follows:

1. Define the objective.
2. Develop a broad awareness of the process and concepts.
3. Define the system's throughput channel.
4. Map the critical component of the overall system.
5. Analyze the system's capacity.
6. Quantify the system potential and actual performance.
7. Identify the leverage points.
8. Establish improvement teams.
9. Select/develop solutions.
10. Implement solutions.
11. Measure.

There are some success stories about companies that used TOC to enhance their production. For example, a project was successfully completed by the Clowes Group in England in 1999 in which, by the end of the first quarter, the revenue was already 150% more than anticipated (AGI, 2005). Similarly, the AGI (2005) assisted with change management in the United States Air Force Healthcare System[6].

2.4.3.1.2 Theory of constraints and re-engineering

Although TOC was developed by Goldratt & Cox (1992) for the manufacturing environment, if mapped to the steps in the re-engineering environment, there is a correlation between many of the steps used in re-engineering for businesses, those used in re-engineering for the HEI environment and the steps identified for TOC as illustrated in Table 2.11.

[6] For the interested reader, more case studies are available at the Goldratt's Institute website at http://www.goldratt.com/.

Table 2.11: Re-engineering in BPR, HEI and TOC

Step / Phase	BPR			HEI		TOC
	Davenport (1990)	Hammer (1993)	Muthu (1999)	Bruno *et al.* (1998)	Tait (1999)	TOC Center (2001)
Develop business vision	1	1	1		1	1
Determine important metrics					2	
Implement a change management plan				Separate	3	
Identify processes to be redesigned	2	1				2
Map the process		2	2			
Choose the process to re-engineer		3	3	1	4	3
Understand the current processes	3	4		2	5	4
Identify IT levers	4					
Identify affected and involved parties				Separate	6	8
Design and build a prototype of the new process	5			3	7	9
Re-engineer the process		5				
Implement the re-engineered process			4	4	8	10
Improve process continuously			5	5	9	11

Eight of the eleven processes from the TOC can be mapped to similar activities either in the re-engineering of the HEI or the business application domain. It is therefore possible to conclude that the TOC is a form of re-engineering applied in the manufacturing environment.

The concept that I am particularly interested in is the identification of the constraint within TOC. In re-engineering in businesses and HEI there is an activity, *'choose the process to re-engineer'*. However, in the theory not much is written on how to choose the process to re-engineer. TOC uses a technique that is based on the concept of Throughput and Demand covered in steps 5, 6 and 7 of the TOC process (TOC, 2001). It is clear that these steps are not covered in any of the re-engineering efforts and there is therefore, a gap in the existing approaches with regard to the selection of the process to be re-engineered.

If there is a relation between TOC and re-engineering in other application domains, as shown in the table above, it should be feasible to apply the concepts of Throughput and Demand in HEI in the step, *'Choose the process to re-engineer'*.

2.4.3.1.3 Identification of constraints

In the remainder of this section I discuss the theory related to the concept of Throughput and Demand in a manufacturing environment. In section 4.3.2.1.1 I will investigate the feasibility of the use of these concepts in a re-engineering effort.

The three steps not included in the re-engineering procedures, steps 5-7, focus on the identification of the constraint, using Throughput and Demand to determine the constraint. According to Onirik (2000) it is known that 'when dependent events occur in combination with *statistical fluctuations* the fluctuations accumulate at the lowest possible Throughput – because the dependency limits the opportunities for higher fluctuations. The maximum speed of any whole process is the maximum of the slowest part or subprocess of the process. A capacity constraint (or bottleneck) is any resource or subprocess whose capacity is equal to or less than the demand placed on it. And the goal is to balance flow through the process with demand from the market (not to balance according to capacity)'.

The reasons for constraints differ in different application domains. The constraint could be a pile-up, or it could be that there are not enough resources to handle the work, or that some resources are doing nothing while another resource is doing all the work due to poor resource distribution. In a manufacturing or production environment it is very easy to find the constraint, walk through the process chain and see where the work is piling up (Onirik, 2000). In the HEI it is necessary to identify the different processes and to found out where the problem areas are using the capacity theory.

2.4.4 Overview: process re-engineering

The focus of the second research question was on the usability of the process model structures identified in the first research question and more specifically, the usability in the re-engineering of the HEI application domain. In section 2.4, the current literature on re-engineering was investigated with the focus on both the business application domain and the HEI application domain. The existing procedures available for re-engineering in HEI are based on the original BPR procedures defined for the business application domain. A gap in the procedures available is the identification of the potential process to be re-engineered. A possible solution is the use of TOC where the focus is on the Throughput and Demand as discussed in 2.4.3.

One problem is that there are no procedures currently available for the investigation of the usability of generic process model structures in an effort such as the re-engineering of processes. The theory on re-engineering discussed for the business application domain, the HEI application domain and the concepts discussed on TOC are used in Chapter 4 to propose a procedure to answer the second research question.

2.5 PROCESS PRESERVATION

The last research question addresses the preservation of the process model structure. The underlying concepts in preservation are reusability, classification and the repository. An overview of reusability is given in section 2.5.1. The classification of systems is discussed in section 2.5.2 followed by a discussion in section 2.5.3 on the preservation of processes in repositories.

2.5.1 Reusability

The Merriam-Webster (2005) Dictionary defines reuse as 'to use again especially after reclaiming or reprocessing'. The preservation of objects for reuse is nothing new; the earliest form of reuse of information is the stories told and re-told for generations. Books were the next form of storing information for reuse and until very recently, the only way to preserve information. With the computer revolution starting in the 1950s, a new form of preservation evolved through data storage on computer disks. The most popular way of storing data was, and is still, through the use of databases. Even today it is still the most efficient way to store data especially for large numbers of records, e.g. student records in a university or patient records at a hospital. In a programming language, reuse refers to 'the use of some pre-existing product, e.g. existing requirements, design, code, test software, and documentation' (Firesmith & Eykholt, 1995:395).

The term 'reusability' became popular with the introduction of the object-oriented paradigm. The first two languages that used object-oriented concepts were Simula I and Simula 67 in 1967 (Dahl & Nygaard, 2002). In the early 1980s C++ was developed, which is still one of the most popular object-oriented programming languages today. Many of the concepts used in Simula were also used in the C++ programming language, including the reusability of components.

The relationship between reusability and generic structures is very important (generic structures were discussed in section 2.3.5). A generic structure implies reusability. The opposite is not necessarily true; a reusable structure is not necessarily generic.

2.5.2 Classification of systems

Generic structures are also related to the classification of systems of various domains. Classification of systems is used to name the world and its pieces that relate to the world. It provides a language for the scientific population and a system through which the knowledge of the world can be organized and stored (Malone *et al.*, 2003). Among the well-known classification systems used today are the Periodic Table of elements developed by Mendeleev in 1869, the Biological Classification used by the biologists to classify living organisms, the Dewey system in the library application domain where books are categorized according to a system used world-wide (Dewey Classification, 2005), and more recently, the Human Genome project used to identify and store all the DNA genes in the human body (Malone *et al.*, 2003). Malone (2003) provides a list of engineering handbooks that provides classification systems in the engineering application domain. These include:

- Design Information Group: University of Bristol. (1997), A Multi-Media Handbook for Engineering Design.
- Perry, R.H., Green, D.W.& Maloney, J.O. (1997), Perry's Chemical Engineers' Handbook.
- Fink, D.G., Beaty, H.W., and Beaty, W. (1999), Standard Handbook for Electrical Engineers.

In a classification system the components that form the building blocks of the system, is generic. This emphasizes the fact that it is possible to reuse the components in different applications where the meaning of the component will be exactly the same, irrespective of the environment in which it is used in. For example, in the Dewey classification system the main class with the value 600 relates to books dealing with Technology (Applied Sciences). If you pick up a book anywhere in the world that has been categorized according to the Dewey system, and the book number starts with a 6, you would know that this book is classified as a Technology book. For example, the book *Computer Technology* written by Boris Doncov is classified in UNISA library as 621.38195016 DON. The starting number 6 indicates that this book belongs in the Technology class. Similarly, there is a specific meaning to the 21 that follows the 6 in 621.38195016 DON, etc.

Classification is therefore an important activity in the preservation of generic, reusable components such as the process model structure of a university. In the vision of identification of generic process model structures and the preservation of these structures to make them reusable, the classification of the process model structure is an important activity. The classification of components in the HEI process model structure does not really resemble the examples mentioned, but the examples have some characteristics that relate to the vision of classifying the HEI activities.

The vision in this research is closely related to the vision of researchers at the MIT Center for Coordination Science. They developed a Process Handbook from the early 1990s with the intention of creating a classification system for business activities (Malone *et al.*, 2003). My interest in this classification system is that it is the only system I could find that:

- Uses object-oriented concepts for the preservation of the process model structures.
- Supports the notion of specialization and generalization.
- Supports the identification of generic process model structures for reuse by more than one company.
- Provide tools to access the process repository using the web.

The representation that Malone *et al.* uses to construct the Process Handbook, is based on the notion of specialization of processes from object-oriented programming and on the management of dependencies from coordination theory (Malone *et al.*, 1999a). A more detailed discussion is given in 2.3.3.3 on the use of these object-oriented concepts to construct the process model representation within the business application domain.

2.5.3 Process repositories

A repository is described as a place where data is stored. It could be in a database or as files and could be distributed over a network or directly accessible to the user without using a network infrastructure. There are three important concepts in the building of a repository: the *abstract representation* used, the *physical storage* of the data and the *software* used to access and view the data.

For *abstract representations* we draw schemas or models to present the structure of the data. For example, in a database environment an entity relationship diagram is used to show the entities and the relationships between the entities (Cardenas, 1985). In the MIT process repository the authors refer to a representation when they discuss the structure used in concepts. In this study, I refer to MIT process repository frequently and will therefore adapt the use of the word 'representation' when describing the elements and relationships between the elements.

The *physical storage* of data is done on external data storage devices and typically managed through *software*. In a database environment, the software is called the 'data base management system' which is responsible for the storage and management of the data (Cardenas, 1985). Examples of well-known database management systems are Oracle (2005) and Informix (2005).

The process models stored in the Process Handbook are accessible through the Phios software (Phios, 1999) developed by the Phios Corporation (section 2.5.3.2).

As mentioned previously, the MIT process repository is used as a guideline in this study for the preservation of process models, because it supports the concept of reusability and specialization of generic structures also used in object-oriented methods. Furthermore, it focuses on the organization of knowledge, which is not supported in other organizational models such as those of Cohen March and Olsen (1972) or, more recently, Masuch and Lapotin (1989), which focus more on the simulation of knowledge (Malone *et al.*, 2003). The MIT process repository also provides access to the process models, which may be changed, added or deleted.

The MIT process repository concepts discussed above are illustrated in Figure 2.6, where the process model representation is used as a guideline in the development of the physical structures, which are in turn accessible through the Phios software from a computer system.

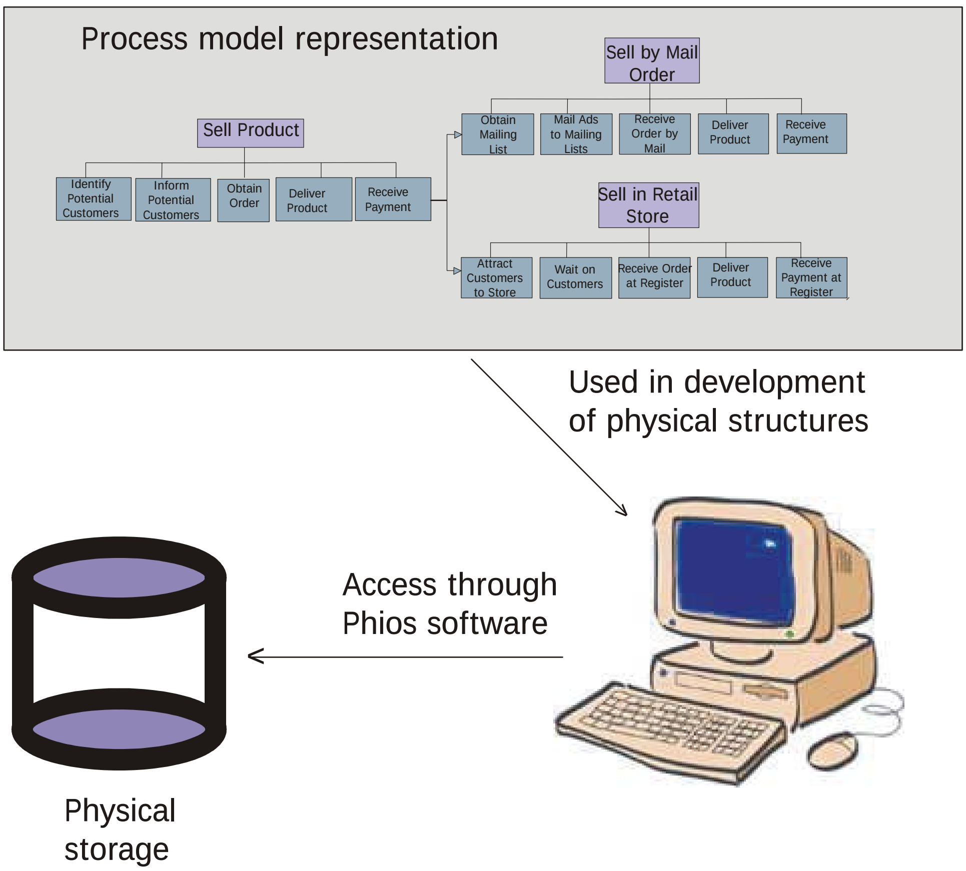


Figure 2.6: Components in the MIT process repository

The MIT repository representation is discussed in more detail in section 2.5.3.1, which is followed by a discussion on the Phios Model used to access the process models stored in the repository in 2.5.3.2.

2.5.3.1 MIT process repository representation

Section 2.5.3.1 and section 2.5.3.2 are based on information retrieved from the MIT Process Handbook (Malone *et al.*, 2003), the Phios white paper (Phios, 1999), Phios website (www.phios.com) and articles published by a different authors on the MIT process repository.

Specialization and parts of the process

The MIT process repository representation uses the specialization concept to show how process models can be inherited. The MIT process repository representation extends existing process mapping techniques and, not only uses the break-down of a process into subprocesses or *parts*, but also defines different *types* for the process. Authors involved in research in the MIT process repository regularly use the *Sell Product* example to describe the process repository representation for specialization of the processes (Klein & Myers, 1999; Malone *et al.*, 1999a; Phios, 1999; Malone *et al.*, 2003). The process representation of *Sell Product* is given in Figure 2.7.

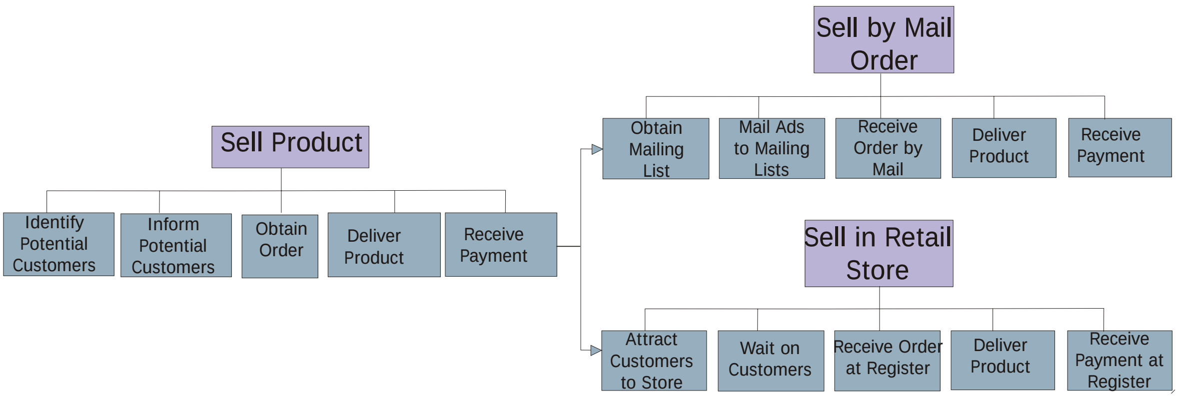


Figure 2.7: Generic sell product (Malone *et al.*, 2003)

In this representation the *Sell Product* is broken down into *parts,* also called 'subactivities' or 'subprocesses'. The subprocesses include the identification of potential customers, to inform potential customers, to obtain an order, deliver a product and to receive payment. For each generic process representation (such as *Sell Product*) it is also possible to map the representation to special cases of the process. For example, *Sell by Mail Order* and *Sell in Retail Store* are examples of special cases for the generic *Sell Product* (Figure 2.8).

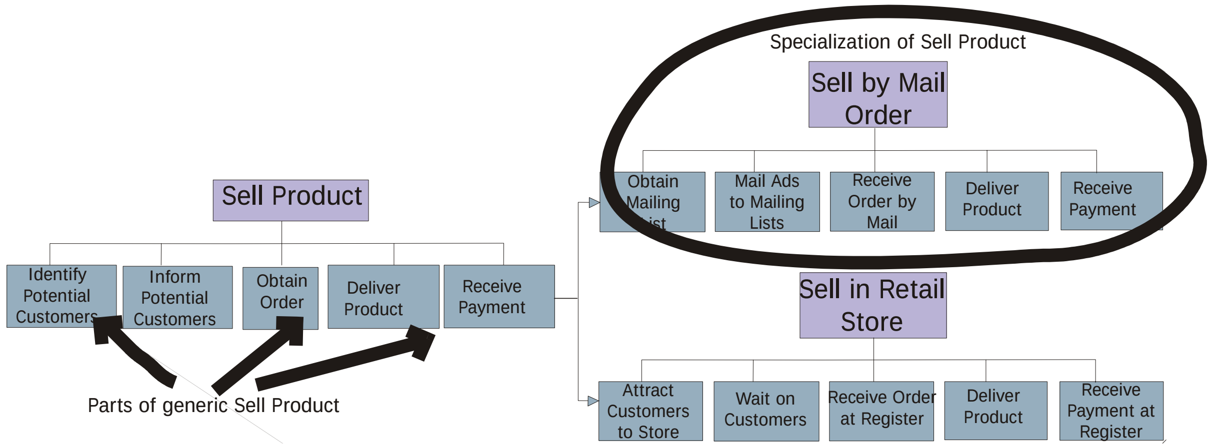


Figure 2.8: *Parts* and *Specializations*

The concept that the MIT process repository supports is based on *inheritance* used in object-oriented development. According to Firesmith and Eykholt (1995:203) inheritance is the 'incremental construction of a new definition in terms of existing definitions without disturbing the original definitions and their clients'. In inheritance, the child class (subclass) inherits the properties from the parent class (superclass). For example, in an IT company employees could either be full-time employees or contractors. In the case of full-time employees the employee will receive a salary. In the case of a contractor, the employee will receive a payment at the end of the month based on his hourly wage and the hours that the he worked (Figure 2.9).

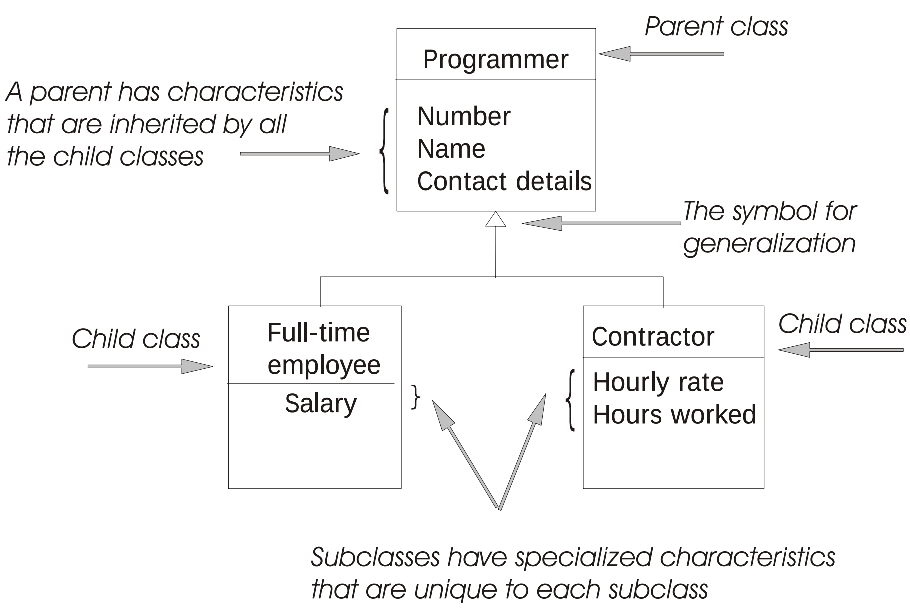


Figure 2.9: Employee types in an IT company

In this example, the subclasses *Full-time employee* and *Contractor* inherit the Number, Name and Contact details from the superclass *Programmer.* The *Full-time employee* also has an additional attribute Salary and the *Contractor* includes two additional attributes, Hourly rate and Hours worked. The *Full-time employee* and *Contractor* are called specializations of *Programmer.* If the diagram is read from the top-down, object-orientation refers to the concept of generalization. Generalization is the 'process of creating a generalization from one or more specializations' (Firesmith & Eykholt, 1995:183). In our example, the *Programmer* is a more general element than the *Full-time employee* or the *Contractor*. Therefore, the *Programmer* is a generalization for *Full-time employee* and *Contractor.*

Therefore, in the MIT process repository representation the *Sell by mail order* and the *Sell in retail store* inherits the *Sell Product* from the parent. Both are specializations of *Sell Product* and it is possible to deduce that *Sell Product* is the more general structure, or the generalization. There are, however, two minor problems with the way that Phios represents the structure.

Problem 1: Notation used in MIT process repository

The first problem with this model is that the authors used object-oriented concepts but do not represent the model in object-oriented notation. UML is the standard object-orientated notation for the Object Management Group (OMG). UML was accepted as a standard after three well-known authors with different methods merged their efforts to create one standard language (Jacobson *et al.*, 1999). The first author was Booch (1996) who created the Booch method. He was joined by Rumbauch (1991), who was the principal developer at the General Electric Research and Development Center of OMT (Object Modeling Technique). In October 1995 they released version 0.8 of the Unified Method at Rational. Jacobson who was also well-known for his efforts in object-orientation (Jacobson, Ericsson & Jacobson, 1995), joined Rational during this period and soon afterwards version 0.9 was released. The latest version available is 2.0 and it is available for download at the OMG website at www.omg.org.

In the 2001 specification[7] (OMG, 2001a:3-86), generalization is 'shown as a solid-line path from the child (the more specific element, such as a subclass) to the parent (the more general element, such as a superclass), with a large hollow triangle at the end of the path where it meets the more general element'. Generalization is illustrated in Figure 2.10.

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[7] In 2003 UML 2 was released that did not include a similar example, therefore the notation is illustrated from the 2001 release.

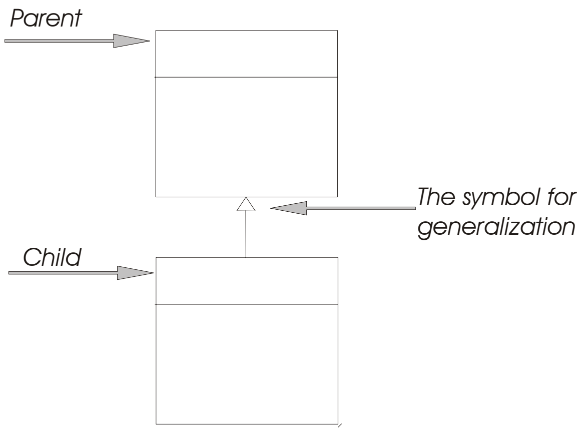


Figure 2.10: Generalization relationship

Note that the hollow triangle points towards the more general class, or the parent. In the notation used by Malone *et al.* the arrow points away from the parent.

Problem 2: Changes in the specialization

Another difference between true object-oriented use of inheritance and the MIT process repository representation is that the MIT process repository representation allows changes to the parts of the specialization. To describe this in more detail, it is first necessary to look at the notation used for a class (Figure 2.11).

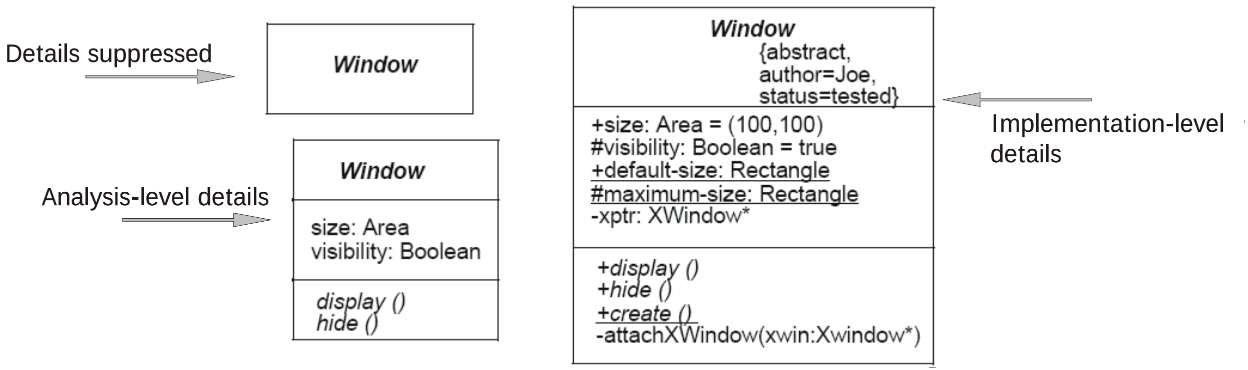


Figure 2.11: Class Notation (OMG, 2001a:3-37)

Process models relate to the analysis level of the class notation where the data and methods are displayed in the class. In the example above, the *Window* class has two attributes, size and visibility. It also has two methods, display() and hide(). If a subclass inherits from this class, it will inherit all the attributes and the methods. For example, if there are two subclasses *Blinking_window* and *Wave_window* for the *Window* class that display a window on the screen, both these will inherit the ability to display and to hide (Figure 2.12).

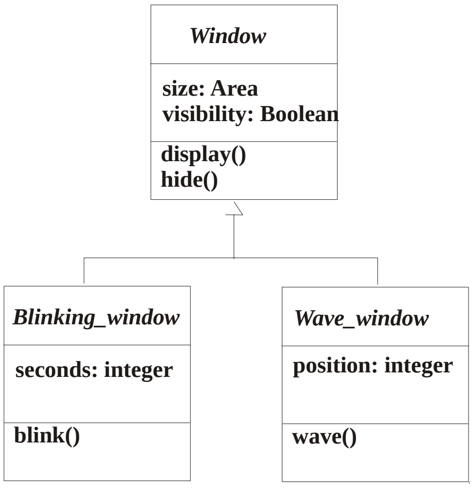


Figure 2.12: Two subclasses inherit methods from *Window* class

In the example, the *Blinking_window* subclass will also be able to 'blink' and the *Wave_window* will be able to 'wave'. The programmer is allowed to add methods and attributes to the subclasses and he is allowed to change the way that the two windows are displayed and hidden (methods inherited from the superclass), but he is not allowed to change the function of the method. If the function was to display the window, the window must still be displayed, irrespective of the inner workings of the program manipulating it to display. The result should only be a window that is displayed on the screen.

In the MIT process repository example, the authors allow a change to the function of an inherited subprocess. For example, *Sell in Retail Store* inherits from *Sell Product* the subprocess *Wait on customers*. The function in the original process structure was to inform clients, which is done in the *Sell by Mail Order* specialization. But in the *Sell in Retail Store* specialization the function is not to inform, but to wait. This is a change in the original intention of the subprocess (Figure 2.13).

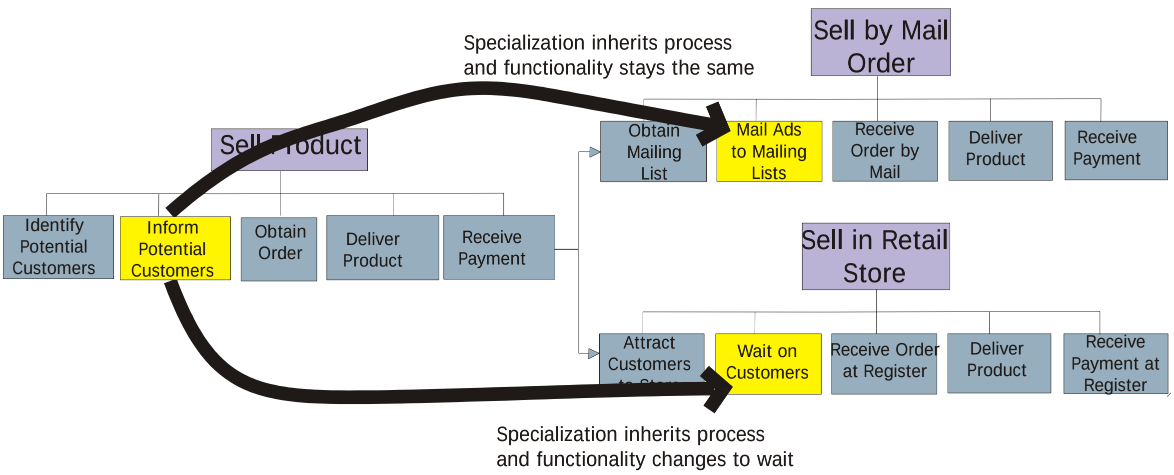


Figure 2.13: Specialization changing the function of the inherited process

These two issues are addressed in more detail in section 4.3.3. In section 2.5.3.2 the management of the process models through the Phios software is discussed.

2.5.3.2 Management of the process models

The MIT process repository (Malone *et al.*, 2003) uses a compass to show in the vertical dimension, the conventional way of representing processes through subactivities. In the horizontal dimension the MIT process repository representation shows the analyzing of processes according to their type (Figure 2.14).

Figure 2.14 : Compass Explorer (Phios, 1999)

The Phios software developed to manage the process structures supports this notion and from any activity in the repository one can either go up to larger activities, of which this one is a part, go down to subactivities, go right to the different types of activities or go left to the different activities of which this one is a type. There are two issues related to the use of the Phios software that support the MIT process repository: the data (also called ‘processes’ or ‘activities’) and the management of the data.

In the examples used in the Phios software, the existing data are based on five generic processes defined by the creators of the MIT process repository, including design, purchasing and inbound logistics, production, sales and outbound logistics, and general management and administrative functions. According to Malone *et al.* (2003), they used the discussion given on generic business process models from Davenport (1993) and other resources to identify these processes as the generic business processes. No detail is given on HOW they decided that these were the five generic processes. They do not even mention Porter’s (1985) value chain theory in their Process Handbook (Malone *et al.*, 2003). In comparing the two approaches, one should realize that the views are different. Although Malone *et al.* (2003) claim that these are the generic processes, they do not claim that these processes are predominant in the business domain. They also say that ‘many such views are possible, and they are all functionally equivalent, so it would not make sense to claim that any particular set of generic business processes is definitely or intrinsically superior’ (Malone *et al.*, 2003:29). I agree with this viewpoint, but am of the opinion that finding generic procedures should advance the reusability concept. of the Process Handbook provides for different viewpoints it may extend the *flexibility* but limit the *uniqueness* and therefore the usability thereof.

The Process Handbook extends these concepts to a taxonomy of four very general activities including: Create, Destroy, Modify and Preserve (Malone *et al.*, 2003). According to them, these general processes can occur for any kind of object. They simply call this the most promising approach used to date, without giving any formal justification for the inclusion of these four activities.

Although the purpose of this study is not to discuss the Phios software, some of the functionality of the Phios software is discussed as necessary background information for further discussions in Chapter 7. The Phios software is available on the web at http://repository.phios.com/SCOR/ and is accessible free of charge after registration on the system. The Licence Agreement gives users permission to view, use, copy and distribute information in the Phios Process Repository (Figure 2.15).

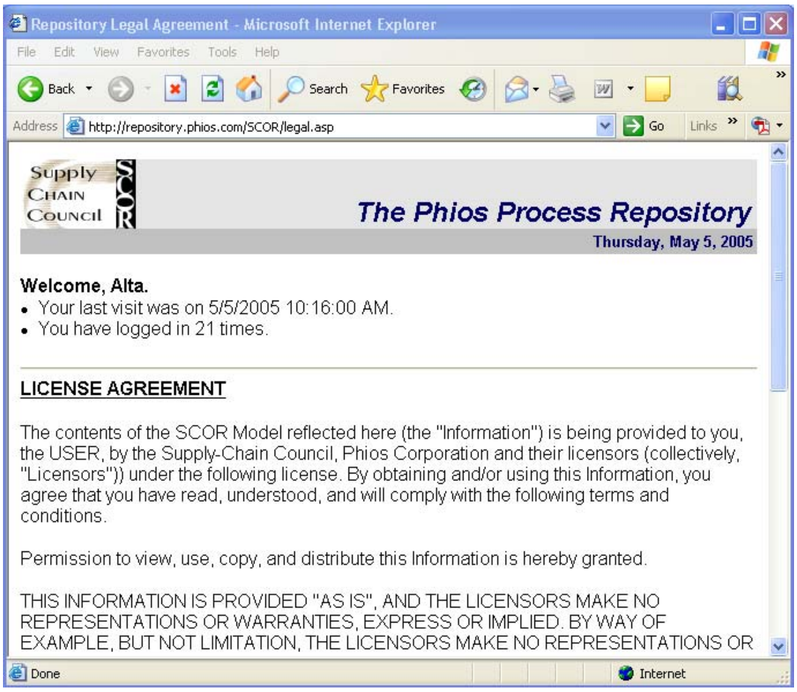


Figure 2.15: The Phios Process Repository licence agreement (Phios, 2005)

The *Sell Process* described in the MIT process repository is used to illustrate the use of the Compass Explorer in the Phios software. In accessing the repository a search for *Sell* will list the different activities associated with *Sell*. For example, *Sell, Sell Product, Sell Service* and *Sell to Business*. For each process the options in Figure 2.16 are available.

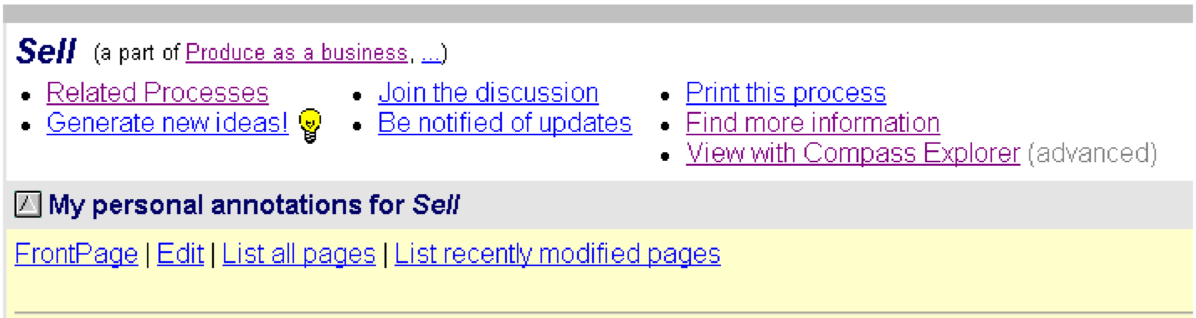


Figure 2.16: Functions available for the *Sell process* (Phios, 2005)

A user may view related processes, join a discussion on the specific process, print the detail of the process, view a list of ideas generated from other processes that are similar to the one viewed, be notified of updates to the process or search for more information on the process. The user can also explore the process using the Compass Explorer, which relate to the theory available for the MIT process repository abstraction previously discussed. If you click on the Compass Explorer, the description of the process will appear with the Compass Explorer as a clickable navigation on the left-hand side (Figure 2.17).

Figure 2.17: *Sell Process* view through the Compass Explorer

If the user clicks on the Generalization, Specialization, Parts or Uses dimension on the compass, he will be guided to one of the four screens with more information on these components for the *Sell*

Process. For example, in Figure 2.18 a screen display is given of the Specializations listed in the repository for *Sell Process*.

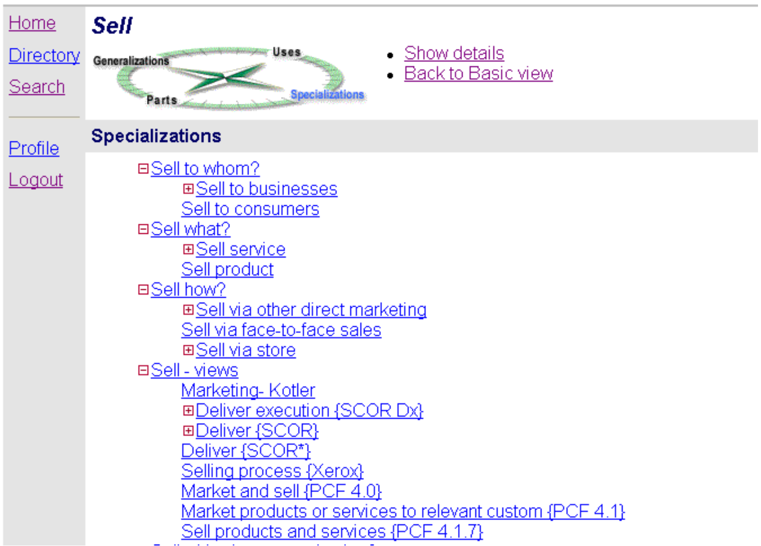


Figure 2.18: Specialization for *Sell Process* view through the Compass Explorer

The software uses question guidelines such as ‘Sell to whom?, ‘Sell what?’ and ‘Sell who?’ to categorize the specializations.

One of the concerns briefly discussed previously is that there seems to be duplication in the repository. If you do a search on *Design*, two processes, both called *Design*, appear in the list of 144 options retrieved (Figure 2.19). Duplication is something that is to be avoided in a database and in relational databases one of the prime concerns is the elimination of duplication through normalization (Rob & Coronel, 2004).

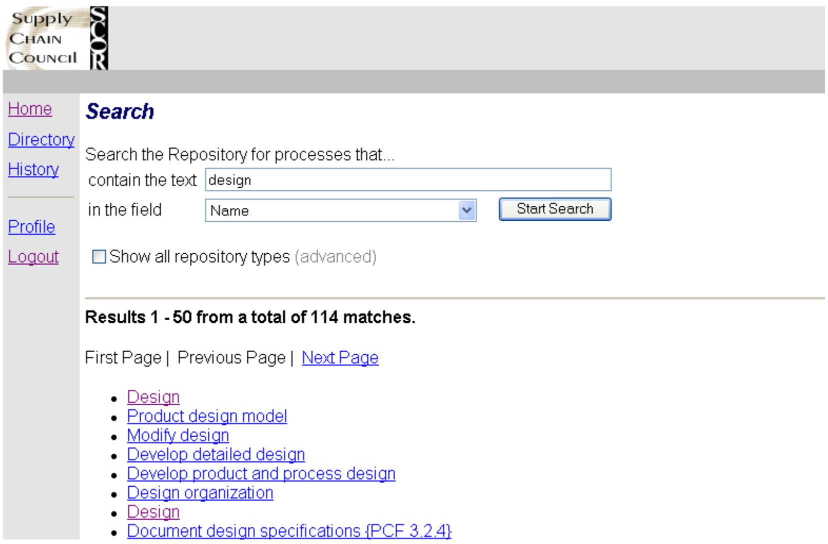


Figure 2.19: Duplication of the *Design* process in the Phios process repository

2.5.4 Overview: process preservation

Process model structures can only be reused if they are preserved and stored. The third research question focuses on the preservation of the generic process models structures (related to Research Question 1), which are used in efforts such as re-engineering (related to Research Question 2). In this section, reusability and the classification of systems are discussed. An existing representation of the preservation of business process model structures was discussed in section 2.5.3.

Business process model structures are successfully stored using the MIT process repositories, but, the existing abstraction and notation used for the abstractions are not standardized. Some suggestions are made in Chapter 4 on how to adapt the notation.

2.6 SUMMARY

This Chapter commenced with a motivation for the research in section 2.2 where the current changes in the HEI application domain were emphasized and the importance of the three research questions discussed. The theory related to the three research questions were discussed in sections 2.3 to 2.5.

In dealing with the first research question, the different concepts in the process model structure were discussed, including the process, process modelling, the notation, the identification of the process model structure, the identification of generic structures and process modelling tools. As regards the second research question, re-engineering was discussed from a business perspective and from an HEI perspective. The relationship between TOC and re-engineering was investigated and the concept of TOC constraint identification investigated as a possibility in re-engineering processes within the HEI application domain. Lastly, in relation to the third research question, reusability and classification of systems were discussed, followed by an overview of process repositories. Two problems were identified in the current use of the MIT process repository representation, which will be addressed in Chapter 4 as part of the discussion on the preservation of a process model structure within the HEI.

3. Contextual Analysis

3.1 INTRODUCTION

Chapter 3 provides some background on the activities that I was involved in at the UNISA with regard to the implementation of technological innovations. The activities are divided into two sub-categories. Firstly, there are those that contributed to the study before definition of the research questions. These include activities that contributed to the background knowledge obtained before initiation of the study and thus played an indirect role in the research. These are called *preliminary activities* and discussed in section 3.2.

The second group of activities are those that I was involved in after the research questions were defined with the aim of understanding the higher education application domain. Note that although this was done at a DEU, the differences between the residential and distance education institution should not have an impact on the outcome of this study. This is due to the fact that the common denominator is learning where only the deliverance mechanisms in which this are accomplished, may differ. In information systems, the activities related with the 'understanding of an environment' are referred to as *structured analysis* (Whitten *et al.*, 2000) and is discussed in section 3.3 under the heading 'Structured Analysis'.

3.2 PRELIMINARY ACTIVITIES

As a lecturer within the School of Computing at the UNISA, I was exposed in the early 1990s to the use of the web as a teaching delivery environment. Two activities that contributed to my personal contextual background on the topic were my involvement as module leader in modules where we used the web as a support structure and, on an organizational level, my involvement as web representative for the department. These two activities are discussed in section 3.2.1 and 3.2.2.

3.2.1 Module head: development of web-based courses (1995-2000)

My first introduction to the use of technology in higher education was as module head of a number of courses. Between 1995 and 2000 the web grew enormously as a teaching tool and several predictions were made to the effect that this technology would have a significant impact on learning in the future (Laurillard, 1993; Katz & Oblinger, 2000). As a module leader involved in different modules at the university, I held discussions with colleagues on the future of e-learning innovation in higher education. In 1999 there were three distinct groups in our department, the early adopters, the indecisive and the late adopters.

The *early adopters* were people actively involved in the development and implementation of course material although they have not specifically been asked to do so. People in this group used HyperText Markup Language (HTML) to create and update the websites for the courses that they taught. Mostly web servers were self-maintained and web pages were static and changed periodically. Guidelines in the field of human computer interaction (HCI) for websites were rudimentary and often developers made bad choices with regard to colours and fonts on websites. *Early adopters* were very intolerant about University initiatives to implement e-learning guidelines. In discussions with a number of people in this group, the general feeling was that they knew what they were doing and should not be bothered with guidelines. This group did, however, contribute tremendously to initial initiatives at UNISA to investigate the use of e-learning technologies. Some meetings were held with representatives from the different departments involved in e-learning, with management representatives, and computer services (implementation department).

The *indecisive* group was not really interested in the hype surrounding e-learning initiatives and would ignore any meetings or discussions on this topic. They did not feel any responsibility for decision-making and considered this a 'new' technology that would disappear or play a small role in future, like the use of other media such as video technology or satellite broadcasts. This was the group that later on converted easily to the adoption of these technologies once they grasped the advantages thereof.

The third group, *the late adopters*, was the largest group. This group was the group that didn't want any changes made to the way that things 'are currently done'. They were totally against the introduction of any innovation and believed that the current way of teaching was the best for students. Reasons for not changing to e-learning included the unavailability of technology, the price thereof and the duplication of work already included by means of paper-based media.

In a short survey done in 1999, out of a total of 27 respondents in the School of Computing, 7 (26%) were in the early adopters group, 8 (30%) in the indecisive group and 12 (44%) in the unfavourable group. This clearly showed that most of the people concerned were against the use of technology as learning medium in a distance learning environment. The main reason behind this was the belief that it will create more work.

These results can be related to research done by Rogers (1995) in the mid-nineties. He introduced five adopters called innovators (2.5%), early adopters (13.5%), early majority (34%), late majority and laggards (16%). The adopting rate of the adopters is graphically depicted in Figure 3.1.

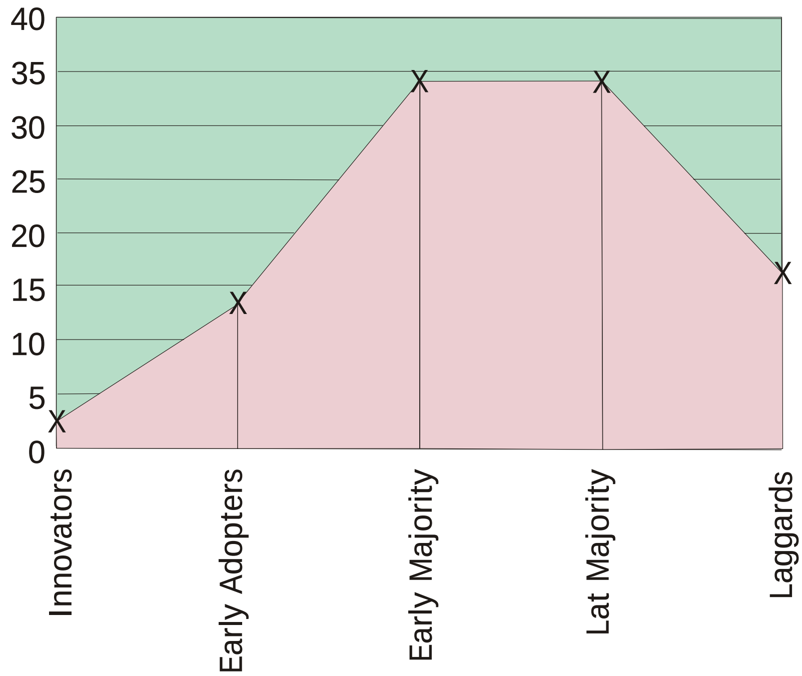


Figure 3.1: Rogers adopters curve

It is possible to relate the three UNISA groups previously described to Rogers's five categories of adopters. Rogers's *innovators* and *early adopters* were described in my survey as *early adopters*. The *indecisive group* described at UNISA maps to the *early majority* in Rogers model. Similarly, Rogers refers to *late majority* and *laggards* whereas I used the term *late adopters* in my survey (Table 3.1).

Table 3.1: Mapping at UNISA

Rogers Model		Model described at UNISA
Innovators Early adopters	→	Early adopters
Early majority	→	Indecisive
Late majority Laggards	→	Late adopters

After discussions with various interested parties and involvement in the lecturing of an on-line certificate course, an article was published on the problems encountered during the implementation and maintenance of an e-learning environment (Van der Merwe & Cloete, 2000).The paper was written from a practical perspective on e-learning initiatives, and focused on problems in virtual administration, the generation of study material, communication, assignments, assessments and feedback.

3.2.2 Departmental web representative (1997-2000)

During 1997-2000 I acted as the departmental web representative. In meetings related to web development, representatives were in favour of using technology in the institution. The reason for the positive approach was that most of the representatives were early adopters and could therefore see the positive results of using the web as a teaching delivery tool in higher education. Meetings were held quarterly or on demand and during these meetings representatives were invited to become involved in activities such as the selection and evaluation of Learning Management Systems (e.g. WebCT) and the testing of web activities.

One of the main concerns raised and confirmed by different authors (section 1.1), was that there is a lack of the preservation of documentation on the structures of the HEIs, which may assist the development team during technological innovations. This is one of the reasons why this study was initiated: to investigate the preservation of structures Human Computer Interaction.

3.3 STRUCTURED ANALYSIS

In the re-engineering of environments, the development team looks at the institution from different viewpoints. In constructing a database, the database administrator may only be interested in the data captured, while the financial administrator may only be interested in actions that involve financial transactions. This project focuses on the improvement of processes in higher education using technological innovations. This includes people, products, data, services and most importantly, the processes. During definition of the research questions, I was only familiar with a limited number of processes at the university. Before I could really start to focus on the problem domain, I needed to understand the framework of the higher education domain.

One of the activities directly related to the modelling of course material that contributed to this knowledge, was my involvement with the UML task team. The goal of the team was to look at the possibility of using UML as a communication interface between content specialists and information technologists. An overview of the UML project team activities is given in section 3.3.1.

Using a number of data-gathering techniques, a technical report was composed that reported on the structure of a DEU (Van der Merwe, 2001). The structure was described from a process, people, product and service perspective and is discussed in section 3.3.2.

3.3.1 UML project team (August 2001 – January 2002)

I was part of the UML project team with a number of representatives from different departments at UNISA. The goal of the team was to look at the possibility of using UML as a communication interface between content specialists and information technologists.

This group consisted of 11 members from UNISA, who were all from the early adopter group and therefore also had a positive attitude towards the idea of using technology in the higher education problem domain. Meetings were held periodically during the period from August 2001 to January 2002. The most valuable information that was gathered from these meetings was that there is a need for content specialists and instructional designers to bridge the gap between developing course material in traditional environments and technologically advanced environments.

The finding of the UML project team was that UML has the capacity to be used as a modelling tool, provided that additional training is provided for members unfamiliar with the use of modelling concepts. This is necessary because these members did not intuitively use the concept of modelling to capture the abstraction of the environment. In Figure 3.2 an example of a snapshot is given from one UML diagram created during this period. The diagram shows the actors involved in *Course Presentation* at UNISA.

In conclusion, from my involvement in the UML project team I learned the following facts which contributed to my background knowledge during completion of this study:

- Developing UML use case diagrams similar to the example shown in Figure 3.2 gave me valuable experience in process modelling practice, which I used during development of the requirements elicitation procedure (discussed in Chapter 4).
- Although UML may be ideal for modelling the system description from a development perspective for technologists, as a modelling tool for lecturers with no modelling experience it seems to be too difficult to use.
- Lecturers and technologists speak different languages. System developers need to consider the technological abilities of lecturers before involving them in efforts to design new systems.

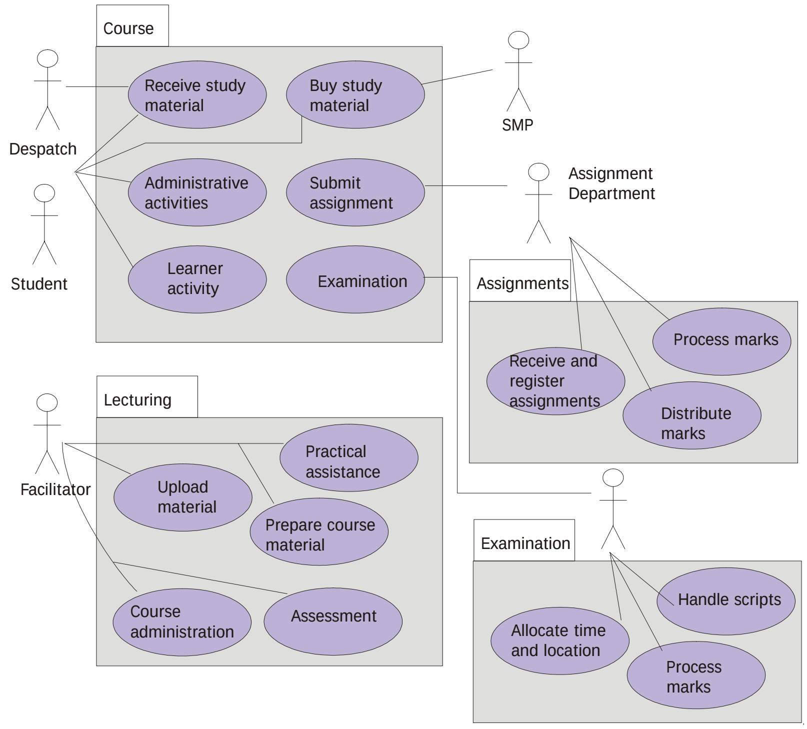


Figure 3.2: Snapshot of a UML use case diagram created as part of the UML Project team

3.3.2 The distance education university structure (2000-2001)

There are many definitions of what a university is and how it operates. For the purposes of this study, a University is an institution that prepares students to become thinking and educated people within a learning environment. University staff is involved with research efforts to contribute to the knowledge pool through publication activities and is involved in service activities. The university is a monetary entity (Van der Merwe, 2001:1).

Institutions such as universities may be viewed from different perspectives. Financial departments view the institution from a financial perspective and develop financial models to study financial indicators. Human resource departments view the institution from a different perspective and will use different information from the institution to determine human resource needs. System developers may view the institution from a product point of view; typically with the aim of looking at the deliverables returned to the community, for example educated students and publications. The focus in this initial structured analysis was to look at the DEU from a product point of view.

The DEU product view is discussed in terms of the interaction of four basic components, namely support and infrastructures, role players, products, and management functions (Figure 3.3).

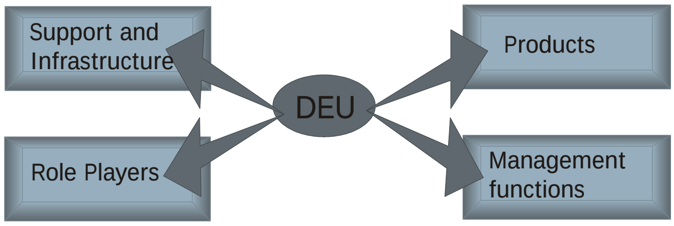


Figure 3.3: High-level diagram of the DEU

The following is a brief description of each of the components:

- *Support and infrastructures* include all the components within the DEU that support the main functions of the university, namely the teaching and learning processes and research activities.
- *Products* are all the measurable components produced by the DEU as output.
- *Role players* are all the people involved in different roles at the university, actively involved with learning and teaching activities, support activities or research activities.
- *Management functions* include all the activities by management role players that include decisions on policies, management and structures.

The support and infrastructure, role players, and management function components interact with one another to produce the different products (Figure 3.4).

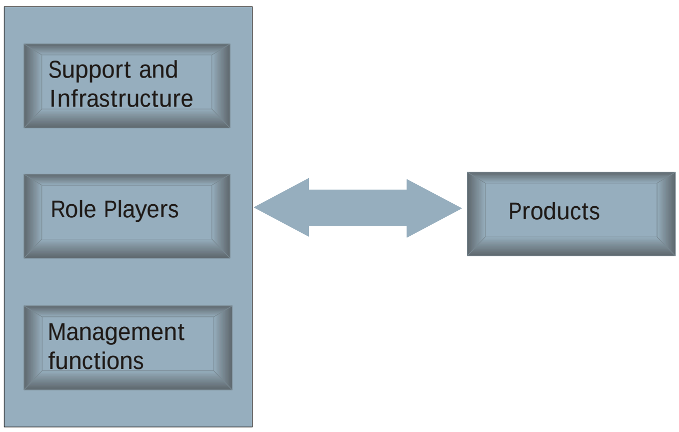


Figure 3.4: Different components working together to produce products

Each of these components can be broken down into other components. Figure 3.5 diagrammatically depicts the breakdown structure of the high-level model in Figures 3.3 and 3.4. Each component is broken down into a number of sub-components. For example, the *management* component includes issues on *policies* and *structures* while *products* include *graduates, course material, research outputs* etc.

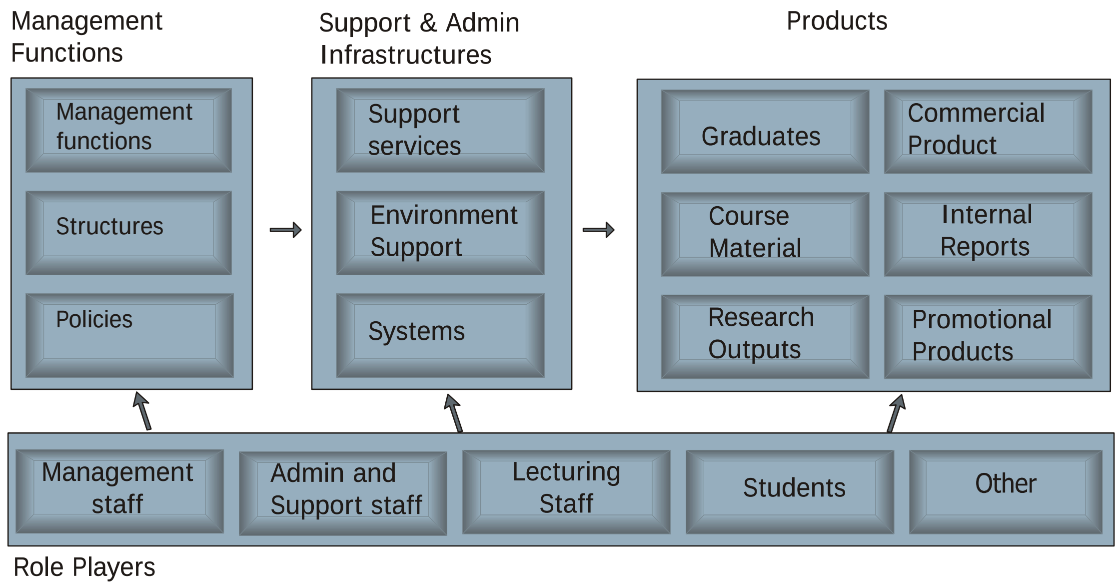


Figure 3.5: Component breakdown of the DEU high-level diagram

The focus of this section of the structured analysis was on the processes involved in delivering the various products within the DEU. The production cycle of these products is impossible without the proper support infrastructures. In section 3.3.2.1 the different infrastructures involved in the production cycle are discussed. Concurrent with the infrastructures the role players are also supporting the production cycle of the various products (discussed in section 3.3.2.2). Section 3.3.2.3 consists of the breakdown of products and their production cycle with the relationship defined between the role players and infrastructures. Although this study does not focus on managerial issues, a short overview is given in section 3.3.2.4.

3.3.2.1 Distance education university support and administration infrastructures

The backbone of the DEU is the administration infrastructures, which, with the help of different role players, supervises the fluent operation of the university. Infrastructures were divided into three categories, namely support services, environmental support and systems.

The units involved with *Support services* can support students, or staff, or both. The infrastructures available to staff are intended to improve their working conditions and include services such as editorial, financial, scheduling and copying services (a more detailed list of infrastructures is available in Appendix 3, Table 1, on the accompanying CD). The infrastructures available to students should improve their general learning environment and provide additional assistance. Examples include counselling services, bursary services and information services.

Environment Support is comprised of the university infrastructures and systems available to students and staff that create a learning environment to make learning outcomes possible and to create learning products. Examples include examination support, academic support, telecommunication support and postal support.

Within the DEU *Systems* can be created to support either staff or students. Staff systems include the hardware and software that create a basic working environment for university staff. Examples include the accounting systems, internal web services and personnel systems. The DEU University also provides student system to monitor the learning progress and to interact with the learning environment. Examples of student systems are web systems and registration systems.

The three categories of components which form the infrastructure and support systems, work together with the various role players within the DEU with the aim to produce high quality products. A discussion on the different role players within the DEU follows in section 3.3.2.2.

3.3.2.2 Distance education university role players

A role is any part played by something (e.g. a person, piece of equipment, or organization). A role captures the purpose of something, the position it holds, or its capacity, job, or viewpoint. According to Firesmith and Eykholt (1995), roles may be implemented as model, protocol, relationship, or view roles. For the purpose of this study in the context of the educational domain, I use the term *role player* to refer to the active role that a person or group of persons play in the development cycle of the product.

Categorization of role players is very difficult due to the flexibility of the person involved. A lecturer can play a teaching role in one process and that of developer in the next process. In future discussions, I will refer to specific roles, except in the high-level diagrams. For the sake of clarity, I give a description of the role player terminology used in section 3.2.3 (more examples in Appendix C). On a more detailed level, such as the role played by librarian staff, the terminology is self-explanatory.

- When referring to the *lecturing staff*, this includes all staff who are involved in the lecturing and teaching processes; for example: lecturers, markers, assistants and educational technologists.
- *Students* include any person enrolled for a course at the DEU.
- *Administration and support staff* consists of any member of staff involved in the production and support systems at the DEU. Examples include the production staff, despatch staff and library staff.
- *Management staff* includes any person involved on a managerial level in decisions affecting the structures and policies within the university.
- The role o*ther* refers at a high level to any role players involved in the education application domain, who do not naturally fall into one of the above-mentioned categories. These include researchers, task groups, quality assurance teams and consultants.

The purpose of this study is not to identify and define the different roles in the institution. The descriptions are given as context for future reference. It is inevitable that any changes of structures will have an impact on role players and therefore the different role players involved in the DEU structures cannot be ignored.

3.3.2.3 Distance education university products

According to the Cassell Concise Dictionary (1997), a product is defined as something that is produced by natural processes, labour, art or mental application. For the purposes of this study, a product is a deliverable of the university that is either a physical product or a measurement of knowledge.

There are six products defined in the DEU (Figure 3.5). Two important products delivered by the university are the graduate and the published research output (Hobbs, 2001). There are more products that are sometimes not so easy to identify. One of these, which plays a role during the production cycle of the graduate, is course material. Without course material, it is impossible to deliver the graduate as product. Another product is the material used to promote the activities at the university. Without promoting the university and the programmes available at the institution, student numbers may drop or prospective students might not become aware of possibilities. An internal report is also developed in-house and may be published externally. The last product is any product developed that has a commercial value. Commercial products include any product sold on the open market, either to generate revenue on a profit base, or to cover the development cost of the product. For the remainder of this section, I will briefly discuss the development cycle and the role players involved in the development cycle of each product. The detailed modelling of the different products is available in Appendix 3, on the accompanying CD.

3.3.2.3.1 Course material product

At the DEU, course material is the material that supports the different teaching and learning processes. It serves as an information tool and a communication tool and partially replaces the traditional classroom meeting between the learner and the lecturer. It is compiled with the co-operation of different role players from the environmental support, student system and staff support components.

Role players from the environmental support component are responsible for the duplication and distribution of the course material, while the student system gives access to distribution information. During production of course material, the staff support systems are used to produce the particular product (Figure 3.6).

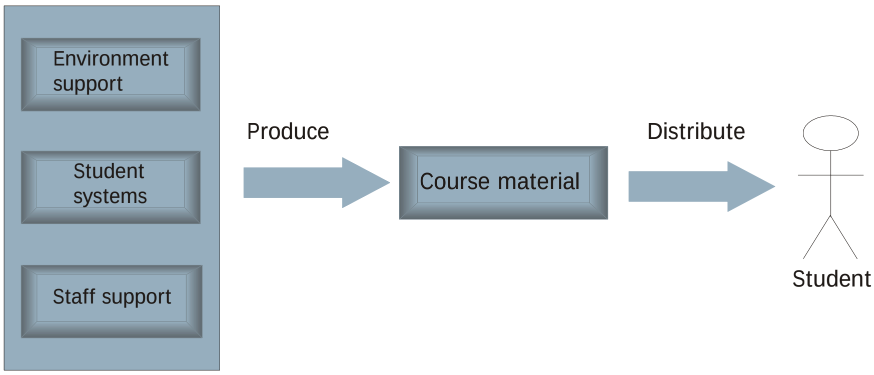


Figure 3.6: Infrastructures and course material

The subprocesses and role players involved in producing a course material product are depicted in Figure 3.7.

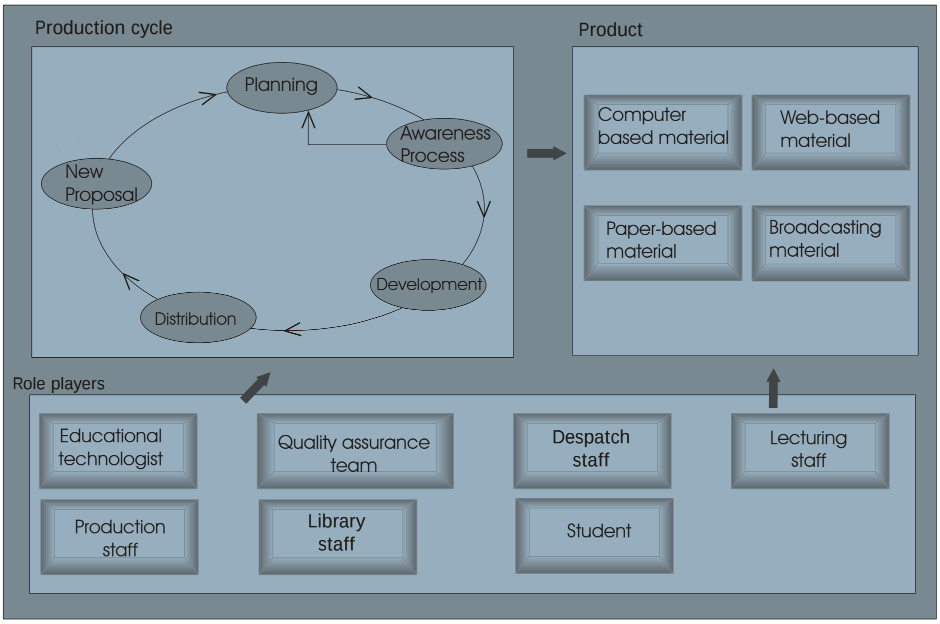


Figure 3.7: Components in the production of course material product

Production cycle

The DEU uses a group development approach that requires a production cycle. The production cycle of course material products consists of five activities:

- *The Product proposal* where the product under development is initially proposed.
- *The planning* where the detail plan is developed for the product development.
- *An awareness process* where the team members are introduced to techniques and tools available for the development of a course material product.
- *The development cycle* where the development team compiles the product.
- *The distribution* where the product is made available, for example the course material is send to the student.

The detail of the processes within each phase differs according to the type of product. For example, the distribution phase methods for publishing a web page will differ from the methods used in a radio broadcast or in sending a tutorial letter to a student.

Different types of course material products

Course material includes all educational items used by the DEU during the teaching and learning processes. The DEU develops course material in-house or buys it from external parties. There are four sub-categories of course material products: web-based material, paper-based material, multi-media and broadcasting products.

- *Non-web computer based training material* comprises of software and applications that combine text, high-quality sound, graphics, and animation or video (CELT, 2002). Examples of multimedia products that are used by the DEU include compressed video and audio, graphics, computer-assisted educational software, interactive software, interactive tests, electronic books and transparencies.
- *Web-based material* is material developed or used by the instructor with the web as the communication medium. Examples include bulletin boards, electronic mail, static / dynamic web pages, chat, virtual worlds, newsgroups, downloadable electronic material with text, graphics, video and sound, interactive educational web pages, examinations / tests, and electronic books.
- *Paper-based material* is material that is printed and duplicated on a paper medium. The paper-based material is distributed to the student or prescribed for the student's own account. Examples include books, printed tutorial letters, examination papers, photographs and posters.
- *Broadcasting material* is material that uses transmission mechanisms to distribute course material or discuss subject-related issues. Examples include television broadcast, videoconference, television conference, tape and video.

Role players

It is impossible for the DEU to function without people. Each person works at the DEU in a certain capacity with certain responsibilities. I use the term 'role player' to refer to person involved in a unit (unit refers to any logical unit within the DEU, e.g an academic department). For example, despatch staff have the despatch function as their responsibility within the distribution unit. The role player in this case is 'despatch staff'. Staff working at the DEU can be involved in one or more roles, while a student can also be involved in different roles (e.g. lecturer and student).

The relationship between the different role players and the production team, as well as the learning and teaching component, are important in defining the structures of the DEU. A cross-section table is used to indicate the relationship between the role players and the production cycle (Table 3.2) as well as the teaching and learning processes (Table 3.3).

Table 3.2: Relationship between role players and production cycle components

		Production Cycle				
		New Proposal	Planning	Awareness process	Development	Distribution
Role	Educational technologist		√	√	√	
	Quality assurance team				√	
	Despatch staff					√
	Lecturing staff	√	√	√	√	
	Production staff		√	√	√	
	Library staff		√		√	

In the production cycle, the educational technologist plays a role in the planning, awareness process and development component. The quality assurance team will be involved in the development component while despatch staff are only involved in the distribution component. Lecturers are involved in all the components of the production cycle, except in the distribution component. Production staff help in the planning process, could be involved in the awareness process and help during the development process. Library staff are involved in the planning and development cycle.

Table 3.3: Relationship between role players, infrastructure role players and teaching and learning processes

		Learning and teaching processes			
		Learning activity	Course communication	Assignments	Examination
Role players & infrastructure	Lecturing staff	√	√	√	√
	Library staff	√			
	Student	√	√	√	√
	Staff Support	√	√	√	√
	Student system	√	√	√	√
	Environment support	√	√	√	√

Learning and teaching processes form the core of the university. In Table 3.3, a cross-reference table, the relationship between the learning and teaching processes, and the different role players is depicted. Except for the library staff, who are only involved in the learning activity, all the other role players are involved in the different learning and teaching processes.

3.3.2.3.2 Research output product

According to Hobbs (2001), the second dimension of a university is the building of knowledge or research. Part of the mission statement of most universities is to conduct research of high quality (Michigan, 2002; Ontario, 2002; Unisa, 2002). According to the Cassell Concise Dictionary (1997), research is a systematic study of phenomena. When research is done, a systematic investigation approach is followed that includes research development, testing and evaluation in order to contribute to the body of knowledge.

The research product is the deliverable produced by the research activities in the DEU and is defined as *any output generated from research activities*. Role players from all the infrastructures' component categories are involved in the 'production cycle' of a research product (Figure 3.8).

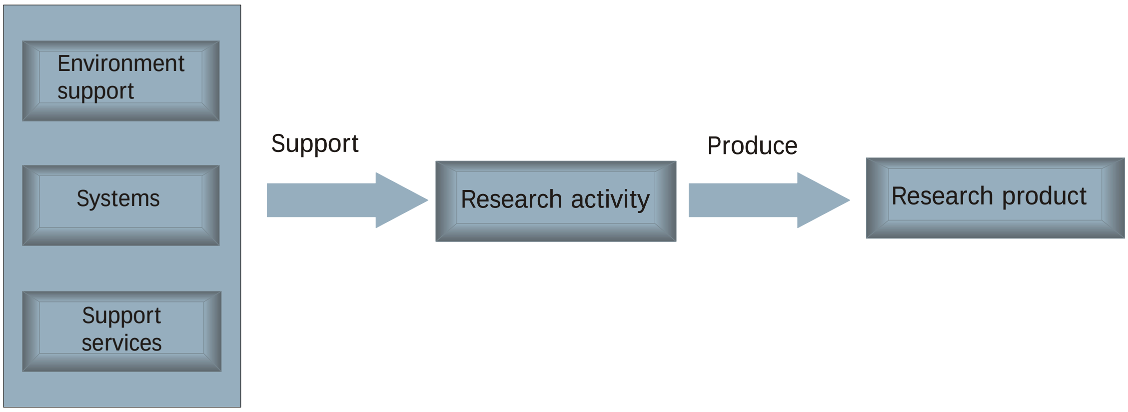


Figure 3.8: Infrastructures and research product

The different infrastructures support the activities in research to produce a research product for distribution. For each research product produced in the DEU, the type of product determines the detail in the production cycle. The type of product is not the only component of importance; there are also a number of role players involved in the production of a research product (Figure 3.9).

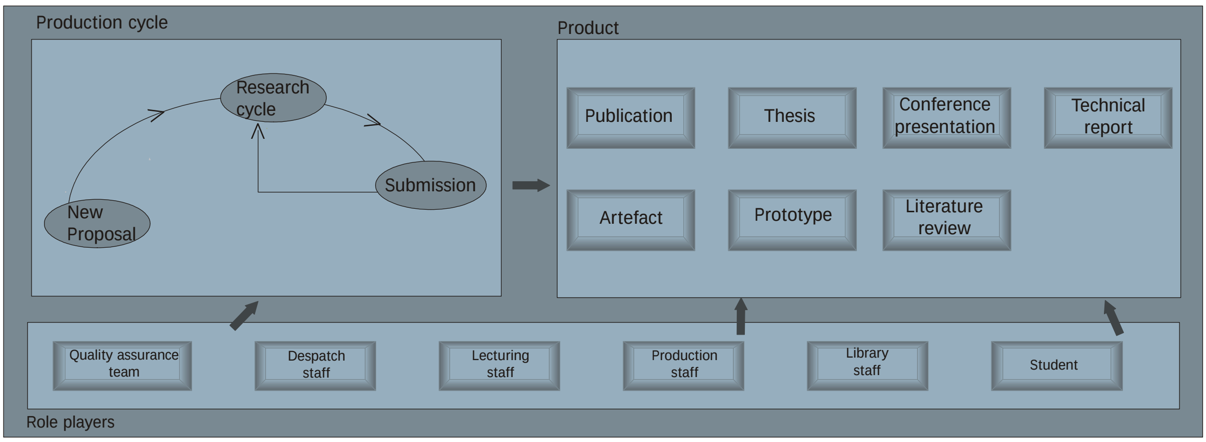


Figure 3.9: Components in the production of research product

Research products are the deliverables of a research production cycle that could differ depending on the type of product. The following is a list of types of research products with a brief description of each (Table 3.4):

Table 3.4: Types of research products

Product	Description
Publication	A publication is an article published in an academic journal, or book, or conference proceedings, or digital library.
Thesis	An essay or dissertation submitted by a candidate for a masters or doctoral degree.
Conference presentation	A conference presentation is a verbal report on a subject, which can include illustrative material, at a conference meeting.
Artefacts	An artefact is a product of human skill or workmanship.
Prototype	A prototype is a pre-production model used for testing to trace design faults or to indicate improvements.
Technical report	A technical report is a report used to give an account of a specific subject using or requiring specialist knowledge.
Literature review	A literature review is a summary on a specific topic giving an overview including information and resources on research already done, current state of affairs and research opportunities in the field.

As already stated, the research cycle of each differs. On a high level, it consists of a proposal, research cycle and submission of the product. After submission, a revision is possible where the researcher is once again involved in the research cycle. A cross-section table is used to indicate the relationship of the different role players and the production process (Table 3.5). Note that *Student* or *Library* staff plays a role in the *New Proposal* and the *Submission* of the production cycle only if the researcher is a *Student* or member of the *Library* staff.

Table 3.5: Relationship between role players and production cycle components

		Production cycle of research product		
		New Proposal	Research cycle	Submission
Role players	Quality Assurance team			√
	Lecturing staff	√	√	√
	Production staff	√		√
	Library staff	√	√	√
	Student	√	√	√

3.3.2.3.3 The graduate as a product of the distance education university

The graduate who completes a diploma, certificate or degree at a DEU is a deliverable of the University. In order to be successful in the education process of a graduate, the institution needs interaction between all the support and administration infrastructures, as demonstrated in Figure 3.10.

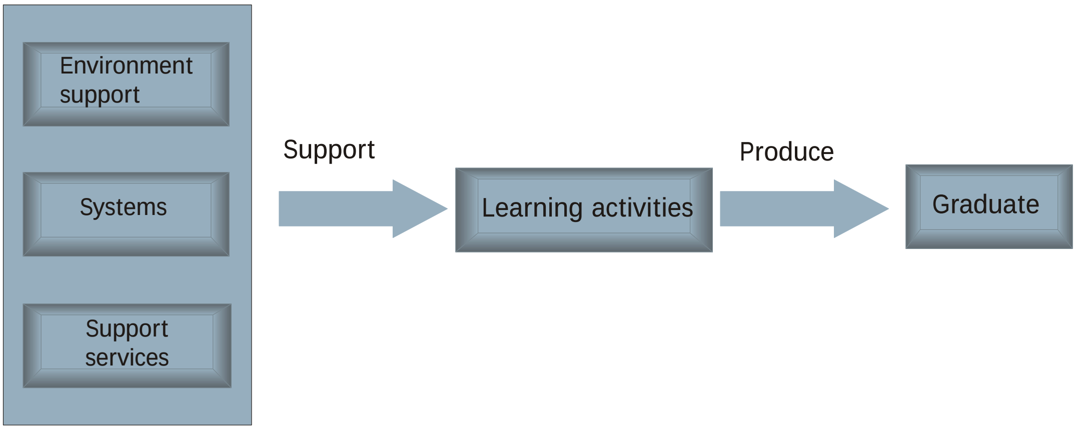


Figure 3.10: Infrastructures and the graduate as a product of the DEU

The graduate instruction cycle begins with the registration of a student for a particular degree, diploma or certificate. The student goes through a learning cycle, with one or many assessment milestones. A graduation follows the successful completion of all the modules needed for the degree, diploma or certificate. This process is shown in Figure 3.11.

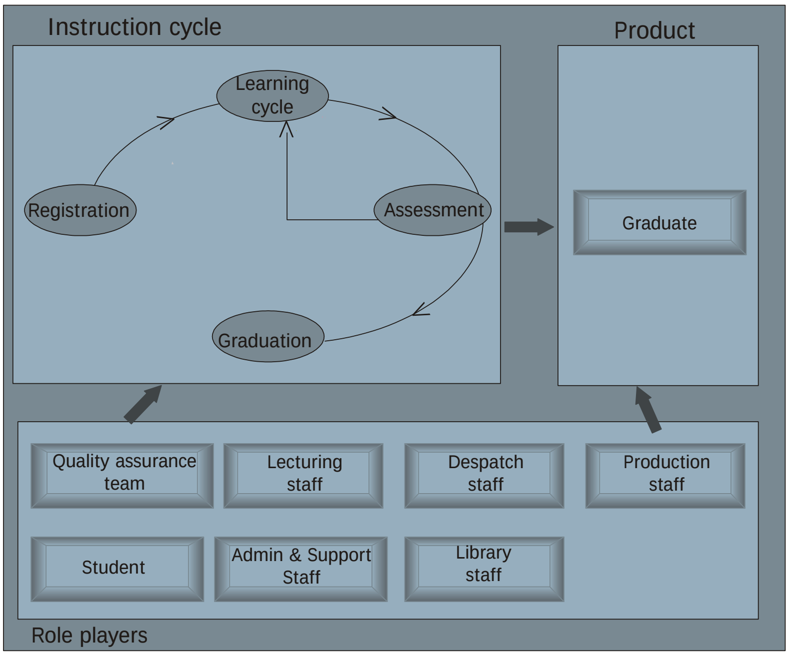


Figure 3.11: The production cycle for a graduate

Some role players are involved in the instruction of a graduate. In Table 3.6 a cross-section table is given to indicate the relationship between the different phases in the instruction process and the role players.

Table 3.6: Relationship between role players and instruction cycle components

		Instruction Cycle			
		Registration	Learning cycle	Assessment	Graduation
Role players	Quality assurance team		√	√	√
	Despatch staff	√	√		
	Lecturing staff		√	√	
	Production staff		√		
	Library staff		√		
	Student	√	√	√	√
	Admin & support staff	√	√	√	√

An observation that comes naturally from the cross-section table is the important role that administration and support staff play throughout the total instruction cycle in the DEU.

3.3.2.3.4 Promotional products

It is crucial for universities to promote themselves. The growing market of private institutions competing for the available student population is one reason why universities cannot neglect promotion of their products. Another factor is the tendency of governments to cut down on subsidies per student. This leads to bigger classes to make courses economically feasible, with the result that competition for student numbers between institutions rises.

Developing promotional products within the DEU is usually the responsibility of the Marketing Research Unit, which falls under the support services. Development of promotional products is also supported by staff related to environment support (Figure 3.12).

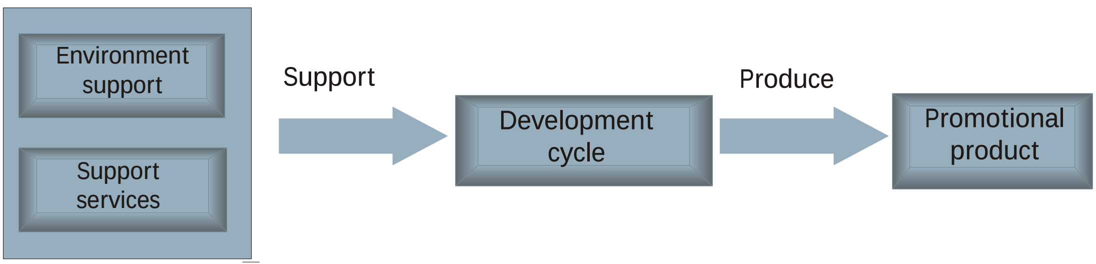


Figure 3.12: Infrastructures supporting the promotional product

There are two promotional product categories. Firstly, the products that are used to advertise the different academic options available at the university and secondly the material used to supply information, called ‘information resource material’. Advertisements include materials such as radio broadcasts, newspaper publications and posters. Information resources include brochures, booklets, and web-based material (Figure 3.13).

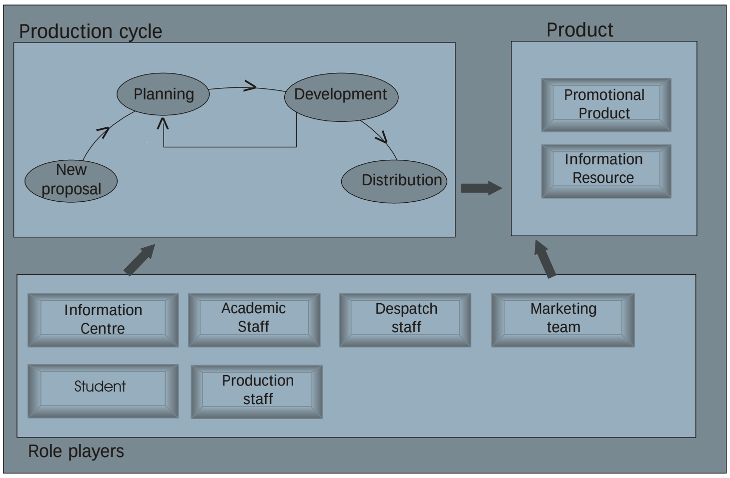


Figure 3.13: The production cycle for a promotion product

There are four phases in the development cycle of the promotional product. The responsible role players propose a new product and after approval, the planning cycle begins. On completion of the planning cycle, the development team develops the proposed product. If problems arise during the development cycle, the team return to the planning cycle to re-evaluate the possible solutions. After development, the product is distributed to the intended market.

The role players involved in the production of a promotion product include the marketing team, with help from academic departments that are familiar with the content of the various courses. The production and despatch staff are involved in the production and distribution of the material. The information centre stocks promotional products for distribution to interested students. Table 3.7 is a cross-reference table to indicate the relationship between the different role players and the production cycle of the promotional product.

Table 3.7: Relationship between role players and the promotional product production cycle

		Production cycle			
		New Proposal	Planning	Development	Distribution
Role players	Marketing team	√	√	√	
	Despatch staff				√
	Academic staff		√	√	√
	Production staff		√	√	
	Student				√
	Information Centrum				√

3.3.2.3.5 Commercial product

A commercial product is a product developed by University staff and after development distributed in the open market as a profitable product. Originally the aim of the product may not have been to generate revenue, but often research *efforts produce a marketable object.* An example of this kind is medication developed as part of research in a university. If the product developed proves to be effective, it may have market value. In such a case institutions may decide to distribute it as a product and to accumulate revenue from it for future research efforts. Figure 3.14 indicates the support infrastructures involved in the development of a commercial product.

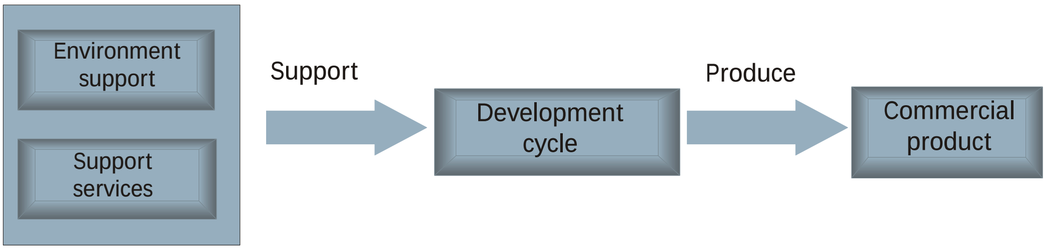


Figure 3.14: Infrastructures used in producing a commercial product

Producing a commercial product involves a new process, namely patent registration. Patent registration often involves complications that require assistance of legal departments. Furthermore, sometimes the university needs to sell the product to a third party because it does not have the infrastructure to support the production of the product or to finance the marketing process. In Figure 3.15, the relationship between the product, role players and production cycle is graphically depicted. The commercial products are divided into seven different categories. A *hardware device* includes items such as robots, computers and alarms. *Software* refers to games, educational products, financial packages or new programming objects. The model category includes a system model or a model for physical devices. Any design sold as a product, e.g. constructing an iconic model of a building or a bridge and selling the design afterwards falls into the *prototype* category. Lastly, the institution produces a number of *printed, visual and audio materials* and markets them as commercial products. Examples include books, tapes or videos on related topics.

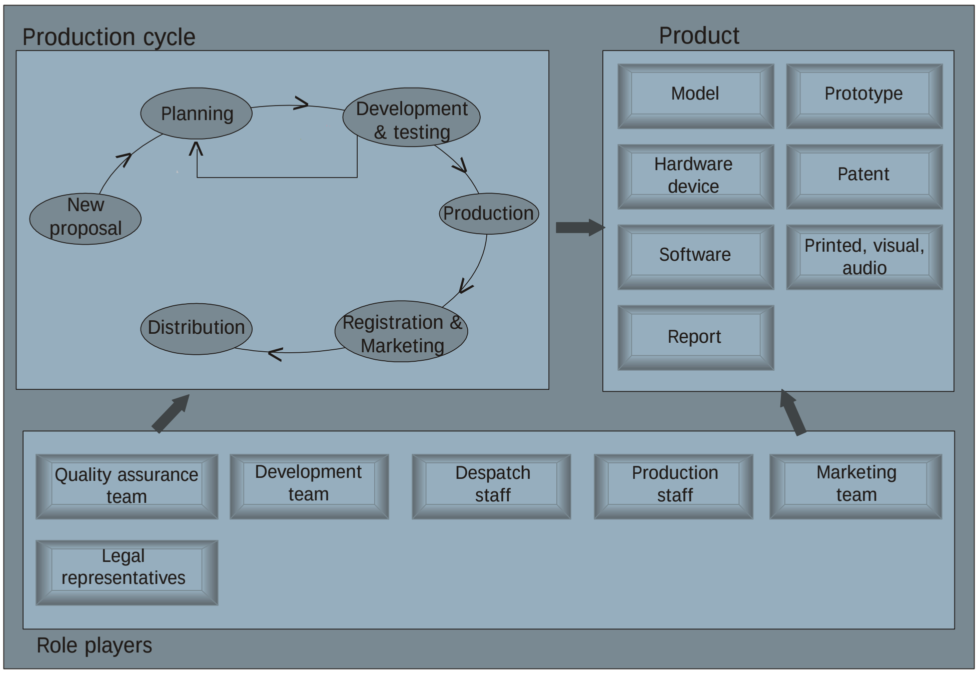


Figure 3.15: The commercial product breakdown

The cross-referencing in Table 3.8 shows the relationship between the role players and the production cycle.

Table 3.8: Relationship between role players and commercial product production cycle

		Production cycle					
		New Proposal	Planning	Development & testing	Production	Registration & marketing	Distribution
Role players	Quality assurance team			√			
	Despatch staff						√
	Development team	√	√	√			
	Production staff				√		
	Marketing team					√	√
	Legal representatives					√	

3.3.2.3.6 Internal report

An internal report is any product that is produced by University role players related to University issues. Reports are mostly for internal use, but distribution of results or findings to external parties does occur. The infrastructures involved in the production of the internal report are the staff support, staff systems and environmental support systems (Figure 3.16).

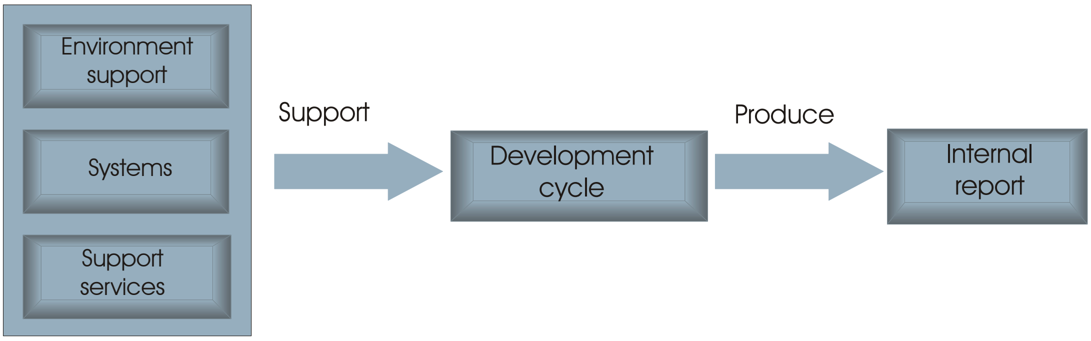


Figure 3.16: Infrastructures involved in the compilation of an internal report

Within the development and distribution cycle of the internal report, the activities may differ from the proposed structure depending on the nature of the report (Figure 3.17). For example, the yearly reports do not have a new proposal each year. Should it be necessary to implement changes, the cycle enters the development cycle at the planning node. The *target field* (Figure 3.17) indicates the field or topic on which the relevant report is providing information.

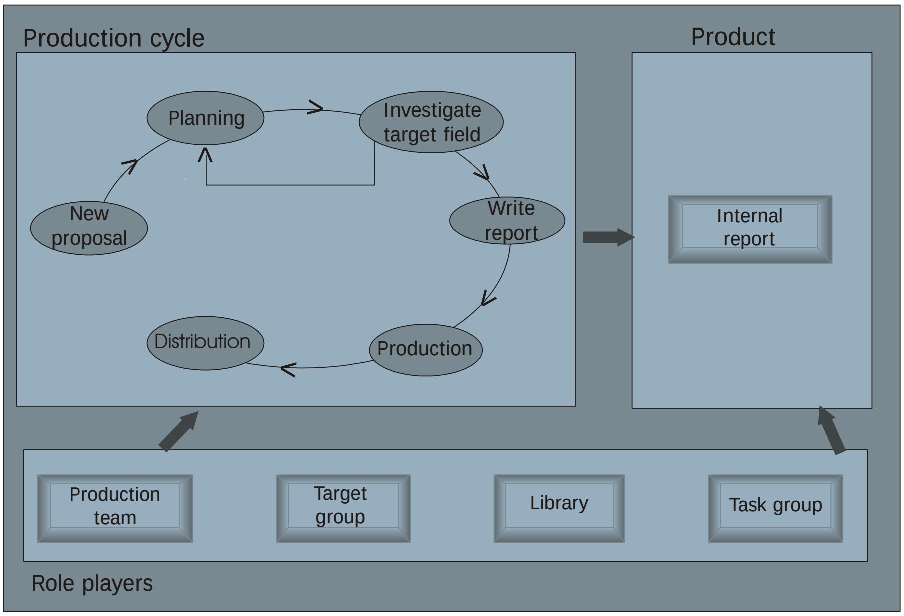


Figure 3.17: The Internal report production

The target group indicated in the role player component includes all the people involved during the data-gathering of information intended for use in the report. For example, in composing an annual report for human research purposes at the university, the target group consists of academic staff and administrative staff.

The production cycle starts with the new proposal followed by planning, investigation, report writing, production and distribution of the report. As mentioned previously, steps within each activity may differ depending on the nature of the report. In Table 3.9, cross-referencing indicates the relationship between the different role players and the production cycle.

Table 3.9: Relationship between role players and report production cycle

		Production cycle					
		New Proposal	Planning	Research target field	Write report	Production	Distribute report
Role players	Task group	√	√	√	√	√	√
	Library			√	√		
	Target group			√			
	Production staff					√	

From the cross-reference table one can clearly see the importance of the task group throughout the production cycle. The library can be included in the information-gathering process or as reference when writing the final report.

3.3.2.4 Management role

Management is not involved in production of any products. The role that management plays in structured analysis is limited to approval and sponsorship of the project (Whitten *et al.*, 2000). The structure for management may differ from institution to institution. It is not our present concern to discuss managerial structures. I acknowledge the importance of the role of management, but embark on my discussion on the basis that management is in favour of re-engineering efforts.

3.3.3 Summary: the university product view

Universities do not usually look at themselves from the production viewpoint, mainly because they do not view themselves as a manufacturing business busy with a production process. In modelling university processes one can use different views, a financial view, system view, instruction view, etc. In this Chapter, the different components and the relationships based on the DEU model were described using a structured analysis approach from a product point of view (Van der Merwe & Cloete, 2002). Cross-reference tables were used to show the relationships between different role players. In Figure 3.18 the relationship between the different role players in the DEU are graphically depicted.

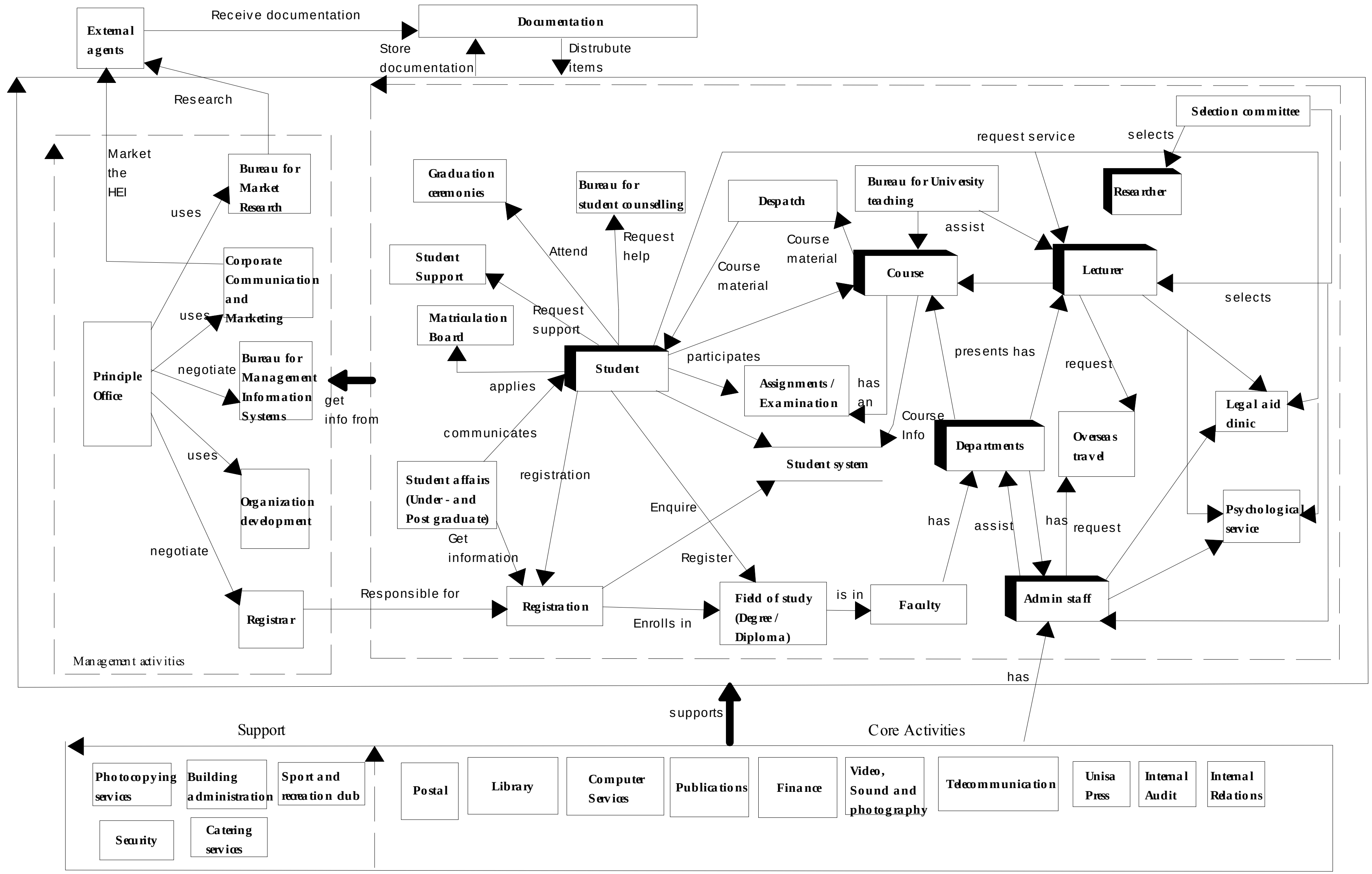


Figure 3.18: Relationship between the different role players in the DEU

3.4 SUMMARY

This Chapter first give a brief overview of the e-learning activities that I was involved in at UNISA, which sparked my interest in this study. In section 3.2 an overview is given of the period during which I was involved as Module Head in the development of course material, which was published as static pages on the web. A full structured analysis is compiled in section 3.3 where the focus was on the use of UML notation in defining a learning environment. The DEU institution was described in section 3.3.2 from an administrative, role player and product perspective.

4. Research Design and Methodology

4.1 INTRODUCTION

The reorganization of higher education needs a disciplined approach to ensure that its application of new technologies is cost-effective and can still improve learning (Laurillard, 1993; Bates, 2000; Ryan *et al.*, 2000). The application of new technologies includes the study of existing processes and the identification of processes ideal for conversion. The purpose of this study was to identify the higher education process model structure, to investigate how the flow within an educational process model can be managed and to discuss the preservation of the higher education process model. There are three research questions defined for this study, including:

1. What is the process model structure of the higher education institution?
2. To what extent is the generic process model structure useful in a re-engineering effort?
3. How can the educational process model be preserved and reused?

The purpose of Chapter 4 is to discuss the research design and methodology followed in order to investigate the research questions. Section 4.2 initiates this discussion with reference to different research approaches available and the reasons for selecting development research for this study. Section 4.3 is the detail discussion of all the different tools and techniques used in this study. Section 4.4 includes some notes on the authentication and trustworthiness of the study, followed by the limitations of the study in section 4.5. Lastly, section 4.6 comments on the methodological costs of the study. The different sections are summarized in Table 4.1.

Table 4.1: Structure for Chapter 4

Section	Topic	Description
4.2	Research approach	Development research is discussed with reference to the three research questions. An overview is given of the data collection techniques used in the study.
4.3	Research design	Techniques and tools used in answering the three research questions.
4.4	Authentication and trustworthiness	Validity, reliability and limitations of the research approach.
4.5	Limitations of the study	What was not included in the study, why not and what the result of excluding it was.
4.6	Methodological cost	What could have been done differently and what are the Methodological costs of doing it in the way that the research was done.
4.7	Summary	An overview of the Chapter.

4.2 RESEARCH APPROACH

The goal of this study is to focus on the identification of the educational process model structure and to investigate the preservation of this structure for future activities such as the re-engineering of the educational processes. All data gathered in a research study reach the researcher either as words or as numbers where the data dictate the methodology (Leedy, 1993). All studies are therefore either qualitative or quantitative.

Quantitative research focuses on numbers where variables are manipulated and natural phenomena are controlled (Leedy, 1993). In contrast, qualitative research focuses more on human being. Meyers (2004) describes qualitative research as 'the use of qualitative data, such as interviews, documents and participant observation data, to understand and explain social phenomena'. This is the data source of the present study, which places it within the qualitative research paradigm.

4.2.1 Selection of a qualitative research approach

Within qualitative research a number of approaches are available. The approaches mostly used in information systems are (Avison *et al.*, 1999; Meyers, 2004):

- Interpretive research.
- Critical social theory.
- Action research.
- Case study research.
- Ethnographic research.
- Grounded theory.

Sections 4.2.1.1 to 4.2.1.6 provide a short description and an example of each of these approaches.

4.2.1.1 Interpretive research

Information systems research can be classified as interpretive if it is assumed that our knowledge of reality is gained only through social constructions such a language, consciousness, shared meanings, documents, tools, and other artifacts (Klein & Myers, 1999).

It is used in cases where the study is mainly a theoretical study with some contradictions and interpretation linked to the research.

A good source for examples and discussions on interpretive research is the special issue in the Journal of Information Technolgy with Micahael D Myers and Geoff Walsham as editors. In this issue, Lee Komito (1998) uses interpretive research in the implementation of an electronic document management system within a government department in the Irish Civil Service (Komito, 1998). The study focuses on meta-information contained in paper case files and how it is important and apparently necessary for the work of the organization. The dependence and confidence on paper files relates not only from the information rich properties of paper documents, but also to the protection of professional/occupational status. Some information only available in paper documents, requiring the interpretation of a specific individual, is defined as essential to do the work properly. This 'reliance' places a restriction on the use of electronic case files (NOTES in this case) as a shared information system, and also reduces the amount of information that can be shared within the organization. The Komoto article argues that only when the perceived threat, posed by the introduction of information system, was lessened in some or other way, would innovation in work practices and improved sharing of information within the organization become a reality.

4.2.1.2 Critical social theory

'Critical social theory can be thought of broadly as covering the interactions between the explanatory, the normative and the ideological dimensions of social and political thought' (*Centre for Critical Social Theory*, 2002). The researcher is mainly involved with social activities.

In a study done by Ngwenyama and Lee (1998) they used critical social theory in focusing on the definition for Information Richness Theory (IRT). According to them IRT has enjoyed recognition by information systems researchers for some time but that unfavorable empirical evidence in the second half of the 1990's,precipitated a shift away from IRT towards a search for a new theory, requiring a new definition of communication richness to succeed the IRT definition. According to Ngwenyama and Lee information systems research on communication richness has since its inception been limited to the perspective of positivism and, and only later became interpretive. In their article they introduce a new perspective to the study of communication richness in computer-mediated communication, namely critical social theory. They outline a critical social theory-based definition of communication richness and compare it with positivist and interpretive definitions of communication richness. They also introduce a critical social-based social action framework for empirical study of organizational communication within the context of the use of media in any situation.

4.2.1.3 Action research

'Action research combines theory and practice (and researchers and practitioners) through change and reflection in an immediate problematic situation within a mutually acceptable ethical framework' (Avison *et al.,* 1999:94). The focus is on what practitioners do where theory is applied with the goal to enhance the theory.

An example is where a requirements elicitation procedure was developed to derive the process model structure of higher educational institutions (Van der Merwe *et al.*, 2004b). The procedure (theory) was defined as a five-phase procedure with deliverables at the end of each phase. In deriving the process model structure the procedure was used at three different institutions where the focus was on what the activities is within a workflow to accomplish specific goals. After each application, the researchers added to the existing theory according to what 'was learned' in the cycle at the institution.

4.2.1.4 Case study

'As a research strategy, the case study is used in many situations to contribute to our knowledge of individual, group, organizational, social, political, and related phenomena' (Yin, 2003:1). In *case study* research the investigator has little control and often focuses on the life cycle.

A very good example of a case study research was done by Markus (1983) in his investigation of theories of resistance to management information systems. According to Markus, three basic theories of the reasons of resistance lie behind many prescriptions and rules for management information systems implementation: (1) their own internal factors, (2) poor system design, and (3) the interaction of specific system design features with facets of the organizational context within which the system is used. The theories differ in their basic assumptions about systems, organizations, and resistance, predictions that can be derived from them, and their implications for the implementation process. In his study, the differences between the theories are described. Data from a case study is used to illustrate the theories, evaluate the theories based on the identified differences, and to demonstrate the superiority, for implementers, of the interaction theory (Markus, 1983).

4.2.1.5 Ethnographic research

'Ethnographic research comes from the discipline of social and cultural anthropology where an ethnographer is required to spend a significant amount of time in the field' (Myers, 1999).

Kvasny (2002) was involved in an ethnographic study for her PhD studies, when she studied community technology centers aimed at promoting greater access to information technology, that are emerging across the USA. Because of the situated nature of the problem, she used ethnographic methods to develop conceptual structures to study the relationships between increased citizen participation in technology-rich environments and improved life chances. She accomplished this by examining a community technology initiative in a historically underserved neighborhood in an urban municipality over an eight-month period. The program began on June 26, 2000, and one year later, there were seven community technology centers located primarily in low income, predominantly African American communities. She found that because information technology engenders a monolithic culture that reproduces and privileges American middle-class competencies and ideologies, it was relatively more foreign to the native culture of the target communities. Consequently, those with the greatest training needs received the least exposure to the technology.

4.2.1.6 Grounded theory

Strauss and Corbin (Strauss & Corbin, 1994) explain grounded theory approach as 'one that is inductively derived from the study of the phenomenon it represents. That is, the phenomenon is discovered, developed, and provisionally verified through systematic data collection, analysis, and theory that stand in reciprocal relationship with each other. One does not begin with a theory, and then prove it. Rather, one begins with an area of study and what is relevant to that area is allowed to emerge'. (Martin & Turner, 1986:141) describe it as an 'inductive, theory discovery methodology that allows the researcher to develop a theoretical account of the general features of a topic while simultaneously grounding the account in empirical observations or data'.

A good example of a grounded research study was done by Orlikowski (1993) with an empirical study into two organizations' experiences with the adoption and use of CASE tools over time. The findings of the study was used to develop a theoretical framework for conceptualizing the organizational issues around the adoption and use of CASE tools, issues that have been largely missing (according to Olikowski) from contemporary discussions of CASE.

Table 4.2 gives a short description of each of these approaches and the characteristics associated with them.

Table 4.2: Research approaches used in information systems (IS)

Approach	Description	Characteristics
Interpretive research	IS research can be classified as interpretive if it is assumed that our knowledge of reality is gained only through social constructions such as language, consciousness, shared meanings, documents, tools and other artifacts (Klein & Myers, 1999).	• Theoretical study. • Contradictions. • Interpretation.
Critical social theory	‘Critical social theory can be thought of broadly as covering the interactions between the explanatory, the normative and the ideological dimensions of social and political thought’ (Centre for Critical Social Theory, 2002).	• Social role. • Social reality.
Action research	‘Action research combines theory and practice (and researchers and practitioners) through change and reflection in an immediate problematic situation within a mutually acceptable ethical framework’ (Avison *et al.,* 1999:94).	• Focus on what practitioners do. • Explicit criteria. • Practitioners and researchers with mutual goals. • Apply theory with goal to enhance. • Cyclic in nature.
Case study	‘As a research strategy, the case study is used in many situations to contribute to our knowledge of individual, group, organizational, social, political and related phenomena’ (Yin, 2003:1).	• Investigator has little control. • Contemporary phenomenon with real-life context. • Study life cycles.
Ethnographic research	‘Ethnographic research comes from the discipline of social and cultural anthropology where an ethnographer is required to spend a significant amount of time in the field’ (Myers, 1999) .	• Active participation. • Observational data. • Social contact with participants. • Extended in-depth study. • Limited to one field study.
Grounded theory	Strauss and Corbin (1994) explain the Grounded Theory approach as ‘one that is inductively derived from the study of the phenomenon it represents. That is, it is discovered, developed, and provisionally verified through systematic data collection, analysis, and theory which stand in reciprocal relationship with each other. One does not begin with a theory, and then prove it. Rather, one begins with an area of study and what is relevant to that area is allowed to emerge’.	• Starts with a phenomenon. • Data sampling should provide for a pluralist perspective on the studied phenomenon (Esteves, Ramos & Carvalho, 2002). • Theoretical account of the general features (Martin & Turner, 1986). • The generation of theories of process, sequence, and change pertaining to organizations, positions, and social interaction (Glaser & Strauss, 1967).

To determine the research approach to this study, the available strategies were matched against the three research questions, using the technique described by Van der Merwe *et al.*(2005) and illustrated in Table 4.3.

Table 4.3: Data collection techniques matched against the research questions

	Characteristics	Research Question		
		1	2	3
Interpretive research	Mainly theoretical study			√
	Contradictions			√
	Interpretation	√	√	√
Critical social theory	Social role			
	Social reality			
Action research	Focus on what practitioners do	√	√	√
	Explicit criteria	√	√	√
	Practitioners and researchers with mutual goals	√	√	√
	Apply theory with goal to enhance	√		
	Cyclic in nature	√		
Case study	Investigator has little control	√	√	
	Contemporary phenomenon with real-life context	√	√	
	Study life cycles	√	√	
Ethnographic research	Active participation			
	Observational data	√		
	Social contact with participants			
	Extended in-depth study	√		
	Limited to one field study		√	√
Grounded theory	Starts with a phenomenon	√		
	Data sampling should provide for pluralist perspective			
	Theoretical account of the general features (Martin & Turner, 1986)			
	The generation of theories of process, sequence, and change pertaining to organizations, positions, and social interaction (Glaser & Strauss, 1967)	√	√	

Evaluation of the criteria list shows that the research can be characterized as an action research problem with some application in the case study domain. The characteristics of action research are similar to those of development research, which is also known as 'experimental' or 'formative' research (Reeves, 2000). For the purpose of this study, we will refer to it as 'development research'. The nature of development research is discussed in more detail in section 4.2.1, which will also introduce the necessary concepts applicable to case study research.

4.2.2 Development and case study research

Van den Akker (1999:8) describes development research as follows: 'More than most other research approaches, development research aims at making both practical and scientific contributions. In the search for innovative 'solutions' for educational problems, interaction with practitioners is essential. The ultimate aim is not to test whether theory, when applied to practice, is a good predictor of events. The interrelation between theory and practice is more complex and dynamic: is it possible to create a practical and effective intervention for an existing problem or intended change in the real world? The innovative challenge is usually quite substantial; otherwise the research would not be initiated at all. Interaction with practitioners is needed to gradually clarify both the problem at stake and the characteristics of its potential solution. An iterative process of 'successive approximation' or 'evolutionary prototyping' of the 'ideal' intervention is desirable. Direct application of theory is not sufficient to solve those complicated problems'.

Development research therefore consists of 'complex, innovative tasks for which only very few validated principles are available to structure and support design and development activities' (Van den Akker, 1999:7). It uses a cyclic approach (see Figure 4.1), according to which the problems are first analysed, solutions are developed with a theoretical framework, the solutions are evaluated and tested in practice, and documentation is produced to reflect on the 'design principles' (Reeves, 2000).

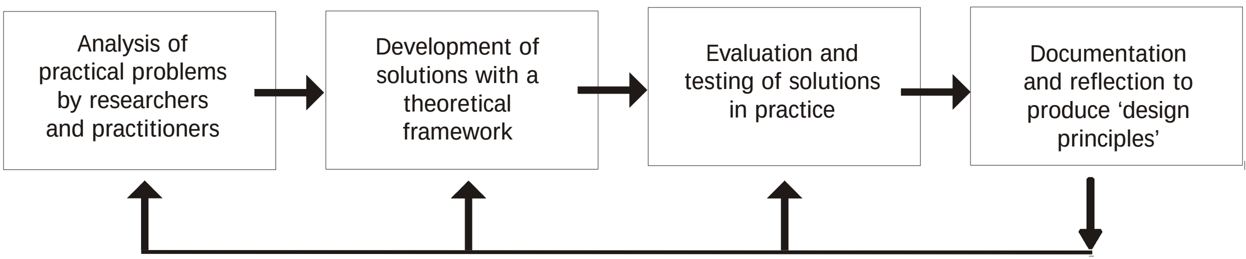


Figure 4.1 : Development research approach (Reeves, 2000:9)

In this study, the cyclic approach suggested by Reeves (2000) was adopted to produce 'design principles'. Brown (1992) and Collins (1992) define the critical characteristics of development research as:

- Addressing complex problems in real contexts in collaboration with practitioners.
- Integrating known and hypothetical design principles with technological affordances to render plausible solutions to these complex problems.
- Conducting rigorous and reflective inquiry to test and refine innovative learning environments as well as to define new design principles.

A short descriptive summary is given of the implementation details for each of the research questions.

The first research question was defined as:

What is the process model structure of the higher education institution?

To answer this question the cyclic approach demonstrated in Figure 4.1 was applied by developing and using a requirements elicitation procedure to analyse different educational environments. The process was first used at UNISA. It was then also used at two other institutions to verify the results obtained at the first institution and to elaborate on the findings in the first cycle. Furthermore, a set of characteristics to which a good requirements elicitation procedure should adhere was identified and the proposed procedure was measured against these characteristics, which map to the last phase in the approach.

With regard to the critical characteristics, the research question addresses complex problems in real contexts in collaboration with practitioners, uses known design principles to find solutions and define new design principles through the definition of a new procedure.

The second research question in this research study was defined as:

To what extent is the generic process model structure useful in a re-engineering effort?

For this question I suggested a process management flow procedure that uses the process model derived in the first research question, to identify process constraints. To comment on the usefulness and to document the design principles derived from this question, the registration process (one of the high-level processes identified in the first research question) was used as a case study environment.

A single case study is appropriate when the researcher asks a *how* question and applies it to a *representative* or *typical* case (Yin, 2003). The goal is to record the circumstances and conditions of an everyday situation, as is the case with using the registration process as a case study. For a business process in the educational domain, it is appropriate to use a case study because it is accepted as a common research strategy in business environments (Ghauri & Grohnaug, 2002) and also, as previously discussed, in information systems (Myers, 2004).

With regard to the critical characteristics, Research Question 2 addresses the study of real-life problems with practitioners in discussing the feasibility of structures identified in this study.

The third research question was defined as:

How can the educational process model be preserved and reused?

For this question the use of an educational process model repository was suggested. Existing theory on process repositories was used as a starting point (Carr, 2003), with minor adaptations to the notation of the model structure and the use of polymorphism in specializations. The registration process was used in discussions on the feasibility of the adapted model structure and the preservation of the structure in a repository.

With regard to the critical characteristics, for Research Question 3, the focus was on the reusability of the structures and the theoretical abstraction of an existing solution for preservation was scrutinized and suggestions made to enhance theory.

4.2.3 Data collection techniques

In qualitative research the researcher is involved in data collection, analysis and reporting (Yin, 1994). Furthermore, he is responsible for analysis and synthesis activities to understand the interaction of variables in a complex environment (Leedy, 1993). This study included both activities, firstly by using sound methods to derive process models (analysis) and secondly in using these models to derive meaningful contributions (synthesis) to the knowledge base on the structure of HEI.

A combination of data collection techniques can be used to answer the research questions defined. The intention of data collection is to record current practices. The data collection techniques commonly used in information systems include interviews, observation, contextual analysis, Joint Application Development (JAD) and questionnaires (Dennis & Wixom, 2000). JAD sessions, in which the project team, users and management team work together to do an analysis of the problem domain and to find solutions to problems, were not a feasible option for data collection. The project was done as a research study at UNISA and not a development project. Had the latter been the case, JAD sessions would have been an option for data-gathering.

Six data collection techniques were used in this study: four established techniques and two new techniques. The four from established data collection resources that were used include interviewing, observation, contextual analysis and a check list (in the form of a questionnaire)

(Dennis & Wixom, 2000). A short overview of the four techniques is given in sections 4.2.2.1 to 4.2.2.4. In each of the case studies in section 4.3.1.3, more detail is given on the specific data collection technique used in the phase accompanied by examples. The two new techniques developed, the requirements elicitation procedure and process management flow procedure, are discussed in section 4.3.1 and section 4.3.2 respectively. Table 4.4 gives an overview of the data collection techniques, with the six techniques listed in the first column and an indication of where each data collection technique was used in the last three columns.

Table 4.4: Research subquestions and data collection techniques used for each question

Techniques	Focus	Question 1	Question 2	Question 3
Interviewing	Structured interviewing	√	√	√
Observation	Non-participant observations	√	√	
	Participant observation	√	√	
Contextual analysis	Contextual analysis	√	√	√
Checklists	Structured, self-administered checklists		√	
Requirements elicitation procedure	Derive process models	√		
Process management flow procedure	Identify constraints within the education process model		√	
Educational process model repository	Preserve process models for future reuse.			√

Interviewing and contextual analysis were used for all three research questions. Observation, checklists and the process management flow procedure were used for Research Question 2. Observation and the requirements elicitation procedure were used for Research Question 1.

4.2.3.1 Interviews

The data collection techniques used relate to the 'implicit' role of the qualitative researcher, where the bulk of the data was collected by means of in-depth discussions or interviews with a number of informants. These discussions were based mainly on personal or telephonic interviews, but asynchronous e-mail was also used to collect data. In conducting the interviews, an interview guide was used but, in accordance with recommendations by Seidman (1991), the conversation was often initiated by the researcher after which the interview was allowed to flow naturally, using the interview guide only if the conversation dried up or when it was felt that the conversation was no longer on track. For the interviews held with the different role players, the information was captured using interview templates or field notes.

4.2.3.2 Observation

Observation was another data collection technique used and it consisted of either participant or non-participant observation. For selected processes non-participant observation was used, where the observer watches the situation, openly or covertly, but does not participate (IDRC, 2004). For example, in collecting information within the institution on a physical process such as production where the flow of processes from one activity to another could be viewed, non-participant observation, combined with interviews, was used to construct the process model. Participant observation was also used in collecting information on some of the activities in the institution. In participant observation, the observer takes part in the situation he or she observes (IDRC, 2004). Course development is a process in which the researcher was involved in the development cycle of the processes as an observer. The data was captured using field notes.

4.2.3.3 Contextual analysis

Contextual analysis was done firstly for background purposes and reported on in Chapter 3. Furthermore, it was also used as a data collection technique in retrieving data from existing documentation, in order to answer the research questions. For example, one of the steps in the requirements elicitation procedure was to define the different units in an institution. The collection technique used was to consider existing documentation at the institutions, such as telephone lists and organograms, in order to be able to identify the different units.

4.2.3.4 Structured checklists

Structured checklists are a data collection method used by researchers to obtain more detailed information, where the goal is to use the information to do some form of statistical analysis. For this study, a checklist was designed as a tool to determine what the level of electronic activity is in the registration process.

4.3 RESEARCH DESIGN

Process models are used in different application domains to model the flow within the organization. Process models may be used for different purposes, e.g. to facilitate human communication and understanding of a specific domain, support process improvement, support process management, etc. (Curtis *et al.*, 1992).

My goal in investigating the nature of process models for the educational domain is:

- To establish the generic high-level process model of the higher education environment (Chapter 5).
- To investigate the usefulness of the generic high-level process model in a re-engineering activity (Chapter 6).
- To investigate the feasibility of the use of process repositories for preservation of the process models (Chapter 7).

In the remainder of this section, the research design for the three research questions is defined. Section 4.3.1 addresses the research design for the first question: *What is the process model structure of the higher education institution?* is addressed.

4.3.1 The educational process model structure

Three subactivities were identified for the establishment of the educational process model structure. The subactivities include:

- The development of a requirements elicitation procedure (section 4.3.1.1).
- The identification of a set of characteristics to which a requirements elicitation procedure should adhere (section 4.3.1.2).
- The application of the requirements elicitation procedure to different application domains in order to carry out the data collection (section 4.3.1.3).

4.3.1.1 The requirements elicitation procedure

The research design for the requirements elicitation procedure is discussed in three subsections, the development thereof, the characteristics of a requirements elicitation procedure and the data collection at the different institutions. This section address the first of the three subsections, namely the development of the requirements elicitation procedure (highlighted in yellow in Figure 4.2).

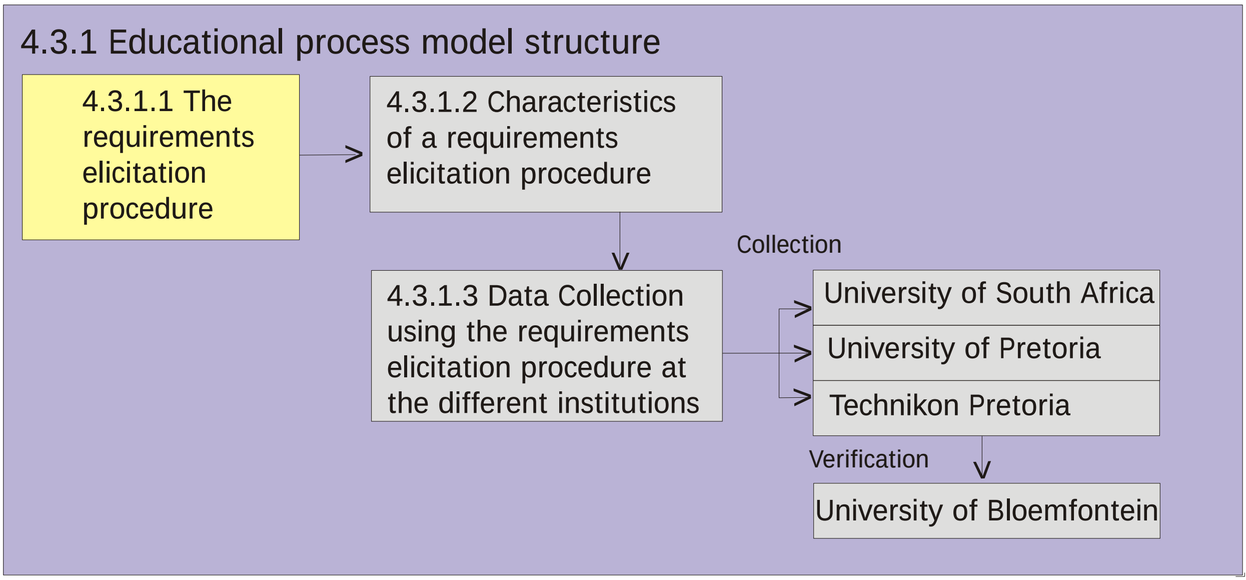


Figure 4.2: Research design: The educational process model structure

The development of the requirements elicitation procedure is discussed according to the method used to develop the procedure (section 4.3.1.1.1), the phases of the procedure (section 4.3.1.1.2) and the tools and deliverables of each phase (section 4.3.1.1.3).

4.3.1.1.1 Development of a requirements elicitation procedure

Modelling is a well-known technique used in different application domains to describe the processes and dynamics involved in a system. Various requirements elicitation procedures exist in the business application domain for collecting data and for constructing process models (Borja *et al.*, 2000; Van der Aalst, Desel & Oberwies, 2000; Belmiro & Pina, 2001; Van der Merwe *et al.*, 2004b). Similarly, a number of techniques are available in software engineering to construct models of the software application domain (Pressman, 2000; Whitten *et al.*, 2000) None of these are, however, focused on the higher education problem domain. A procedure was needed that could be used to establish the high-level process model and submodels for the higher education environment. The absence of such a procedure led to this research to develop a requirements elicitation procedure for the identification of process models in the higher education application domain.

The requirements elicitation procedure was developed at UNISA. This institution was selected for the following reasons:

- UNISA is an established DEU, which is an ideal environment to test the implementation of technology to enhance the institution's service to the student population. In 2004 UNISA was involved in presenting 4402 courses to approximately 160000 students.
- As an academic staff member I was involved in the implementation of different technologies at UNISA. This provided me with the ideal opportunity to use UNISA as a case study environment to develop a requirements elicitation procedure.

As mentioned previously, the goal was to gain a complete understanding of the critical processes (and their subprocesses) in the application domain. This understanding was possible through the identification of the different core processes, subprocesses and the work flow between them.

The development process included different activities. The first activity included the study of existing requirements elicitation methods and techniques. This activity was followed by the identification of existing formal requirement elicitation methods currently used at UNISA. It was found that a number of different requirement elicitation methods are used at the institution to gather information for specific projects, e.g. for course design and computer systems development. However, the methods used at the institution focused on different problem domains and none was found with the specific goal of identifying the core processes (and subprocesses) in the institution.

Before the different processes and the flow between them could be modelled, a list of them was needed. Subsequently, my first task was to compile a list of all the processes within the institution. After listing all the processes that could be identified from the resources, a course of action was required to ensure that the process list included all possible processes. The institutional structure was consulted and representatives identified in each unit (also known as a department/bureaux/institutes/centres/sections) to compare the list with their own list of responsibilities (processes within the unit). Any processes neglected in the first round of process identification were added after this activity.

The next step was to group processes together to distinguish between core processes and subprocesses. In the grouping process, processes that belong together were categorized together. For example, the atomic activities (activities that cannot be broken down into sub-activities) *answering student e-mail* and *answering postal queries* were grouped together under a higher-level process, namely *answer student queries.* The identification and categorization of these processes led to the identification of a core list of high-level processes as presented in Chapter 5

4.3.1.1.2 The phases of a requirements elicitation procedure[8]

The procedure consists of 5 phases, namely (Figure 4.3):

- Phase 1: Establish objectives.
- Phase 2: Identify critical institutional units.
- Phase 3: Identify primary processes.
- Phase 4: Construct the high-level process model.
- Phase 5: Refine the high-level processes and determine the subprocesses (Van der Merwe *et al.*, 2004b).

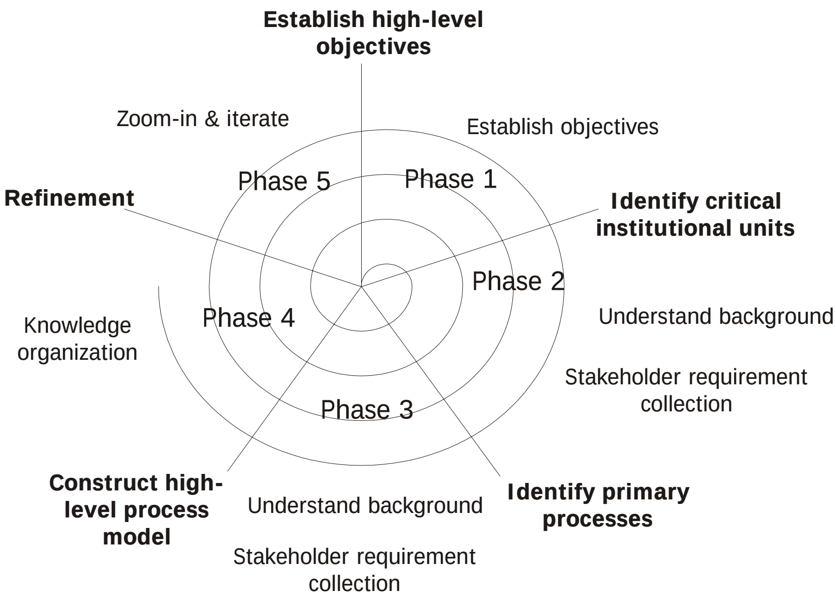


Figure 4.3: Proposed requirements elicitation procedure (Van der Merwe *et al.*, 2004b)

Figure 4.3 shows the phases of the procedure as a spiral model, in which the different phases are not discrete activities, but are interleaved and may be revisited more than once to build a complete high-level process model. In the remainder of this section each phase will be

[8] The requirements elicitation procedure discussed above was formalized and presented at the Seventh World Conference on Integrated Design and Process Technology (Cloete, Van der Merwe, Petorius, 2003). The paper was selected as one of the best papers and subsequently published in the September issue of the International Journal of Integrated Design & Process Science (Van der Merwe *et al.*, 2004b).

described, followed by a sample list of documentation / tools and the deliverable used for each phase.

Phase 1: Establish objectives

In Phase 1, the requirements engineering team, in co-operation with stakeholders, compiles a detailed description of the higher-level purpose of the requirements elicitation exercise. As the higher-level purpose focuses on approval for the adoption and integration of new systems affecting the entire organization, the stakeholders at this stage usually comprise members of the management of the institution. If management does not launch the requirements elicitation initiative, it is at least essential that approval and collaboration commitment be secured before continuation. This is necessary because one of the primary causes of unsuccessful or rejected projects is the failure to establish upper-management commitment to these projects (Singh, 2000; Whitten *et al.*, 2000).

The deliverable of the first phase is a descriptive document acting as a framework available for future reference and verification purposes. A document of this nature includes a short description of the objective(s) as well as a clear specification of the required deliverables. Typically, it includes a single primary objective supported by one or more secondary objectives. A primary objective rationalizes the reason for performing the requirements elicitation exercise, acting as guidance throughout the elicitation exercise and also during the development and deployment of the intended systems. A lack of awareness of the primary goal might cause the requirements engineering team to deviate from their task unnecessarily, leading to expensive time delays. The secondary goals serve as a refinement of the primary goal and often also embody constraints within the application domain.

Tools / documentation used in phase: Notes on objectives.

Deliverable: A descriptive goal statement (example of a template is given in Table 4.5).

Table 4.5: Empty goal statement

Project name : __________________________ Compiled on (Date): _____________________ Compiled by (Stakeholders): ______________________________ Primary goal description: ______________________________ Deliverables for primary goal: 1) _________________________________ 2) _________________________________ Subgoal (if any): ______________________________ Deliverables for subgoal: 1) _________________________________ 2) _________________________________ ..

Phase 2: Identify critical institutional units

As stated earlier, the objective is to identify the critical processes in the higher education application domain in order to examine their essential activities and work flow. In Phase 2, the goal is to identify the different critical units in the institution. As a first step, all the units in the institution are listed – this can be done by retrieving information from documentation and diagrams such as organizational diagrams or through interviews. The second step involves extracting those units that are actively involved in the creation and presentation of learning environments. Units focusing on other aspects of the institution are then labelled as *support units* and are deleted from the unit list. For example, the Catering Services Department prepares refreshments but is not responsible directly for, or involved in the learning environment, and will therefore be removed from the unit list. The deliverable of Phase 2 is a listing of the critical operational units of an institution.

Tools / documentation used in phase: Unit list (example of an empty unit list is given in Table 4.6).

Table 4.6: Unit list template

Academic units		Involved in learning and teaching activities	
Unit name	Short description of main responsibility	Yes	No
Non-teaching units		Involved in learning and teaching activities	
Unit name	Short description of main responsibility	Yes	No

Deliverable: Critical list (example of an empty critical list is given in Table 4.7).

Table 4.7: Critical unit list template

Unit name	Short description of main responsibility	Unit name	Short description of main responsibility

Phase 3: Identify primary processes

In the next three phases a formal approach is suggested to identify the relevant processes. In the case of small institutions, the identification of core processes and follow-up results is generally simple, but the complexity often increases dramatically with the size of an institution. The use of a formal approach to describe a specification provides developers with the means to:

- Accurately and concisely present the detail.
- Unequivocally express the interpretation assigned to specific aspects.
- Make the different results portable, reusable and extensible.
- Be both operational and expressive (Kotze & Cloete, 2004).

A distinction is drawn between *primary* and *support* processes in the application domain. *Primary processes* are those critical activities responsible for (or involved in) the design and construction of the student's learning environment. *Support processes* are those processes that provide sustenance for the primary processes playing a secondary role in accomplishing the defined goal. The purpose of Phase 3 is to identify the primary processes in each of the critical units of the application domain.

The Process Model Inc. (1997) suggests that identification of primary or core processes is a first step towards constructing a process model. Porter (1985) identifies five primary activities in the business environment contributing to the value of businesses. The activities include inbound logistics, operations, outbound logistics, marketing and sales, and services. Applying the fundamentals of his work to the educational application domain yielded a list of primary processes applicable to this domain. This list should be considered only as a starting list since modifications or expansion might be necessary to describe the application domain correctly and completely. The elements of the starting list include:

- The registration process (REGISTRATION).
- Development of course material (COURSE DEVELOPMENT).
- Production (PRODUCTION) of course material. At residential universities, this activity is often embedded in the development of course material and is the responsibility of lecturers. At distance learning institutions it is a separate process and is handled by sections responsible for production of the material.
- Distribution of course material (DISTRIBUTION).
- Academic support available to the student (ACADEMIC STUDENT SUPPORT).

The following steps can be used to expand the above list and to verify its adequacy and completeness. These steps should be applied to the unit list created in Phase 2, and repeated for each of the units.

1. List and document the most important processes of the particular unit in order to establish the main duties within it. The focus is on the goals to be achieved rather than on the individual activities that might realize these goals. A general guideline is to include *what-processes* rather than *how-processes*. A *what-process* is goal-oriented in its description, expressing the objective of the particular process, while a *how-process* is action-oriented, explaining the particulars of specific activities to accomplish the specified goal.
2. Categorize each process as either being a support or a primary process using the definitions provided above.
3. Attempt a mapping of each of the newly identified primary processes to an item on the starting list. A process list is created from items on the starting list that correspond to primary processes through their mappings, whilst primary processes that cannot be mapped are added as new items on the process list.

The deliverable of Phase 3 is a process list consisting of a set of the identified primary processes (P), namely $\{P_k\}_{k=1}^{m}$ with $k, m \in \mathrm{N}$, where m denotes the total number of processes for all critical operational units.

Eriksson & Penker (2000) comment that it is unusual, even for a complex environment, to have more than ten primary processes and they advise modellers to identify only between five and ten primary processes portraying the high-level duties that add value to an organization. In the case of more than ten processes, it is advisable for the development team to reconsider individual items on the process list and, where possible, combine items with close associations. A model with too many processes is complex to interpret and as a result loses some of its functionality intended to improve understanding (Eriksson & Penker, 2000).

Tools / documentation used in this phase:

- The expanded critical unit list from Phase 2 with all the critical units as well as the different activities within each process as illustrated in Table 4.8.

Table 4.8: Units and processes

Unit	Processes

- The starting list suggested by the requirements elicitation procedure as in Table 4.9.

Table 4.9: Primary process starting list

Process
REGISTRATION
COURSE DEVELOPMENT
PRODUCTION
DISTRIBUTION
ACADEMIC STUDENT SUPPORT

- A mapping tool linking the processes and the starting list elements as illustrated in Figure 4.4.

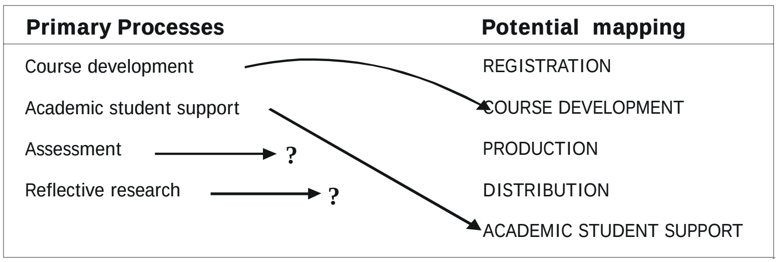


Figure 4.4: Mapping primary processes to starting list

- The process list with all the processes listed as illustrated in Table 4.10.

Table 4.10: Process list

Units	Process	Primary/Support	Mapping

Deliverable: From the process list in Table 4.10, all the support processes are left out of the list so that the list includes only the primary processes P_k. An example of the primary process list is given in Table 4.11.

Table 4.11: Primary process list

	Process
P_1	REGISTRATION
P_2	COURSE DEVELOPMENT
P_3	PRODUCTION
P_4	DISTRIBUTION
P_5	ACADEMIC STUDENT SUPPORT
:	:
P_m	

Phase 4: Construct the high-level process model

Process modelling presents a technique (involving several activities) to graphically depict the series of processes that accomplish a predefined goal (Curtis *et al.*, 1992; Snowdown, 2002). A *process model* is a *structure* that represents a group of processes and their relationship to one another, together accomplishing a specific goal. A *high-level process model,* on the other hand, is defined as the structure depicting all the *primary processes* and their relation to one another to accomplish the high-level objectives of the modelling exercise. From this explanation, it is apparent that for a specific application domain, there is one high-level process model only and possibly several smaller subprocess models to augment and refine the high-level process model. To achieve the said objectives, the procedure involves not only the activities to create a high-level process model, but also the essential subprocess models.

There are a number of significant elements that are used to depict a particular process, and different process modelling methodologies suggest different significant elements all depending on the specific application domain. Wang (1999) describes different elements for a process model, including an activity, a task, input/output, roles and a user. Eriksson and Penker (2000) provide a higher abstract of these elements to include the process itself, process resources and the goal description of the process. Process resources can either be *input* or *output* resources. An *input resource* is used to assist in the flow of process activities. For example, in a student registration process, the registration form (input) is used (initially) to capture the student information. An *output resource* is the resulting output of the activities in a specific process, and in turn might serve potentially as an input resource to another process. Each process has at least one input resource and one output resource associated with it. The first construction step towards the high-level process model is to define the goal, input resources and output resources associated with each item on the process listing created in the previous phase. At the end of this step, a set of all the resources *R,* for primary processes of the application domain can be described as $\{R_j\}_{j=1}^{n}$ with $j,n \in \mathrm{N}$, where *n* is the total number of resources. Furthermore, the set of goals, G, are defined as $\{G_i\}_{i=1}^{p}$ with $i,p \in N$ and where p is the total number of goals for the institution.

The second step is to indicate the work flow between the different primary processes through input and output resources. This task remains simple as long as there is only a small number of primary processes to consider and can be done by simply connecting related processes through directed lines. However, as the number of primary processes increases, the complexity of depicting the work flow also increases considerably. In such a case, a more formal approach is suggested to establish relationships between primary processes.

The objective is to identify the resources that serve as both input and output resource for the different processes and then eliminate redundant resources (those resources that would appear more than once on the same process model diagram). To identify these resources, determine the association value (say A) that a resource R_j has with a process P_k (for all j and all k). These association values A may be an input (I), output (O), or *no* association (Null). Each value is stored as an entry in an association list, which tabulates vertically all processes from top to bottom and tabulates horizontally all resources from left to right.

The following steps assist in indicating the work flow and associations between the different processes and as a result describe the high-level process model.

- For k = 1..m and j = 1..n, describe all the resources (R_j) in terms of their association values A with P_k. This is written as a triple $T_{kj} = (P_k, R_j, A)$ where Null values can be ignored.
- For k = 1..m, graphically depict P_k on a diagram with its associated goal.
- For j = 1..n, add the identified resources, R_j to the diagram.
- Use the set of triples (identified in 1), in particular the third coordinate, A, to add directed lines between processes and resources.

The output of these steps is the high-level process model for the application domain. For example, for a process P_1 = *Get Student Name* the input resource is R_1 = *Student Number* and the output resource is R_2 = *Student Name.* The association table is given in Table 4.12.

Table 4.12: Association T_{kj} table example

	Student Number (R_1)	*Student Name (R_2)*
Get Student Name (P_1)	I	O

The value for T_{11} is (P_1, R_1, input) and for T_{12} is (P_1, R_2, output). The process model for this set of values, with the goal defined as *Obtain Student Information,* is given in Figure 4.5.

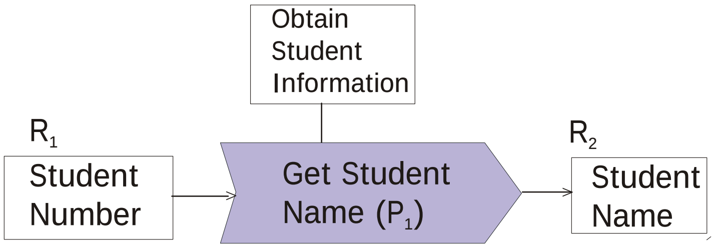


Figure 4.5: Process model for process-resource example in Table 4.12

Tools / documentation used in phase:

- The expanded process list from Phase 3 with all the primary processes, associated goals, and resources (template example for REFLECTIVE RESEARCH and COURSE DEVELOPMENT as illustrated in Table 4.13).

Table 4.13: Process list with goals and resources

Process (P)	Input/output resources (R)	Goal (G)
REFLECTIVE RESEARCH	Input: Research & other material Output: Research Report Output: Research Publication	Research a specific field
COURSE DEVELOPMENT	Input: Research Report Output: Study Material[9]	Develop study material

- The association list linking the resources and the processes as illustrated in Table 4.14.

Table 4.14 : Association table example

	Student Number (R_1)	*Student Name (R_2)*
Get Student Name (P_1)	I	O

- The triple list used to derive the high-level process model. Table 4.15 gives a few examples of triples that portray the relationship between a resource and the process.

Table 4.15: Triple list

Triples
(P_1, R_1,input)
(P_1, R_2,output)
(P_1, R_{12},input)
(P_2, R_3,input)
(P_2, R_2,input)
(P_3, R_4,input)

[9] Study material is any course material used in the educational environment, e.g. tutorial letters and study guides.

Deliverable: The triple list compiled (similar to the one in Table 4.15) is used to derive the high-level process model. An example of a process model was presented in Figure 4.5.

Phase 5: Refine the high-level processes and determine the subprocesses

As mentioned earlier, a complete understanding of the application domain is depicted through a single high-level process model with several smaller (sub) process models to accomplish the intended goal. The purpose of the refinement phase is to decompose and particularize the individual processes in the high-level process model through iterative steps into a set of subprocesses or *atomic* activities. An *atomic activity* is a process that cannot be broken down into further subprocesses. The steps to derive the atomic activities (or subprocesses) are similar to those described in the previous phase for the high-level diagram:

For each primary process (which will be a subprocess during further refinement), identify the set of affiliated subprocesses involved in the generation of its output resource(s).

- For each subprocess, define its associated goal, input and output resources.
- Associate the subprocesses with one another through input and output resources as described in Phase 4.
- Draw the process model, which depicts the subprocesses and their relationships graphically.

Repeat these steps for each of the identified subprocesses until all processes are atomic *or* the requirements engineering team decides against further refinement. The deliverable of this step is a set of smaller subprocess models augmenting the high-level process model.

Tools / documentation used in this phase:

- The expanded subprocess list with all the subprocesses for the selected primary process, associated goals, and resources (template example for REFLECTIVE RESEARCH and COURSE DEVELOPMENT in Table 4.13).
- The association list linking the resources and the processes (example in Table 4.14).
- The triple list used to derive the high-level process model (similar to the ones used in Phase 4. An example is given in Table 4.15).

Deliverable: From the triple list compiled as illustrated in Table 4.15, the subprocess model is derived.

For example, given Figure 4.5, two subprocesses can be defined to support the main process *Get Student Name,* say *Retrieve Student Info* and *Filter Student Name*. The breakdown of the process into two subprocesses creates a new subprocess model, depicted graphically in Figure 4.6.

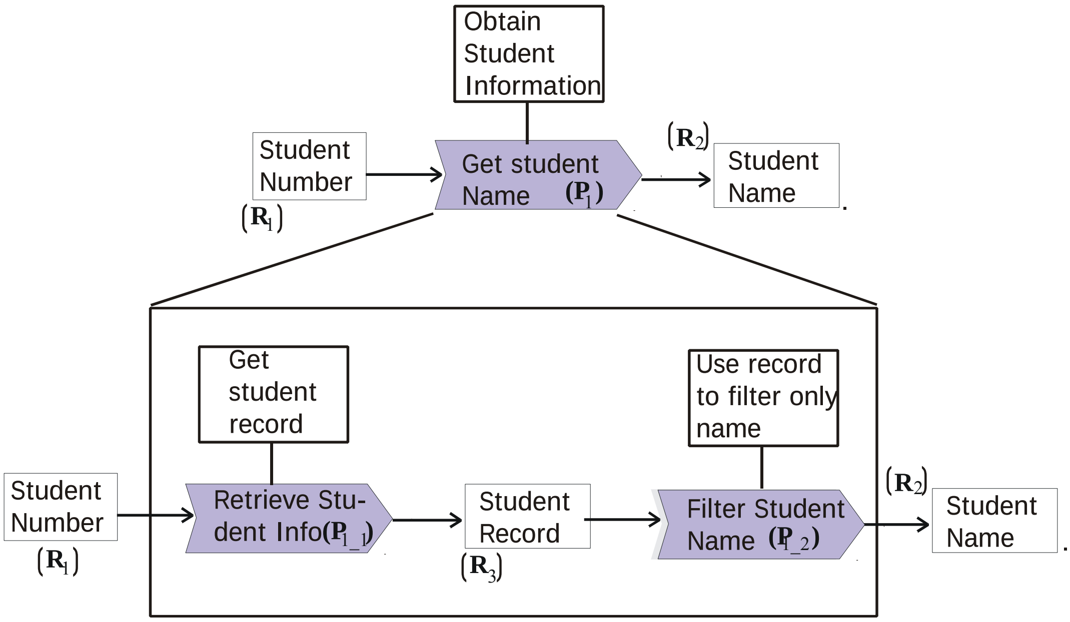


Figure 4.6 : Process model for process-resource example in Table 4.12

4.3.1.1.3 Tools and deliverables

Each phase in the requirements elicitation has a set of tools or documentation that assist the development team in finding the deliverable for the phase. At the end of each phase a sample template was given of the tools and deliverables of the specific phase. In Table 4.16, a summary of all the tools and deliverables is given for all the phases. The list may be used in future re-engineering activities, e.g. for identification of the constraints (section 4.3.2) and to use as a control document to ensure that the necessary documentation is compiled during the different phases of the procedure.

Table 4.16: Tools and deliverables for the requirements elicitation procedure

Phase	Phase description	Tools / Documentation	Deliverable
1	Establish objectives		Goal statement
2	Identify critical units	• Unit list	Critical units
3	Identify primary processes	• Unit -> Process list • Starting list • Mapping tool • Process list	Primary process list
4	Construct the high-level process model	• Process list with goals and resources • Association options • Association triple list with processes and resource options	High-level process model
5	Refine the high-level process model to subprocesses	• Subprocess list • Process list with goals and resources • Association list • Association triple list with processes and resource options	Subprocesses

The following information is represented in Table 4.16:

- For the establishment of the objectives in Phase 1, the deliverable is the *objective statement* giving a description of the objectives.
- For Phase 2, the identification of the critical units, the development team compiles a *unit list* and the description of each unit to eliminate from the list the units that are not critical in teaching and learning activities. This phase produces a *critical unit* list as a deliverable.
- In Phase 3, the *critical unit list is extended* to give a description of the activities in each unit on the list. This list is used to map the activities to the primary process starting list provided, using the *mapping tool* described in the procedure. The output is a *process list* from which all support activities are eliminated so that the development team is left with only the deliverable of the phase - the *primary process list*.
- For Phase 4, the *goal, input and output resources* are defined for each of the processes on the primary process list. From this list the *association list* is created that shows the relationships between processes through input and output resources. A *set of triples* is compiled, which is used to derive the *high-level process model*.
- In Phase 5 the development team defines for each process (or the process focused on) the *list of subprocesses* and repeats the activities in Phase 4 for this subset of processes (unless all processes are atomic or the development team decide not to do further refinement). This will produce the subprocess model for the selected process.

4.3.1.2 *Characteristics of a requirements elicitation procedure*

This section, addresses the different characteristics that a requirements elicitation procedure should adhere to are identified and listed. In Figure 4.7, this activity is emphasized in yellow.

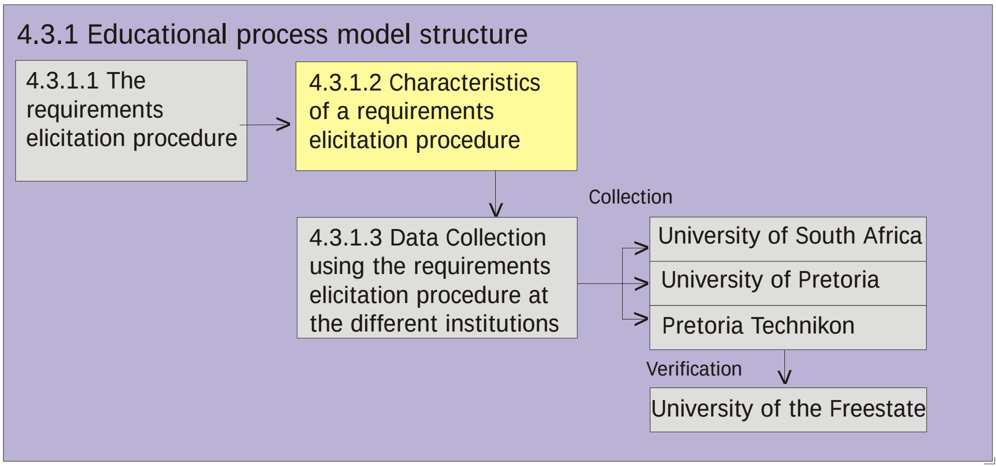


Figure 4.7: Research design: requirements elicitation characteristics identified

Requirements elicitation and process modelling exist within cyclic methodologies that have the aim of developing software, or re-engineering current environments (Pressman, 2000; Hickey & Davis, 2003). A requirements elicitation procedure with the aim of producing process models of the higher education domain should adhere to characteristics found in similar procedures. This section comprises an overview of the characteristics identified that a requirements elicitation procedure should adhere to, followed by a discussion on the application of the procedure in three different HEI domains (see section 4.3.1.3).

Although various authors propose different steps in a requirements engineering process, the core of these methodologies includes (Macaulay, 1996; Sommerville & Sawyer, 1997; Hickey & Davis, 2003):

1. A feasibility study.
2. Requirements elicitation.
3. Requirements modelling.
4. Triage.
5. Verification.
6. Cross-phase activities.

The requirements elicitation procedure developed focus on elicitation, modelling and cross-phase activities (Figure 4.8).

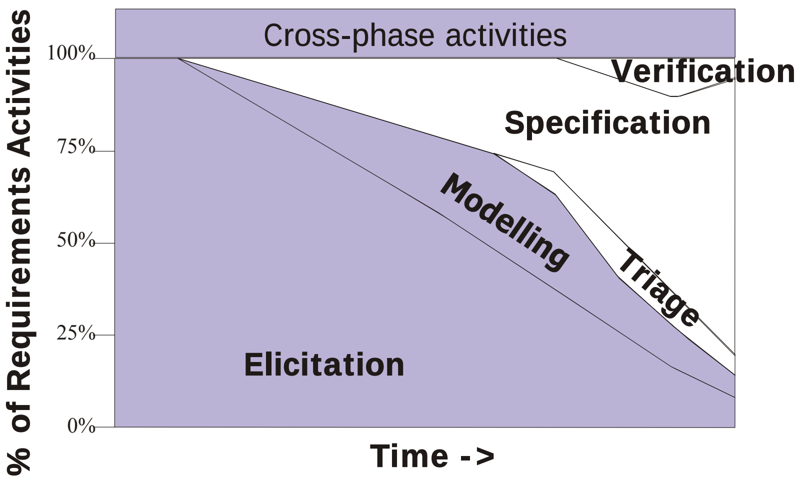


Figure 4.8: Requirements elicitation activities (adapted from Hickey & Davis (2003))

An extensive literature review conducted revealed no information that described the characteristics of a requirements elicitation procedure with the aim of producing process models for the HEI domain, or any other domain as a matter of fact. A literature review was then conducted on existing characteristics for requirements elicitation, process modelling and cross-phase activities for other domains, in order to derive a characteristic list for a requirements elicitation procedure for the HEI domain[10] (Van der Merwe *et al.*, 2004a). Twenty-six of the resources consulted, mentioned useful characteristics (Appendix 4, Table 1, on the accompanying CD). After a number of cycles of identification of characteristics and working through references, maturity occurred with fifty-eight characteristics identified (Appendix 4, Table 2, on the accompanying CD). After several more cycles, the data become saturated and no new characteristics were added to the list.

Some of the characteristics identified as important for requirements elicitation belonged to other activities that the requirements elicitation procedure developed do not focus on, for example the feasibility stage. These characteristics were not relevant to the elicitation stage in the requirements elicitation procedure developed and therefore were removed from the list, which result in a list of characteristics that were relevant only to this study., namely the

[10] The characteristics and the way that the requirements elicitation procedure adheres to them were presented in July 2004 at SACLA 2004 (Van der Merwe, A., Cronje, J. & Kotze, P., 2004a).

requirements elicitation, modelling and cross-phase activities. Characteristics with the same meaning were merged so that the end-list consists of a total of fifty characteristics. As a last step, the characteristics that belong naturally together were grouped into subphases. The characteristics and the phases that they were grouped into are given in Appendix B, Table B2, on the accompanying CD. The characteristics identified are summarized in Table 4.17.

Table 4.17: List of characteristics

	Subphase	Characteristic
All Phases	Support	Provide automated support for the requirements elicitation process
	Standards	Provide standardised ways of describing work products
		The precision of definition of its notation
		Process model standards
	Techniques	Select appropriate technique for the problem domain
		Use of use cases to describe related tasks
		Support a systematic step-by-step approach
		Modifiable solutions and be iterative in
	Documentation	Support documentation of requirements
	Maintenance	Procedures for maintaining work products
	Conflict	Conflict negotiation
Requirements elicitation	Specification	Requirement completeness
		Requirement relevance
		Expectations during specification of requirements
		Correctness
		Communication during specification of requirements
		Requirement accuracy
		Importance of necessity: requirements document
		Level of control over specifying requirements
	Boundaries	Specify constraints / boundaries
	Problem analysis	Support analysis
		Degree of understanding of the task and process
	Data-gathering	Support data-gathering techniques
	Client/customer	Support customer/client involvement
Requirements modelling	Support modelling	Motivation to support modelling
	Goal Modelling	Model the purpose by describing behaviour
	User involvement	Reflect the needs of customers / users
	Modelling	Model business rules
		Support modelling of work flows
		Clarity of business process
		Model system services
		Systems architecture modelling

For some of the characteristics identified, it was only possible to indicate whether the requirements elicitation adheres to them after the procedure was used for requirements elicitation. Therefore, it was necessary to use the requirements elicitation procedure first before the characteristics could be discussed, which is done in Section 5.3.1.

4.3.1.3 Data collection using the requirements elicitation procedure at the different institutions

In this section the way in which the procedure was used at three different institutions to identify and refine the educational process models, is discussed. In Figure 4.9 this step is highlighted in yellow.

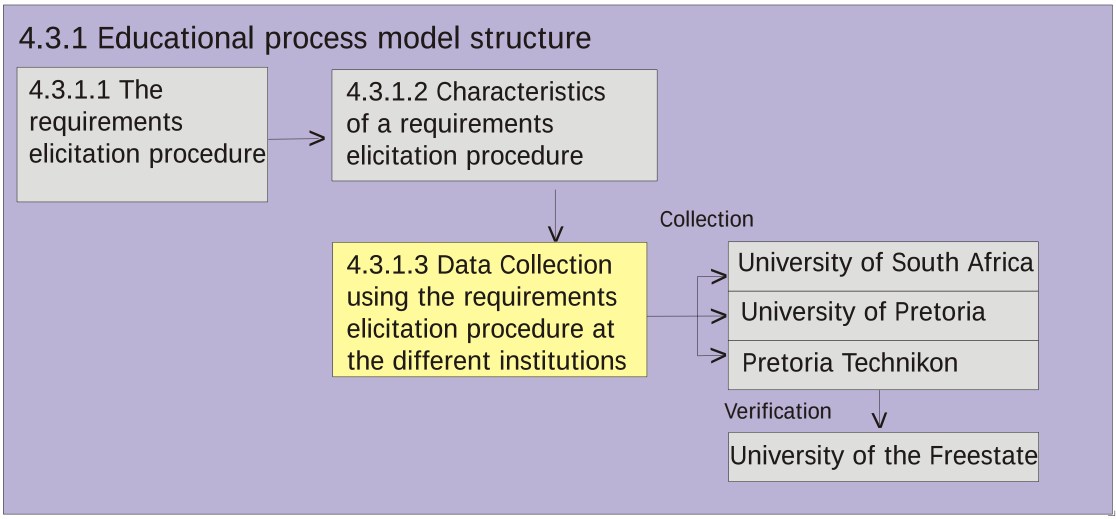


Figure 4.9: Research design: Data collection at different institutions

There are a number of perspectives from which the analyst may describe a real-life environment (Pressman, 2005). This study focused upon processes, but *data* were gathered using a requirements elicitation procedure in which *people* were the main sources for supplying the data required.

Van den Akker (1999) mentions that cooperation with practitioners is required in development research so as to gradually gain an understanding of both the problem at stake and the characteristics of its possible solution. Also, an iterative process of 'sequential relation' of the ideal intervention is desirable. In the present research, this iterative process was applied by 'visiting' the different institutions using the same requirements elicitation procedure and the data from the previous institution(s) (or pre-knowledge) to refine the process models and the requirements elicitation procedure. In the data-gathering at different institutions, practitioners were consulted on the different processes in which they are involved. The different role players were interviewed and valuable information was gained from them on the processes and process flow. The researcher was involved in the application of a proposed requirements elicitation procedure. The data collection procedure is illustrated in Figure 4.10.

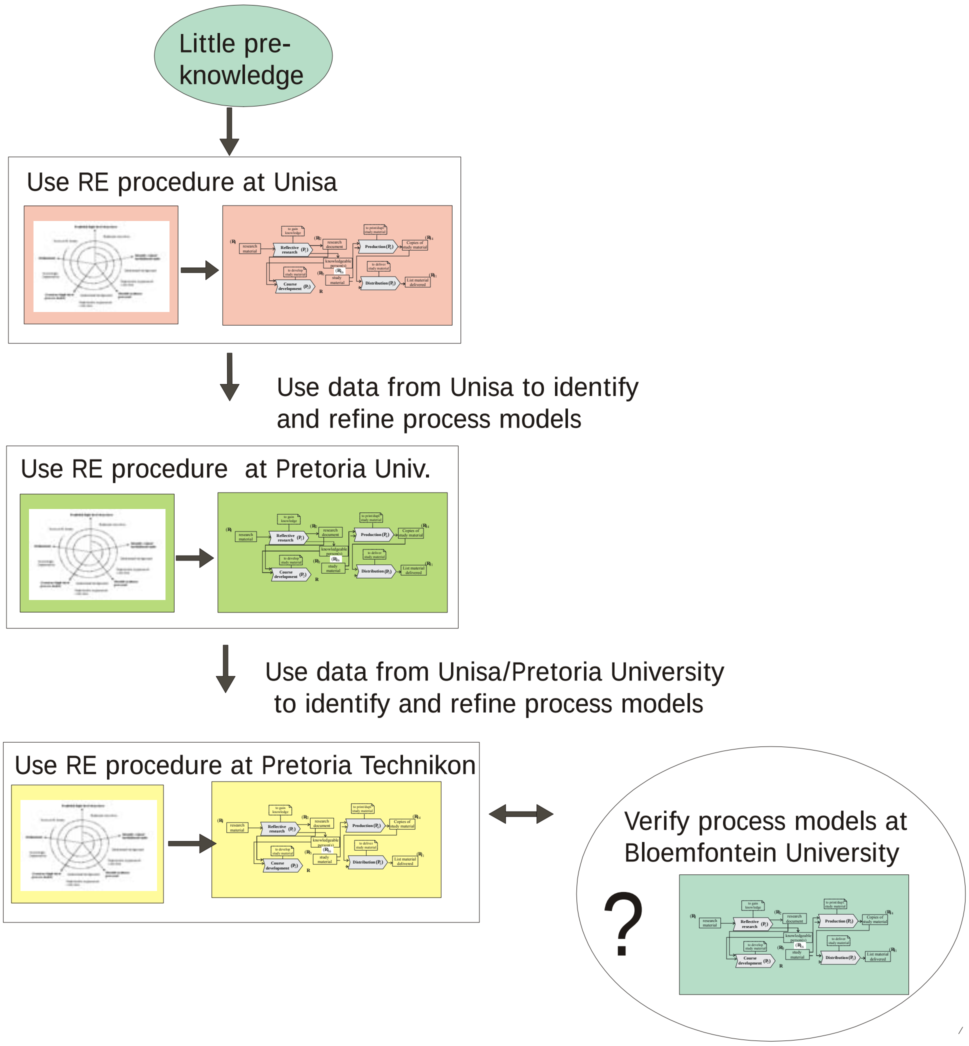


Figure 4.10: Requirements elicitation and verification

The proposed procedure developed at UNISA was used during the data collection for the building of process models. After the first cycle at UNISA, it was also used at the University of Pretoria (UP) to refine the results obtained in the first cycle. Lastly, the procedure was used at Technikon Pretoria (TechPta) in a shorter cycle to verify and refine the results.

After the three cycles the University of the Freestate (UFS) was visited and the results found in the previous cycles were discussed at a meeting with key role players involved in technological changes (Figure 4.10). Each cycle was shorter than the previous one, due to the familiarity and similarity of the application domain.

A brief overview of the requirements elicitation process at each institution is given under the headings ‘people’, ‘data collection’ and ‘requirements elicitation’.

4.3.1.3.1 University of South Africa

The data-gathering process at UNISA commenced early in 2001 with visits to the different units where role players were interviewed with the intention of understanding the processes in which they are involved. This activity was very time-consuming and the realization dawned that a more formal approach was necessary to gather data at the different institutions in an organized manner. This led to the development of the formal procedure described in section 4.3.1.1. After development of the procedure it was used at UNISA to identify the high-level process model and the submodels. (Note that all the data gathered is based on information that was supplied during 2002; the current structure may differ due to the amalgamation mentioned in Chapter 1).

People

In the first phase of implementation at UNISA, the goal of the requirements elicitation activity was described as: ‘to build the high-level process model and subprocess models for all units involved *actively* in teaching and learning activities’. This goal was confirmed with the researcher’s supervisor and co-supervisor and as it was the focus of the study, it was not necessary to confirm this goal with any other role players.

For the second phase it was necessary to identify the critical institutional units. Existing organograms and UNISA telephone list were used to identify all the units. The organograms were obtained from the Human Resource Department and discussed in an interview with a representative of that department. The units that were not involved in teaching and learning activities were eliminated from the list.

For Phase 3, it was necessary to identify the critical processes within each unit. The list retrieved in Phase 2 was used and all the units were either phoned or visited personally to discuss the function(s) of the unit. This involved interviews with 40 non-academic units. The 59 academic departments are all involved in the same teaching and research activities, and were therefore categorized under one heading, ‘academic departments’. For the non-academic units the different units were phoned and in each unit a person was identified who could assist with a *task list* for the unit. Some units, such as the Scheduling Unit, provided me with job descriptions for role players in the unit. This simplified the information-gathering task. For the academic units, informal discussions were held on the nature of academic units at UNISA. The job descriptions for the different levels in the faculty were studied to summarize the responsibilities of academics at UNISA. The task lists identified for both academic and non-academic units were limited using the prescribed rules in Phase 3, to identify the primary processes in UNISA. The construction of the high-level process model involved interaction with the study leader as quality control.

For Phase 5 it was necessary to refine the data gathered to identify the subprocesses in each high-level process. The representatives identified for the different units were consulted once more to identify the different subprocesses and the flow between them. It was the REGISTRATION, COURSE DEVELOPMENT and PRODUCTION processes in particular that required extensive discussions with role players involved in tasks to ensure that the data flows suggested represent the real-life scenario.

Data collection

For data collection at UNISA interviews, observation and contextual analysis were used during data collection as illustrated in Table 4.18.

Table 4.18: Data collection tools used at UNISA

Phases	Interviews	Observation	Contextual Analysis	Institution resource	Self-compiled
1. Goal statement					√
2. Identify units	Identify unit goal			√	
			Organograms	√	
			Telephone lists	√	
3. Identify primary processes	Identify primary responsibilities				√
4. High-level process model	Identify goals, input, output				√
5. Refine	Identify sub-activities				√
	Identify goals, input, output				√
		Observe process activities			√
			Existing models	√	
			Job descriptions	√	

The *interviews* were conducted to identify units, identify primary processes, the high-level process model and during refinement.

1. The first interview was a short interview conducted to determine the goal of each unit and the primary activities in each unit (Phases 2 and 3). In this way the units not

involved in critical activities at UNISA could be eliminated from the unit list and no further interviews were necessary with the unit. Not all the units were interviewed; some such as Catering Services and Building Administration were clearly not involved in teaching activities. For each interview the name of the unit, date and person interviewed, was recorded. Furthermore, four questions were used as guidelines in the interview (Table 4.19) and a summary of the field notes made for the answers to the questions were documented. From these questions the unit list (Table 4.6), the critical list (Table 4.7), and the unit list with important processes (Table 4.8) were compiled. The unit list with the important processes was used to determine the primary process list (deliverable of Phase 3).

Table 4.19: Interview template for identification of critical units and main activities

<table>
<tr><td>Unit:</td><td></td><td>Date :</td></tr>
<tr><td>Interview with:</td><td colspan="2"></td></tr>
<tr><td colspan="3">Questions:
1. What is the goal of this unit?
____
2. Are you directly involved in any teaching activities?
____
3. Is your goal related to a service linked to the teaching and learning activities at the university?
____
4. If YES to either Question 2 or Question 3, what are the most important activities of this unit?
____
____________________</td></tr>
</table>

2. For Phase 4, interviews are conducted to record the input and output resources for each process in the primary list. For each process the input and output resources were listed in the process list with goals and resources (Table 4.13). In case of any uncertainties, the persons involved in the process were contacted to assist in the identification of the resources. At the end of Phase 4, the deliverable was the high-level process model (Phase 4) derived from the process list, association list and triple list.

3. In Phase 5, the *refinement* of the high-level process model, I started with the identification of the subprocesses for each process in the high-level process model. An *interview* template was used to describe for each scenario[11], $S_{a,,}$, with $1 \leq a \leq k,\ a,k \in \mathrm{N}$ and k the number of scenarios, the subprocesses for the scenario (an example of an interview template in Table 4.20). If a subprocess was not atomic, the subprocesses were broken down into another level of subprocesses. The template in Table 4.20 shows the process on the highest level as process S_aP_i, with $1 \leq i \leq n,\ i,n \in \mathrm{N}$ and n the number of processes, where each process S_aP_i may be broken down into a sub-set of processes, S_aP_{ij}, with $1 \leq j \leq m,\ j,m \in \mathrm{N}$, with j the number of subprocesses. Once again, each process S_aP_{ij} may be broken down into a subset of processes. For explanatory reasons the example is limited to four levels. Examples of data gathered using Interview Template 1, are given in Chapter 5, section 5.2.1.5. (Note that if there is only one scenario, the development team may decide to exclude the reference S_a before the process reference P_i.)

Table 4.20: Determine subprocesses in a unit

<table>
<tr><td colspan="2">Unit</td><td></td><td>DATE :</td></tr>
<tr><td colspan="2">Goal</td><td colspan="2"></td></tr>
<tr><td colspan="2">Interview with</td><td colspan="2"></td></tr>
<tr><td colspan="2">Known generic process</td><td colspan="2"></td></tr>
<tr><td colspan="4">Scenario (S_a)</td></tr>
<tr><td rowspan="7">S_aP_i PROCESS NAME</td><td rowspan="3">S_aP_{i1} *Subprocess of* S_aP_i</td><td>S_aP_{i11} *Subprocess of* S_aP_{i1}</td><td>S_aP_{i111} : *Subprocess of* S_aP_{i11}
S_aP_{i112} : *Subprocess of* S_aP_{i11}
… (etc).</td></tr>
<tr><td>S_aP_{i12} *Subprocess of* S_aP_{i1}</td><td>S_aP_{i121} *Subprocess of* S_aP_{i12}
S_aP_{i122} *Su process of* S_aP_{i12}
… (etc).</td></tr>
<tr><td>…etc.</td><td></td></tr>
<tr><td rowspan="3">S_aP_{i2} *Subprocess of* S_aP_i</td><td>S_aP_{i21} *Subprocess of* S_aP_{i2}</td><td>S_aP_{i211} *Subprocess of* S_aP_{i21}
S_aP_{i212} *Su process of* S_aP_{i21}
… (etc).</td></tr>
<tr><td>S_aP_{i22} *Subprocess of* S_aP_{i2}</td><td>S_aP_{i221} *Subprocess of* S_aP_{i22}
S_aP_{i222} *Su process of* S_aP_{i22}
… (etc).</td></tr>
<tr><td>..etc</td><td></td></tr>
<tr><td>… etc.</td><td></td><td></td></tr>
</table>

[11] Each process may have different scenarios, e.g. a student may register electronically or at the counter.

4. The last *interviews* were held to determine the goal and resources for each subprocess. This activity is similar to the one in Phase 4 and the goals and resources were listed in a process resource list similar to the one in Table 4.13.

Observation was used as a data collection technique in COURSE DEVELOPMENT. As a lecturer at UNISA, I have been involved in the development of several courses. Some field notes on the activities involved in the development of course material were made. This was done mostly during participation in course development and the different options available for different types of course material were documented (Chapter 5). For course material in which the researcher was not involved directly, the development was discussed with participants in the development cycle. These notes were used to identify the subprocesses within the process.

During the contextual analysis the following resources were considered:

- Institutional organograms and a telephone list to compile the list of units (Phase 2).
- Job descriptions for the identification of processes and subprocesses in different units (Phase 5).
- Existing flow diagrams compiled for the determination of the different flows between subprocesses (Phase 5).

The requirements elicitation procedure

The requirements elicitation procedure was used successfully at UNISA. The activities prior to implementation of the procedure (discussed in Chapter 3) contributed to the understanding of the processes within UNISA. The objective was stated clearly in the first phase in a objective statement. In the second phase the critical institutional units were identified and used to identify the primary processes in Phase 3. The high-level process model was constructed in Phase 4 and used to refine the high-level process model to sets of subprocesses (Phase 5). A summary with the data collection methods, tools used and deliverables for each phase at UNISA is given in Table 4.21.

Table 4.21: Data collection, tools and deliverables for UNISA

Phases	Data collection			Tools	Deliverable
	Interviews	Observation	Contextual Analysis		
1. Goal statement				Goal statement	Goal statement
2. Identify units			Organograms Telephone lists	Unit list	Critical units
3. Identify primary processes	Identify primary responsibilities			Mapping tool	Primary process list
4. High-level process model	Identify goals, input, output			Process list Association list Triples list	High-level process model
5. Refine	Identify sub-activities Identify goals, input, output	Observe process activities within units	Existing models	Process list with goals and resources Association list Triples list	Subprocess models

4.3.1.3.2 University of Pretoria

Data collection commenced at UP in September 2002. UP was selected as the second case study for a number of reasons:

- The registrar, Prof. N.J. Grové, had a positive attitude towards the research and gave permission for interviews and discussion with staff at the institution.
- UP is one of the biggest residential universities in South Africa and the structure differs from a distance university, which made it an ideal case study to compare to data already gathered at UNISA.
- UP is a respected institution with regard to research and teaching activities.

People

My first interview at UP was with the registrar, Prof. N.J. Grové. I explained the purpose of my research to him. He was very interested in the topic and agreed that it is relevant amidst the current changes being experienced in higher education (as described in section 5.2.2). He gave me permission to interview staff at UP on the processes that they are involved in and the responsibilities in different units.

As at UNISA, the different units were identified with contact persons in each unit. Most of the interviews were conducted telephonically with the different departments. For those units where it was not possible to apply pre-knowledge, the units were visited to take field notes or to conduct interviews to gain an understanding of the working of the unit at the specific university. These include the Department of Academic Administration, Department of Information Technology, and Human Resources. Most of the staff members of the units who were visited or interviewed telephonically felt positive about the process and were interested in the research conducted.

Data collection

Early in August and September 2002, data collection activities commenced at UP to assist in the compilation of the high-level process model for the institution. The data collection methods used at UP are summarized in Table 4.22.

Table 4.22: Data collection used at UP

Requirements elicitation phases	Interviews	Contextual Analysis	Institutional resource	Compiled Resource
1. Goal statement				√
2. Identify units	Identify unit goal		√	
		UP web pages	√	
3. Identify primary processes	Identify primary responsibilities			√
4. High-level process model	Identify goals, input, output			√
5. Refine	Confirmation interviews			√

A very valuable institutional resource for identifying the critical units at UP was the websites published for informational purposes by the university (UP, 2000). All the academic units at the university are published at http://www.up.ac.za/academic/ and the service departments at http://www.up.ac.za/services/. These web resources illustrated in Figure 4.11, were used as a starting point to identify the different units within UP. For units that were not similar to units at UNISA, the interview template proposed in Table 4.19 was used to record the nature of the unit.

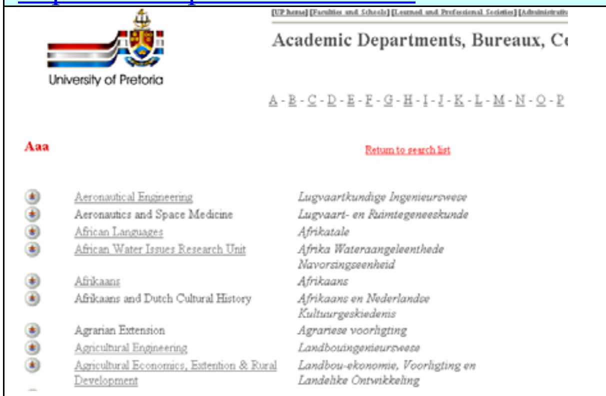
Academic Units http://www.up.ac.za/academic/	Service Units http://www.up.ac.za/services/
	

Figure 4.11: Snapshots of academic departments and service departments at UP

The initial unit list consisted of 267 different units that were identified from the different resources. Most of these were academic units or bureaux involved in learning and teaching activities, and were grouped together under one heading, Academic Department. The remaining units were service units and administration units. Some of these were not involved in learning and teaching activities and, after confirmation with role players, were therefore eliminated from the lists. Each of the units remaining on the list was used in Phase 3 to identify the critical processes. For the units where the primary responsibilities were not clear, the interview sheet in Table 4.19 was used. The goal, input and output resources were identified for each process, using the information gathered, or contacting role players to confirm the knowledge gained during the data collection process.

It was not necessary to proceed with the breakdown of all the subprocesses for the set of high-level processes. This study was limited to the high-level structure, but for the sake of clarity some of the subprocesses at UP were verified. For example, COURSE DEVELOPMENT was discussed with the head of the Telematic Learning and Educational Innovation Unit, and lecturers in the Computer Science Department. REGISTRATION was discussed with role players involved in administrative tasks in the Academic Administration Department. The results of these discussions are given in Chapter 5.

The requirements elicitation procedure:

The requirements elicitation procedure was used successfully at UP. It had already proved to be successful in its first cycle for requirements elicitation at UNISA and the results obtained were confirmed for determination of the process models at UP. One of the reasons for developing a more formal approach to data-gathering was to reduce the time taken at other institutions. The data-gathering done at UP was completed within a significantly shorter period in comparison with the process at UNISA. A summary of the data collection, tools used and deliverables for each phase at UP is given in Table 4.23.

Table 4.23: Data collection, tools and deliverables at UP

Requirements elicitation procedure phases	Data collection method		Tools	Deliverable
	Interviews	Contextual Analysis		
1. Goal statement			Goal statement	Goal statement
2. Identify units	Identify unit goals	UP web pages	Unit list	Critical units
3. Identify primary processes	Identify primary responsibilities		Mapping tool	Primary process list
4. High-level process model	Identify goals, input, output		Process list with goals and resources Association list Triples list	High-level process model
5. Refine	Confirmation Interviews		Process list with goals and resources Association list Triples list	Selected subprocess models

4.3.1.3.3 Data-gathering procedure at Technikon Pretoria

Early in 2002, I was introduced to Prof. P. van Eldik, Director of Strategic Planning at TechPta. He is involved in various technological implementations at the Technikon and after discussing the proposed research with him, he gave permission that TechPta may be used as one of case studies for data collection. TechPta was selected as the third case study because:

- It is one of the biggest residential technikons in South Africa and the structure differs from universities. This enabled me to compare data already collected at two universities with another institution before drawing any conclusions on higher education structures.
- The Technikon is a respected institution with regard to teaching activities and has shown some growth in research activity over the past few years.

People

Early in November 2002 a formal interview was scheduled with Prof. P. van Eldik to proceed with previous informal discussions on the research project. The data already gathered at UNISA and UP was discussed. Prof. Van Eldik was very interested in the research and we had lengthy discussions on the differences between structures of distance teaching and residential institutions. The Technikon has a very strict policy on research programmes conducted by external parties. Prof. Van Eldik assisted me in this regard and arranged permission to conduct interviews within the institution. He arranged interviews himself with a number of role players and also assisted to acquire documentation on the structure of the Technikon.

The documentation received from Prof. Van Eldik combined with the Technikon's website (TechPta, 2000), provided me with the list of units involved with teaching and learning activities. Most of the interviews with units were conducted telephonically, although a meeting was also scheduled with role players at the Telematic Unit, responsible for technological innovations in the institution. The goal was described to each person interviewed. A few respondents were not positive about the interviews and did not want to give information on the working of the unit without discussions with unit management. Prof. Van Eldik assisted me in clarifying the goal of the research with key management persons, after which the data-gathering process proceeded successfully.

Data collection

In November 2002 data collection activities at TechPta commenced with the goal of establishing a high-level process model of the institution. The data collection used at TechPta is summarized in Table 4.24.

Table 4.24: Data collection at TechPta

Phases	Interviews	Contextual analysis	Institution resource	Self compiled
1. Goal statement				√
2. Identify units	Identify unit goal		√	
		TechPta web pages	√	
		Telephone list	√	
3. Identify prim processes	Identify primary responsibilities			√
4. High-level process model	Identify goals, input, output			√
5. Refine	Confirmation interviews			√

To identify the critical units (Phase 2), interviews with institutional representatives (using the Interview Template provided in Table 4.19), the TechPta website (Figure 4.12) and the telephone list of TechPta were used as recourses.

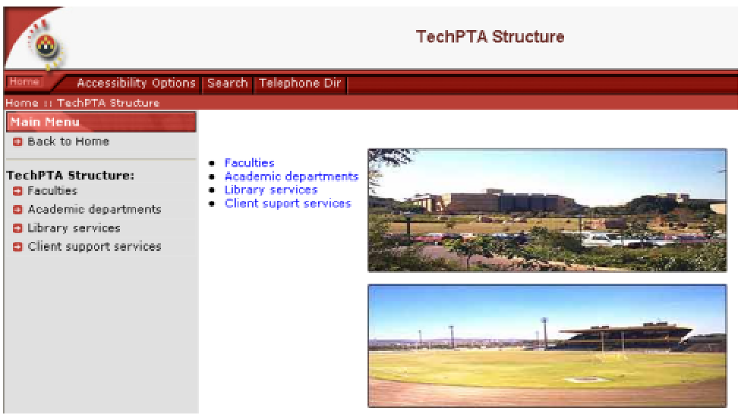


Figure 4.12: TechPta Structure – website resource

Selecting the critical units was easy due to familiarity with the application domain. The processes within each unit were confirmed with representatives from the different units (using the Interview Template provided in Table 4.19). From these interviews the goals, input and output resources for each process were identified.

As in the case of UP it was not necessary to proceed with the breakdown of all the subprocesses for the set of high-level processes. The study was limited to the high-level structure. Some of the subprocesses were confirmed during interviews with representatives on the identification of unit activities. Examples of interviews are given in Chapter 5.

The requirements elicitation procedure

The procedure was used successfully at TechPta, with the determination of the high-level process model structure succeeding after one cycle. The results obtained from previous institutions made it possible to accelerate the cycle at the Technikon and successfully compare the process models identified previously with the process flow at the Technikon. A summary of the data collection techniques, tools and deliverables used in this cycle is given in Table 4.25.

Table 4.25: Data collection, tools and deliverables at UP

Requirements elicitation procedure phases	Data collection		Tools	Deliverable
	Interviews	Contextual Analysis		
1. Goal statement			Goal statement	Goal statement
2. Identify units	Identify unit goals	TechPta web pages	Unit list	Critical units
3. Identify primary processes	Identify primary responsibilities		Mapping tool	Primary process list
4. High-level process model	Identify goals, input, output		Process list with goals and resources Association list Triples list	High-level process model
5. Refine	Confirmation Interviews		Process list with goals and resources Association list Triples list	Selected subprocess models

4.3.1.3.4 Data verification at the University of the Freestate

The last phase in the data-gathering process was to verify the results at the University of the Freestate (UFS). The idea was not to refine the process models any further, but to:

- Show the process model(s) to the representatives of the University of the Freestate.
- Establish whether or not they agree with the structure presented.

- To discuss the results and to see if there is any discrepancy not identified previously.

Prof. M. Fourie, Vice-registrar of Academic Planning at the University of the Freestate, was contacted early in 2003. After discussing the rationale behind the research, she arranged a meeting with key University representatives in the week of 23-28 March 2003. This meeting was attended by Prof. M. Fourie, representatives of Information Services and Technology, the Deputy Director from the Centre for Higher Education Studies and Development, and other interested parties.

During the discussion, the process models derived (given in Chapter 5) were handed out to the representatives attending the meeting. The agenda was to introduce the representatives to the notation used, to discuss briefly the contents of the high-level model and the main submodels, and to discuss the generic value of the models.

The following questions were addressed during the group interview:
1. Are there any formal re-engineering procedures used at the institution? If so, which one?
2. What are the current re-engineering activities with regard to the implementation of technological changes?
3. How familiar is the group with the use of process modelling as a tool in re-engineering efforts?
4. Is the high-level process model presented descriptive of the current activities at the institution?
5. Do you think this model can be used as a re-engineering tool?

The results of this meeting are discussed in Chapter 5. In the following section, a discussion is given on how the educational process model can be used in re-engineering efforts.

4.3.2 Management of the educational process model structure

In section 4.3.1, a procedure was suggested to identify the educational process model. In section 4.3.2, this model serves as point of departure to answer the second research question, namely: *To what extent is the generic process model structure useful in a re-engineering effort?*

In order to show how the process models can be used in a re-engineering effort, a re-engineering procedure based on best practices was developed and is presented in section

4.3.2.1 (highlighted in yellow in figure 4.13). The process model is used as a documentation tool within the procedure, which uses business process re-engineering theories to identify constraints in the educational process model. This procedure also elaborates on the options available to enhance the Throughput in selected chains. In section 4.3.2.2, the use of the procedure at UNISA is discussed, followed by the measurement procedure used to answer Research Question 2, in section 4.3.2.3.

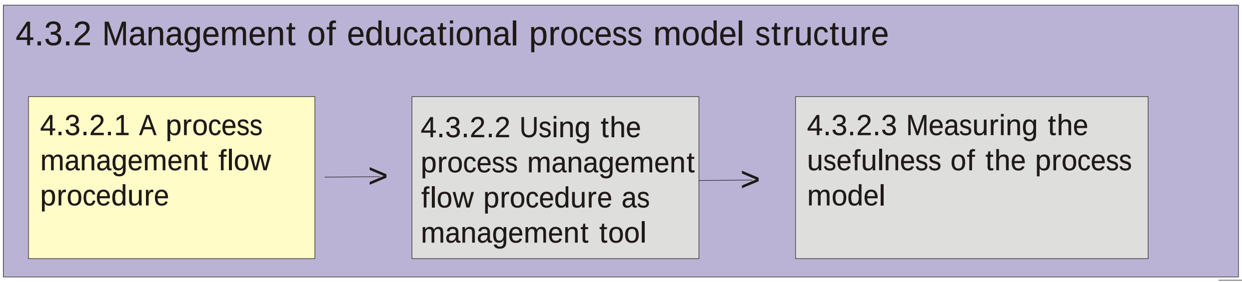


Figure 4.13: Development of a process management flow procedure

4.3.2.1 A process management flow procedure

According to Hammer (1990), there are five steps in re-engineering when using a process model, namely:

1. Name the processes and state your goal.
2. Map the process.
3. Choose the process to re-engineer.
4. Understand each process.
5. Re-engineer the process.

This correlates with the five steps defined for process re-engineering by Davenport and Short (1990). In both approaches the goal is to identify the processes, focus on the process to be re-engineered and to understand the process (Davenport & Short, 1990; Hammer, 1990). I used the concepts from these two approaches and mapped it to a procedure to investigate the flow within the educational application domain. The procedure is called the ‘process management flow procedure’.

In selecting the process for re-engineering in a higher education environment, one should look at processes in which unwanted delays are experienced. The higher education application domain is a complex environment consisting of a combination of production and administration systems. Delays in any of these systems may cause frustrations within the institution for staff or students. The identification of constraints is an ongoing process used to improve Throughput of different components.

As discussed in section 2.3.2, numerous re-engineering methodologies exist. The theory of constraints (TOC) was selected as the basis for identification of constraints within the process model (Goldratt & Cox, 1992). Goldratt conceptualizes the idea of TOC. Although many other authors have also done some work on TOC, all of them refer to Goldratt's theory as the basis of TOC (Cox & Spencer, 1997; Scheinkopf, 1999; Onirik, 2000; TOC, 2001; Patrick, 2002). In my research, TOC will therefore be used as introduced initially by Goldratt & Cox (1992) and referred to as Goldratt's theory of constraints.

The goal for this section was to use some concepts in this theory, developed originally for a manufacturing environment, in a higher education environment to see how they can be used in this environment as a tool to identify constraints. The process management flow procedure, which is based on concepts in the theoretical work published on Goldratt's theory, was suggested and used on a selected process in the higher education process model, as illustrated in Figure 4.14.

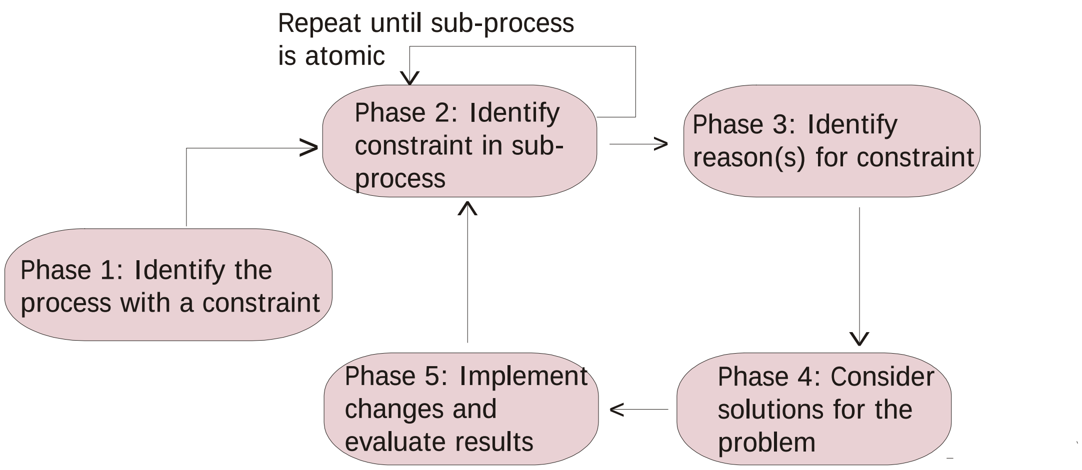


Figure 4.14: Phases within the process management flow procedure

1. In the first phase of the process management flow procedure, the goal is to identify the process subject to an unwanted delay.
2. The second phase is to identify the set of subprocesses within the process and to determine the constraint within this chain of processes.
3. Next, the team should consider the reasons for the constraint before solutions are suggested in the fourth phase.

4. In the fourth phase the development team consider the solutions for the problem.
5. The last phase consists of implementation and testing.

The procedure becomes iterative when the team returns to Phase 2 where they seek the other constraints (Figure 4.14). An overview of the process will be given before a discussion follows of the way in which it was used at UNISA (section 4.3.2.2).

4.3.2.1.1 Phase 1: Identify the process subject to a constraint

A constraint, or bottleneck, is any resource or subprocess whose capacity is equal to or less than the demand placed on it (Onirik, 2000). The first step in finding solutions for possible constraints is to identify the delays. Any process with an output created by the process has the potential to contain constraints. The re-engineering team should first identify the processes within the higher education application domain before the process to be re-engineered is selected. In section 4.3.1 one possible procedure was suggested to determine the high-level process model. In this phase the process model, in combination with the following steps, is used to identify the constraints:

1. Use a high-level process model to identify (or focus on) possible constraints.

2. Derive from the process model a table that lists all the processes: the list of processes can be defined as before as $\{P_k\}_{k=1}^{m}$ with $k, m \in \mathrm{N}$, where m denotes the total number of processes. (If the requirements elicitation procedure suggested was used to derive the process model, the development team may use the process list used to derive the process model in this step).

List a Throughput value and a Demand value for each process. The possible values for Throughput are the set Throughput = {possibility, none, satisfactory, a} where $a \in \mathrm{N}$ and similarly, Demand = {possibility, none, satisfactory, b} with $b \in \mathrm{N}$. The following options are available for Throughput and Demand:

- A numeric value, a and b respectively, is given for attributes Throughput and Demand, where it is possible to determine the values.
- A ‘possibility’ value is given if the re-engineering team suspects a constraint in subprocesses but is not sure.

- A value of ‘satisfactory’ is given if the current Throughput is satisfactory and ‘none’ if the Throughput is not quantifiable.

3. Add a column called Constraint with a ‘Yes’ indicating a constraint or ‘No’ if not. This value is determined using the definition of a constraint with the following algorithm[12]:

If (Throughput = ‘satisfactory’ or Throughput = ‘none’) then constraint = ‘No’ else
    If Throughput = ‘possibility’ then constraint = ‘Yes’ else
        If Demand > Throughput then constraint = ‘Yes’ else constraint = ‘No’;

In short, this algorithm will assign a Yes value to any process in which the current Throughput is less than the Demand or where the possibility of a constraint exists.

Table 4.26 gives an example for process P_k with 100 units per hour Throughput and a Demand of 120 units. Using the algorithm provided, a constraint is identified based on the Demand being more than the Throughput.

Table 4.26: List with processes and resources derived from process model

Process	Throughput	Demand	Constraint
P_k	100	120	Yes
P_{k+1}	None	None	No

Management can, depending on its priorities, select the process that needs re-engineering from this list. There may even be more than one process, depending on the resources available to investigate the constraints. Selecting the process for re-engineering is a strategic decision and should be made by the relevant stakeholders of the institution after considering the available resources.

4.3.2.1.2 Phase 2: Identify constraint in subprocess

The second phase in the procedure is to determine the subprocess that causes the constraint in the selected process. The selected process may have more than one scenario that influences the throughput. For example, in the REGISTRATION process there is two scenarios: the

[12] Note that this algorithm is not necessarily programmed exactly as given here; it is only used as an example of the actions involved.

registration done at the counter at UNISA and the registration done by post (including electronic registration). Both these scenarios will have an influence on the final throughput of registration numbers.

In Phase 2, the re-engineering team determines the constraint in a chain of subprocesses. If there is more than one scenario, the development team should select the one that they want to focus on or repeat the activities in this step for both the scenarios and select the one to be re-engineered, depending on the objectives of the re-engineering effort.

In Phase 1, the re-engineering team used a high-level process model to select the process for re-engineering. For Phase 2, a similar procedure is needed for the subprocesses in the selected process. To accomplish this, the following steps are suggested:

1. Select the scenario with the constraint (if there is more than one scenario).
2. Determine the list of subprocesses for the process being scrutinized.
3. Determine the Demand and Throughput for each subprocess.
4. Identify the constraint in the list of subprocesses using the procedure described in Phase 1.
5. Select the subprocess to be scrutinized.
6. If the selected subprocess has subprocesses, go back to Step 2.

The deliverable of these steps is a list of subprocesses for a process on a higher level in the process model, with one or more possible constraints within the list of subprocesses. The re-engineering team decides on the biggest constraint that should be addressed in the remaining phases.

4.3.2.1.3 Phase 3: Identification of reason(s) for a specific constraint

The third phase is to identify the reasons for the specific constraint. The chain of events consists of two dimensions: the first being the chain of events with one constraint and the second going deeper into underlying paradigms, policies and measures (Patrick, 2002). For each application domain, the reasons for constraints may differ. In a business environment, a product is sold with financial gain from the product and demands are created by the market. For the perspective of this study, where the goal is to create a better learning environment for the student, throughput focuses on service.

Unfortunately, there is not a repository of reasons for constraints. However, I do suggest a list of types of reasons (which may not be exhaustive) that the developer might want to consider in the analysis of the constraint (Table 4.27). The list is categorized according to the processes in the high-level process model and was compiled from discussions with role players involved in the different processes.

The deliverable of this phase is for the development team to write a report, which lists the reasons for the constraints. This is the most important step in finding the solution to constraints in a chain of events and a great deal of interaction will be needed with role players in that chain. In a PRODUCTION system, the development team will need to look at the different processes from a scheduling perspective. In the educational environment the development team will have to think differently about the processes since the focus is not on higher production for financial gain, but on higher throughput for better service.

Table 4.27: Examples of reasons for constraints in the higher education domain

Process	Reasons	
REFLECTIVE RESEARCH	• Material availability and support • Time constraints • Information overflow • Rapid change	• Seeking the unknown • Maturity in subject • Motivation • No guidance in reflective research methodology
COURSE DEVELOPMENT	• Financial constraints • Poor project management • Limited human resources • Unskilled human resources	• Time constraints • No project planning • Unavailable resources • Unexpected changes to prescribed material
REGISTRATION	• Student system availability • Calendar changes • Complexity of registration requirements • Incorrect information capture • Payment verification	• Human resource availability • Resources kept busy with other tasks that hinder throughput • Re-engineering options are not considered • Management commitment to resource availability
PRODUCTION	• Re-scheduling needed, course material received late • Machine breakdown	• Resources in peak periods • Material unavailability • Tasks with higher priority
DISTRIBUTION	• Human resource	
STUDENT SYSTEM	• System downtime • Incorrect data processing (software-related) • Network problems • Human resource availability	• Maintenance • Legacy systems • Incompatibility • Merging of different systems
ASSESSMENT	• Distribution	• Human resource during peak periods
ACADEMIC STUDENT SUPPORT	• Human resource during peak periods	

4.3.2.1.4 Phase 4: Consideration of solutions to the problem

In Phase 4, the development team should consider solutions to the constraints identified. Unfortunately, solutions are constraint-dependant and it is not possible to give one specific solution.

As stated previously, the focus of this study is on the use of technology as a solution to constraints. There may be other solutions to constraints, which may be used in future research. For the moment, the focus is on the arguments that relate to the implementation of technological solutions.

There are two approaches that the re-engineering team can select from during re-engineering efforts. The first is to look at the chain of events and to simplify it by combining several activities (or eliminating some) using technological innovations. The second is to focus only on the activity with the constraint and look at feasible solutions for the single activity. There are different solutions that the development team may consider in using technological for either of the approaches. The following are guidelines for selecting a technology innovation as a solution:

- The team should consider different options and should do a feasibility study before deciding on the direction.
- Consider the use of tools to determine what the current state of technological use is, within the institution, for the specific process.
- Resistance is an issue in change and the development team should acknowledge the importance thereof and incorporate it in its implementation strategies (Conger, 2002; Senge, 2002).
- Consider the effect on role players and resources in implementing the changes that will not show necessarily in using the different tools discussed.
- Decide on an implementation plan. This will give direction in the search for a solution.

4.3.2.1.5 Phase 5: Implementation of changes and evaluation of results

The last phase consists of the implementation, testing and evaluation of the solution. Before implementation it is necessary to look at concerns that the new solution will raise. It is also necessary to evaluate the changes after implementation to ensure that the constraint is eliminated and that the solution does not create a still bigger constraint.

The team may now return to Phase 2 where the list is once more examined to identify the new constraint that appeared after eliminating the current one.

4.3.2.2 Using the process management flow procedure as a management tool

There are various processes in a higher education environment that can gain from re-engineering efforts, especially using technological innovations (Bruno *et al.*, 1998; Bates, 2000; Katz & Oblinger, 2000). UNISA was selected as a case study for using the suggested process management flow procedure as a management tool in the identification of constraints. This activity is highlighted in yellow in Figure 4.15.

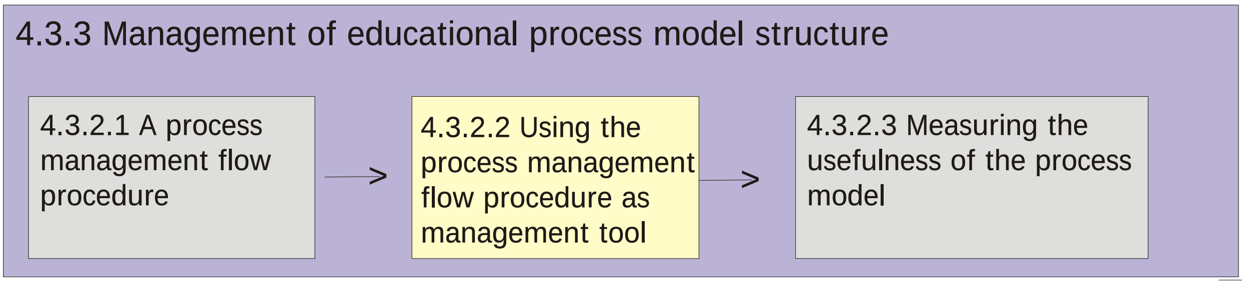


Figure 4.15: Process management flow procedure as a management tool

According to Yin (2003), a single case study is appropriate if it is a typical case. From data collected in answering the first research question: *What is the process model structure of the higher education institution?* It was already established that a HEI may be represented by a single higher-level process model (discussed in more detail in Chapter 5). Therefore, in order to answer Research Question 2: *To what extent is the generic process model structure useful in a re-engineering effort?* the results obtained from the first question were used as the starting point, with UNISA as a typical case.

In this section, the way that the process management flow procedure was used at UNISA is discussed. As in section 4.3.1.3, the procedure will be discussed according to the people involved, the data collection done and the use of the procedure.

People

In Phase 1, the purpose was to identify the process with the constraint. The first step was to list the different processes in a higher education domain. The high-level model developed in section 4.3.1 was used as a guideline, and eight different processes were identified as the core processes within the university.

The next step was to identify the process in this list of processes that causes a constraint in the educational domain. The following are some comments on discussions relating to some of the primary processes identified in the previous step:

- For the identification process, the representatives within the different processes were contacted and the possible constraints in the applicable departments were discussed with them. In the case of REFLECTIVE RESEARCH, COURSE DEVELOPMENT, ACADEMIC SUPPORT and PRODUCTION respondents were positive and did not experience enquiries as a threat. In some of the other processes, respondents were cautious about giving information, which could have given rise to inaccurate information or led to the development team overlooking a possible constraint.
- The head of the Registration Section, Dr. S.P. Pretorius, granted me valuable interviews, which enabled me to understand the activities within the REGISTRATION process. Representatives from different units associated with this process also supplied me with the necessary data to identify this as a constraint within UNISA.
- After discussions with lecturers and representatives from the unit responsible for assisting lecturers in COURSE DEVELOPMENT, this process was also identified as a constraint. As a lecturer involved in lecturing, the constraints within one's own teaching environment were easy to identify. The constraints were confirmed by fellow lecturers in other schools, which indicated that if not considered for re-engineering at this stage, this should be considered at a later stage. Furthermore, discussions were initiated with the Bureau for Learning Development, which is involved in the development of course material in a team approach with lecturers.
- In PRODUCTION, a few bottlenecks were identified after discussions with different units responsible for the flow of activities relating to this process. The most important was the breakdown of machines for producing material and the unscheduled tasks that occur unexpectedly.

After selecting the REGISTRATION process for re-engineering activities, the electronic/postal registration scenario was identified as a problematic scenario (reasons given in Chapter 6). As in Phase 1, it was necessary to identify the subprocesses within the chain of events that cause a constraint. For this, more detailed interviews were necessary with different representatives of units involved in the electronic or postal registration process. The units involved in this process included the Documentation Section, Computer Services, Undergraduate Section and Financial Section. Telephonic and personal interviews were used to discuss the functions and delays experienced during the different processes.

The process experiencing a constraint in the chain of subprocesses was the activities in the Undergraduate Section. The identification of this constraint led to further discussions with representatives in the Undergraduate Section and also with the head of the section, during which problems were discussed, as well as the option of using technological solutions to eliminate constraints.

Data collection

In Phase 1, the data collection was focused primarily on throughput. The requirements elicitation procedure used in section 4.3.1 provided a list of high-level processes and therefore the focus in this phase was to determine the Throughput for each process. It was impossible to express throughput for all of the processes as a numerical percentage. A university is different from a business where 'It's all about the money' (Brouns, 2001). Money is important, but being a partially subsidised institution based on the number of students who register and complete courses, service is of greater importance. Throughput is therefore measured in certain processes as being satisfactory rather than by using percentages; where it was applicable and possible, Throughput was expressed in terms of numerical values.

The following are some comments on data collection related to the primary processes:

- For REGISTRATION, where a serious delay was experienced, SQL queries were done on the student database that reflected the registration pace for the 2003/2004 registration period. Registration closes on 28 February, but one week for slack time was provided to obtain the total registrations processed by this week.
- For COURSE DEVELOPMENT, it is almost impossible to determine exact numbers. There are many variables that play a role in determining the rate of Throughput.

Interviews were used to collect the data from lecturers and the Bureau of University Teaching, and the results depended on the type of material developed.

- For the PRODUCTION process, data collection was based on interviews. Throughput statistics are noted on a daily basis and were therefore easier to obtain. The constraints identified from the data-gathering process were easy to identify and were confirmed by different role players as delays experienced in receiving resources from other units or due to resources that experience problems within the unit.
- In the ASSESSMENT process there is a possibility of a constraint due to examinations in the June period that causes a backlog in the distribution of assignments to the different departments.
- The other processes were either experiencing no delays or were satisfied with the Throughput being achieved in the specific process.

The process list derived from the process models was a valuable tool for documenting the data gleaned during data collection. Interviews were documented using Interview Template 1 for reference purposes. The statistics were either obtained using SQL queries from the current databases or from the annual report obtained from key persons in the different units. Where possible, data was verified for validity against information from other resources.

In Phase 3, the table with reasons given in the process management flow procedure was used as a guideline in identifying the reasons for constraints.

The process management flow procedure

The procedure was used for Phase 1 to Phase 4 within the University. No direct implementation was done at the University although Harley Green, a project student, built a prototype in 2003 to test the feasibility of an electronic registration system (Green & Van der Merwe, 2004).

During Phase 1 and Phase 2 the process model developed previously proved to be a valuable resource and constraints were identified without problems. The procedure provides for the educational domain where throughput is difficult to establish because the focus is on service and not numbers. The electronic registration was selected as the focal focus subprocess and a table was derived using variables such as 'satisfactory' and 'possibility' to indicate constraints.

In Phase 3 the list of problems already identified for key processes within the university proved to be valuable in interviews with role players in the processes. The problem list suggested in the procedure was useful; the representatives were more positive when one suggested problems and this served as a point of departure in discussions. Solutions were more difficult to agree on and were addressed in Phase 4. As a triangulation exercise to confirm the different constraints found in Phase 1, a check list with 42 questions was compiled that cover the different possibilities in registration communication (see Table 4.28). The purpose was to identify candidate processes for conversion to electronic processes. This checklist was compiled by consulting every activity in the REGISTRATION process and focusing on the 'way' in which the activity was done.

The checklist was discussed with registration representatives and it gave an indication that there were still many activities with the potential to be converted into electronic processes

In discussions on the possibility of re-engineering current processes, existing staff involved in the constraint processes appeared to have a negative attitude towards change. Before mentioning possible opportunities created by the implementation of technological options, arguments were raised against the use of automatic processes. Human resource issues lie outside the scope of this study, but it is suggested this should be a high priority in any automation and implementation of electronic processes.

The implementation of changes at the institution was also not feasible and suggestions were made to role players responsible for technological changes on possible future opportunities. It is understandable that the focus is currently on the merging of different systems and re-engineering efforts where REGISTRATION is not the main priority. As an alternative, I was involved in the development of a prototype for electronic registration with an honours project student with the goal of creating a prototype to test the feasibility of an electronic system that simulates the current registration system (Green & Van der Merwe, 2004).

Table 4.28: Questions used to determine the extent of communication

1	Do you support general e-mail registration enquiries?
2	Do you support personal registration enquiries?
3	Do you support postal registration enquiries?
4	Do you answer enquiries electronically?
5	Are any queries at your institution answered electronically and automatically?
6	Do you provide a help desk to answer personal registration enquiries?
7	Do you answer postal queries through the post?
8	Is it possible for a student to fill the registration form in on the web?
9	Is it possible for a student to fill the registration form in personal?
10	Is the data from the electronic registration form automatically placed in a temporary database, before processing?
11	Does your institution receive registration forms in person at the institution?
12	Does your institution receive registration forms through postal services?
13	Do you assign a student number automatically after the application was received?
14	Do you capture information from the registration form manually in the student system?
15	Is matriculation verification done automatically against an existing system?
16	Is matriculation verification done manually by means of certification identification?
17	Is special admission done automatically against an existing system?
18	Is special admission done manually by the institution staff?
19	Is information received from an electronic application automatically captured on the student system?
20	Is information received from an electronic application manually captured?
21	Is course enrolment automatically verified against an intelligent system from the electronic application?
22	Is course enrolment manually tested against an expert system?
23	Can students pay student accounts electronically?
24	Can students' accounts be paid automatically and electronically from information received on the application form?
25	Can students make a personal payment at the institution?
26	Can students send a payment through postal systems?
27	Will a student's financial record be updated automatically after payment has been received?
28	Will a student's financial record be updated manually after payment confirmation?
29	Can a student send his record profile updates to the institution electronically?
30	Are existing student record profile updates received personally at the institution?
31	Are student profile updates received telephonically / through postal systems?
32	Can existing student record profile updates be done automatically after submitting information electronically?
33	Are student profile updates done manually at the institution?
34	Is course material made available to students electronically?
35	Is course material made available to students automatically and electronically?
36	Is course material handed in person to the student?
37	Is course material dispatched to students through postal systems?
38	Does your institution use a central student system to keep a record of the students' registration profile?
39	Does your institution use an intelligent system to verify course enrolment?
40	Does your institution use the South African Universities Vice-Chancellors Association (SAUVCA) database to verify matriculation results?
41	Does your institution use a financial system for student accounts?

The development of this system was done in 2003, with the current limitations and rules used. Two functions were institution-based and difficult to simulate as a result of restricted access to the resources. These were 'the verification of the academic record' and the 'verification of the selected course profile' against the Expert System[13]. Both are limitations that are easy to overcome by means of direct access to the resources and should not be a factor in considering the feasibility of implementing the registration process. The five phases of the process management flow procedure are summarized in Table 4.29, in which a list is given of the important documentation, tools and deliverables.

Table 4.29: Documentation, data-gathering tools and deliverables

Phases	Documentation	Data-gathering tools at UNISA	Deliverable
Phase 1: Identify main constraint	High-level process model Process list	Process model Interviews	Selected process with constraint
Phase 2: Identify constraint in subprocess	Subprocess models Subprocess list	Subprocess models Interviews	Identified constraint on lower level
Phase 3: Identify reason for constraint	Reasons for constraints	Reason list (Table 4.27) Interviews	List identified with reasons
Phase 4: Consideration of solutions	Solution options Feasibility study Process models	SQL queries Interviews	Implementation plan
Phase 5: Implement changes	Adapted process models	Proof of concept	Implemented solution for constraint

In order to support discussions on the usefulness of the process models in the re-engineering effort, it is necessary to identify some measurements. In section 4.3.2.3 a tool is suggested to measure the usefulness of the process model in a re-engineering effort described in this section.

4.3.2.3 Measuring the usefulness of the process model

An old adage says, 'If it exists, it is measurable'. According to Leedy (1993:31), this saying can be extended: 'If it exists, then it *must* be measurable'. Qualitative researchers are involved in research that is concerned mainly with words and not with numbers. However, this does not mean that nothing is 'measurable' in qualitative research. Measurement is a checkpoint or a comparison against a point of limitation (Leedy, 1993). As quoted by Leedy (1993), S. S. Stevens suggested four levels of measurement that are widely accepted as the classic categorization for statisticians and researchers in 1946. The levels include the *nominal, ordinal, interval* and *ratio level of measurement*.

[13] The Expert System is a system developed in-house with all the business rules for the different qualifications at UNISA (also discussed in 6.2.2.1).

In Table 4.30, a summary is given of the 4 levels with examples of how each of them may be used (Stevens, 1946; Leedy, 1993; Becker, 1999; Wharrad, 2004).

Table 4.30: Levels of measurement

Level of measurement	Description	Example
Nominal	Data is measured and restricted by assigning names (or numbers) to them.	Gender Answer (e.g. Yes/No)
Ordinal	The object being measured is more or less or equal to a comparative object.	Beef rating Movie rating
Interval	The interval scale is characterized by two features (1) equal units and (2) zero point has been established arbitrarily (Leedy, 1993).	Degrees / Fahrenheit Most personality measures
Ratio	Ratio scale can express values in terms of multiples and fractional parts (Leedy, 1993).	Length or distance Annual income in Rands

For Research Question 2: *To what extent is the generic process model structure useful in a re-engineering effort?* an ordinal measurement is suggested. Ordinal is selected because it is possible to compare the usefulness of the process models in the re-engineering effort only to a predefined 'rating' value. The values defined for measurement of the usefulness include high, medium, low and none according to 'the extent' that the process model was used in a specific phase. The values and the description of each are given in Table 4.31.

Table 4.31: Rating used to describe the 'extent' of usefulness for process models

Rating	Description
High	A phase is rated *high* if the process model is used extensively and it is not possible to commence the phase without the process models.
Medium	A phase is rated *medium* if either the process model or the process list is used as reference in activities in the phase.
Low	A phase is rated *low* if there are one or two references made to the process model.
None	A phase is rated *none* if no reference is made to process models.

If most of the phases in a procedure are measured as being high or medium, it is rated as being highly useful. If most phases are medium or low, the procedure is rated as moderately useful. If most phases are rated as low or none, the procedure is rated as not useful.

This concludes the discussion on the research design for Research Question 2. The research design of Research Question 3 is addressed in section 4.3.3.

4.3.3 The educational process model repository

With the first research question, the structure for the educational process model was established. This structure was used as input in answering the second question: *To what extent is the generic process model structure useful in a re-engineering effort?* For this part of the research, the focus is on the preservation of the structure for future re-engineering efforts. The related research question is:

How can the educational process model be preserved and reused?

In section 2.2.2 the importance of *reusability* was emphasized. Reusability was one of the reasons for the development of a new paradigm called the 'object-oriented paradigm' (Coad & Yourdon, 1990; Booch, 1991). The MIT Sloan School introduced a method to document, in meticulous detail, every major business process in which re-usability and inheritance plays an important role (Carr, 2003). In this section, I introduce an adapted version of this method for the documentation of the educational process model, called the 'Educational Process Model Repository'.

One of the advantages of computer technology is the ability to store and access large amounts of data or information on storage devices. Researchers are busy constantly enhancing techniques to store data more efficiently and to make it platform-independent. This is accomplished by introducing standardisation concepts such as the use of XML for data representation.

According to a white paper published by the Phios Corporation (1999), they believe that many successful companies in the 21st century will devote just as much time to the management of processes as to their products. This implies the need for more systematic methods of managing the process knowledge in the different application domains. One method proposed by MIT is the use of process repositories (Carr, 2003). As discussed in section 2.5.3, process repositories enable the re-engineering team to use existing process models within the application domain and therefore limit the time spent on developing process models for generic processes.

For the educational domain, I could not find any repositories describing the activities for the *core processes.* In this work I suggest an adaptation of the Phios Model proposed by MIT (Malone *et al.*, 1999b; Carr, 2003). The reason for preferring the Phios Model is that it uses object-oriented principles where specialization is part of the model. The adapted model that I suggest is similar to the Phios Model (discussed in section 2.5.3), with some adaptations related to the inheritance of subprocesses discussed in section 4.3.3.1 and the notation discussed in section 4.3.3.2. In section 4.3.3.3 a guideline is given for investigation of the feasibility of the suggested educational process model representation.

4.3.3.1 Inheritance in the educational process model representation

Consider the generic process P_1 with subprocesses P_{11} to P_{1n} in the Phios Model (Figure 4.16).

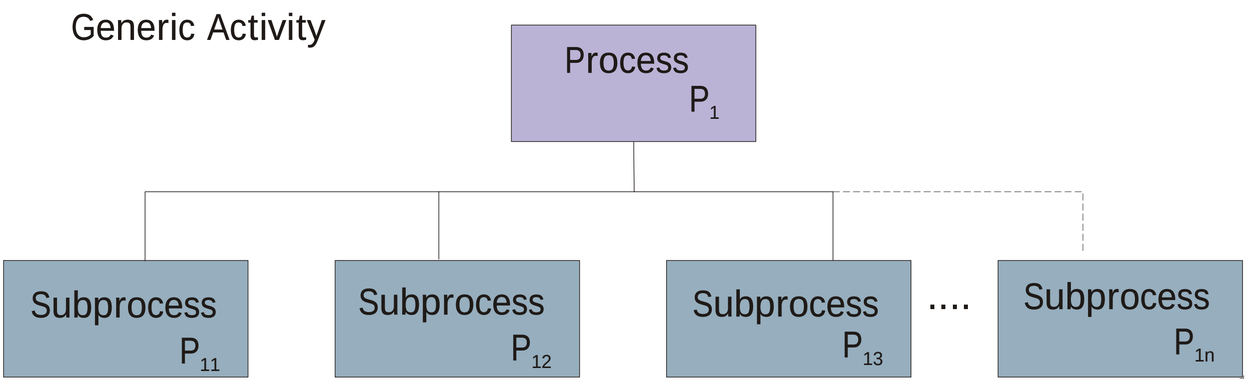


Figure 4.16: Phios Model

The Phios approach specifies that: 'Each activity *inherits* automatically the subactivities[14] and other properties of its generalization, except where the specialized activity *adds* or *changes* a property' (Phios, 1999:15). The implication in the model above is that the model may be extended (properties may be added to include another subprocess $P_{1(n+1)}$)) or any property of the subprocesses may be changed (P_{12} may be changed to another process P_{kl}). To relate this to a real-world example, consider *Sell Product* and its five subactivities:

- *Identify Potential Customers.*
- *Inform Potential Customers.*
- *Obtain Order.*
- *Deliver Product.*
- *Receive Payment* (Figure 4.17).

[14] The Phios Model uses the words 'activity' and 'subactivity' where I used 'process' and 'subprocesses'. For the purposes of this study, the meaning is the same, a specialization of a higher-level process.

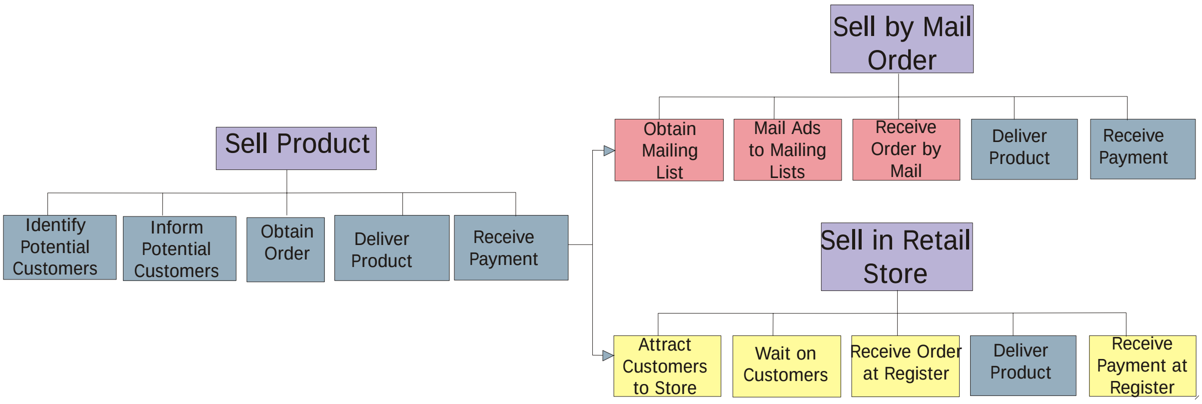


Figure 4.17: Specializations of the generic sales product 'Sell Something' (Phios, 1999)

In this example, *Sell Product* has two specializations, *Sell by Mail Order* or *Sell in Retail Store*. For the subprocess, *Identify Potential Customers* the mapping is to *Obtain Mailing List* and *Attract Customers to Store.* Similarly, *Deliver Product* maps to *Deliver Product* in both specializations (Figure 4.18).

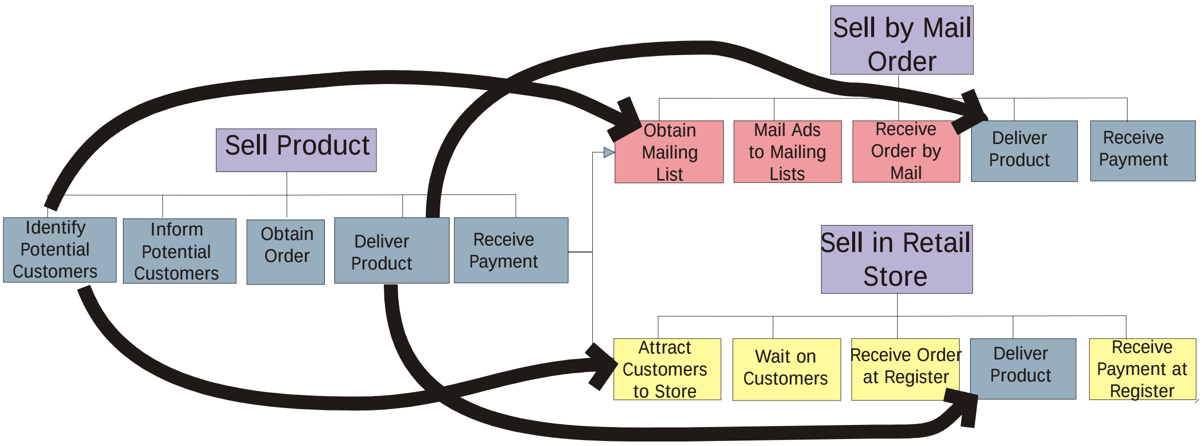


Figure 4.18: Mapping between specializations

The problem with this model is that the Phios Model allows the user to have different outputs for a mapping. For example, *Inform Potential Customers* maps to *Mail Ads to Mailing Lists* and to *Wait on Customers*. The outputs for the two subprocesses are not the same. In the first, *Mail Ads to Mailing Lists,* the goal of the subprocess is to mail the advertisements to the potential users. So the output for the subprocess (or activity) will be the mailed advertisements. In the second, *Wait on Customers*, there is no output; the subprocess specifies that the user must wait for customers to contact them. This implies that the output for the two subprocesses differs, which means that the Phios Model does not support the concept of *polymorphism,* which specifies that the output of an inheritance should stay the same (even if the methods change).

In the object model, using the concept of polymorphism allows the user to change the *way* in which a method arrives at the desired output, but the output stays the same. For example, if you give the same command to two of your children, 'Please make me some coffee', the method that the two children will follow may differ, but the output, the cup of coffee, should be the same.

My adapted model suggests that the rule that applies to polymorphism to the effect that the output of a subprocess should stay the same, should be included. This implies that the educational process model representation cannot be modelled as was suggested in the Phios Model example. The solution for this is to include fewer subprocesses on a higher level, where all the subprocesses have the same goal as the subprocesses in the base model. In other words, the specialization inherits the original subprocesses from the generic model and, if necessary, subprocesses can be added to the specialization. The suggested educational process model structure is illustrated in Figure 4.19. The adapted model suggests that Specialization 1 is not allowed, where the output of the subprocess differs from the output of the parent, but Specialization 2 is allowed where the output of the subprocess has the same form as in the parent abstraction.

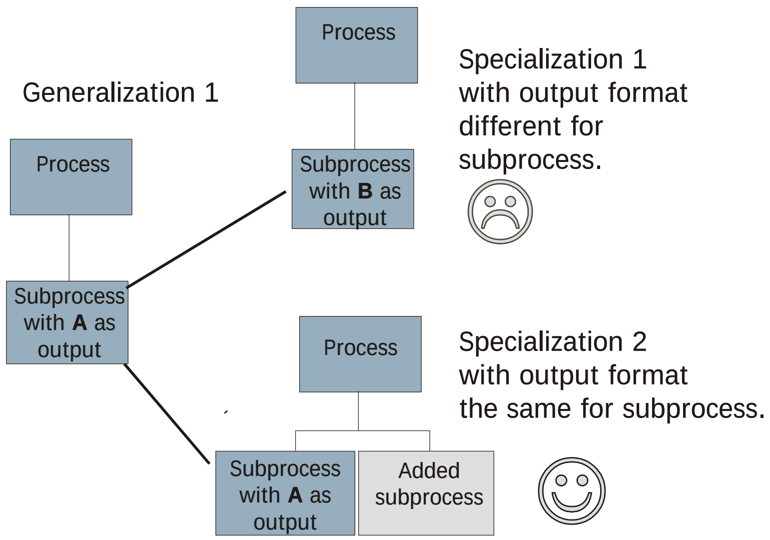
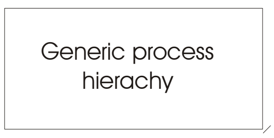
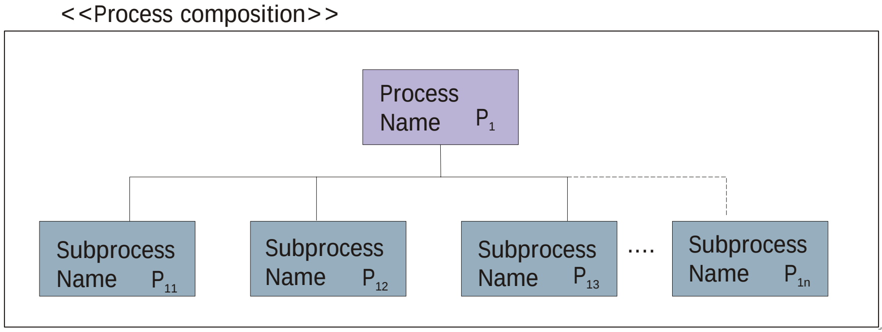


Figure 4.19: Inheritance and additions of subprocesses

4.3.3.2 *Notation in the educational process model representation*

The Phios Model claims to use generalization and specialization from the object-oriented paradigm. According to the *Sell Product* example used in most of the written papers on the process repository, the notation does not agree with the notation used for specialization in the object-oriented paradigm. In object technology, the arrow shows from the child object to the parent and not as in this example, where the arrow shows from the generic process to the specialization. I believe that the notation in this model does not have a significant meaning; it is never discussed in the papers where the authors refer to this example (Phios, 1999; Bernstein, Klein & Malone, 2003).

I therefore suggest an adaptation of this model to support the notation used for generalization and specialization in the object-oriented paradigm, with the arrow pointing to the generalization and not the other way around. In Figure 4.17 and 4.18 the arrow shows from the parent to the specializations and in the adapted model, Figure 4.19, it goes from the specializations to the parent. Furthermore, I also suggest the use of a new stereotype called the *Process Composition Stereotype* to formalize the specialization between the generic process and the representations. Stereotypes are used to extend the existing object notation and therefore formalize the model within the object-oriented paradigm. The description for the Process composition stereotype is the following:

UML Metaclass Extended	Class
Semantics	The generic process consists of one or more subprocesses used to derive the goal for the process. If only one subprocess, the process is called ‘atomic’.
Constraints	Must produce at least one output.
Diagram Notation	The notation used is <<process composition>> In a diagram the process composition is described by a rectangle with the generic process and subprocesses drawn in the rectangle as a process hierarchy. <<Process composition>> 
Predefined process composition	Each generic process composition consists of a generic process with a subset of subprocesses. In a specialization, polymorphism is applied – the method of reaching the goal of the subprocess may differ, but the output stays the same. In a specialization, subprocesses may be added. <<Process composition>> 

The suggested adapted notation with the stereotype definition is illustrated in Figure 4.20 for the *Sell Product* example from the Phios Model.

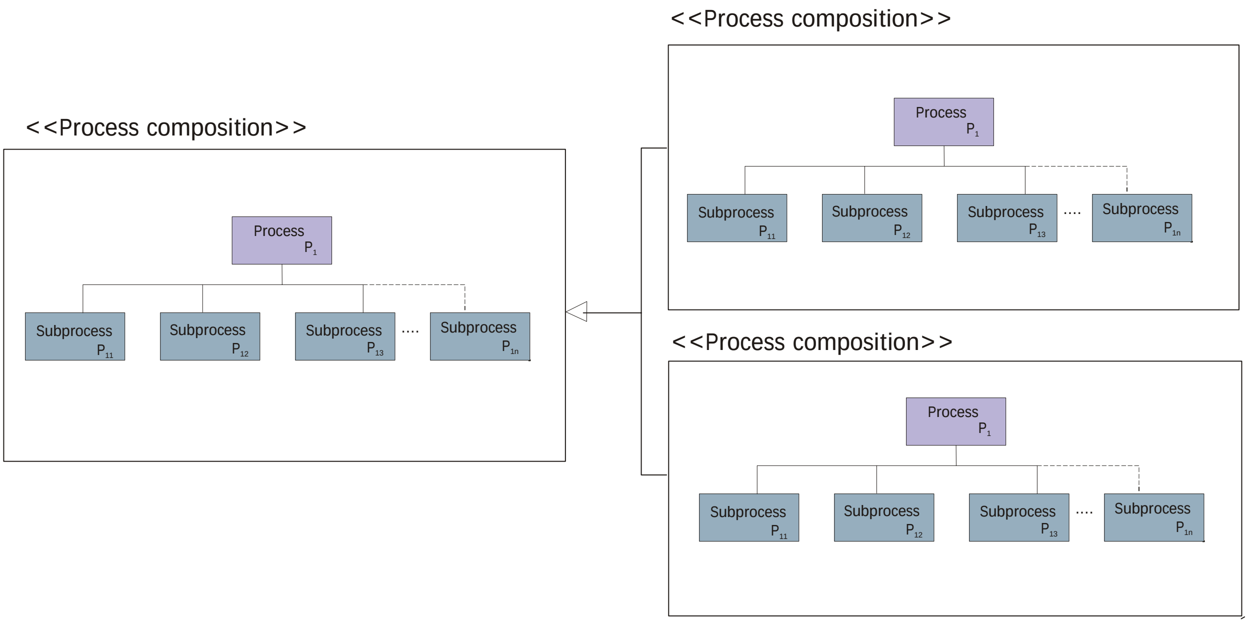


Figure 4.20 : Suggested notation for specialization in the educational process repository

In Chapter 7 the REGISTRATION process is used as an example to discuss the use of the adapted educational process model representation.

4.3.3.3 The feasibility of using the educational process model representation

In order to discuss the feasibility of implementing the educational process model in a repository, it is necessary to discuss the implementation on the basis of the four components included in dimensions of the Phios compass namely the *specialization, generalization, uses* and *parts* (Phios, 1999). The following questions need to be addressed for each of these:

- Specialization: In what other way can this activity be done?
- Generalization: What other activity is like this one?
- Uses: In what larger activities is this one used?
- Parts: What are the different parts?

These questions are addressed in a discussion on the feasibility of preserving the educational process model, in section 7.3.

This concludes the discussion on the research design for the three research questions. In section 4.3 trustworthiness and authentication in this study is discussed, followed by a brief overview of the limitations of the study in section 4.4. In section 4.6 some remarks are made on the methodological costs of the study followed by a conclusion.

4.4 TRUSTWORTHINESS AND AUTHENTICATION

Trustworthiness and authentication in research refer to the validity of the research done by the researcher. The researcher should be able to explain why the reader should ‘believe’ what he is reading. In quantitative studies the results are measurable, which makes it easier to believe (but should still be based on valid data). Qualitative studies rely on data that is verbal, and therefore do not involve any formal measurement (Leedy, 1993). To ensure trustworthiness and authenticity in this study, the measures put in place for the different research questions are summarized in Table 4.32 and an overview of each is given in sections 4.4.1 to 4.4.6.

Table 4.32: Trustworthiness/authenticity for research questions

Technique used to ensure trustworthiness/authenticity	Research Question		
	1	2	3
Characteristic list	√		
Feasibility study	√	√	√
Case study	√	√	√
Member checking / peer reviews	√	√	√
Triangulation	√	√	√
Publications	√		
Research projects	√		

4.4.1 Characteristic list

The requirements elicitation procedure developed for collecting data to determine the structure of a university was screened against a list of characteristics compiled from best practices in other requirements elicitation application domains.

4.4.2 Feasibility study / Case study

Development research is distinguished from other research methods by applying existing knowledge and adding to the theoretical writings on a topic. My contribution in answering the research questions was not only to develop methods that the development team may use during re-engineering efforts, but also to test these methods and to enhance them if they are not feasible. For all three research questions, feasibility was proved by applying the procedures developed to at least one case study environment. The requirements elicitation procedure developed for Research Question 1 was used at three different institutions before it was accepted as a feasible procedure for doing data-gathering (data discussed in Chapter 5). For the second question, existing techniques used in business applications were used to propose a procedure for determining constraints within the educational domain. The registration process was used as a case study to determine the feasibility of using the procedure. Lastly, the adapted process repository suggested for Research Question 3 was also tested using the registration process. To show why it is an improvement upon the Phios process repository, the structure of the two repositories for the registration process was compared.

4.4.3 Member checking / peer review

For the mathematics included in Research Question 1, Prof. E. Cloete[15], reviewed the formulae used in the different procedures. Prof. J. Heidema[15], also provided valuable information on set theories and the way they are mathematically presented. For the adapted models suggested for Research Question 3, colleagues in Computer Science assist in the verification of the abstractions.

The data gathered at the different institutions were compared before the generic high-level process model for an educational institution was suggested. Process models derived were verified by role players involved in the different processes.

4.4.4 Triangulation

The research for Research Question 1 was conducted from a process model perspective. *Triangulation* refers to ‘any similar trigonometric operation for finding a position or location by means of bearings from two fixed points a known distance apart’ (Merriam-Webster, 2005). Triangulation was reached by looking at process models initially from an input, output and resource perspective. Different procedures were studied and best practices were selected from these. For Research Question 2, triangulation was reached by using two different techniques to confirm what the constraints are in the subprocesses for the REGISTRATION process. The results indicated the same area of constraints.

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[15] At the time of the member checking professors in the Faculty of Science, UNISA

4.4.5 Publications

Often results in a thesis of this scope are published only after the thesis has been written. In the present research strategy, the validity of the research was tested by reporting on the results while doing the study. Valuable input was received in this way from peers involved in the reviewing of the work and during conference presentations. The lists of publications include papers on:

- Personal experiences in the on-line environment (Van der Merwe & Cloete, 2000).
- A requirements elicitation procedure (Cloete, Van der Merwe & Pretorius, 2003; Van der Merwe *et al.*, 2004b).
- The application of the procedure (Van der Merwe, 2003).
- A list of characteristics that a requirements elicitation procedure should adhere to (Van der Merwe *et al.*, 2004a).
- The relationship of the resulting high-level process model to value chain theory (Van der Merwe & Cronje, 2004).
- The selection of a qualitative research method in Information Systems (Van der Merwe *et al.*, 2005).

4.4.6 Research projects

It was not possible to implement suggestions that resulted in using the process management flow procedure for the registration process at UNISA. To establish the feasibility of the solution, a project was defined to develop a web-based registration prototype simulating the solution. This project was completed by Mr. H. Green early in 2004 (Green & Van der Merwe, 2004).

4.5 LIMITATIONS OF THE STUDY: PRODUCT

There are two distinct limitations to the study. Note that these relate to the development of the product. The first became evident when the process management flow procedure was used for the registration process and the second one cropped up in the user interface level for the educational process model repository.

4.5.1 Limitation to the application of the process management flow procedure

The five phases within the process management flow procedure consists of:

- Phase 1: Identification of the constraint(s).
- Phase 2: Identification of constraint(s) within a selected subprocess.
- Phase 3: Identification of reason(s) for the selected constraint.
- Phase 4: Considerations of solutions to the problem.
- Phase 5: Implementation of changes and evaluation of results.

The registration process was selected as a case study to show that it is feasible to use these phases in determining the constraints within a process model. Unfortunately, due to the sensitive nature of the registration process at the university, the suggested changes could not be implemented in the specific application domain. As mentioned previously, a project was defined to develop a prototype of the proposed solution. The activities that were not simulated were the testing of matriculation results against the SAUVCA system, the module enrolment against the Expert System and the automatic credit card verification. All three activities are possible from a programming point of view with the automatic electronic verification already being used in a number of e-commerce web-applications. For example, credit card verification is done automatically for the purchase of digital books (Amazon.com, 2004). The effect on this study was that it was possible only to comment on the technical feasibility without implementation.

4.5.2 Implementation of the educational process model repository

For the educational process model repository no software implementation was done. Instead, SCOR (2004) has a working application environment for the business process model repository powered by the Phios Model (Phios, 1999; SCOR, 2004). It is already feasible to program all the functions as demonstrated at the SCOR website. Therefore it was only necessary to show that it is feasible to implement the adapted educational process model. It was sufficient to do so as a theoretical feasibility study (Chapter 7). This limitation creates an opportunity for future research as discussed in Chapter 9.

4.6 METHODOLOGICAL COSTS

Methodological costs refer to what is lost by not using the most attractive alternative. In development research, the focus is on the enhancement of existing theory through studying practical environments (Van den Akker, 1999; Reeves, 2003; Van den Akker, 2004). In this study, three procedures were suggested to answer the different research questions. The procedures, with a summary of the solutions and the alternatives, are given in Table 4.33.

Table 4.33: Summary of solutions and alternatives

Research Question	Suggested procedure	Characteristics / advantage of procedure developed	Disadvantages	Alternatives
Question 1: What is the educational process model of the higher education institution?	A requirements elicitation procedure to determine the process model structure.	Structured procedure Cyclic in nature Clear deliverables Developed during practical implementation	Prescriptive	Use more formal procedure. Use existing re-engineering procedures.
Question 2: To what extent is the generic process model structure useful in a re-engineering effort?	A process management flow procedure based on Goldratt's (1992) TOC.	Use existing theory. Incorporate process models to investigate activities. Focus on reasons for constraints and solutions.	Lack of measurement procedures.	Incorporate Program evaluation and review technique (PERT) with the focus on time management. Use more formal procedures.
Question 3: How can the educational process model be preserved and reused?	An educational process model repository adapted from the Phios Model (Carr, 2003).	Based on an existing working model. Enhance the model to include additional specialization activities.	Limited human interface resources for manipulation.	Use existing Phios Model.

4.6.1 Methodological costs for Research Question 1

For the requirements elicitation procedure, an alternative would be the use of existing re-engineering procedures. The reason that existing re-engineering procedures were not used was that most procedures are developed for business environments with financial gain and not services as the objective. The focus of this study is on services. In establishing the process models, the focus was not on the financial aspects of the university (although the importance thereof is acknowledged). A more practical procedure was needed to reuse at other institutions. The development of the procedure was therefore done on the basis of two things, to gather the necessary information and to reuse the procedure at other institutions. This initiated the development of a requirements elicitation procedure that may be used in data-gathering with the focus on process models for educational environments.

Another alternative is the use of formal methods to describe the procedure. The results of an informal procedure are often not sufficient in terms of preciseness. It is also true that formal methods may assist in the precise specification of the procedure but lack flexibility and ease of use (George & Vaughn, 2003). In the procedure proposed, an informal approach was used to make the resultant models clearer and more readable for non-technical staff.

The methodological cost of informal methods has several negative repercussions (Meyer, 1985). Table 4.34 gives a list of the repercussions discussed by Meyer (1985) and indicates how this may be an issue in the present study.

Table 4.34: Repercussion list (Meyer, 1985) for not using formal methods

Repercussion	Methodological cost of not using formal methods in Research Question 1	Methodological cost of not using formal methods in Question 2
Redundant information may be present	Phase 2 may be unnecessary if Phase 3 is done efficiently.	Redundant information may assist only the user to clarify the problem domain.
There may be an absence of necessary information	Supplying guidelines in the establishment of the primary processes may lead the reader in such a way to a solution that he may ignore important processes.	Tools are guidelines only and in defining solutions important information may be neglected.
Information overflow where the reader is given too much information on the solution without understanding the problem	The requirements procedure is focused not only on the high-level process model, but also the subprocesses. The subprocesses may be too much information for the reader of the models.	The development team may experience the procedure as a frustration when the problem is already identified.
Contradictions in the text	-	-
Ambiguity, where information makes it possible for the reader to interpret it in different ways	Process models may be read in different ways depending on the background of the person using the model. Extra care was taken to ensure that only the essential elements are captured.	Using theory of constraints is a creative process and unnecessary time may be spent on the creation of irrelevant models.

To sum up, the methodological cost involved in keeping the procedure informal may have a limited impact on the resulting models with regard to mathematical preciseness. Whitten (2000) defines modelling as the act of drawing one or more graphical representations of a system. He says it is a communication technique based on the old saying that a picture is worth a thousand words'. For the purpose of this study, I selected a more informal approach where graphical representations are represented mostly with informal notations accomplished by 'words' as descriptions. This makes it more acceptable to be used as a reference model for the non-technical user. I do, however, support the notion of using standards such as in UML.

4.6.2 Methodological costs for Research Question 2

For the process management flow procedure defined in section 4.3.2.1, the alternative is to look at a procedure in which time plays a more pertinent role and to implement this using PERT as a management tool (see Table 4.34). I decided not to follow this route because although time is important in this study, the procedure suggested is based on communication with the role players in the different activities where the resources are trusted. Investigating the option where time is more pertinent, opens up an opportunity for further research as discussed in Chapter 9.

The same arguments hold for the use of formal techniques in Research Question 2 as for Research Question 1 (discussed above). The probable methodological cost of not using formal methods with regard to Meyer's (1985) repercussion list is given in Table 4.34.

The intention of the proposed procedure is to lead the user to use his critical thinking skills with regard to the origination of the constraints in his application domain. The proposed techniques are driven graphically to help the user to 'see' his constraints and solutions, rather than using precise mathematical notations that may make the approach difficult for non-technical users.

4.6.3 Methodological costs for Research Question 3

Lastly, for the educational process model repository proposed for Research Question 3, the alternative is to use the existing Phios Model (Table 4.33). As discussed in this Chapter, the methodological cost of following this route is that the model created using the Phios Model may not provide for extensibility on lower levels. The result will be a limited representation of models.

4.7 SUMMARY

In this Chapter, development research was introduced as the research approach for this study. Development research is a cyclic approach and was used in developing the research tools and testing the tools in different application domains.

For the first research question: *What is the educational process model structure of the higher education institution?* a requirements elicitation procedure was developed and three institutions, including UNISA, UP and TechPta, were selected for data-gathering. The University of the Freestate was selected for verification of the process model structure. In section 4.3.1 the tools and methods used to gather the data in the different application domains were discussed. The requirements elicitation procedure was described in a formal way, which has several advantages, including the implementation thereof in a computer system where elements in the process lists can easily be stored, retrieved and manipulated.

For the second research question: *To what extent is the generic process model structure useful in a re-engineering effort?* a re-engineering procedure was suggested based on Goldratt's (1992) theory of constraints, using the registration process as a use case study.

The methods and techniques to answer the question: *How can the educational process model be preserved and reused?* were considered in section 4.3.3. An adaptation of the current Phios Model was proposed in which the model makes provision for more formal notation in the presentation of the model and also stricter rules on polymorphism during specialization.

The Chapter concluded with some notes on limitations, methodological costs, trustworthiness and authentication in sections 4.4, 4.5 and 4.6 respectively.

In Table 4.35 a summary is given of some of the design issues in this Chapter.

Table 4.35: Research design summary

Design	**What is the process model of a changing university?**					
Data collection	Checklist	Observations	Structured Interview	Contextual analysis	Requirements elicitation procedure	Process management flow procedure
Data collection instruments	Compiled questions and data collected from case study	Researcher field notes in the form of observation sheets.	Interview schedule	• Documents describing organizational structures • Telephone lists to determine units • Work allocation lists • Responsibility lists	Use procedure and observation, interviews, and contextual analysis to retrieve requirements.	Use procedure and observation, interviews and contextual analysis to retrieve information on constraints.
Data source	Respondent during registration	Researcher and role players within different units.	Researcher and role players within different units.	Researcher	Researcher and role players within different units.	Researcher and role players in different units.
When administered	August – September 2004	UNISA: February 2002 – August 2002 UP: - TechPta: -	UNISA: February 2002 – August 2002 UP: September 2002 – November 2002 TechPta: November 2002 – January 2003	UNISA: February 2002 – August 2002 UP: September 2002 – November 2002 TechPta: Nov 2002 – Jan 2003	February 2002 – January 2003	
Who conducted	Researcher	Researcher	Researcher	Researcher	Researcher	Researcher
Verification: Trustworthiness and authentication	Member checks	Member checks and peer reviews	Member checks	Characteristic list Triangulation	• Characteristic list • Feasibility study • Case study • Member checking / peer Reviews • Triangulation • Publications	• Feasibility study • Case study • Member checking / peer Reviews • Triangulation
Ethical considerations	What you ask. How you ask it.	Informed about researcher	• What you ask. • How you ask it. • Obtain consent. • Gain trust.	Obtain permission to use documentation supplied by resources.	Restrict information to case studies only.	Restrict information to case studies only.

5. Evidence and Discussion: Educational Process Model Structure

5.1 INTRODUCTION

The goal in Chapter 5 is to establish the educational process model structure, which leads to the research question: *What is the educational process model structure of the higher education institution?*

Chapter 5 is divided into three sections. Section 5.2 contains a report on the data gathered at three different institutions using a requirements elicitation procedure developed (section 5.3) to produce the educational process model structure (section 5.4). This is depicted graphically in Figure 5.1 with the first activity, the data-gathering, highlighted in a blue box.

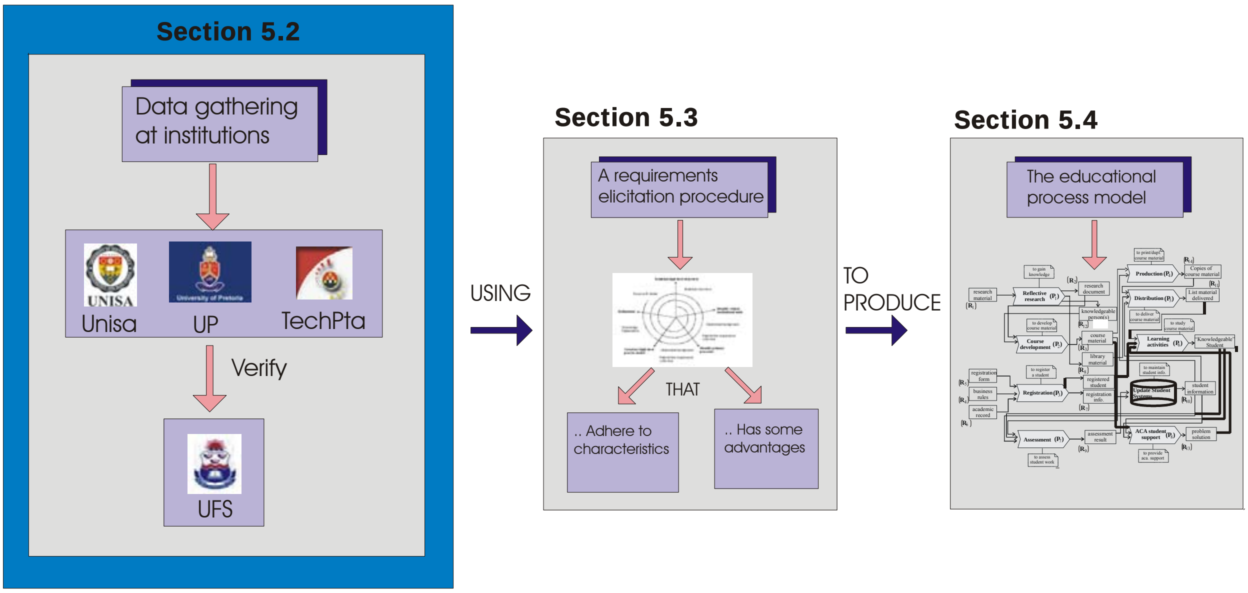


Figure 5.1: The three sections discussing the educational process model structure

5.2 DATA-GATHERING AND VERIFICATION AT THE DIFFERENT INSTITUTIONS

The requirements elicitation procedure that was developed was used at three institutions, namely UNISA, the University of Pretoria (UP), and Technikon Pretoria (TechPta). Data verification was done at the University of the Freestate (UFS) during a visit in April 2003. The data retrieved during the different phases of the requirements elicitation procedure, which is reflected in this

Chapter, is reflected as it was at the stage of data-gathering. There is a possibility that there may be some changes in units between the data-gathering date and the date of publication. However, this should not influence the output of the research.

Section 5.2.1 consists of all the data gathered at UNISA. Section 5.2.2 includes a discussion on the data retrieved from UP, followed by a discussion in section 5.2.3 of the data retrieved at TechPta. In section 5.2.4 the verification process at Bloemfontein University is discussed.

For data-gathering and verification at the different institutions, the requirements elicitation procedure suggested a set of tools or documentation with a deliverable at the end of each phase (discussed in Chapter 4). This list of documentation/tools and deliverables was used as a guideline during the application of the procedure at the different institutions and referred to in these sections (Table 5.1).

Table 5.1: Tools and deliverables for the requirements elicitation procedure

Phase	Phase description	Tools / Documentation	Deliverable
1	Establish objectives		Goal statement
2	Identify critical units	• Unit list	Critical units
3	Identify primary processes	• Unit -> Process list • Starting list • Mapping tool • Process list	Primary process list
4	Construct the high-level process model	• Process list with goals and resources • Association list • Triple list	High-level process model
5	Refine the high-level process model to subprocesses	• Subprocess list • Process list with goals and resources • Association list • Triple list	Subprocesses

5.2.1 Data-gathering procedure at University of South Africa

The data-gathering process at UNISA began in 2001. To my knowledge, there was no existing procedure available then for the determination of the educational application domain structure using process models. A requirements elicitation procedure was defined and refined (Chapter 4) and the different phases were followed during data-gathering. The first phase in the procedure is to define the objectives of the requirements elicitation activity.

5.2.1.1 Phase 1: Establish objectives

From 2000-2003 I was involved in efforts at UNISA to adopt best practices in e-learning and e-learning standards. During this time formal as well as informal interviews were conducted during analysis activities within the educational domain. From the information gathered it emerged that it is important to find and apply the best technological strategies in order to promote e-learning as one of the core teaching strategies. Yet many of these efforts seemed to fail. At the time when this project was established as a research project, the primary goal was redefined as the necessity to acquire domain knowledge in order to gain a comprehensive understanding of the critical processes at the institution. During the first phase, a descriptive report was compiled that depicts the primary goal and the secondary goal as well as the intended deliverables.

The following goal statement was compiled as the deliverable of Phase 1 (Table 5.2):

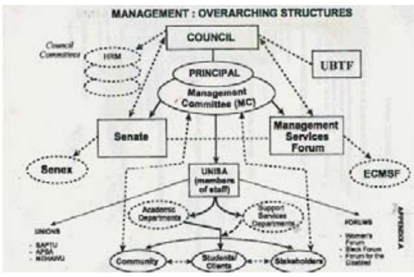
Table 5.2: UNISA goal statement

Project name : Requirements elicitation at UNISA Compiled on (Date): March 2002 Compiled by (Stakeholders): Alta van der Merwe, Elsabe Cloete		
Primary goal description:	The necessity to acquire domain knowledge for gaining a comprehensive understanding of the critical processes at the institution.	
Deliverables for primary goal:	After completion of the five phases be able to describe the structure of the educational domain with the help of process models.	
Subgoal & deliverables:	Goal	Deliverables
	Derive the process models	Phase 2: Critical unit list. Phase 3: Primary process list. Phase 4: High-level process model. Phase 5: Subprocess models.

5.2.1.2 Phase 2: Identify critical institutional units

According to the requirements elicitation procedure used, Phase 2 consists of the gathering of information on the different units within the educational domain. During this phase UNISA telephone list, organograms and UNISA website were used as resources (Table 5.3).

Table 5.3: Examples of resources used for identification of the list of units within UNISA

<table>
<tr>
<td>1.Telephone list
</td>
<td>2.Organograms

</td>
<td>3. UNISA website
www.unisa.ac.za</td>
</tr>
</table>

UNISA distinguishes between different units including teaching departments, administrative departments, sections, bureaux, institutes and centres. The comprehensive unit list for the university consisted of 101 units, with 61 teaching and 40 non-teaching units.

Table 5.4 presents UNISA units list compiled from the above-mentioned resources. Note that all the teaching departments were categorized under one unit, namely Academic Departments.

Table 5.4: List of units after first information gathering iteration

Academic Departments (59 teaching)	Institute for Behavioural Sciences
Assignments	Internal Audit
Building Administration	Internal Relations
Bureau for Management Information	Legal Aid Clinic
Bureau for Market Research	Library Services Matriculation Board
Bureau for Student Counselling	Organisation Development
Bureau for Learning Development	Staff Member
Catering Services	Post-graduate Student Affairs
Centre for Applied Psychology	Principal Office
Committee for University Principles	Production
Committee Services	Registrar
Community Development	Safety Services
Computer Services	Scheduling Section
Corporate Communication and Marketing Departments	Student Support
Despatch	Telecommunication Services
Documentation	Training and Development
Editorial Department	Typing Centre
Examinations	Undergrad Student Affairs
Finance	UNISA Press
Health Psychology Unit	UNISA Retirement Fund
	Unit of Video & Sound / Photography

The next step was to go through the list and to eliminate units not obviously involved in the creation of a learning environment. The initial list was reduced from 41 units to 29 units after removing units such as the *Health Psychology Unit* and *UNISA Retirement Fund*, which are not actively involved in the creation of a learning environment. The remaining 29 units are given in Table 5.5.

For each unit in the table, a brief description is included in a separate column with a 'Yes' or 'No' indicator. This indicator is used to indicate the importance of the unit in relation to learning and teaching activities. Each unit was scrutinized and if it did not carry out a primary activity in teaching and learning activities, it was assigned a 'No' in the field provided.

Table 5.5: Initial list of Units with descriptions: Institution 1

Unit Name	Brief description	Involved in learning and teaching activities Yes / No
Academic departments	Responsible for all tasks of an academic nature in developing and offering courses at the institution.	Yes
Assignments	Unit responsible for all the administration with assignments.	Yes
Building Administration	Unit responsible for the maintenance, reservation of rooms, furniture and parking at the Institution.	No
Corporate Communication & Market Research	Unit responsible for marketing and marketing research.	Yes
Bureau for Learning Development	Responsible for the development of courses;	Yes
Bureau for Management Information	The Bureau for Management Information is responsible for statistical research at the institution and reports back to government on the resource usage at the institution.	Yes
Catering services	Catering	No
Computer Services	Computer Services are a department that is responsible for all issues related to computers in the HEI. They are responsible for all activities related to the network, hardware, software, databases, security and web development. These activities include to: • create and maintain the infrastructure • develop new environments • purchase technology and install the infrastructure needed • educate and support the end-users.	Yes
Despatch	The unit responsible for distribution and store of study material.	Yes
Documentation	The unit responsible for document quality control of study material before it is delivered to the despatch department.	Yes
Editorial	The unit responsible for editorial quality control of study material before it is delivered to the despatch department.	Yes
Enquires	The unit responsible for directing enquiries received.	No
Examination	The unit responsible for handling all examination administration.	Yes
Finances	Unit responsible for all finances of students and lecturers at the Institution	Yes
Human Resources	Unit involved in all issues related to human resources.	Yes
Library	The library is responsible for the collection of library material, the management, storage and maintenance of library accounts, research support, course support and cataloguing of material.	Yes
Matriculation Board	The Matriculation Board is responsible for the administration with special cases applying for student status.	No
Organisation Development	Helps with psychological services (testing, selection and post evaluation)	No
Postgraduate Student affairs	All administrative activities related to postgraduate students	Yes
Production	A production section is responsible for the print work of course material.	Yes
Publications	All activities related to the publication of work.	No
Safety Services	Safety within the Institution	No
Scheduling Section	Schedules the different printing matter in the HEI.	Yes
Student Support	Student support	Yes
Telecommunication	Responsible for all telecommunication within the institution	Yes
Typing Services	Typing of study material	Yes
Undergraduate Student Affairs	The registration of students for courses at certain periods.	Yes
UNISA Press	Printing of books / certain material to be published	Yes
Unit Sound and Video / Photography	Compilation of material to be used by lecturers in study material or published with in UNISA.	Yes

The list of units was reduced to include only 19 non-teaching units and all the teaching units were grouped together under the heading ‘Academic Department’ (Table 5.6). Units belonging together, e.g. Assignments and Examination, which fall under the same administration, were combined in one unit called ‘Examination and Assignment Handling’. Units removed from this list are units such as Publications and Matriculation Board. The importance of these units is acknowledged, but for the purposes of this study they act as support activities at UNISA and do not contribute directly to the learning environment of the student.

Table 5.6: Unit list after third iteration

Academic Department	Human Resource
Bureau of Learning Development	Library Services
Bureau for Management Information	Production
Corporate Communication & Marketing	Scheduling
Computer Services	Student Support
Despatch	Typing Centre
Documentation	Telecommunication Centre
Editorial	UNISA Press
Examination and Assignment Handling	Unit for Video & Sound Photography
Finances	Undergraduate[16] Student Affairs

The 20 units derived after three iterations (Table 5.6) are the deliverable of this phase and act as input for Phase 3 of the requirements elicitation procedure.

5.2.1.3 Phase 3: Identify primary processes

The deliverable for Phase 3 is the list of primary processes. For identification of the primary processes, it is necessary to do one of the following:

- Identify the list of activities in each unit and map each activity to the process list that was suggested as the preliminary list in Phase 3 of the requirements elicitation procedure.
- Identify a new primary process and add it to the starting list
- Remove the activity from the list.

The suggested list included REGISTRATION, COURSE DEVELOPMENT, PRODUCTION, DISTRIBUTION and ACADEMIC STUDENT SUPPORT. For identification of additional

[16] Although Postgraduate Studies plays a particularly important role in serving a very wide community of students, we omitted it from this report because the constraints of its registration procedures add unnecessary complexities. A separate re-engineering exercise for this is identified for future research.

critical processes and removal of unnecessary ones, a table was used during the mapping of the process scrutinized on and the primary processes list. Where mapping was not possible, the particular primary process was added to the starting list, and where no element was mapped to a particular item on the starting list, the item was removed from the draft list.

For example, in the previous phase in UNISA application domain (Phase 2), a generic Academic Department was created, which embodies the typical processes and activities of any academic department (Table 5.7). The first four processes in Table 7 concern the design and construction of learning environments and as a result are considered to be primary, as opposed to general research, which contributes to the knowledge of the community at large and for this study is considered a support process.

Table 5.7: The processes within a generic Academic Department

Units	Process	Maps to process on process list	Primary (P) /Support (S)
Academic Department	Course development	COURSE DEVELOPMENT	P
	Academic Student Support	ACADEMIC STUDENT SUPPORT	P
	Assessment	ASSESSMENT	P
	Reflective Research	REFLECTIVE RESEARCH	P
	General Research	-	S

In the next step, the four processes identified were mapped to those on the starting list: course development mapped to COURSE DEVELOPMENT and academic student support mapped to ACADEMIC STUDENT SUPPORT. However, neither the assessment nor the reflective research processes matched any process on the starting list and as a result were added to the draft list. This is illustrated in Figure 5.2.

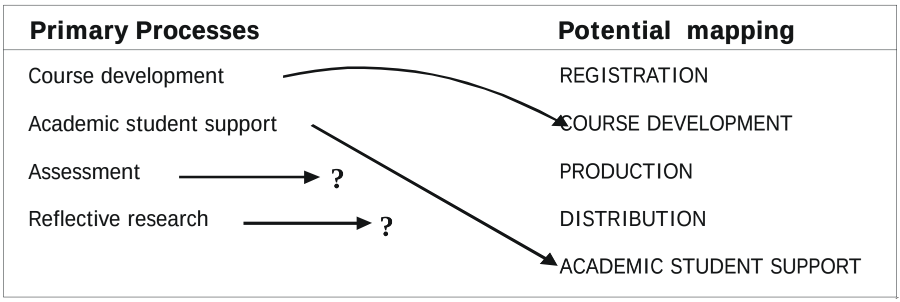


Figure 5.2: Evolution of service functions

The procedure was iterated for each unit and each unit was linked to a process in the list or a new process was added to the list. The resulting list with the important processes and mappings are shown in Table 5.8.

Table 5.8: Primary process elicitation at UNISA

Units	Process	Prim (P)/ Support (S)	Mapping
Academic Department	Course development Academic student support Assessment Reflective research Research	P P P P S	COURSE DEVELOPMENT ACADEMIC STUDENT SUPPORT ASSESSMENT REFLECTIVE RESEARCH
Corporate Communication & Marketing	Marketing Market research	S S	
Undergraduate Student Affairs	Registration Student administration	P S	REGISTRATION
Examination and Assignment handling	Assessment	P	ASSESSMENT
Bureau of Learning Development	Course development Reflective research	P P	COURSE DEVELOPMENT REFLECTIVE RESEARCH
Finances	Student finances Infrastructure finances	S S	
Student Support	Student support	S	
Safety Services	Safety	S	
Bureau for Management Information	Prepare management information reports	S	
Catering Services	Catering	S	
Building Administration	Building maintenance & development	S	
Human Resources	Resource planning & administration Labour relations Human resource development Employment equity	S S S S	
Editorial	Edit study material	P	COURSE DEVELOPMENT
UNISA Press	Compile study material	P	PRODUCTION
Production	Reproduce study material	P	PRODUCTION
Despatch	Distribute study material	P	DISTRIBUTION
Scheduling	Schedule study material for printing	P	PRODUCTION
Unit for Video & Sound Photography	Prepare study material	P	COURSE DEVELOPMENT
Documentation	Store identified documentation	S	
Library Services	Provide research material Offer & issue support material	S P	 DISTRIBUTION
Personnel	Personnel support	S	
Computer Services	Student system Computer services	P S	STUDENT SYSTEM
Typing Centre	Type study material	P	PRODUCTION
Telecommunication Centre	Telecommunication services	S	

After this step the primary process list consisted of the initial five processes given as a starting list for the procedure (REGISTRATION, COURSE DEVELOPMENT, PRODUCTION, DISTRIBUTION and ACADEMIC STUDENT SUPPORT) and three additional processes, namely STUDENT SYSTEM, REFLECTIVE RESEARCH and ASSESSMENT.

At this stage it is appropriate to discuss STUDENT SYSTEM as a primary process. The process does not really contribute to the learning environment, but being the technological backbone, it was included in the list of primary processes because it stores information for two other processes within the learning environment, the ASSESSMENT and REGISTRATION processes. It also provides information for PRODUCTION, DISTRIBUTION, ACADEMIC STUDENT SUPPORT and ASSESSMENT (examination). It is therefore important that it should be included in the high-level process model, and for the purpose of this study it is used as a special primary process.

The next step of the requirements elicitation procedure is identification of the different goals, inputs and outputs of the processes. For example, for the REFLECTIVE RESEARCH process, Research Material was identified as a basic requirement (input resource) and the output can either be a Research Document or the Knowledgeable Person(s) (Table 5.9).

Table 5.9: Primary processes with their resources and goals

Process	Input/output resources	Goal description
REFLECTIVE RESEARCH	Input: Research Material Output: Research Document Output: Knowledgeable Person(s)	To gain knowledge or an understanding of a specific topic.
COURSE DEVELOPMENT	Input: Research Document Input: Knowledgeable Person(s) Output: Study Material	To develop study material
REGISTRATION	Input: Registration Form Input: Academic Record Input: Business Rules Output: Registration Information	To register a student
PRODUCTION	Input: Study Material Input: Student Information Output: Copies of Study Material	To duplicate/print study material
DISTRIBUTION	Input: Student Information Input: Copies of Study Material Input: Library Material Output: List Material Delivered	To deliver study material
STUDENT SYSTEM	Input: Registration Information Input: Assessment Results Output: Student Information	To record student information
ASSESSMENT	Input: Study Material Input: Assignment/Exam Paper Input: Student Information Output: Assessment Results	To assess students' work
ACADEMIC STUDENT SUPPORT	Input: Student Information Input: Assessment Results Input: Study Material Output: Problem Solution	To provide academic support to students

For REFLECTIVE RESEARCH it is possible that the two outputs stipulated are not the only outputs since an individual or team who undertook the research may have gained insight and applied it in another process, without documenting it. The *goal* for this process was to gain knowledge needed for the development of course material. Note that not all the inputs are necessarily used for a specific process. For example, the DISTRIBUTION process can distribute Copies of Study Material or Library Material or both.

Each of the processes in the primary list was linked with an input resource(s), output resource(s), and a goal. The results are depicted in Table 5.9.

5.2.1.4 Phase 4: Construct the high-level process model

In this phase, the primary processes were linked with one another through their respective input and output resources. A process-resource table was constructed and presented in Table 5.10 from the data in Table 5.9 to show the different associations. The relationship between a resource and a process is indicated by either an 'I' or an 'O' where the first indicates an *input* relationship and the latter an *output* relationship.

Table 5.10: Associations between resources and primary processes

		Input / Output Resources														
		R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	R_{11}	R_{12}	R_{13}	R_{14}	R_{15}
		Research Material	Research Document	Study Material	Business Rules	Registration Form	Academic Record	Registration Information	Assignment/Exam paper	Assessment Result	Student Information	List Material Delivered	Knowledgeable person(s)	Problem Solution	Copies of Study Material	Library Material
P_1	REFLECTIVE RESEARCH	I	O										O			
P_2	COURSE DEVELOPMENT		I	O									I			
P_3	REGISTRATION				I	I	I	O								
P_4	PRODUCTION			I							I				O	
P_5	DISTRIBUTION										I	O			I	I
P_6	STUDENT SYSTEM							I		I	O					
P_7	ASSESSMENT			I					I	O	I					
P_8	ACADEMIC STUDENT SUPPORT			I						I	I			O		

Table 5.11 gives the subsequent definition of triples to associate processes and resources with one another. Note that it is a list of 28 triples without any significance in the order that they are listed in the table.

Table 5.11: Triples depicting associations between processes and resources

(P_1, R_1,input)	(P_3, R_7,output)	(P_6, R_9,input)
(P_1, R_2,output)	(P_4, R_3,input)	(P_6, R_{10},output)
(P_1, R_{12},output)	(P_4, R_{14},output)	(P_7, R_3,input)
(P_2, R_2,input)	(P_4, R_{10},input)	(P_7, R_8,input)
(P_2, R_3,output)	(P_5, R_{10},input)	(P_7, R_9,output)
(P_2, R_{12},input)	(P_5, R_{11},output)	(P_7, R_{10},input)
(P_3, R_4,input)	(P_5, R_{14},input)	(P_8, R_9input)
(P_3, R_5,input)	(P_5, R_{15},input)	(P_8, R_{13},output)
(P_3, R_6,input)	(P_6, R_7,input)	(P_8, R_{10},input)
(P_8, R_3,input)		

As a first step, the eight primary processes with their respective goals were drawn. Subsequently, the fifteen resources identified previously were added to the high-level process model, and the list of triples was used for linking the different processes with one another through resources, resulting in the high-level process model (Figure 5.3).

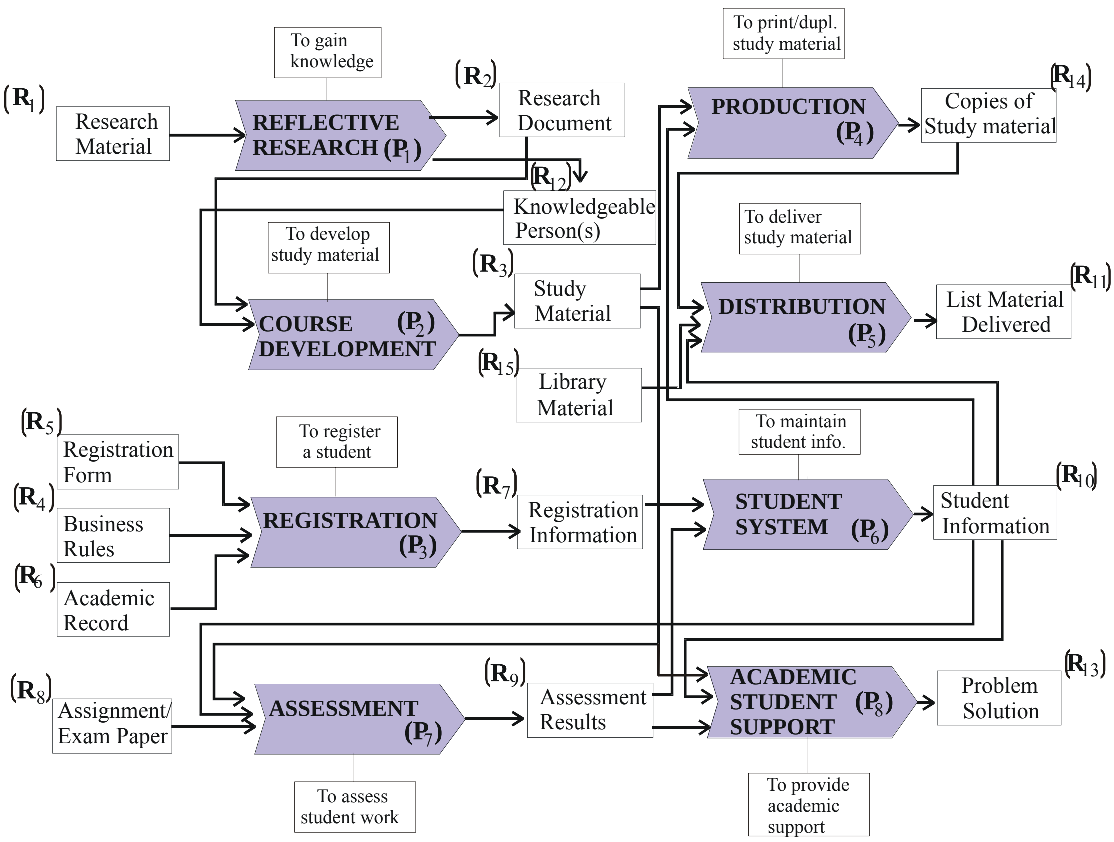


Figure 5.3: Main processes within UNISA

5.2.1.5 *Phase 5: Refine the process model*

In this phase, the goal was to construct subprocess models, which augment the high-level process model of Phase 4 in order to complete the understanding of the application domain. The REGISTRATION process was selected for inclusion in this Chapter; the other processes were also part of the requirements elicitation process and considered during the construction of the high-level process model. Some of the data gathered on the other processes are presented in Appendix 5, on the accompanying CD. Due to space limitations, not all the subprocesses are presented here, but the documentation used in data-gathering activities is available for viewing.

The first person consulted in this phase was Dr. Stephan Pretorius, with whom the processes and subprocesses within the Registration Unit were discussed. Flow diagrams indicating the current flow of processes were used (Figures 5.4 and 5.5) in combination with the information captured from Dr. Pretorius to derive the relevant subprocesses for the different scenarios at the institution.

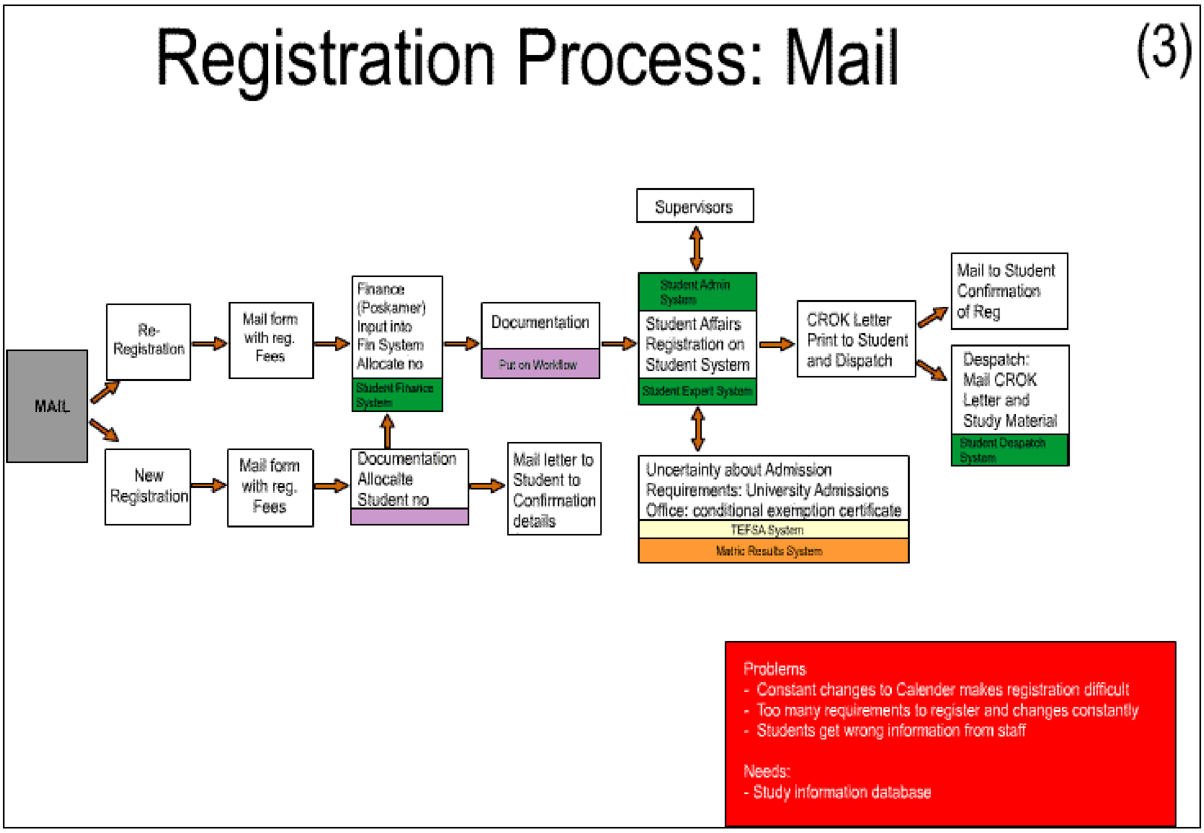


Figure 5.4: Mail registration source document (copy made from UNISA original)

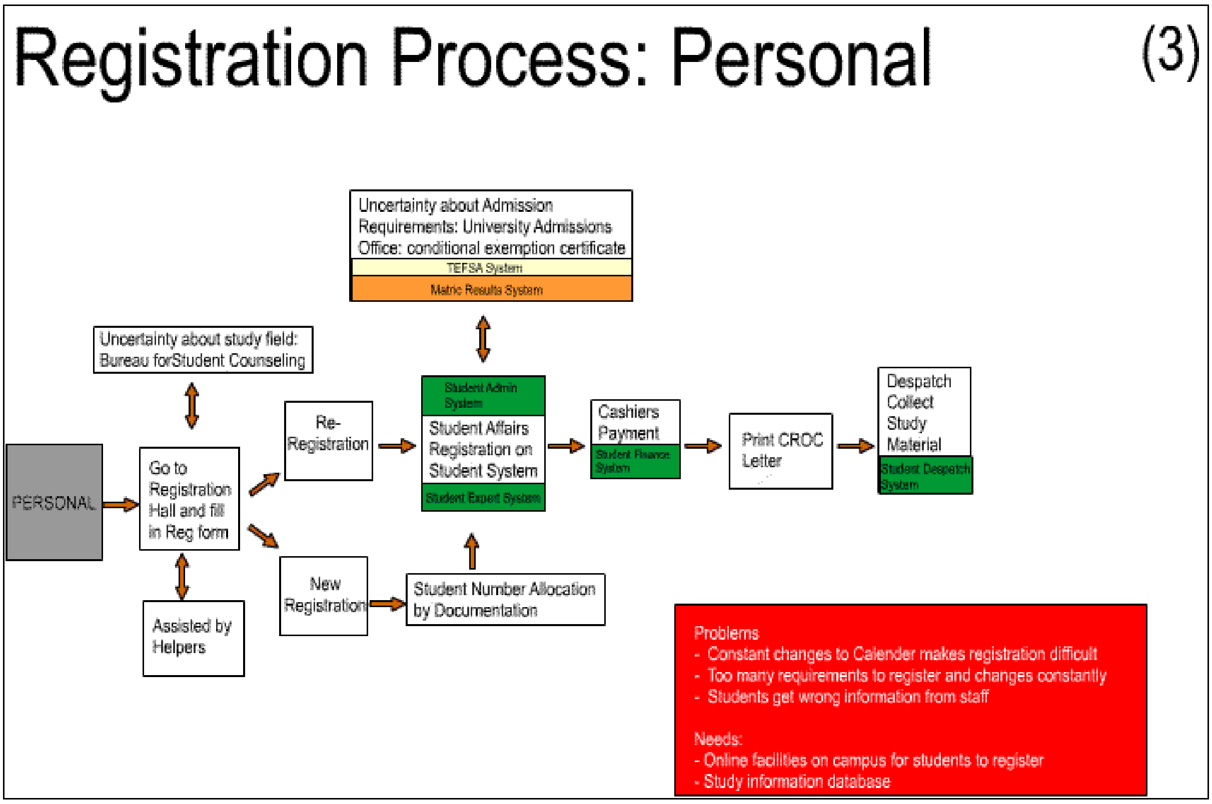


Figure 5.5: Counter registration source document (copy made from UNISA original)

The scenarios included an on-line, personal (counter) and postal registration. The subprocesses captured for the three different scenarios are presented in Table 5.12 and Table 5.13.

Table 5.12: Interview sheet : Dr. Stephan Pretorius

Unit	Registration	Date:	March 2002
Goal	To determine the subprocesses within the registration Unit		
Interview with	Dr. Stephan Pretorius		
Known generic process	REGISTRATION		
Scenario : Mail existing student (S_1)			
REGISTRATION S_1P_3	S_1P_{31} *Application Process*	S_1P_{311} *Application form completion*	
	S_1P_{32} *Payment Verification*	S_1P_{321} *Register & verify student payment*	
	S_1P_{33} *Academic Verification*	S_1P_{331} *Scan application & put on work flow* S_1P_{332} *Course profile verification* S_1P_{333} *Course data capture.* S_1P_{334} *Print confirmation to despatch & student*	
	S_1P_{34} *Course Material Distribution*	S_1P_{341} *Course material distribution*	
Scenario : Mail new student (S_2)			
REGISTRATION S_2P_3	S_2P_{31} *Application Process*	S_2P_{311} *Application form completion* S_2P_{312} *Capture student information and issue student number* S_2P_{313} *Send confirmation of actions to student.*	
	S_2P_{32} *Payment Verification*	S_2P_{321} *Register & verify student payment*	
	S_2P_{33} *Academic Verification*	S_2P_{331} *Scan application & put on work flow* S_2P_{332} *Course profile verification* S_2P_{333} *Course data capture.* S_2P_{334} *Print confirmation to despatch & student*	
	S_2P_{34} *Course Material Distribution*	S_2P_{341} *Course material distribution*	

Table 5.13: Interview sheet : Dr. Stephan Pretorius

Unit	Registration	Date:	March 2002
Goal	To determine the subprocesses within the registration Unit		
Interview with	Dr. Stephan Pretorius		
Known generic process	REGISTRATION		
Scenario: Counter existing student (S_3)			
REGISTRATION S_3P_3	S_3P_{31} *Application Process*	S_3P_{311} *Application form completion*	
	S_3P_{32} *Academic Verification*	S_3P_{321} *Course profile verification* S_3P_{322} *Course data capture.*	
	S_3P_{33} *Payment Verification*	S_3P_{331} *Register & verify student payment.* S_3P_{332} *Print confirmation to despatch & student*	
	S_3P_{34} *Course Material Distribution*	S_3P_{341} *Course material distribution*	
Scenario: Counter new student (S_4)			
REGISTRATION S_4P_3	S_4P_{31} *Application Process*	S_4P_{311} *Application form completion* S_4P_{312} *Capture student information and issue student number*	
	S_4P_{32} *Academic Verification*	S_4P_{321} *Course profile verification* S_4P_{322} *Course data capture.*	
	S_4P_{33} *Payment Verification*	S_4P_{331} *Register & verify student payment.*	
	S_4P_{34} *Course Material Distribution*	S_4P_{341} *Print confirmation to despatch & student* S_4P_{342} *Course material distribution*	
Scenario: Electronic new student (S_5)			
REGISTRATION S_5P_3	S_5P_{31} *Application Process*	S_5P_{311} *Student number application* S_5P_{312} *Student number allocation* S_5P_{313} *Send confirmation of actions to student.* S_5P_{314} *Application form completion* S_5P_{315} *Put on work flow*	
	S_5P_{32} *Academic Verification*	S_5P_{321} *Course profile verification* S_5P_{322} *Course data capture.* S_5P_{323} *Send confirmation of actions to student.*	
	S_5P_{33} *Payment Verification*	S_5P_{331} *Register & verify student payment.*	
	S_5P_{34} *Course Material Distribution*	S_5P_{341} *Course material distribution*	
Scenario: Electronic existing student (S_6)			
REGISTRATION S_6P_3	S_6P_{31} *Application Process*	S_6P_{311} *Application form completion* S_6P_{312} *Put on work flow*	
	S_6P_{32} *Academic Verification*	S_6P_{321} *Course profile verification* S_6P_{322} *Course data capture.* S_6P_{323} *Send confirmation of actions to student.*	
	S_6P_{33} *Payment Verification*	S_6P_{331} *Register & verify student payment.*	
	S_6P_{34} *Course Material Distribution*	S_6P_{341} *Course material distribution*	

A more detailed description of the different actions in the different scenarios is given in Table 5.14.

Table 5.14: Descriptions of actions in subprocesses

<table>
<tr><td colspan="2">Postal services</td></tr>
<tr><td>New Student</td><td>Existing Student</td></tr>
<tr><td>1. Application is completed manually and sent to institution with payment.
2. Institution allocates student number.
3. Payment for student is verified and recorded on student system.
4. A letter is mailed to student to confirm initial registration
5. Application form is scanned in and put on Workflow management system.
6. Representative tests application courses against Expert system and registers student on the student system.
7. The student is notified of his successful registration and any applicable course material is despatched to the student.</td><td>1. Application form received from institution is verified and fields are changed if necessary. Student sends application form to institution with payment.
2. Payment for student is verified and recorded on student system.
3. Application form is scanned in and put on Workflow management system.
4. Representative tests application courses against Expert system and registers student on the student system.
5. The student is notified of his successful registration and any applicable course material is despatched to the student.</td></tr>
<tr><td colspan="2">Counter Registration (Personal)</td></tr>
<tr><td>1. Student matriculation certificate and preferred course to enrol for is verified informally.
2. Application form is completed manually.
3. Student receives a student number and student information is captured on the student system.
4. Representative verifies application for legitimate registration, e.g. courses enrolled for are verified against Expert system.
5. Student courses are registered on student system.
6. Registration is confirmed only when the student pays the minimum fee.
7. The student is notified of his successful registration and any applicable course material is handed to the student.</td><td>1. Application completes registration form received from institution and changes relevant information if necessary.
2. Representative verifies student number against student system. Representative changes any information indicated on registration form.
3. Courses enrolled for are verified against Expert system.
4. Student courses are registered on student system.
5. Student is notified of initial registration and request payment is requested from student.
6. After payment is received, applicable course material is despatched to the student.</td></tr>
<tr><td colspan="2">Internet - Electronic</td></tr>
<tr><td>1. Student study course options on static web pages.
2. Student applies for student number.
3. Documentation receives application; allocate a student number on student system and send number to student.
4. Student completes the on-line registration form and submits it.
5. Student application is put on the work flow for processing.
6. Representative verifies application for legitimate registration
7. Student courses are registered on student system.
8. Registration is confirmed and student is notified of a minimum period before payment must be done.
9. After payment the student may request access to the SOL (Student on-line system)
10. Course material is despatched to the student.</td><td>1. The existing student completes the on-line registration form and submits it.
2. Student application is put on the work flow for processing.
3. Representative verifies application for legitimate registration, e.g. courses enrolled for are verified against Expert system.
4. Student courses are registered on student system.
5. Registration is confirmed and student is notified of a minimum period before payment must be made.
6. After payment the student may request access to the SOL (Student on-line system) and any applicable course material is despatched to the student.</td></tr>
</table>

The processes for the six scenarios are similar to one another and for the purpose of this thesis scenario 5, the electronic registration process (S_5P_3), was selected randomly to illustrate the decomposition of the REGISTRATION (P_3) primary process. In Table 5.15, the different subprocesses for a new student going through the electronic registration process are listed with the input, output and goal for each subprocess given.

Table 5.15 : Subprocesses, resources and goals for the electronic new student

	Process (P)	Input/output resources (R)	Goal (G)
S_5P_{31} Application Process	*S_5P_{311} Student number application*	Input: Empty form Output: Application with information	To apply for a student number
	S_5P_{312} Student number allocation	Input: Application with information Output: Student number allocated	The application is verified against the existing database and if the student is not an existing student, a number is allocated to him/her.
	S_5P_{313} Send confirmation of actions to student.	Input: Student number allocated Output: Student number information	An e-mail is compiled with the newly allocated student number and mailed to the student.
	S_5P_{314} Application form completion	Input: Student number information Input: Qualification rules Input: Academic Record Output: Registration information	The student fills in the registration form on the web after selecting the qualification for enrolment.
	S_5P_{315} Put on work flow	Input: Registration information Output: Application on work flow	The application is received and included in the work flow for processing.
S_5P_{32} Academic Verification	*S_5P_{321} Course profile verification*	Input: Application on work flow Input: Business rules Output: Student enrolment verified	The application is verified against the business rules of the qualification and the academic information for the student
	S_5P_{322} Course data capture.	Input: Student enrolment verified Output: Enrolment captured on database	The student information is captured on the database.
	S_5P_{323} Send confirmation of actions to student.	Input: Compile notification to student of enrolment Output: Notification of enrolment and payment details	E-mail is compiled to let the student know that he has to pay for the course, after which the course material will be dispatched.
S_5P_{33} Payment Verification	*S_5P_{331} Register & verify student payment.*	Input: Receive student payment confirmation Output: Registered student	The student pays the necessary fees and sends confirmation to the institution.
S_5P_{34} Course Material Distribution	*S_5P_{341} Course material distribution*	Input: Registered student Output: Course material distribution	Course material is distributed to student after successful registration.

For demonstration purposes S_5P_{31} was selected to illustrate the building of the process model for subprocesses on a third level. The decomposition for the other processes is similar and therefore

I selected the subprocess (S_5P_{31}) with the most subprocesses (five). The association table for the *Application process* (S_5P_{31}) is given in Table 5.16.

Table 5.16: Associations between resources (A) and processes (P) for *Application process* (S_5P_{31})

		Empty application form (S_5R_{311})	Application with information (S_5R_{312})	Student number allocated (S_5R_{313})	Student number information (S_5R_{314})	Qualification rules (S_5R_{315})	Academic record (S_5R_{316})	Registration information (S_5R_{317})	Processed application (S_5R_{318})
S_5P_{311}	*Student number application*	I	O						
S_5P_{312}	*Student number allocation*		I	O					
S_5P_{313}	*Send confirmation of actions to student*			I	O				
S_5P_{314}	*Application form completion*				I	I	I	O	
S_5P_{315}	*Put on work flow*						I	I	O

This association table is used to construct the diagrammatic depiction of the relationships between the different processes (Figure 5.6).

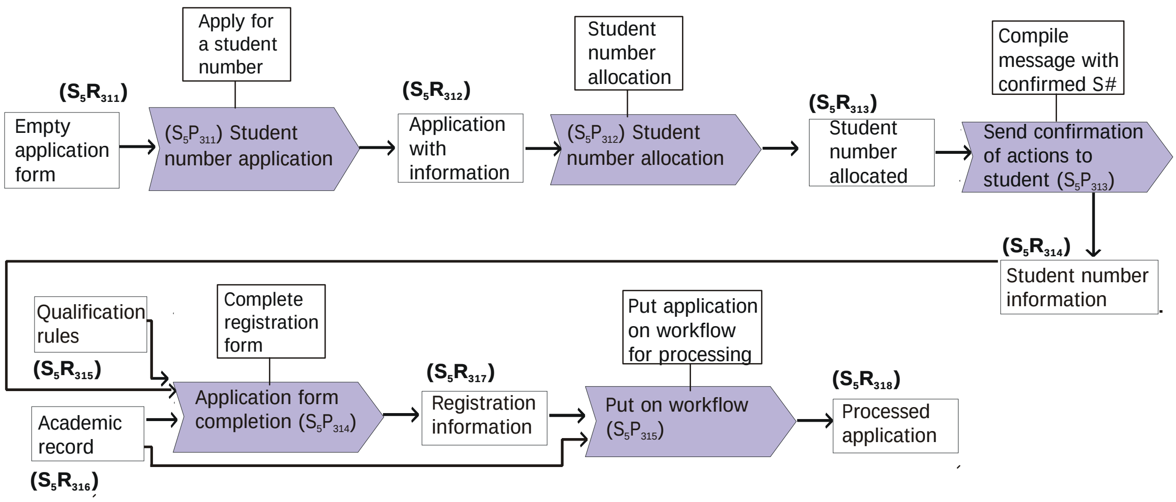


Figure 5.6: UNISA subprocess electronic registration (new student)

Similarly one can model the processes for the remaining set of subprocesses or, on a higher level, for the other primary processes.

5.2.1.6 *Findings after the first research cycle*

In Chapter 4, development research was selected as the research method for this study. Development research is based on a cyclic activity where problems are analysed, solutions are built with a theoretical framework, tested and the documentation reflect the results as ‘design principles'. At this stage, the first research cycle is complete and it is possible to reflect on the findings.

The findings in this section concern both on what the process model structure is and on the requirements elicitation procedure used to identify the process model. It is necessary to include a reflection on the procedure developed due to the fact that the theory used in this research activity forms part of the research effort.

5.2.1.6.1 Findings on the requirements elicitation procedure

When the development of the requirements elicitation procedure commenced, the initial requirements elicitation steps for finding and defining the structure of UNISA were unrealistic. Here are the steps as they were defined in 2002:

The University may be viewed from different perspectives. The different views are included in the following five phases, which are the basis for defining the educational model:

1. Define the institution's strategy, concepts and value chain.
2. Construct the high-level process model.
3. Model the institutional structure.
4. Model the resource behaviour.
5. Refine the model.

The problem with these steps was that they focused on a variety of concepts in one representation of the educational structure. It is not impossible to present different views in one structure, but requires more time and resources than work required for a thesis study. It was decided to limit the scope to process modelling, which resulted in the research question focussing only on the process model structure of the higher education domain. This meant that the theory developed, namely the requirements elicitation procedure, was developed with the aim of producing the high-level process model and the subprocess models. However, during application of the theory in UNISA application domain, I realized that there is a need for a model that models not only the processes but also includes responsibilities. Although the requirements elicitation procedure was not changed to reflect this, it was suggested as future work arising from this study.

Furthermore, the initial procedure did reflect the process model as a mathematical model. During the use of the procedure, the development of a case tool that will model the process model graphically was considered. In doing a feasibility study for the development of this kind of tool it was realized that if the processes were presented mathematically it would be easier to define them as related sets in a programming language (i.e. to represent them in arrays). Thus, during the use of the procedure at UNISA, the theory was changed to reflect these new principles in Phase 4 and Phase 5.

5.2.1.6.2 Findings on the process model structure

A valuable observation during the application of the procedure at UNISA is that it is impossible to separate the processes and the persons involved in them. People and processes form a unit and both should be included in any re-engineering effort, even if one knows what the processes are.

Furthermore, even though this was not the focus of this study, numerous problems or constraints were identified just from being involved in the modelling process. For future work it is necessary to look at the role of human resources within the modelling of the educational domain, as well as the responsibility of human resources (as mentioned in the previous finding).

The deliverable was the high-level process model and the set of subprocesses. The subprocesses for the REGISTRATION process were given to illustrate the use of the procedure and to show that it is possible to derive the subprocesses for the main process using the procedure.

In order to conclude that the findings in this research cycle may be generic in other environments, I went on to do a second research cycle in which the procedure was used at UP.

5.2.2 The data-gathering procedure at University of Pretoria

In August 2002, data-gathering started at UP. The five phases of the requirements elicitation procedure were used as a guideline for data-gathering and the results are described in more detail in this section.

5.2.2.1 Phase 1: Establish objectives

After discussions with Prof. Grove and with my study leaders, the following goal statement was compiled as the deliverable of Phase 1 (Table 5.17):

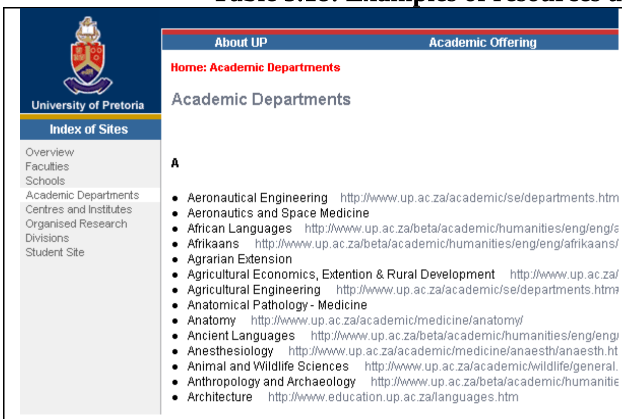
Table 5.17 : University of Pretoria goal statement

Project name : Requirements elicitation at UP Compiled on (Date): August 2002 Compiled by (Stakeholders): Alta van der Merwe, Elsabe Cloete, Prof. N Grove		
Primary goal description:	The necessity to acquire domain knowledge in order to gain a comprehensive understanding of the critical processes at the institution.	
Deliverables for primary goal:	After completion of the four phases be able to describe the structure of the educational domain and to compare it with the findings at UNISA.	
Subgoal & deliverables:	Goal	Deliverables
	Derive the process models	Phase 2: Critical unit list Phase 3: Primary process list Phase 4: High-level process model Phase 5: Electronic registration

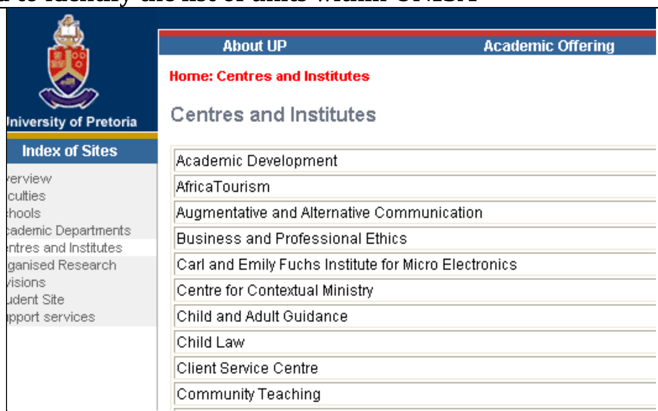
5.2.2.2 *Phase 2: Identify critical institutional units*

In the second phase, the different units within the University were identified. In this phase, UP website was used as the main resource (Table 5.18).

Table 5.18: Examples of resources used to identify the list of units within UNISA



1.Academic Departments
http://www.up.ac.za/index/eng/dept.html#a



2.Centres and institutes
http://www.up.ac.za/index/eng/centres.html

3. Services - http://www.up.ac.za/services/

The list of academic units consists of more than hundred departments and as in the UNISA case study, these were grouped under one heading: 'Academic Department'. A list of units and descriptions was compiled and all the units not involved actively in the teaching and learning activities were removed from the list. Interviews were conducted with a number of role players at the University to confirm their responsibilities. Some of the interview sheets that were used to determine the list of primary processes are provided in Appendix C, on the accompanying CD. The units involved in teaching and learning activities derived, is given in Table 5.19.

Table 5.19: Initial list of Units with descriptions: UNISA

Unit Name	Short description	Involved in learning and teaching activities Yes / No
Academic Departments	Responsible for all academic-related tasks in developing and offering of courses within the institution.	Yes
Academic Information Services	Similar to Library services at UNISA. Responsible for the Library Catalogue, Electronic Journals, Databases, etc. Available at www.up.ac.za/asservices/ais/	Yes
Bureau for Institutional Research and Planning	Similar to Bureau for Management Information at UNISA. The Bureau of Institutional Research and Planning assists the Executive and senior management of the University in professional and strategic support service. www.up.ac.za/services/birap/	No
Client Service Centre	Consists of the call Centre, Fulfilment Centre (handles student queries, etc.), Specialist Consultant (general queries) and Financial aspects (bursaries, etc.)	Yes
Department of Academic Administration	Responsible for administration contact with students, from registration to graduation. Supplies annual timetables, calendars etc. www.up.ac.za/services/academic-admin/frewelc1.html	Yes
Division for Process Integration	Sub-division of Department of Academic Administration: Student system – responsible for management of all data within the University. System development, system support, as well as timetables, venue bookings.	Yes
Division for Academic Administration	Sub-division of Department of Academic Administration: Responsible for applications, hostel placement, study financing, graduation ceremonies, faculty functions etc.	Yes
Department of Finance	Asset Management, budget control, creditors, debtor management, financial system, etc.	No
Department of Information Technology	Similar to UNISA Computer Services. Includes computer user support, infrastructure, systems and operating, Lab, Student Computing, Internet & Network, Client Services.	Yes
Department of Marketing Services	Responsible for Corporate Communication and Marketing, including Cultural affairs, the Alumni and Marketing Research http://www.up.ac.za/services/marketing/	No
Employment Equity	Responsible for employment and equity at the University	No
Human Resources	Responsible for appointment of staff in available positions.	No
Facilities and Services	The Unit Facilities and Services are responsible for provision services to staff and students including Campus Services, Food Services and Accommodation.	Yes
Research Support and International Affairs	Supports staff with research activities. Includes grant opportunities, e.g. NRF applications, and report on current research conducted at the University.	No
Division Sport and Recreation	Supports Sport activities at the University	No
Telematic Learning and Education Innovation	Supports academic staff in various education innovations, with a focus on the establishment of a flexible learning environment http://www.up.ac.za/telematic/	Yes

The unit list, after eliminating those not directly involved in teaching and learning activities, was limited to 7 units (Table 5.20). When the unit list was compared with UNISA unit list during the same iteration, I found that this list consisted of fewer units. The reason for this was that the educational environment was more familiar after the first iteration at UNISA, which made the elimination of unwanted units easier at UP.

Table 5.20: Unit list after elimination of unwanted units

Unit
Academic Department
Academic Information Service
Client Service Centre
Department of Academic Administration
Department of Information Technology
Facilities and Services
Telematic Learning and Education Innovation

5.2.2.3 Phase 3: Identify primary processes

The various steps used at UNISA were also used at UP. The unit list with different responsibilities was first compiled. This list was used to do the mapping to the suggested process list in Chapter 4. The processes included REGISTRATION, COURSE DEVELOPMENT, PRODUCTION, DISTRIBUTION and ACADEMIC STUDENT SUPPORT. The resulting list with the processes and mappings is shown in Table 5.21.

After this step the primary processes consisted of the initial five processes and three additional ones, namely STUDENT SYSTEM, REFLECTIVE RESEARCH and ASSESSMENT. At this stage I realized that even if the units were different to those units at UNISA, the primary processes were exactly the same.

In collaboration with my study leaders, I decided to proceed to Phase 4 and to discuss the resulting high-level process model obtained at UP with different role players at the University to see if this model does indeed represent UP activities

Table 5.21: Primary process elicitation list at UP

Unit	Process	Primary / Support	Mapping
Academic department	Reflective research Research Student academic support Course material development Course material production Course material distribution Class meetings Assessment Update student records Filing systems (course-related material) Marketing-related initiatives Departmental committees Departmental coordination admissions Departmental management Departmental administration Staff development	P S P P P P P P P S S S S S S S	REFLECTIVE RESEARCH ACA STUDENT SUPPORT COURSE DEVELOPMENT PRODUCTION DISTRIBUTION DISTRIBUTION ASSESSMENT STUDENT SYSTEM
Academic Information Service (Library)	Provides research material Provides support course material	S P	 DISTRIBUTION
Department of Academic Administration	Handles student records Handles examination results Student administration system Time-tables Academic (SAQA) programme registration Venue Bookings Promotional Ceremonies (e.g. graduation) Student finances Registration application Registration selection Registration processing Subject changes Updates Regulations (Year book) Hostel applications	P P P S S S S S P P P P P S S	STUDENT SYSTEM STUDENT SYSTEM STUDENT SYSTEM REGISTRATION REGISTRATION REGISTRATION STUDENT SYSTEM REGISTRATION
Department of Information Technology	User support Infrastructure Systems and operating (Student system) Lab	S S S S	
Facilities and Services	Printers Facility Management Properties and Facilities Technical, Building and Ground Services Operational services Accommodation and Food Services	P S S S	PRODUCTION
Telematic Learning and Education Innovation	Reflective research Research Course material development Course material production Course material distribution	P S P P P	REFLECTIVE RESEARCH COURSE DEVELOPMENT PRODUCTION DISTRIBUTION

5.2.2.4 *Phase 4: Construct the high-level process model*

The high-level process model identified during the case study at UNISA (Figure 5.3) included all the high-level processes identified at UP. During Phase 4, the representatives at UP were contacted to confirm the findings on the different processes. The following remarks made during discussions are significant:

- The high-level process model is an accurate model of the activities at UP.
- Lecturers are responsible for PRODUCTION and DISTRIBUTION of course material, in contrast to units at UNISA where the unit is responsible for these activities.
- Printing at the Production Unit is mainly for UP brochures such as calendars. Only a few lecturers use the printing facility for teaching and learning activities.
- E-learning played an important role and in 2002 there were already 105 courses produced with Web-CT.
- The *responsibility for tasks* on lower levels differed at UNISA and UP. Furthermore, the *sequence of tasks* may not be at the same within units.

5.2.2.5 *Phase 5: Refine the process model*

The last step in the requirements elicitation procedure is to refine the high-level process model. As mentioned before, the REGISTRATION process was selected randomly as a case study for UNISA. To be able to compare these processes it was logical that this process should also be refined at UP.

Two interviews were conducted with Mrs. Erna Esterhuizen, a staff member involved in the REGISTRATION process at UP. Mrs. Esterhuizen is involved with the electronic applications at the university and understands the different application scenarios. Our discussions were informal using the knowledge gained at UNISA as the point of departure. She was first asked to describe the different types of application process scenarios at the University. This was followed by a comparison of the different scenarios at UNISA and UP. The application process itself was also discussed and the sequence of events confirmed.

The following two differences are significant enough to mention before discussing the breakdown of the REGISTRATION process[17]:

- At UP, a student first applies to be admitted to the University. The application is approved by the relevant faculty and only upon confirmation of his payment and verification of his details will he be registered. For each application the student pays an administration fee of R150 (amount in 2005).
- UP has two modes for handling applications, either electronic or personal. Postal applications and counter applications are dealt with in exactly the same manner. These are grouped together under 'personal applications' (also referred to as 'manual applications').

The subprocesses for the two scenarios discussed are shown in Table 5.22. Note that there is only an electronic procedure available for new students (or students who took a break from studies and want to start again). There is no electronic procedure for existing students – these students will complete a letter of intention at the end of the academic year. This will give an indication of whether or not the student wants to proceed with the current registration.

[17] UP uses the term 'application process' and not 'registration process'. Registration takes place after approval from faculty and confirmation of payment. For my purpose, *Registration process* includes UP application process.

Table 5.22 : Interview sheet for Mrs. Erna Esterhuizen

Unit		Registration	Date:	September 2002 January 2005 (confirmation)
Goal		To determine the subprocesses within the registration Unit		
Interview with		Mrs. Erna Esterhuizen		
Known generic process		REGISTRATION		
Scenario: Personal existing student (S_1)				
REGISTRATION S_1P_3	*S_1P_{31} Application Process*	*S_1P_{311} Student completes a letter of intention for the following registration period.*		
	S_1P_{32} Academic Verification	*S_1P_{312} Early in year, course module selection and verification*		
	S_1P_{33} Payment Verification	*S_1P_{313} Verify payment*		
	S_1P_{34} Course Material Distribution	*S_1P_{314} Confirm registration and distribute course material.*		
Scenario: Personal new student (S_2)				
REGISTRATION S_2P_3	*S_2P_{31} Application Process*	*S_2P_{311} Receive application form and supporting material.*		
	S_2P_{32} Payment Verification	*S_2P_{321} Verify application fee payment.*		
	S_2P_{33} Academic Verification	*S_2P_{331} Application is scanned on the system.* *S_2P_{332} Submission of supporting documentation.* *S_2P_{333} Application to faculty* *S_2P_{334} Receive approval / rejection from faculty.* *S_2P_{335} Notify student of application results and request minimum payment.* *S_2P_{336} Course module selection and verification.*		
	S_2P_{34} Payment Verification	*S_2P_{341} Receive payment from student.*		
	S_2P_{35} Course Material Distribution	*S_2P_{351} Confirm registration and distribute course material.*		
Scenario: Electronic existing student (S_3)				
REGISTRATION S_3P_3	*S_3P_{31} Application Process*	*S_3P_{311} Application form completion* *S_3P_{312} Confirmation of application*		
	S_3P_{32} Payment Verification	*S_3P_{321} Verify application fee payment*		
	S_3P_{33} Academic Verification	*S_3P_{331} Supporting material is scanned on the system.* *S_3P_{332} Application to faculty* *S_3P_{333} Selection process. Receive approval / rejection from faculty.* *S_3P_{334} Notify student of application results and request minimum payment.* *S_3P_{335} Course module selection and verification.*		
	S_3P_{34} Payment Verification	*S_3P_{341} Verify payment received from student.*		
	S_3P_{35} Course Material Distribution	*S_3P_{351} Confirm registration and distribute course material.*		

For the REGISTRATION process at UNISA, I focused on the electronic registration to illustrate the identification of the subprocesses within one scenario. To show the differences / similarities between the different case study environments, I focused on the same process (S_3P_3) at UP. During Phase 2 and Phase 3 information was gathered on *all* the processes. Except for

REGISTRATION, the information was not modelled on subprocess level, but was filed and is available for viewing from the researcher, if needed.

The next step was to build the association table listing all the subprocesses for the selected subprocess (S_3P_3). I first listed all the subprocesses and identified the different input and outputs associated with each process (Table 5.23).

Table 5.23: Descriptions for actions in subprocesses

Internet – Electronic New Student			
Subprocess	Subprocess	Input/Output	Goal
S_3P_{31} Application Process	*S_3P_{311} Application form completion*	Input: Empty form Output: Completed application form	Application form completion on Internet by prospective student.
	S_3P_{312} Confirmation of application	Input: Completed application form Output: Application confirmed	Auto-reply message to applicant for confirmation of application.
S_3P_{32} Payment Verification	*S_3P_{321} Verify application fee payment*	Input: Application confirmed Output: Captured application	Verify credit card payment for application fee online. Confirmation on screen. Auto-reply to student.
S_3P_{33} Academic Verification	*S_3P_{331} Supporting material is scanned on the system.*	Input: Captured application Input: Academic record Input: Qualification rules Output: Captured information	Submission of supporting documents to electronic fax after which images are scanned on system.
	S_3P_{332} Application to faculty	Input: Captured information Output: Application in faculty *In Box*	Data management verify application and prospective application goes to the *In Basket* of the faculty's computers.
	S_3P_{333} Selection process	Input: Application in faculty *In Box* Output: Processed application	Faculty selects/rejects student and sends result to administration.
	S_3P_{334} Notify student of application results and request minimum payment.	Input: Processed application Output: Rejected applications Output: Accepted applications	Notify student of application results. If successful include a letter of approval. Inform student of minimum payment before registration confirmation.
	S_3P_{335} Course module selection and verification.	Input: Accepted applications Input: Course Qualification rules Output: Enrolment information	Select and capture course modules for current year.
S_3P_{34} Payment Verification	*S_3P_{341} Verify payment received from student.*	Input: Enrolment information Input: Payment information Output: Approved registration	Receive payment from student.
S_3P_{35} Course Material Distribution	*S_3P_{351} Confirm registration and distribute course material.*	Input: Approved registration Output: Registered student	Register student as confirmed and provide course material

It is possible to draw process models for any one of the five subprocesses on the second level. I randomly selected the *Academic Verification* (*S_3P_{33}*) subprocess as an example in the remainder of the phase. The information in Table 5.23 is used to construct the association table (Table 5.24) where the subprocesses for *S_3P_{33}* are listed in the first column and the resources associated with the subprocesses at the top of the table. For example, the relationship between resource *Captured application* (S_3R_{331}) and subprocess *Supporting material is scanned on the system* (S_3P_{331}) is shown with an input (I) indicator in the cross-section between the resource and the process, which shows that the subprocess responsible for scanning the supporting material received from the student, needs the application information already captured in the system in order to proceed.

Table 5.24: Associations between resources and subprocesses for S_3P_{33}

		Captured application (S_3R_{331})	Qualification rules (S_3R_{332})	Academic record (S_3R_{333})	Captured information (S_3R_{334})	Application in Faculty *In box* (S_3R_{335})	Processed application (S_3R_{336})	Accepted application (S_3R_{337})	Rejected application (S_3R_{338})	Course qualification rules (S_3R_{339})	Enrolment information ($S_3R_{33\_10}$)
S_3P_{331}	*Supporting material is scanned on the system.*	I	I	I	O						
S_3P_{332}	*Application to faculty*				I	O					
S_3P_{333}	*Selection Process*					I	O				
S_3P_{334}	*Notify student of application results and request minimum payment.*						I	O	O		
S_3P_{335}	*Course module selection and verification.*							I		I	O

This association table is used to construct the subprocess model on the third level for the *Application verification (S_3P_{33})* on the second level. The diagram with the applicable subprocesses on the third level is given in Figure 5.7.

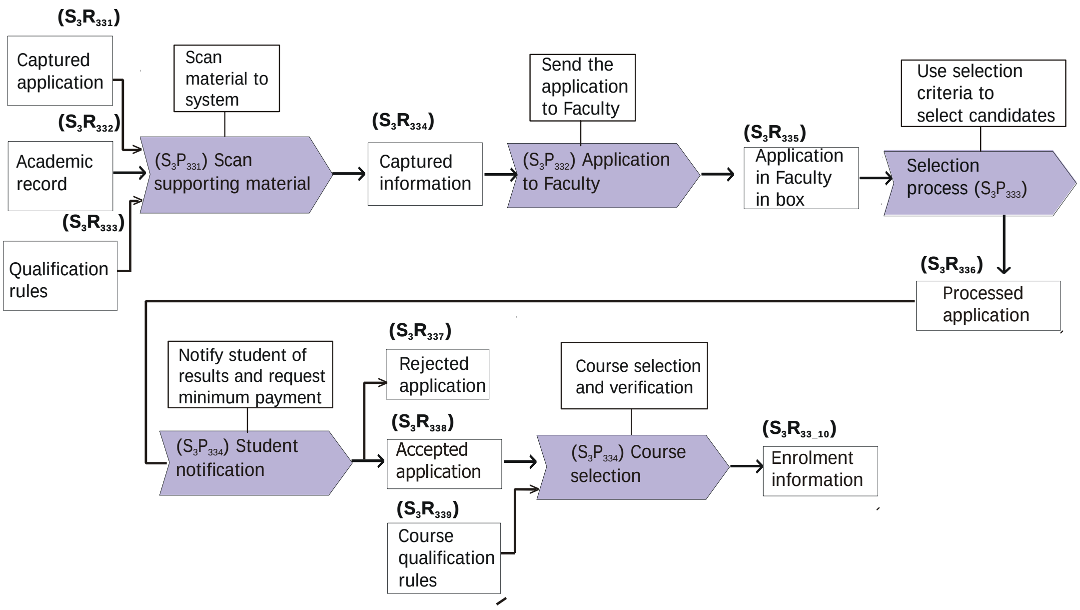


Figure 5.7 : UP subprocess electronic registration (new student)

5.2.2.6 Findings after the second research cycle

As mentioned previously, for Research Question 1 this study reflects both on the procedure developed and the procedure applied. In this section I will give a brief overview of the findings after the second research cycle on both these topics.

5.2.2.6.1 Findings on the requirements elicitation procedure

The application of the procedure delivered the desired results and therefore proved to be successful at UP. The high-level process model was derived without difficulty. The concept that I changed in the requirements elicitation procedure after the second research cycle at UP, was to include in Phase 2 the web and telephone lists as resources in unit identification. In the first edition of the procedure, Phase 2 specified only that the development team needs to identify the different units. After I used the procedure at UP I realized that the sources from which information is retrieved are sometimes not sufficient and I therefore suggested that they should be included in the procedure.

5.2.2.6.2 Findings on the process model structure

For the first time I was confronted with respondents who were very sceptical about my work and unsure of the reasons for being interviewed. It was necessary to make use of innovative approaches to set the respondents at ease and to assure them that there was no threat in the questions directed at them. The strategy used was to return to the theory and read what has been written on interview techniques. The technique that I found best was to be very friendly and interested in the person that I was talking to and in this way to make them comfortable. I started the conversations by asking the respondent what his role was in the organization and something personal, such as do they enjoy this kind of work? This worked better than confronting the person with the aim of the interview at the beginning of the conversation.

My most important discovery after the second iteration of using the requirements elicitation procedure was the fact that on a high level the process model was a representation of both UNISA and UP. On lower levels, there was a core of subprocesses that are similar, even if the execution sequence differs.

5.2.3 Data-gathering procedure at Technikon Pretoria

The application of the requirements elicitation procedure was started at TechPta in November 2002. The data gathered using the different phases is described in more detail in this section.

5.2.3.1 Phase 1: Establish objectives

As mentioned previously, the first interaction with TechPta was with Prof. Pieter van Eldik, the Director of Strategic Planning of TechPta (in 2002 still referred to as TechPta, now known as Tshwane University of Technology). The goal statement was confirmed with my study leader as shown in Table 5.25.

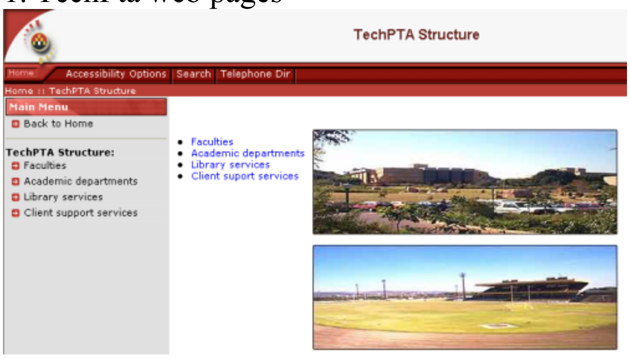
Table 5.25: Goal statement at TechPta

Project name : Requirements elicitation at TechPta Compiled by (Stakeholders): Alta van der Merwe, Elsabe Cloete, Prof. P. van Eldik	Compiled on (Date): November 2002	
Primary goal description:	The necessity to acquire domain knowledge in order to gain a comprehensive understanding of the critical processes at the institution.	
Deliverables for primary goal:	After completion of the four phases be able to describe the structure of the educational domain and to compare it with the findings at UNISA and UP.	
Subgoal & deliverables:	Goal	Deliverables
	Derive the process models	Phase 2: Critical unit list Phase 3: Primary process list Phase 4: High-level process model Phase 5: Confirm UNISA/UP findings

5.2.3.2 Phase 2: Identify critical institutional units

The web pages of the Technikon were used in conjunction with the telephone list to assist in the identification of the critical institutional units (Table 5.26).

Table 5.26: Examples of resources used to identify the list of units at UNISA

1. TechPta web pages	2. Telephone list
	

All the academic departments were grouped together under one heading, 'Academic Department'. The list of units consisted originally of 48 units (Table 5.27). Note that where there were sub-units at TechPta, only the main unit was listed. For example, the Finances Unit consists of a number of subunits including *Salaries* and *Credits*, but for the purpose of this study, it is appropriate to list only the main unit.

Table 5.27: Unit list for TechPta

Academic Departments	Transport	Rectorate
Student Affairs	Publication and Development Services	Examination Administration
Graduate Ceremonies	Student Affairs	International Affairs
Postal Services	Bureau for Management and Administration	Collaboration Unit
Systems Development	Sport	Student Administration
Student Services	Centre for Psychological Support	Recruitment
Vacation School	HIV Centre	Housing Scheme
Library Services	Technikon Secretariat	Human Resources
Finances	Personnel Development	Information
Information Technology	Strategic Information and Planning	Corporate Relations
Quality Assurance	Bureau for Academic support	Landscape Services
Logistic Services	Financial Services	Building Administration
Engraving	Student Development	Audio Visual
Techno Confex	Technikon Clinic	Telephone Services
Campus Access	TechPta Foundation	Traffic
Telematic Education		

This list was used as a guideline to limit the units to include only those involved in teaching and learning activities. Telephonic interviews combined with face to face interviews were conducted with role players in the different units to determine the main responsibility of each unit (Table 5.28). Significant data gathered during the requirements process are included in Appendix 5.

Table 5.28: Initial list of Units with descriptions: UP

Unit Name	Short description	Involved in learning and teaching activities Yes / No
Academic Departments	Responsible for all tasks relating to academic matters in developing/offering of courses	Yes
Audio Visual	Responsible for keeping support equipment and making it available to staff	No
Building Administration	Service department	No
Bureau for Academic Support	Support is given to students with study-related problems, e.g. study methods, financial support, sport development, etc.	Yes
Bureau for Management and Administration	Forms part of student affairs.	No
Campus Access	Security, parking	No
Collaboration Unit	Collaboration with other institutions.	No
Corporate Relations	Service department	No
Engraving	Service department	No
Exam Administration	Examination issues	Yes
Finances	Responsible for all financial aspects of the institution	No
Financial Services	All financial support including salaries, credits, financial services, etc.	No

Table 5.28 (continued): Initial list of Units with descriptions: UP		
Unit Name	Short Description	
Graduate Ceremonies	Involved in the arrangement of graduation ceremonies.	No
HIV Centre	Student support, part of Student affairs	No
Housing Scheme	Service department	No
Human Resources	Studies current needs of the Technikon, identifies positions and appoints staff.	No
Information	Service department	No
Information Technology	The Information Technology Unit is responsible for the technological infrastructure, support and software used on campus.	Yes
International Affairs	Supports staff with international collaboration, travel and communication	No
Landscape Services	Service department	No
Library Services	Library services	Yes
Logistic Services	Service department	No
Logistic Services	Service department	No
Personnel Development	This unit is responsible for the development of staff.	No
Postal Services	Responsible for the postal system on campus and to remote locations.	No
Publication and Development Services	This unit is responsible for the printing of Technikon related material.	Yes
Quality Assurance	Procedures, SAQA, Rules & Regulations	No
Recruitment	Service department	No
Rectorate	Management	No
Centre for Psychological support	Student support, part of Student affairs	No
Sport	Student development, service department	No
Strategic Information and Planning	Management information is gathered with the aim of assisting management in strategic decisions.	No
Student Affairs	Support is given to students with study-related problems, e.g. study methods, financial support, sport development, etc.	Yes
Student Development	Forms part of student affairs.	No
Student Services	Student affairs include financial support, academic support, marketing and recruitment.	No
Student Services	Responsible for the capture and distribution of student's marks.	Yes
Systems Administration	Support before registration process	Yes
Systems Development		
Technikon Clinic	Forms part of student affairs.	No
TechPta Foundation	Responsible for marketing-related initiatives to gather funds from industry for bursaries, loans, etc.	No
Technikon Secretariat	Support to management	No
Techno Confex	Service department	No
Telematic Education	Supports staff in the development of study material, presentation of classes and electronic course material development.	Yes
Telephone Services	Unit responsible for the provision and maintenance of the telephone infrastructure	No
Traffic	Service department	No
Transport	All Technikon-related transport	No
Vacation Services	Service department	No

The unit list after eliminating those not involved directly in teaching and learning activities is limited to 8 units (Table 5.29). Note that this list consisted of fewer units than at the same iteration at UNISA. The reason for this is that the educational environment was much more familiar after the iterations at UNISA and UP, which made the elimination of unwanted units easier at TechPta.

Table 5.29: Unit list after elimination of unwanted units

Academic Department
Quality Assurance
Examination Administration
Bureau for Academic Support
Library Services
Student Affairs
Student Service
Telematic Education

5.2.3.3 *Phase 3: Identify primary processes*

The steps in the third phase to establish the primary processes were used and the suggested process list was used to map the different processes to primary processes. The resulting list with processes and mappings is shown in Table 5.30.

Telephone interviews were conducted with representatives at TechPta to identify or confirm the different responsibilities of the unit. Some of the significant contributing interviews are summarized in Appendix 5, on the accompanying CD.

The list of primary processes was given as the five initial primary processes and three additional processes and these were the same 8 processes as the ones identified at UNISA and UP. The extended list included:

- REFLECTIVE RESEARCH.
- ACADEMIC STUDENT SUPPORT.
- COURSE DEVELOPMENT.
- COURSE MATERIAL DELIVERY (DISTRIBUTION).
- PRODUCTION.
- ASSESSMENT.
- STUDENT SYSTEM.
- REGISTRATION.

As in the case study at the University of Pretoria, I proceeded to Phase 4 where the goal is to construct the high-level process model from the identified primary processes.

Table 5.30: Primary process elicitation at TechPta

Unit	Process	Primary Support	Mapping
Academic Department	Reflective research Research Student academic support Course material development Course material production Course material distribution Class meetings Assessment Update student records Filing systems (course-related material) Marketing-related initiatives Departmental committees Departmental coordination admissions, contracts, etc Departmental management Departmental administration Staff development	P S P P P P P P P S S S S S S S	REFLECTIVE RESEARCH ACADEMIC STUDENT SUPPORT COURSE DEVELOPMENT DISTRIBUTION DISTRIBUTION DISTRIBUTION ASSESSMENT STUDENT SYSTEM
Library Services	Provide research material Provide support course material	S P	 DISTRIBUTION
Quality Assurance	Procedures SAQA Rules Regulations Audit – Course development Audit – Teaching & Learning Audit – Assessment	S S S S P P P	 COURSE DEVELOPMENT DISTRIBUTION ASSESSMENT
Student Affairs	Student academic support (Study methods) Vocational guidance (Pre-process to registration)	P P	ACADEMIC STUDENT SUPPORT REGISTRATION
Student Administration	Application handling Registration Student record registration	S P P	 REGISTRATION STUDENT SYSTEM
Examination Administration	Examination table Receive examination papers Duplicate examination papers Examination supervision Examination paper distribution	P P S S P	ASSESSMENT ASSESSMENT DISTRIBUTION
Students Service (Post registration tasks)	Exam papers to lecturer Student records Capture examination marks Academic advise	P P P S	ASSESSMENT STUDENT SYSTEM STUDENT SYSTEM
Bureau for Academic Support	Psychological welfare Study Methods Reading skills Vocational testing Language (Skills) Student personal problem assistance	S P S S S S	 ACADEMIC STUDENT SUPPORT
Telematic Education	Reflective research Research Course material development Course material production Course material distribution	P	COURSE DEVELOPMENT

5.2.3.4 Phase 4: Construct the high-level process model

The primary process model derived for UNISA and UP is the same as the high-level processes derived for TechPta. It was not necessary to repeat the steps in Phase 4 to draw the process model representing the primary processes, as it had already been done previously for UNISA and UP. In collaboration with my study leaders I decided to verify the high-level process model at TechPta with Prof. Peter van Eldik, who was interested in the representation of the HEI.

In January 2003, an interview was conducted with Prof. Peter van Eldik in which we discussed the high-level diagram constructed from the primary processes. During this interview, my aim was to establish whether or not he agrees that the high-level diagram represents the educational structure of a higher education environment.

The interview begun with a preliminary discussion in which the working of the requirements elicitation procedure was explained and the aim of the study was confirmed. The first three phases were described and an overview was given of the steps involved in the identification of the primary processes. The interview was informal and field notes were taken on remarks made by him. Table 5.31 gives a summary of the three questions and the goal of each question that was used during discussions.

Table 5.31: Interview guideline used during discussions with Prof. Van Eldik

Interview question	Goal
To what extent does the high-level process model represent TechPta as a HEI?	To establish whether or not the high-level process model identified is a true reflection of the structure of the Technikon.
To what extent does the flow modelled on the high-level process model reflect the nature of the flow in an educational environment?	To establish whether or not the flow modelled on the high-level process model is a true representation of the flow at the Technikon.
Are there any processes that you feel were omitted from the structure, which should be included in a model of this nature?	To establish what the processes are that are not reflected in the high-level process model.

The following is a summary of the interaction on the different questions.

Question 1: To what extent does the high-level process model represent TechPta as a HEI?

We discussed the high-level process model as a representation of the structure of the institution. In this discussion, the residential institution model was compared with the distance model. It was noted that the role of PRODUCTION and DISTRIBUTION units is not so pertinent at the Technikon. A lecturer involved in lecturing is involved in the development of his own study material and he presents it in front of a class in a real-life situation. Printed material is duplicated in the faculty and handed to students personally in the classroom setting. The distribution is therefore mostly by verbal discussions and the production is done personally by the lecturer. The responsibility is distributed within the institution in contrast to the situation at UNISA, which centralizes the function. At UNISA, it is also not feasible to do the production and distribution within the faculty. In some modules there are thousands of students enrolled which makes the printing and distribution of the material an enormous task. Although PRODUCTION and DISTRIBUTION were not included in Chapter 6 as the focus of a re-engineering effort, it is one of the application domains where successful implementation of electronic material distribution will assist in the reduction of constraints. If a student downloads his material from the Internet and does not require a printed copy, this will reduce costs and eliminate unnecessary time delays experienced between course development and receipt of the course material.

Our discussion continued on the topic of bridging courses and the importance thereof. According to Prof. Van Eldik this is one of the activities that is becoming more and more important at the Technikon where management focuses on preparing students for higher education learning. Before registration for a formal qualification, the student will first complete a set of courses to prepare him/her for the first year at the Technikon. However, after some discussion we agreed that even for these bridging courses students will still needs to register and course material need to be developed, which means that the current structure makes provision for the offering of these courses also.

After these discussions Prof. Van Eldik agreed that the high-level process model does reflect the structure of the Technikon.

Question 2: To what extent does the flow modelled on the high-level process model reflect the nature of the flow in an educational environment?

We discussed the flow between the different processes and the only comment on the representation was that he does not believe a *knowledgeable person* is an output for a process. It is difficult to measure the output – with a research document or copies of study material the output is measurable. We had a discussion on the fact that some processes are not necessarily measurable. For example, the learning process has as output 'knowledge gained', but it is not actually measurable before writing an examination. Similarly, the person doing reflective research gains knowledge in the process but it is not easy to measure. One can see only the results later when the knowledge is applied and the level of tuition is higher.

Prof. Peter van Eldik also commented that it may be valuable to consider a graph with responsibilities, which may enable the user to see that even if processes are generic at different institutions, the shift is in the responsibilities. This could be a topic for future research.

We agreed that the flows within the structure do indeed represent the high-level process model.

Question 3: Are there any processes that you feel were omitted from the structure, which should be included in a model of this nature?

We once again discussed the importance of bridging courses in entering an educational institution, this time commenting on the recognition of prior learning. We both agreed that though important, this is the preserve of management systems and should therefore not be included in the current structure. Re-engineering of current processes includes the focus on what has been done, how it was done and what can be done to better the processes. The creation of new processes requires scrutiny of the creation activities and how these processes will link to the previous processes.

The role of STUDENT SYSTEM as a primary process was also discussed. Student System Supports all the processes within the Technikon. Administration uses it to register the students, keep payment information and schedule the classes, to name but a few. In the process model it is the centre of the model, supporting all the processes by either supplying information for the different academic processes or acting as the backbone in the registration system. Although it does not really ‘do’ anything, but rather stores information and ‘provides’ it when requested to do so, this information resource is such an important support process that we consider it a primary process in a HEI.

Concluding remarks concerning the interview

In conclusion, the interview proved to be valuable and the insights that Prof. Van Eldik gave into the process model helped me to confirm the findings at the previous two institutions. He also agreed that the process model does indeed represent the Technikon structure and that on a higher level there is enough evidence that it represents the activities at TechPta.

5.2.3.5 *Phase 5: Refine the process model*

For the refinement of the process model I used the same procedure previously employed to identify the subprocesses on the second and third level for the REGISTRATION process. TechPta receives new applications through the postal system or physically at the counter. There are therefore three different REGISTRATION scenarios, described in Table 5.32 (retrieved from interviews with Mrs. Christine Tossel at TechPta)

Table 5.32 : Interview sheet for Mrs. Christine Tossel

<table>
<tr><td colspan="2">Unit</td><td>Registration</td><td>Date:</td><td>November 2002
March 2005 (confirmation)</td></tr>
<tr><td colspan="2">Goal</td><td colspan="3">To determine the subprocesses involved in the application and registration process</td></tr>
<tr><td colspan="2">Interview with</td><td colspan="3">Mrs. Christine Tossel</td></tr>
<tr><td colspan="2">Known generic process</td><td colspan="3">REGISTRATION</td></tr>
<tr><td colspan="5">Scenario: Personal existing student (S_1)</td></tr>
<tr><td rowspan="4">REGISTRATION
S_1P_3</td><td colspan="2">S_1P_{31} *Application Process*</td><td colspan="2">S_1P_{311} *Notify student of date to report at TechPta.*</td></tr>
<tr><td colspan="2">S_2P_{32} *Course Material Distribution*</td><td colspan="2">S_2P_{321} *Student arrives at TechPta and receives course information.*</td></tr>
<tr><td colspan="2">S_1P_{33} *Payment Verification*</td><td colspan="2">S_1P_{331} *Verify payment*</td></tr>
<tr><td colspan="2">S_1P_{34} *Academic Verification*</td><td colspan="2">S_1P_{341} *Course selection is verified against student system*</td></tr>
<tr><td colspan="5">Scenario: Personal new student (S_2)</td></tr>
<tr><td rowspan="6">REGISTRATION
S_2P_3</td><td colspan="2">S_2P_{31} *Application Process*</td><td colspan="2">S_2P_{311} *Receive application form and supporting material at counter.*</td></tr>
<tr><td colspan="2">S_2P_{32} *Payment Verification*</td><td colspan="2">S_2P_{321} *Verify application fee payment.*</td></tr>
<tr><td colspan="2">S_2P_{33} *Academic Verification*</td><td colspan="2">S_2P_{331} *Application is captured on the system.*
S_2P_{332} *Issue reference number.*
S_2P_{333} *Do verification according to course enrolment*
(Some more subprocesses on a fourth level for different scenarios)
S_2P_{334} *Notify student of application results and give date to report at TechPta.*</td></tr>
<tr><td colspan="2">S_2P_{34} *Course Material Distribution*</td><td colspan="2">S_2P_{341} *Student arrives at TechPta and receives course information.*</td></tr>
<tr><td colspan="2">S_2P_{35} *Payment Verification*</td><td colspan="2">S_2P_{351} *Receive payment from student.*</td></tr>
<tr><td colspan="2">S_2P_{36} *Registration confirmation*</td><td colspan="2">S_2P_{361} *Confirm course module selection*
S_2P_{362} *Confirm reference number as permanent student number*</td></tr>
<tr><td colspan="5">Scenario: Postal new student (S_3)</td></tr>
<tr><td rowspan="6">REGISTRATION
S_3P_3</td><td colspan="2">S_3P_{31} *Application Process*</td><td colspan="2">S_3P_{311} *Receive application form and supporting material through postal system.*</td></tr>
<tr><td colspan="2">S_3P_{32} *Payment Verification*</td><td colspan="2">S_3P_{321} *Verify application fee payment*</td></tr>
<tr><td colspan="2">S_3P_{33} *Academic Verification*</td><td colspan="2">S_3P_{331} *Application is captured on the system.*
S_3P_{332} *Issue reference number.*
S_3P_{333} *Do verification according to course enrolment*
(Some more subprocesses on a fourth level for different scenarios)
S_3P_{334} *Notify student of application results and give date to report at TechPta.*</td></tr>
<tr><td colspan="2">S_3P_{34} *Course Material Distribution*</td><td colspan="2">S_3P_{341} *Student arrives at TechPta and receives course information.*</td></tr>
<tr><td colspan="2">S_3P_{35} *Payment Verification*</td><td colspan="2">S_3P_{351} *Verify payment received from student.*</td></tr>
<tr><td colspan="2">S_3P_{36} *Course Material Distribution*</td><td colspan="2">S_3P_{361} *Confirm course module selection*
S_3P_{362} *Confirm reference number as permanent student number*</td></tr>
</table>

I did not proceed with another example of building the subprocess models for the REGISTRATION process. The steps will be similar to the steps followed in Phase 5 at UNISA and UP and the results will not add to the research knowledge, except to confirm that the procedure can be used for establishing subprocess models (which has already been confirmed at UNISA and UP).

5.2.3.6 Findings after the third research cycle

In this section, similar to section 5.2.1.6 (UNISA) and section 5.2.2.6, I focus on findings concerning the procedure developed and the procedure applied.

5.2.3.6.1 Findings on the requirements elicitation procedure

The use of the procedure at TechPta produced the desired result, namely the high-level process model that represents the structure of the institution.

In applying the procedure at the Technikon I noticed the danger that the development team can easily become the only active participant. This is dangerous in the sense that if the development team does not take the trouble to return to the respondents after gathering data to ensure that the data represented is a reflection of the truth, they may fall into the trap of reflecting some of their own perceptions and not the real-world situation. Although it is a design principle to return to the user to make sure that the truth is reflected, this was not reflected as check-points in the procedure and may be regarded as a weakness.

5.2.3.6.2 Findings on the process model structure

After two iterations of the procedure it was much easier to use it at the third institution. As was the case at UP, there were some negative respondents who were unsure about the purpose of the research and therefore questioned the reason for the interview. During this research iteration I was much more at home with the application of the procedure and owing to familiarity with the activities at educational institutions, preferred not to become involved in lengthy discussions. I was also more skilled at putting the respondents at ease and began each conversation with the knowledge that I needed to make the person comfortable and to ensure that this was not a judgement of work done, but rather a data-gathering procedure for the purpose of reflecting on the activities in the unit.

There were advantages to the fact that I was the only person involved in the data-gathering activities, one being that I knew exactly what the current status of the data-gathering was. The biggest disadvantage was that the data-gathering cycle could have been much shorter in the case of a development team with more members. I also noted a pattern in the subprocesses listed on the second level for the REGISTRATION process, which may give an indication of the possibility of generic processes not only on the highest level, but also on lower levels.

5.2.4 Verification at the University of the Freestate

Verification of the process model structure started unintentionally at UP and TechPta. This was caused by the results in Phase 3, namely that the primary processes were exactly the same as the ones identified at UNISA. The initial intention was to compare the primary processes of the three institutions and to discuss the differences and preferences at the University of the Freestate. Finding exactly the same primary processes made this task easier with the question being if these were, in the opinion of role players at the University of the Freestate, also the primary processes at the University and if the structure could be modelled with the same high-level process model as the one used at the other institutions.

5.2.4.1 Verification activity

Five questions were used as a guideline in discussions at the University of the Freestate. The feedback of the group was recorded using field notes. A formal questionnaire was not handed to the group; the goal was to initiate interactions in the group session where I led with a question and recorded the answers/issues for each topic. The reason for following this route was two-fold. Firstly, it was necessary to give background information on the concept of a process model structure and a good strategy to do this was to introduce the structure during discussions of the different questions. Introductions of this kind tend to be difficult in a formal written environment. Secondly, the expertise level of group members differed and therefore the interaction route gave the inexperienced role player in this specific field the opportunity to remain inactive.

The following are key issues raised during discussions in the group interview:

- *Are any formal re-engineering procedures used at the institution? If so, which ones?*

There is no formal procedure followed in re-engineering efforts at the University of the Freestate. Each project though, is assigned to a project leader who is responsible for management of the project. This approach proved to be successful but as in any environment there have been projects that have not been successful. However, this should, not necessarily be ascribed to the lack of a procedure. This could be an interesting research topic.

- *What are the current re-engineering activities with regard to the implementation of technological changes?*

There is much happening on the front of technological innovations. At the time of the interview, Internet connections were installed in the rooms of one of the hostels with the aim of extending this to the rest of the campus over the next 3 years.

The University was also involved in an extended distance education programme with the aim of reaching electronically those students who could not be involved in studies full time. (After the interview some regulations were laid down by the Department of Education that allowed only UNISA and Technikon Southern Africa to be involved in distance education).

Lecturers were getting more involved in the e-learning initiative, although the familiar fear of computers was still a reality among the older generation.

- *How familiar is the group with the use of process modelling as a tool in re-engineering efforts?*

Not very familiar, since modelling is done selectively if necessary in projects and depends on the type of project. Software development uses concepts from the System Analysis and Design discipline and is based mostly on the waterfall method. This does not mean that projects are not managed correctly. The project leader and project team are responsible for the project plan, which is subject to the approval of the responsible role players in management at the University.

- *Is the high-level process model presented descriptive of the current activities at the institution?*
- *Do you think this model can be used as a re-engineering tool?*

The group present at the discussion was very impressed with the proposed high-level process model. They felt that it is a true representation of the structure of the University and that it can be used in re-engineering efforts as a tool to describe the working of the University to non-technical users. We discussed the flow and although they also were of the opinion that PRODUCTION and DISTRIBUTION is more the responsibility of the lecturers, they felt that it is not necessary to remove the two processes. At the end of the meeting the representative from Computer Services responsible for the technological changes at the University, requested a copy of the high-level process model. She also asked for a copy of the paper on the work at a conference in Greece during 2003 (Van der Merwe, 2003).

To sum up, the group was very interested in the research work and supported the more focused re-engineering efforts in higher education. Remarks included the fact that most work is focused on businesses and that higher education environments have their own unique environment. More research is needed from a software engineering perspective on the modelling of the higher education domain.

5.2.4.2 Comments on findings after verification activity

The goal of the verification process was to confirm the findings on the high-level process model structure derived at UNISA, UP and TechPta. This was done after a cyclic approach was followed with three iterations at the different institutions and verification at the University of the Freestate.

On lower levels there is a set of subprocesses that forms the core of the level viewed. But there may also be more subprocesses on a level at different institutions or the sequence of subprocess execution may differ.

5.2.5 Summary on the data-gathering activities at the different institutions

In section 5.2, the focus was on data-gathering using a requirements elicitation procedure at three different institutions to derive the high-level process model. After completion of the three research cycles at the different institutions, it is now possible to comment on the characteristics and advantages of the requirements elicitation procedure.

5.3 THE REQUIREMENTS ELICITATION PROCEDURE

The requirements elicitation procedure developed and used at the different institutions has some advantages and adheres to certain characteristics. The most important feature of a procedure is to achieve the desired results, but this is not enough. There are other characteristics that a procedure should adhere to before it is possible to reflect on the success / failure of the procedure.

In section 4.3.1.2 (Chapter 4), a list of characteristics was identified to which a requirements elicitation procedure should adhere. This list of characteristics is used in section 5.3.1 to reflect on the characteristics applicable to the requirements elicitation procedure. This is followed by a discussion in section 5.3.2 on the advantages of the use of the procedure at the different institutions.

At the beginning of Chapter 5 a chapter map was provided with a diagrammatic representation of the Chapter layout. In Figure 5.8, section 5.3 is highlighted with a blue box to indicate which part of the research is addressed in the remainder of section 5.3.

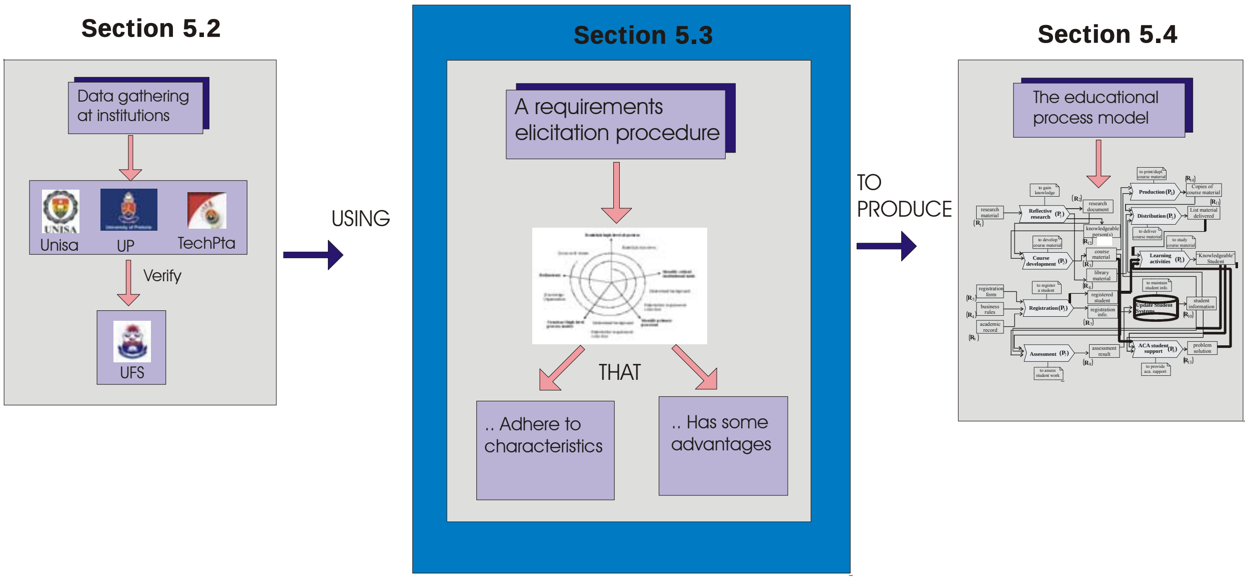


Figure 5.8: Reflecting on findings with regard to the requirements elicitation procedure

5.3.1 Characteristics of the developed requirements elicitation procedure

In this section, the scientific soundness of the requirements elicitation procedure is described in terms of the characteristics previously identified (Chapter 4, Table 4.17). Three descriptors were used to show how each phase adheres to the list of characteristics, i.e. that something does *not adhere*, *partially adheres* or *strongly adheres* to a particular characteristic (Table 5.33).

Table 5.33: Descriptors used to describe the different phases

Descriptor	Description
Does not adhere	The requirements elicitation does not adhere to the characteristic at all.
Partially adheres	Some aspects of the requirements elicitation adhere to the characteristic.
Strongly adheres	The requirements elicitation procedure adheres fully to the characteristic.

In Chapter 4, it was mentioned that requirements elicitation exists naturally in cyclic methodologies that have the aim of developing software or re-engineering current environments. The activities that map to the requirements elicitation procedure developed, include the cross-phase, elicitation and modelling activities. The result of this rating of the different aspects of the developed requirements elicitation procedure is presented in Table 5.34.

Table 5.34: Requirements elicitation procedure and the characteristics

	Subphase	Characteristic	Does not adhere to (NA)	Partially adheres to (PA)	Strongly adheres to (SA)
All Phases	Support	Provides automated support for the requirements elicitation process	√		
	Standards	Provides standardised ways of describing work products			√
		The precision of definition of its notation			√
		Process model standards			√
	Techniques	Selects appropriate technique for the problem domain		√	
		Use of use cases to describe related tasks	√		
		Supports a systematic step-by-step approach			√
		Solutions can easily be modified and are iterative in nature			√
	Documentation	Supports documentation of requirements			√
	Maintenance	Procedures maintaining work products		√	
	Conflict	Conflict negotiation	√		
Requirements elicitation	Specification	Requirement completeness		√	
		Requirement relevance			√
		Expectations during specification			√
		Correctness			√
		Communication during specification			√
		Requirement accuracy			√
		Importance of necessity: requirements document			√
		Level of control over specification			√
	Boundaries	Specify constraints / boundaries			√
	Problem Analysis	Support analysis			√
		Degree of understanding of the task and process			√
	Data-gathering	Supports data-gathering techniques			√
	Client/customer	Customer/client involvement			√
Requirements modelling	Support Modelling	Motivation to support modelling			√
	Goal Modelling	Models the purpose by describing behaviour			√
	User Involvement	Reflects the needs of customers / users		√	
	Modelling	Models business rules			√
		Supports modelling of work flows			√
		Clarity of business process			√
		Models system services			√
		Systems architecture modelling	√		

In the first column the three relevant phases found in the literature that relates to our procedure are given. This is followed by the subphases for each phase. For each subphase at least one characteristic is given. In the third to fifth column each characteristic is related to the requirements elicitation procedure developed.

For example, support is important in all the phases of a requirements elicitation procedure. The requirements elicitation procedure developed does *not adhere* to this characteristic because it was not included as an activity within the different phases. The procedure adheres strongly to the use of standard notation and existing process model standards. It also supports a step-by-step approach, which is defined in the original documentation as iterative. Because reference is made more than once in the procedure to the output of a phase as being a set of documentation, it therefore also supports the use of documentation of the requirements.

In the elicitation phase of the procedure, the procedure supports requirement relevance by excluding units and processes that are not applicable to the goal of the modelling exercise, namely to include only the primary processes that are important in creating a learning environment. The goal and the limitations are discussed at the beginning of the procedure. This indicates that the developers support the definition of expectations and the specification of boundaries. The procedure suggests a systematic method for gathering the information from the different units – information that is correct, necessary and accurate. It also divides the educational environment into units for the purpose of gathering information, and uses communication techniques to extract whatever information is necessary from the employees.

The goal of the elicitation procedure is to analyse the current environment so that a different developer could, with this information and his or her understanding of the environment, identify tasks and processes within the educational domain.

Three of the five phases in the elicitation procedure are concerned with the modelling task. The procedure therefore adheres strongly to the modelling of business rules, work flows and different services. The procedure gives a justification for using modelling in this application domain and also adheres to the purpose by producing the goal, the high-level process model, and subprocess models.

There are only a small number of characteristics that the procedure ‘does not adhere to’ (NA). Table 5.35 includes all the characteristics that the procedure ‘does not adhere to’ or ‘adheres partially to’ (AP), with a comment in the last column on each of the ratings.

Table 5.35: Characteristics that the procedure ‘does not adhere to’

Phase	Characteristic	Rating	Comment
All phases	Provide automated support for the requirements elicitation process	NA	While there is no *automated support* developed for the procedure, it should be possible to use existing tools to support the documentation process.
	Select appropriate technique for the problem domain	PA	The procedure suggested only one way of gathering information. Other techniques such as questionnaires should also be appropriate for the application domain.
	Use of use cases to describe related tasks	NA	A few resources mentioned this as being important. The procedure did not include use cases to describe scenarios. Object-oriented notation supports the use of use cases.
	Procedures for maintaining work products	PA	While the procedure did not specifically mention the importance of maintenance, they support the use of documentation that is easily maintainable.
	Conflict negotiation	NA	No conflict negotiation is mentioned by the procedure.
Elicitation	Requirement completeness	PA	Although the procedure does not specifically define measurements to measure requirements completeness, they do suggest a cyclic system that tries to obtain complete requirements.
Modelling	Reflect the needs of customers / users	PA	Because the goal of the procedure is to model the current business processes, no need analysis is involved.
	Systems architecture modelling	NA	No system architecture modelling is included. This is important during the re-design of current work flows.

One characteristic that needs further investigation is the automated support for the requirements engineering process. As mentioned above, it should be possible to use existing tools, such as CASE tools, to support the documentation process. Furthermore, although the procedure did not specifically mention the importance of maintenance, it supports the use of documentation that is easily maintainable.

Some of the characteristics could be mapped only to certain phases in the requirements elicitation procedure. In Table 5.36 an indication is given of the relationship between the different phases of the developed requirements elicitation procedure and the characteristics identified. From the table, it is possible to deduce that:

- All the phases in the procedure support a systematic approach.
- The procedure is iterative in nature (the procedure is cyclic and is completed only after a number of iterations).
- In all the phases, the information gathered by the developers is documented. This indicates that the procedure supports the documentation of the requirements and the documentation of the different models.
- In Phases 3 to 5, a notation used by modellers in process modelling environments is prescribed. The characteristic ‘provides standardised ways of describing work products’ is therefore adhered to.

- The notation is precise and process model standards are used.

Table 5.36: Relationship between different phases and characteristics

	Characteristic	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
All phases	Provides standardised ways of describing work products			√	√	√
	The precision of definition of its notation			√	√	√
	Process model standards			√	√	√
	Supports a systematic step-by-step approach	√	√	√	√	√
	Modifiable solutions and iterative in nature	√	√	√	√	√
	Supports documentation of requirements	√	√	√	√	√
Requirements elicitation	Requirement relevance		√	√		
	Expectations during specification of requirements		√			
	Correctness		√	√		
	Communication during specification of requirements		√	√		
	Requirement accuracy		√	√		
	Importance of necessity: requirements document	√	√	√		
	Level of control over specifying requirements		√	√		
	Specifies constraints / boundaries	√	√	√		
	Supports analysis	√	√	√		
	Degree of understanding of the task and process	√	√	√	√	√
	Supports data-gathering techniques	√	√	√		
	Supports customer / client involvement	√	√	√	√	√
Requirements modelling	Motivation for modelling support	√	√	√	√	√
	Models the purpose by describing behaviour				√	√
	Reflects the needs of customers / users	√	√	√	√	√
	Models business rules				√	√
	Supports modelling of work flows				√	√
	Clarity of business process				√	√

The characteristic supported in only one phase of the procedure is the 'expectations during specification of requirements'. This is understandable because this characteristic is only applicable to that specific phase of the procedure.

5.3.2 Advantages of the requirements elicitation procedure

The requirements elicitation procedure was developed initially in response to a lack of procedures in the educational domain, with the aim of identifying the process structures of the institution. Developing the requirements elicitation procedure was a tedious task and was based on best practices (Chapter 4, section 4.3.1.1.1). In the remainder of this section, the significant advantages gained from using the procedure, are discussed.

5.3.2.1 *Requirements elicitation characteristics*

In order to answer the first research question in this study: *What is the educational process model structure of the higher education institution?* it was necessary to develop the requirements elicitation procedure first. After using the procedure at three different HEIs, it was possible to reflect on the characteristics of the requirements elicitation procedure. The procedure developed *adhered strongly* to 24 of the 32 characteristics, only 4 were *partially adhered* to and 4 were *not adhered to* (Figure 5.9).

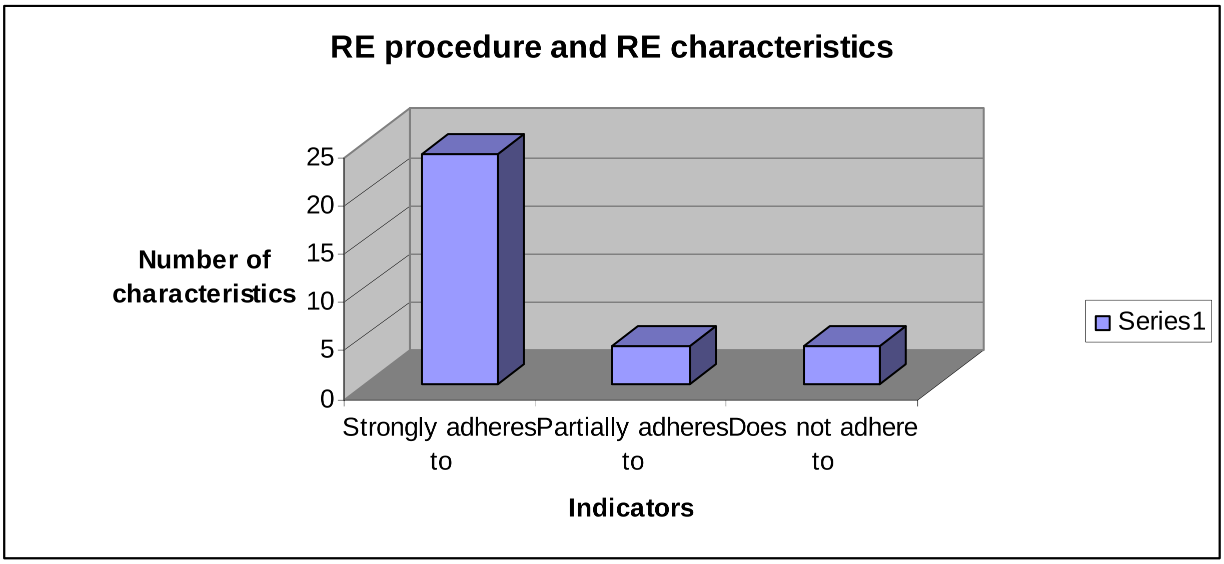


Figure 5.9: Number of characteristics to which requirements elicitation procedure adheres to

There is strong evidence that the procedure can be considered an effective requirements elicitation procedure because it does adhere strongly to most of the characteristics identified for such a procedure.

5.3.2.2 *Scope for improvement*

Another advantage is that even if the initial aim of the procedure is fulfilled, it is still possible to improve the procedure. The 8 characteristics not included in the list of characteristics that the procedure adheres to, give developers the opportunity for further research to add to the basic theory established.

5.3.2.3 *Cyclic nature of the procedure*

The procedure is cyclic in nature which complements the development research theory of analysis of practical problems, development of solutions, evaluation and documentation (Van den Akker, 1999). The steps described in Phase 4 are used and reused in Phase 5 to find all possible subprocesses and to break each subprocess down into a number of subprocesses, until the processes are atomic.

5.3.2.4 Establishment of a high-level process model

After the requirements elicitation procedure has been used at three different institutions and verified at another, there was enough evidence to support the theory that the high-level process model is generic for higher education environments. The model emerged after completion of Phase 4 at UP and was confirmed later at TechPta and University of the Freestate. The process model is discussed in more detail in section 5.4.

5.3.2.5 Produce reference models

It is possible to use the process models as reference models. After showing the model to the University of the Freestate, the remark most often made at the meeting was that it is ideal to show people 'what is happening' within the educational domain. The group felt that the models can be used in other applications, for example in re-engineering efforts. The usefulness of the process models is addressed in more detail in Chapter 6.

5.3.2.6 Reusability

The models identified should be re-usable if accessible. In using it as a reference model (section 5.3.2.5) at the University of the Freestate, the process models were available. In order to be able to reuse it, it must first be established. The advantage therefore is that after the use of the requirements elicitation procedure, the process models are identified and therefore it is possible to proceed with the problem of storing them for future reuse (more about this in Chapter 7).

5.3.2.7 Extendibility

The procedure produced the process models for different institutions. It was used in three different complex environments, which means that there is a possibility that it may be feasible to extend the procedure for usage in business environments. This is an opportunity for further research.

5.3.2.8 Validation

The procedure is systematic with clear deliverables defined for each of its phases (Table 4.16, Chapter 4). This means that after each phase the development team knows what the outcome should be and can first decide whether or not this outcome has been met satisfactorily before proceeding with the next phase. Check-points are a very important aspect of the development of systems and asking questions during the requirements cycle may only contribute to the end-product if used effectively (Pressman, 2005).

5.3.2.9 Time

The 5 phases were repeated for each of the institutions with the longest period of time being spent on the first iteration at UNISA (more or less 270 hours). The second iteration at UP was done in a shorter time period (69 hours) and the third in only 51 hours. The hours per phase per institution are summarized in Table 5.37 followed by a graphical comparison between the three institutions (Figure 5.10).

Table 5.37: Hours used per institution

Phase	University of South Africa	University of Pretoria	TechPta
Phase 1	7.3	0.5	0.5
Phase 2	64.5	28.4	22.3
Phase 3	28	33	14
Phase 4	36	8	4
Phase 5	134	10	10
TOTAL	270	69	51

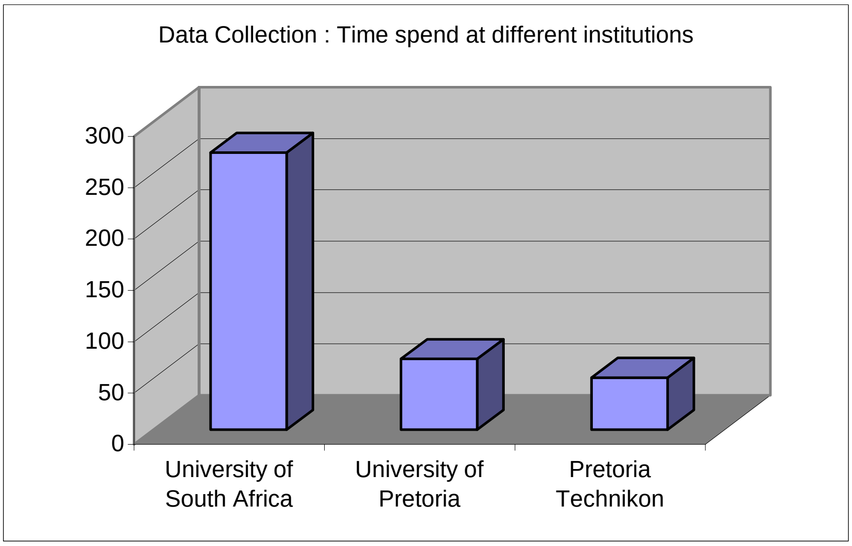


Figure 5.10: Hours spent per institution

The time spent on data collection at UNISA may seem significantly longer than the time spent at UP or TechPta. The following factors caused this significant time difference:

- I was not familiar with all the different units in a HEI the first time that Phase 2, *Identify critical units,* was used at UNISA. In contrast, during the second cycle of this phase at UP, the units were the same at this institution, even if known by different names, which shortened the data collection period. This is also true for the third institution, TechPta, which shortened the data collection time for this phase even more.
- In Phase 3, *Identify primary processes,* the same phenomenon was experienced. The identification of different processes in different units was a tedious process at UNISA, but repeating it at the other two institutions took a shorter period of time because of familiarity with the processes after the first cycle.
- The last phase, *Refinement*, was included in the calculation although the detailed diagrams were refined for at least one sub-level for all processes at UNISA, whereas I refined only the electronic registration process at the other two institutions. After doing the refinement for one process, there was no necessity to do it for others. My goal was only to show that the refinement process works, not to give a complete set of process models. The development team will not refine all processes at one time – only those that are focused on for re-engineering efforts.

The use of the requirements elicitation procedure at the second and third institution definitely contributed to the fact that less time was spent on building the high-level process model at these institutions. However, the fact that familiarity also plays a role can not be ignored. After the first cycle I was more familiar with the environment and it was easier to retrieve information from these two institutions.

5.3.2.10 Financial implications

In this specific study there was no financial implication regarding the use of the requirements elicitation procedure. The time spent on this was not converted to money because it was part of my research responsibilities at the University. If one considers the time that was spent at the first institution and compare it to the time spent at the second and third (section 5.3.2.9), then it is possible to argue that the fact that less time was spent at these institutions does have a financial advantage, even if not an easily measurable one.

The focus of attention moves now from the advantages and characteristics of the requirements elicitation to the contribution of the study, which is discussed in section 4.

5.4 THE EDUCATIONAL PROCESS MODEL STRUCTURE

The goal for this Chapter was to determine the structure of the higher education domain and to comment on the procedure used to determine it. The Research Question was: *What is the process model structure of the higher education institution?* I am now in a position to comment on the educational process model structure (activity highlighted with a blue box in Figure 5.11).

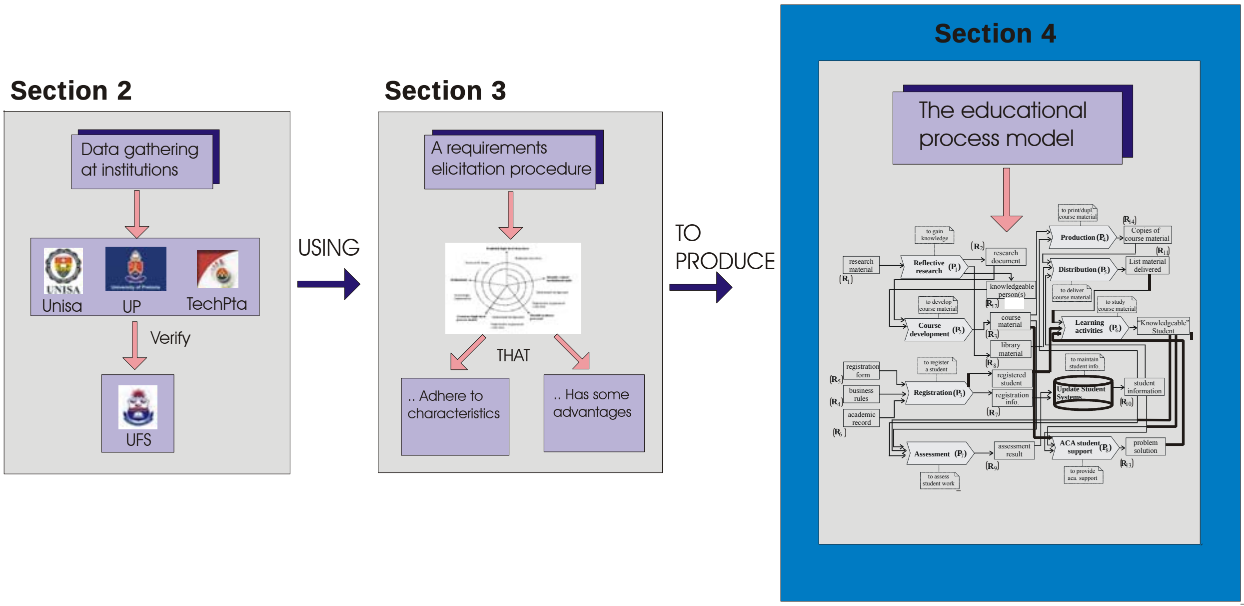


Figure 5.11: The educational process model structure

The answer to the first research question was arrived at by using a cyclic research approach in applying the requirements elicitation procedure at three different institutions.

At the first institution eight high-level processes were derived, including:

1. REFLECTIVE RESEARCH	5. COURSE DEVELOPMENT
2. REGISTRATION	6. PRODUCTION
3. DISTRIBUTION	7. STUDENT SYSTEM
4. ASSESSMENT	8. ACADEMIC STUDENT SUPPORT

The eight processes were also identified at UP and TechPta as the primary processes representing the high-level processes in a higher education environment. It was confirmed at the different institutions that on a high level the process model derived (Figure 5.3) does indeed constitute a generic representation of the structure of the higher education domain. On lower levels I can only comment on the generic nature of the REGISTRATION process, where there is an indication that there is a set of core processes, but that there are also some additional processes in which the sequence of events may differ for different scenarios.

In order to establish the core processes for the second subprocess level (REGISTRATION), it was necessary to compare the subprocesses found at the three institutions. I used the counter registration of a new and existing student as an example, because it is one of the scenarios that is present at all three institutions (Table 5.38).

Table 5.38: Comparison of second-level processes for REGISTRATION

UNISA	UP	TechPta
Scenario: Counter existing student		
Application Process	*Application Process*	*Application Process*
Academic Verification	*Academic Verification*	*Course Material Distribution*
Payment Verification	*Payment Verification*	*Payment Verification*
Course Material Distribution	*Course Material Distribution*	*Academic Verification*
Scenario: Counter new student		
Application Process	*Application Process*	*Application Process*
Academic Verification	*Payment Verification*	*Payment Verification*
Payment Verification	*Academic Verification*	*Academic Verification*
Course Material Distribution	*Payment Verification*	*Course Material Distribution*
	Course Material Distribution	*Payment Verification*
		Registration Confirmation

To find the intersection of the subprocesses for the different institutions, I listed all the subprocesses and used an 'X' as indicator if present at the institution (Table 5.39). If the subprocess is present at all three institutions, I gave a 'YES' value in the last column, which means that there is evidence that it is present at all the institutions and can be described as generic. Alternatively, if not present in all three institutions, a 'NO' value was assigned to the column

Table 5.39: Generic subprocesses on second level for REGISTRATION

Subprocess	UNISA	UP	TechPta	Generic for all 3 institutions
Scenario: Counter existing student				
Application Process	√	√	√	YES
Payment Verification	√	√	√	YES
Academic Verification	√	√	√	YES
Course Material Distribution	√	√	√	YES
Registration Confirmation				NO
Scenario: Counter new student				
Application Process	√	√	√	YES
Payment Verification	√	√	√	YES
Academic Verification	√	√	√	YES
Course Material Distribution	√	√	√	YES
Registration Confirmation			√	NO

From this information it is possible to make the deduction that for the REGISTRATION process, there is a set of generic processes on the second level, consisting of *Application Process, Payment Verification, Academic Verification* and *Course Material Distribution.*

If one compares the subprocesses on the third level for the different scenarios at UP and UNISA, it seems as if there is some overlap, for example on the verification of the payment. The focus in this study was only on the high-level process model structure, and therefore I will not proceed to investigate the nature of generic subprocesses on other levels any further. However, I do emphasize the importance of further investigation into what exactly the total set of the generic structures is, but proceeding down on this path will not contribute in any way towards the current research topic and should instead be included in future projects.

Therefore, to sum up, on a high-level the process model consists of eight generic processes and, from the comparison done for the REGISTRATION process, there is evidence that generic subprocesses exist on lower levels.

5.5 SUMMARY

In this Chapter, the data gathered using the requirements elicitation procedure at UNISA, UP and TechPta was presented. The verification was done at the University of the Freestate where the process model identified at the three institutions was discussed and it was decided that it does indeed represent the structure of the higher education application domain. In section 5.3, the reasons why the procedure used at the different institutions can be seen as a sound requirements elicitation procedure were given. This included the standard notation, cyclic nature of the procedure and the fact that it did indeed result in the goal specified in the beginning. The Chapter concluded with some remarks on the findings during the application of the requirements elicitation procedure and a suggestion of an alternative way of presenting the process model structure through educational value chains.

In Chapter 8, the contribution of the evidence found in this Chapter will be discussed with regard to the contribution made towards the product and the contribution made towards the scientific knowledge in this regard.

6. Evidence and Discussion: Usability of the process model structure

6.1 INTRODUCTION

In Chapter 5 the first of the three sub-research questions: *What is the educational process model of the higher education institution?* was addressed. Data-gathering was conducted at three different institutions to derive the educational process model. The deliverable for the Chapter was two-fold, the high-level process derived and the discussion of the usefulness of the method used to derive the high-level process model.

The research question focused on in Chapter 6 is as follows: *To what extent is the generic process model structure useful in a re-engineering effort?* To address this question in section 4.3.2.1, I suggested the use of a process management flow procedure which uses process models for the educational environment. In section 6.2 of this Chapter I discuss the use of the process management flow procedure, which uses process models for the educational environment, with some remarks in section 6.3 on the usefulness according to some indicators identified in section 4.3.2.3.

6.2 APPLICATION OF THE PROCESS MANAGEMENT FLOW PROCEDURE

This section focuses on the data-gathering activities that took place at UNISA during the application of the suggested process management flow procedure. I selected UNISA as a case study environment because it is the institution at which I work and it was feasible to do the data-gathering at the institution. The results obtained in this data-gathering exercise are acceptable for commenting on the management of flow within an educational environment, because UNISA encapsulates all the processes available at residential institutions, and more.

The suggested process management flow procedure consists of five phases and these were used at UNISA to focus on possible constraints in that institution. The activities in this section are summarized in Figure 6.1.

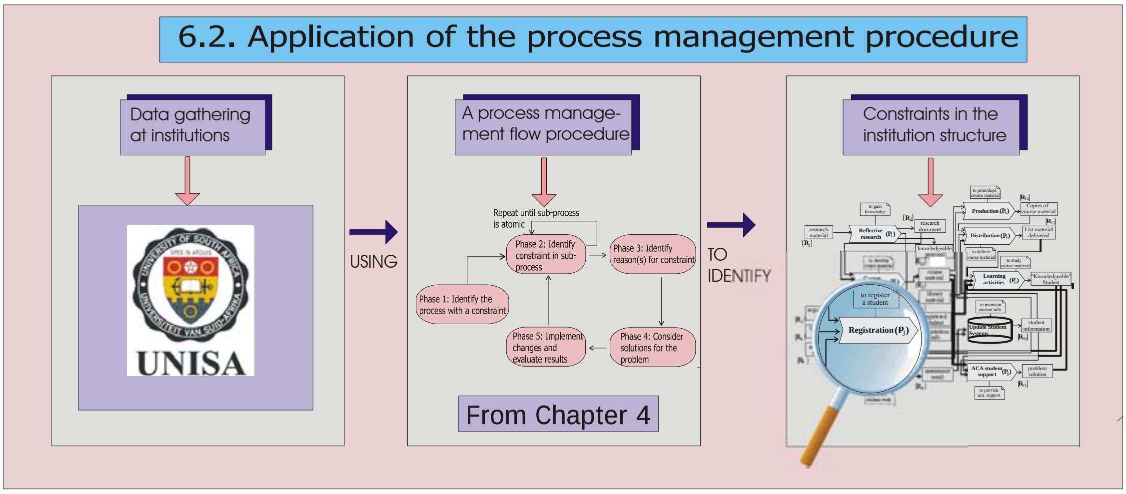


Figure 6.1: Using the process management flow procedure

The five phases, a description, the documentation and the deliverable of each phase are listed in Table 6.1.

Table 6.1: Phases, documentation and deliverables

Phases	Description	Documentation	Deliverable
Phase 1: Identify main constraint	For the first phase the high-level process model of the institution together with the process list are used as a guideline in identifying the main or most important constraint in the educational domain that needs attention.	1. High-level process model 2. Process list	Selected process with constraint
Phase 2: Identify constraint in subprocess	In the second phase the re-engineering team derives the subprocesses for the selected process and once again identifies the problem area (or constraint).	1. Subprocess models 2. Subprocess list	Identified constraint on lower level
Phase 3: Identification of reason for constraint	During the third phase the team focuses on the reasons for the constraint.	Reasons for constraints	List identified with reasons
Phase 4: Consideration of solutions	For the fourth phase, the development team considers the different solutions available for the constraint.	1. Solution options 2. Feasibility study 3. Process models	Implementation plan
Phase 5: Implement changes	The selected solution is implemented in the fifth phase.	Adapted process models	Implemented solution for constraint

Graphically the five phases can be presented as a cyclic procedure (Figure 6.2).

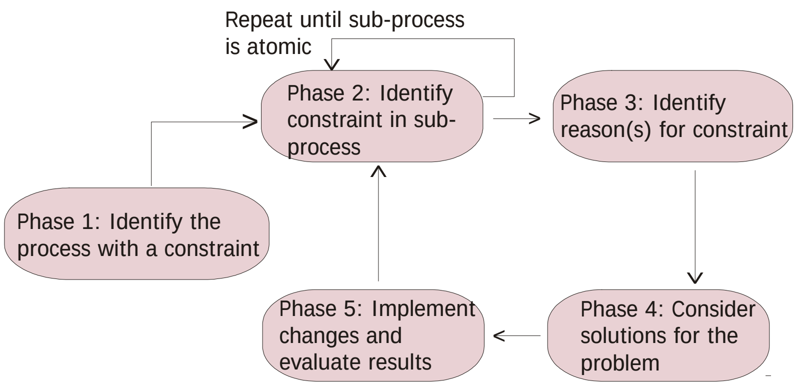
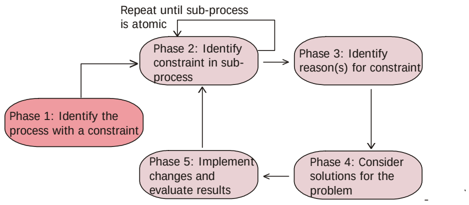


Figure 6.2: The phases in the process management flow procedure

Sections 6.2.1.1 to 6.2.1.5 comprise a discussion of the application of each of the phases of the process management flow procedure at UNISA.

6.2.1 Phase 1: Identify the process with a constraint



The first phase consists of the identification of the main constraint on which the remainder of the procedure will focus. In some re-engineering efforts this step will not be necessary, for example when management has already identified the high-level process that is a problem and requests the identification of constraints within this process. This was not the case in this research project and Phase 1[18] was included in the data-gathering effort.

I first discuss the data-gathering (section 6.2.1.1), followed by some comments on the selection process (section 6.2.1.2) and finally give some comments on preliminary findings applicable to this phase in section 6.2.1.3.

6.2.1.1 Data-gathering at UNISA in Phase 1

For Phase 1, the process management procedure suggests the following steps:

1. Use a high-level process model to identify (or focus on) possible constraints.
2. Derive from the process model a table that lists all the processes.
3. List a Throughput value and a Demand value for each process.
4. Add a column called *Constraint* with a 'Yes' indicating a constraint or 'No' if not.

Step 1: Identify the high-level process model

The high-level process model was derived in Chapter 5 as a deliverable of the requirements elicitation procedure and it was not necessary to duplicate this activity. As reference, the model is repeated in Figure 6.3.

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[18] When referred to a phase in this chapter, except if stated differently, it refers to a phase in the process management flow procedure.

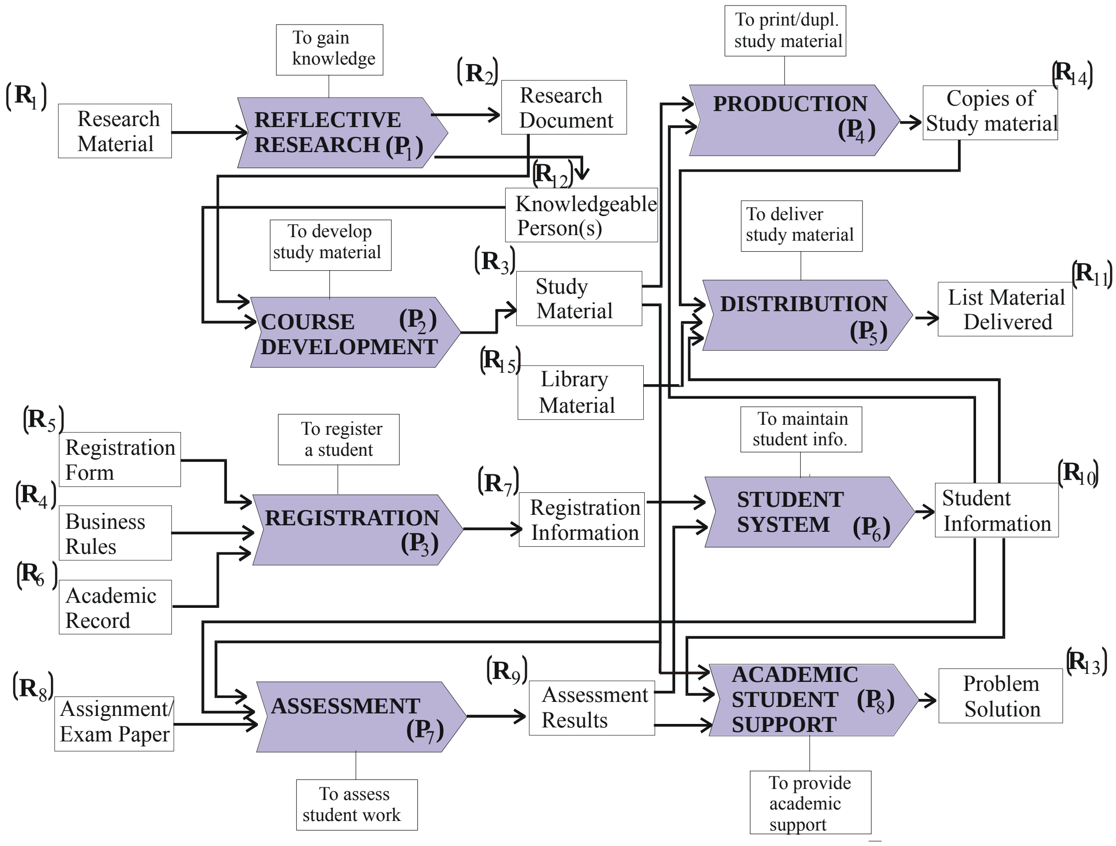


Figure 6.3: High-level process model

Step 2: List the processes

The process management flow procedure specifies that from the high-level process model, the list of processes, $\{P_k\}_{k=1}^{m}$ with $k, m \in \mathrm{N}$, where m denotes the total number of processes, should be derived. Following this requirement, the list of processes was described as a set of eight processes, $\{P_k\}_{k=1}^{8}$, where

$P_1 =$	REFLECTIVE RESEARCH	$P_5 =$	DISTRIBUTION
$P_2 =$	COURSE DEVELOPMENT	$P_6 =$	STUDENT SYSTEM
$P_3 =$	REGISTRATION	$P_7 =$	ASSESSMENT
$P_4 =$	PRODUCTION	$P_8 =$	ACADEMIC STUDENT SUPPORT

Step 3: List a Throughput value and a Demand value for each process

The next step in this procedure was to list a Throughput and Demand value for each process identified. Goldratt & Cox's (1992) theory specifies that a constraint or bottleneck occurs where the capacity of a process is less or equal to the demand placed on it. The set of possible values for the Throughput and Demand are the set Throughput = {possibility, none, satisfactory, a} where $a \in \mathrm{N}$ and similarly, Demand = {possibility, none, satisfactory, b} with $b \in \mathrm{N}$.

Identification of these values needed thorough examination of the different processes. Each of the processes was investigated from a constraints view point and discussed in Table 6.2.

Table 6.2: Summary of constraints experienced within high-level processes

Process	Comments on constraint identification
P_1 REFLECTIVE RESEARCH	REFLECTIVE RESEARCH necessitates the active involvement of the researcher / lecturer in activities related to the course content that he/she is involved in. The Throughput for this activity is not easily measurable – in interviews a few problems were identified related to the activity (discussed in the conclusion). However, the Throughput was reported as satisfactory.
P_2 COURSE DEVELOPMENT	It is very difficult to define Throughput for COURSE DEVELOPMENT. There are different types of course material which influence the end result, for example paper-based material, on-line material or audio visual material. Course development is also subject - related. To identify the different constraints for different subject areas will require an in-depth analysis, which is beyond the scope of this study (but should be considered as future research). From the interviews conducted, the data gave an indication that some processes can be more fluent and therefore the activity was marked as possible.
P_3 REGISTRATION	One of the processes that experienced some serious delays was the REGISTRATION process. SQL queries were done on the database keeping record of registrations to identify the registration rate for the 2003/2004-registration period. Registration closes on 31 January but one week for slack time was provided to obtain the total registrations. The Throughput for registration was 71246 students with a demand of 90739.
P_4 PRODUCTION	For the PRODUCTION process, data collection was based on interviews. Throughput statistics are held on a daily basis and were easy to obtain. The constraints identified from the data-gathering process were easily identifiable and were confirmed by different role players as the delays experienced in receiving resources late from other units, precedence of unscheduled tasks or due to internal delays, e.g. breakage of machinery. There is a possibility of a constraint in PRODUCTION.
P_5 DISTRIBUTION	Material received from the production unit is despatched immediately to students. Delays experienced previously are due mostly to external processes and not internal processes, such as delays experienced at the Post Office. However, there may be a delay at the Production Unit that influences the despatch of study material to students. At the time of the study this process was marked as satisfactory.
P_6 STUDENT SYSTEM	The STUDENT SYSTEM is a support system that, as discussed in Chapter 4, plays such an important role in bonding the different processes together that in could not be excluded from the high-level process model. Re-engineering of the student system is an ongoing process and different techniques are available for software re-engineering, which is not the focus of this study. With regard to student services the down time is usually caused by external factors such as the Internet connection being down or servers not performing up to standard. However, although these problems may be temporarily, if not looked at they will become problematic. At the moment this process is marked as satisfactory with regard to teaching and learning activities.
P_7 ASSESSMENT	The ASSESSMENT of assignments/examinations involves 4 activities, the receiving of material, distribution for marking, recording of marks and despatch of the material back to the student (assignments only). The delay in this process is caused at the Assignments section which is responsible for the registration of the material on the student system. This constraint is, however, time dependant – during some periods no delays are experienced but in peak periods there were reports on delays experienced and the process is marked as possible. For example, during the June 2004 examination period there was a delay in the recording of assignments received due to the examination administration having received precedence.
P_8 ACADEMIC STUDENT SUPPORT	ACADEMIC STUDENT SUPPORT is the responsibility of the lecturers involved in the course modules. There are three scenarios for support used by lecturers: personal contact which is immediate (e.g. phone call or appointment), e-mail which should be handled within a reasonable time span (depending on module policies) and discussion forums (depending on module). The Throughput was indicated as satisfactory for this activity even if there may be different Throughput rates with non-immediate activities such as e-mail. This may be an interesting future quantitative comparative study.

After completion of the information gathering presented in Table 6.2, all the processes were listed and a Throughput value and a Demand value were assigned (presented in Table 6.3).

Table 6.3: Throughput and Demand

Process	Process	Throughput	Demand
P_1	REFLECTIVE RESEARCH	None	None
P_2	COURSE DEVELOPMENT	Possibility	Possibility
P_3	REGISTRATION	71246 (1/12-9/2)	90739
P_4	PRODUCTION	Possibility	Possibility
P_5	DISTRIBUTION	Satisfactory	Satisfactory
P_6	LEARNING ACTIVITIES	Satisfactory	Satisfactory
P_7	ASSESSMENT	Possibility	Possibility
P_8	ACADEMIC STUDENT SUPPORT	Satisfactory	Satisfactory

Step 4: Identify constraint processes

The next activity is to assign a 'Yes' or 'No' value to each process, indicating a constraint is experienced or not. The algorithm suggested in Chapter 4 is:

Add a column to the process list called Constraint with a Yes indicating a constraint or No if none. This value is determined using the definition of a constraint with the following algorithm:

If (Throughput = 'satisfactory' or Throughput = 'none') then constraint = 'No' else

If Throughput = 'possibility' then constraint = 'Yes' else

If Demand > Throughput then constraint = 'Yes' else constraint = 'No';

For each process the algorithm (above) was applied to identify the constraint values as either being a constraint or not (Table 6.4).

Table 6.4: Throughput and demand on processes in the high-level process model

Process	Process	Throughput	Demand	Constraint
P_1	REFLECTIVE RESEARCH	None	None	No
P_2	COURSE DEVELOPMENT	Possibility	Possibility	Yes
P_3	REGISTRATION	71246 (1/12-9/2)	90739	Yes
P_4	PRODUCTION	Possibility	Possibility	Yes
P_5	DISTRIBUTION	Satisfactory	Satisfactory	No
P_6	LEARNING ACTIVITIES	Satisfactory	Satisfactory	No
P_7	ASSESSMENT	Possibility	Possibility	Yes
P_8	ACADEMIC STUDENT SUPPORT	Satisfactory	Satisfactory	No

In the high-level process model the processes with constraints are emphasized by red blocks (Figure 6.4). Note the ripple effect where a constraint in COURSE DEVELOPMENT will have an effect on the PRODUCTION process, which can cause a delay in the distribution of material to the students. Similarly, a delay in the REGISTRATION process causes delays in the distribution of material to the student, which once again will have the effect that he starts his course later than necessary, putting pressure on his study schedule.

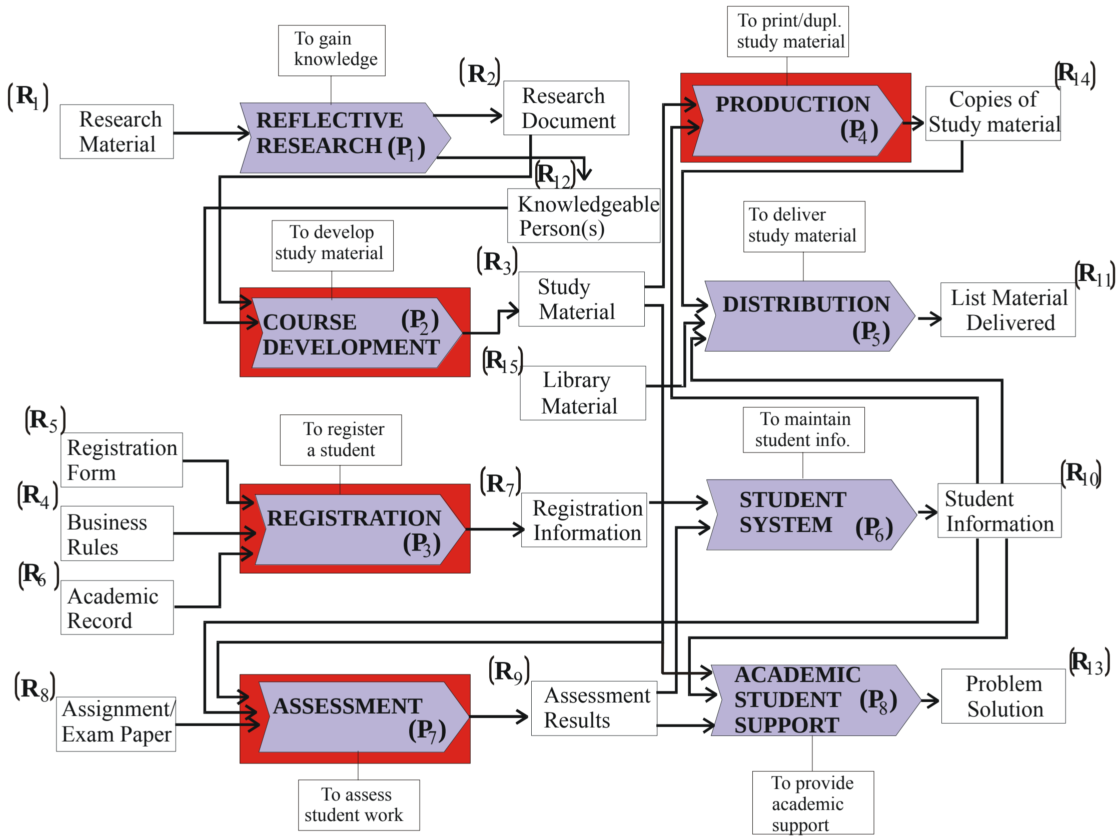


Figure 6.4: Constraint processes highlighted in the high-level process model

6.2.1.2 *Selection of the process at UNISA in Phase 1*

The deliverable of this phase is the selection of the process to focus on in the re-engineering initiative. It is possible that more than one process may be re-engineered at the same time if all dependencies are acknowledged between different processes. The processes identified as problem processes include COURSE DEVELOPMENT, REGISTRATION, ASSESSMENT and PRODUCTION. After discussions with my study leaders, the REGISTRATION process was selected as an example for this study. The reasons for selecting this specific process were as follows:

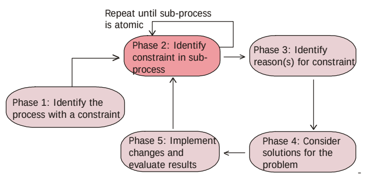
- The REGISTRATION process was used in decomposition in Phase 5 of the requirements elicitation procedure in Chapter 5. It is a known fact that familiarization with a problem domain accelerates the data-gathering process (Whitten *et al.*, 2000; Pressman, 2005).
- Key persons at UNISA had a positive attitude towards the identification of constraints in the Registration Unit, and were therefore approachable for data-gathering initiatives and discussing the feasibility of a solution.

Although the remaining three processes (P_2, P_4, and P_7) for which constraints were indicated were not analysed further, the data used to derive them as constraint processes is available for perusal.

6.2.1.3 Findings at UNISA in Phase 1

The first two steps were completed within a short period of time owing to the availability of information after answering the first research question in Chapter 5. If this procedure is applied in another environment, the re-engineering team will need to go through a requirements elicitation procedure such as that suggested in Chapter 4 to derive the high-level process model (or at least the list of high-level processes). This confirms that the process model was already useful in the first Phase of the procedure.

6.2.2 Phase 2: Identify constraints in subprocess



The second phase focuses on the constraints in the subprocesses for the selected process. The REGISTRATION process was selected as the process on which this re-engineering effort will focus. I first discuss the data-gathering in section 6.2.2.1, followed by some comments on the findings in section 6.2.2.2.

6.2.2.1 Data-gathering at UNISA in Phase 2

In Chapter 4, four steps were identified as activities in determining the subprocesses with constraints. The steps are as follows:

1. Select the scenario with the constraint (if there is more than one scenario).
2. Determine the list of subprocesses for the process being scrutinized.
3. Determine the Demand and Throughput for each subprocess.
4. Identify the constraint in the list of subprocesses using the procedure described in Phase 1.

5. Select the subprocess to focus on.
6. If the selected subprocess has subprocesses, go back to Step 2.

The steps are similar to the steps in Phase 1, except that in the last step the development team may return to step 2, a decomposition activity, until all processes are atomic. A process is atomic if it is not possible to decompose it into any further subprocesses. To be able to determine the exact location of the constraint, it is necessary to be involved in a cyclic activity of deriving subprocesses until the subprocess focused on is atomic. As mentioned before, it is a cyclic activity, meaning that if the subprocesses are derived, and the constraint in the set of subprocesses is identified, it is necessary to ask whether the constraint is clear and easy to define or forms part of a 'hidden' subprocess on a lower level.

There is more than one scenario in the REGISTRATION process and therefore it was necessary to do Step 1.

Step 1: Select scenario

In the REGISTRATION process at UNISA there are three different options when it comes to registration. These scenarios include postal, on-line and personal registration. The question was, in which of these three scenarios is the constraint causing the main constraint in the high-level process model? It was necessary to look at the three scenarios[19] separately before it was possible to select one single scenario.

For all three scenarios undergraduate students may register between the 1 December and 31 January for the academic year that starts on 1 February. Students in the Faculty of Science[20] may register over a longer period. As the latter is a small percentage of students and they were not included in the calculations due to the late registration period.

The Computer Services Unit was consulted to determine the throughput values for the different scenarios. Unfortunately, statistics are only available for electronic and postal registrations combined. UNISA does not keep statistics for the two scenarios separately; they add the numbers for postal and electronic registration together and distinguish only between counter

[19] Queries encapsulate both new and existing undergraduate students. Data do not include postgraduate students.

[20] Faculty of Science (2004 and before) = Faculty of Science, Engineering and Technology (after merger).

registrations and non-counter registrations. Table 6.5 gives the registration numbers for the 2003/2004 registration period (‘special’ indicates students in the Faculty of Science).

Table 6.5: Throughput values for counter and postal registrations

Date	Description	Counter	Postal	Total
2004/03/05	Demand per registration period	56536	34203	90739
2004/02/09	Delivered per registration period	- 45179	-23930	-69109
	Overflow = Demand – Delivered	11357	10273	21630
	Special	-1278	-859	-2137
	End total = Overflow - Special	10079	9414	19493

A total of 90739 students were registered by 5 March 2004 (although it is possible that special cases were still accommodated after this date). Registration closes on 31 January 2004 for this selected group, but after this date (even with a lapse of 9 days), 19493 students still registered. The reason why there are so many late counter registrations is mainly because UNISA allows them. Why these students are allowed to register after the due date lies beyond the scope of this study and should be considered by the institution internally. However, for the non-counter registrations it was worth looking for constraints, and asking if this is also a case of accommodating late students or are there other reasons for delays in these scenarios?

For the non-counter registrations, the postal and electronic registrations, I had to rely on the information retrieved from the respondents on the delays experienced in the two scenarios. Based on conversations with staff involved in the REGISTRATION process, most of the respondents agreed that the biggest delays are experienced within the electronic registration. Therefore, I selected the electronic registration for further discussions.

The electronic registration scenario for a *new student* was selected for further re-engineering because it encapsulates the subprocesses in the electronic registration for an existing student (the results for the electronic registration for an existing student should be the same). My goal is theoretical in nature and is only to discuss the use of the process models in a re-engineering effort, and therefore the scenario selection should not have an impact on the results of the research. In a real-life re-engineering situation where selections have financial implications, a more in-depth analysis will be necessary before this selection is made.

Step 2: Determine the list of subprocesses for the process being scrutinized

The subprocesses for the electronic registration at UNISA were identified as a deliverable of Phase 5 of the requirements elicitation procedure in section 5.2.1.5. The four subprocesses on the second level included the *Application Process, Academic Verification, Payment Verification* and *Course Material Distribution.*

Because the subprocesses were already available on the third level (derived in section 5.2.1.5), it was not necessary to go into a cyclic refinement. A summary of the three levels is given in Table 6.6. For consistency I use the same referencing as was used in the refinement in section 5.2.1.5.

Table 6.6: Three levels for a new student involved in an electronic registration

Scenario: Electronic new student (S_5)		
High-level	Second level	Third level
REGISTRATION S_5P_3	S_5P_{31} *Application Process*	S_5P_{311} *Student number application* S_5P_{312} *Student number allocation* S_5P_{313} *Send confirmation of actions to student.* S_5P_{314} *Application form completion* S_5P_{315} *Put on work flow*
	S_5P_{32} *Academic Verification*	S_5P_{321} *Course profile verification* S_5P_{322} *Course data capture.* S_5P_{323} *Send confirmation of actions to student.*
	S_5P_{33} *Payment Verification*	S_5P_{331} *Register & verify student payment.*
	S_5P_{34} *Course Material Distribution*	S_5P_{341} *Course material distribution*

Note that the distribution mentioned on the third level refers to the distribution of the initial course material and is not the same process as the DISTRIBUTION process in the high-level process model.

It is possible to compile four different subprocess models for the subprocesses on the third level or combine the ten subprocesses into a single subprocess model. A single subprocess model on the third level is feasible because the output of the last subprocess *Put on work flow (S_5P_{315})*, is the input for *Course profile verification* (S_5P_{321}). Similarly the output for *Send confirmation of actions to student (S_5P_{323})*, is the input for *Register & verify student payment* (S_5P_{331}).

If the subprocesses on the third level are combined to form a single subprocess model, the deliverable for Phase 2 will remain the same. The advantage of doing this is that more subprocesses can be viewed at one time on a single subprocess model. To be able to view the ten processes at once, I decided to follow this route and combined the subprocesses on the third level into a single subprocess model for all the processes on the third level (Figure 6.5).

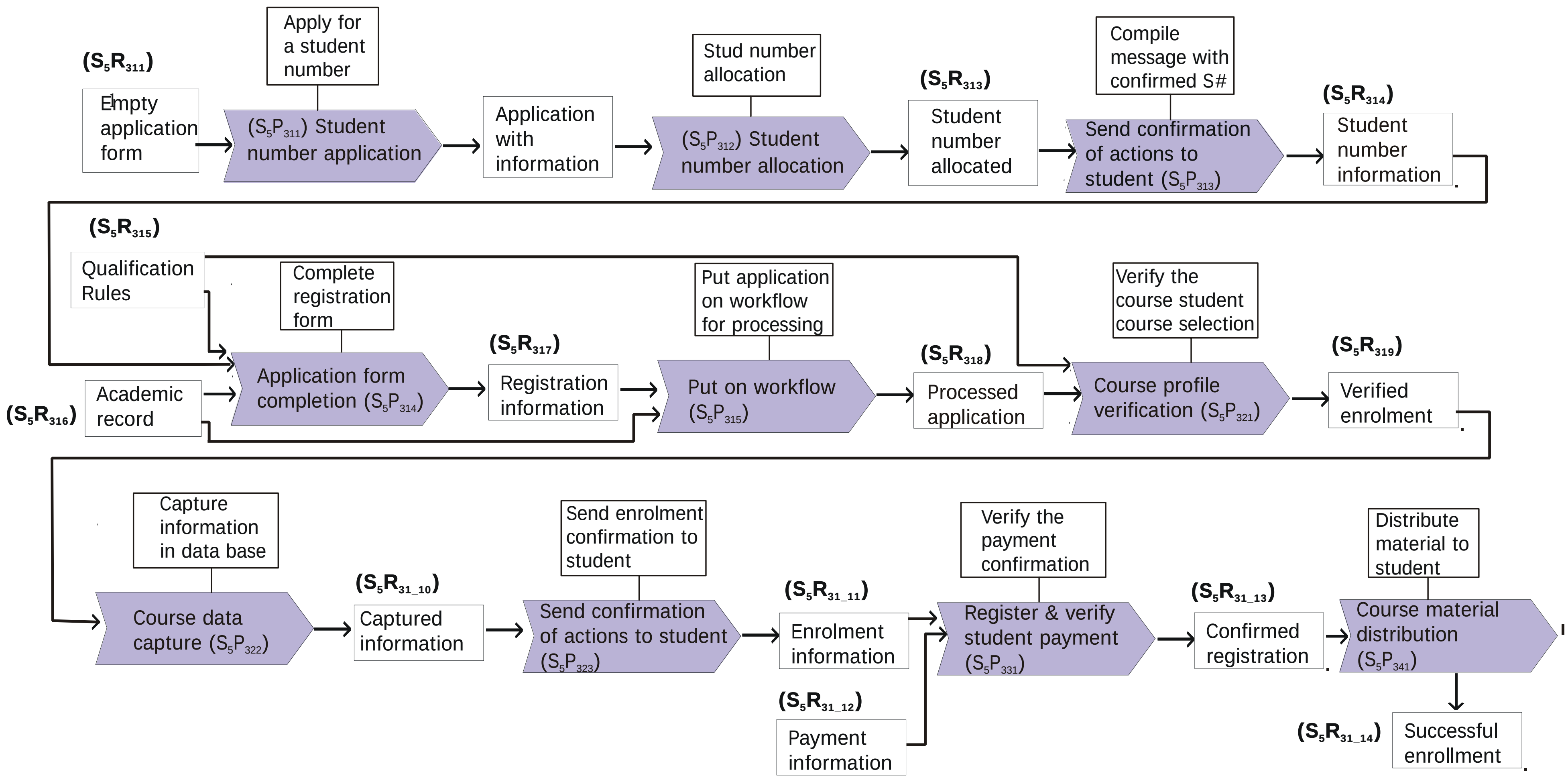


Figure 6.5: Electronic registration subprocess model

The student first applies for a student number electronically (S_5P_{311}). A student number is allocated to the student (S_5P_{312}) and a confirmation is sent to the student with the assigned student number (S_5P_{312}). The student then fills in the electronic application form and submits it to UNISA (S_5P_{314}). UNISA receives the application and puts it into the workflow for verification of the student's academic record and selected course profile (S_5P_{321}). The enrolment is captured on UNISA database (S_5P_{322}) and a confirmation is sent to the student with a request for payment (S_5P_{331}). After confirmation of minimum payment, course material is despatched to the student.

The deliverable of this step is therefore the list of the ten processes in Figure 6.5 (or Table 6.6). For consistency I use the reference numbers assigned to each subprocess in Chapter 5 (section 5.2.1.5). The list of subprocesses includes:

S_5P_{311} *Student number application*
S_5P_{312} *Student number allocation*
S_5P_{313} *Send confirmation of actions to student.*
S_5P_{314} *Application form completion*
S_5P_{315} *Put on work flow*
S_5P_{321} *Course profile verification*
S_5P_{322} *Course data capture.*
S_5P_{323} *Send confirmation of actions to student.*
S_5P_{331} *Register & verify student payment.*
S_5P_{341} *Course material distribution*

Step 3: Determine the Demand and Throughput for each subprocess

Each of these subprocesses was scrutinized, analysed and for each the value for Throughput and Demand was established. For subprocess S_5P_{311} the down-time on servers may cause delays; therefore this subprocess received a 'possibility value' in Table 6.7.

Table 6.7: Subprocesses and constraints

Subprocess	Throughput	Demand
S_5P_{311} *Student number application*	Possibility	Possibility
S_5P_{312} *Student number allocation*	Possibility	Possibility
S_5P_{313} *Send confirmation of actions to student.*	Satisfactory	Satisfactory
S_5P_{314} *Application form completion*	Satisfactory	Satisfactory
S_5P_{315} *Put on work flow*	Satisfactory	Satisfactory
S_5P_{321} *Course profile verification*	24789	34203
S_5P_{322} *Course data capture.*	24789	34203
S_5P_{323} *Send confirmation of actions to student.*	Satisfactory	Satisfactory
S_5P_{331} *Register & verify student payment.*	Possibility	Possibility
S_5P_{341} *Course material distribution*	Satisfactory	Satisfactory

According to staff at the Documentation Unit responsible for subprocess S_5P_{312}, the student will not wait longer than a maximum of two days before he receives a student number from UNISA. The unit receives the application and verifies the student information against the existing database to ensure that the applicant has not registered for any formal qualification previously and therefore has not been assigned a student number. If there is no previous registration, a new student number is allocated. The Throughput is less than desired due to multiple submissions by students. Students are sometimes unsure if the first application was received and send multiple applications. These applications cause unnecessary administrative delays. After a student number has been issued to a student, the third subprocess (S_5P_{313}) is initiated where the Documentation unit sends the new student number to the student. There were no delays in this subprocess and it was given a 'Satisfactory' value for Throughput. The student receives the student number and completes the application form available on-line on UNISA website (S_5P_{314}). There is a possibility of a delay from the student side, but this does not involve UNISA processes and therefore the subprocess is marked as satisfactory in the subprocess list. UNISA receives the application (S_5P_{315}) and puts it into the workflow for processing in the Undergraduate Unit. No significant delays were experienced and it was marked as satisfactory.

A serious concern is subprocess S_5P_{321} in which the application data is verified as a legitimate registration and captured on the system. Subprocess S_5P_{321} focuses on the applicant's academic qualifications and verifies the proposed course enrolment against the Expert System. This is a system developed in-house with all the business rules for the different qualifications. It is maintained by University staff based on information received from the different departments and captured in the yearbooks. A constraint is mistakes in the business rules so that the system is not always updated and intervention is often necessary either from the person using the system or for special permissions on exemptions by the related academic unit. The demand in the 2003 / 2004 in this Unit was to handle 34203 student enrolments; at the end of the registration period only 24789 enrolments were successfully completed by the due date.

A concern with the verification of the applicant's academic qualification is that the supporting material is not always readily available. As from 1996 it is possible to verify the student's academic record given on the application form against the SAUVCA matriculation system, but the exceptions, such as students who received a qualification before 1996 or international students cause delays. For the qualification enrolled for, UNISA verifies the enrolment against UNISA Expert System.

Similarly, the data capturing subprocess (S_5P_{322}), which is done directly after *Course profile verification (S_5P_{321})*, has a demand of 34203 student enrolments and only 24789 enrolments were successfully completed by the due date.

In subprocess S_5P_{323} confirmation is sent to the student that his application was successful or rejected. If he was successful, a minimum payment is requested to confirm the registration. There were no significant delays experienced in this activity and the student confirms his registration by paying the minimum fee. UNISA receives confirmation of the payment (S_5P_{331}) and requests the distribution unit to send the applicable study material to the student (S_5P_{341}). The only constraint that can possibly be experienced occurs when the student does not pay the minimum registration amount, in which case the material will not be sent to him/her and his registration will be cancelled.

Step 4: Identify the constraint in the list of subprocesses

The same procedure used in Step 4 of Phase 1 is used to assign a Yes or No value to each subprocess in the list:

Add a column to the process list (Table 6.8) called Constraint with a Yes indicating a constraint or No if none. This value is determined using the definition of a constraint with the following algorithm:

If (Throughput = ‘satisfactory’ or Throughput = ‘none’) then constraint = ‘No’ else
If Throughput = ‘possibility’ then constraint = ‘Yes’ else
If Demand > Throughput then constraint = ‘Yes’ else constraint = ‘No’;

Table 6.8: Subprocesses and constraints

Subprocess	Throughput	Demand	Constraint
S_5P_{311} *Student number application*	Possibility	Possibility	Yes
S_5P_{312} *Student number allocation*	Possibility	Possibility	Yes
S_5P_{313} *Send confirmation of actions to student.*	Satisfactory	Satisfactory	No
S_5P_{314} *Application form completion*	Satisfactory	Satisfactory	No
S_5P_{315} *Put on work flow*	Satisfactory	Satisfactory	No
S_5P_{321} *Course profile verification*	24789	34203	Yes
S_5P_{322} *Course data capture.*	24789	34203	Yes
S_5P_{323} *Send confirmation of actions to student.*	Satisfactory	Satisfactory	No
S_5P_{331} *Register & verify student payment.*	Possibility	Possibility	Yes
S_5P_{341} *Course material distribution*	Satisfactory	Satisfactory	No

The constraints are presented graphically in Figure 6.6.

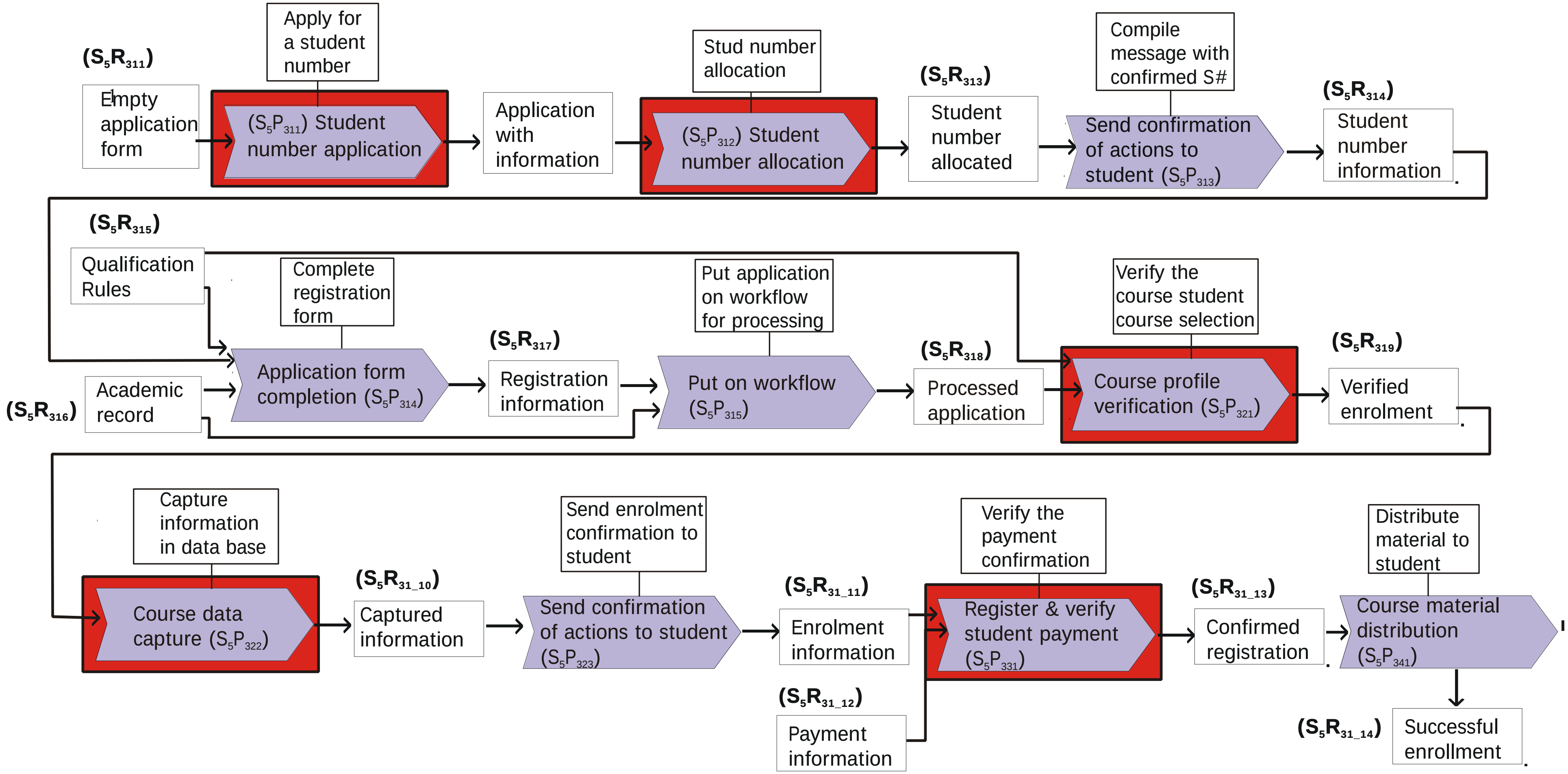


Figure 6.6: Constraints in the chain of subprocesses for the REGISTRATION process

In this chain of events is it easy to see that any constraint will have an effect on the remainder of the subprocesses.

Step 5: Select the subprocess to be scrutinized

From the processes listed, the most serious delay was experienced with subprocesses *Course profile verification* and *Course data capture* in which the Undergraduate Unit verifies the application and the student data is captured. These two subprocesses are combined in one action within the Undergraduate Unit. The remainder of the procedure will focus on the constraint experienced in the electronic registration during the verification and data capturing of a student's information.

Step 6: Investigate the decomposition of the subprocess

It was not necessary to decompose any of the two processes further. Actually, the constraint is in the combination of two subprocesses, namely, *Course profile verification* and *Course data capture*.

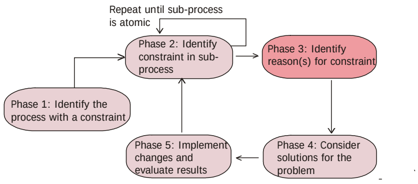
6.2.2.2 Findings at UNISA in Phase 2

From the ten subprocesses listed for REGISTRATION on the third decomposition level, *Student number application, Student number allocation, Register & verify student payment, Course profile verification* and *Course data capture* were identified as possible constraint processes. The last two were selected as the subprocesses to focus on because the biggest time delay was experienced in them. The following are some comments on the constraints in the other subprocesses:

- The constraint in *Student number application* could easily be solved by using backup servers in case the main servers are not working.
- In *Student number allocation* the constraint experienced is due to a ripple effect of the student submitting multiple applications for student numbers or inaccurate data. Previously searches were done on the data base using character strings and not a unique string such as an identification number. This is also a constraint that can easily be solved.
- Respondents disagree on the listing of *Register & verify student payment* as a constraint. A registration that is pending due to a non-payment is not delayed by UNISA and UNISA cannot do anything to force payment.

- The real constraint, in this list of constraints, is experienced at the Undergraduate Unit where nearly 10000 student enrolments are delayed in the *Course profile verification* and *Course data capture* subprocesses.

6.2.3 Phase 3: Identification of reason(s) for a specific constraint

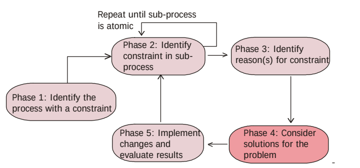


According to Mr. Kobus Nel at Undergraduate Systems, applications are in a queue where a first-in-first-out rule is applied. The first application received is processed first and any other applications received are added to the end of the queue (in the order received). The physical processing of one application is more or less 10 minutes. In the interview some reasons were listed for the constraints, which complement those listed in the constraint reason list (Table 4.27):

1. Staff members are constantly busy with telephone enquiries on the status of student applications.
2. Student applications are duplicated for fear that the first application has not been received.
3. Incorrect information is received from student, i.e. re-registration is required.
4. There are only a few people who can handle the exceptions in course verification.
5. The Expert System is not updated by responsible role players.
6. Management does not realize how dire the lack of resources is.
7. Counter students (65000) involved in the REGISTRATION process get precedence over electronic / postal students and in busy registration periods, staff members are assigned to the counter registration, which causes delays in electronic registrations.

These reasons were taken into consideration in the next step, finding a solution. It is preferable that the proposed solution should address a large proportion of these concerns if it is to be considered successful.

6.2.4 Phase 4: Consideration of for the problem



In this Phase, I will first discuss the data-gathering at UNISA (section 6.2.4.1) then proceed with suggestions for solutions (section 6.2.4.2), followed by some discussions on the technical feasibility of the suggested solution (section 6.2.4.3) and concluding with some remarks on the phase (section 6.2.4.4).

6.2.4.1 *Data-gathering at UNISA in Phase 4*

As stated in the process management flow procedure, there are two ways to look at solutions, to focus on the one constraint or to look at the chain of events and to suggest a 'new' chain. Before a solution was suggested for the single constraint identified, some questions were asked on the current communication activities between the student and UNISA in the REGISTRATION process. This was not part of the original procedure, but used from a *triangulation*[21] perspective as a quality control measure to ensure that the constraints identified are really constraints. The questions in the checklist focused on all communication in REGISTRATION (Table 6.9).

[21] In triangulation the problem is addressed from two different viewpoints to ensure that what is found is confirmed

Table 6.9: Questions used to determine the extent of electronic activities

No	Question	Answer	Opportu-nity
1	Do you support general e-mail registration enquiries?	Yes	No
2	Do you support personal registration enquiries?	Yes	No
3	Do you support postal registration enquiries?	Yes	No
4	Do you answer enquiries electronically?	Yes	No
5	Are any queries at your institution answered electronically and automatically?	No	Yes
6	Do you provide a help desk to answer personal registration enquiries?	Yes	No
7	Do you answer postal queries through the post?	Yes	No
8	Is it possible for a student to fill the registration form in on the web?	Yes	No
9	Is it possible for a student to fill the registration form in personally?	Yes	No
10	Is the data from the electronic registration form automatically placed in a temporary database, before processing?	No	Yes
11	Does your institution receive registration forms in person at the institution?	Yes	No
12	Does your institution receive registration forms through postal services?	Yes	No
13	Do you assign a student number automatically after the application has been received?	No	Yes
14	Do you capture information from the registration form manually in the system?	Yes	Yes
15	Is matriculation verification done automatically against an existing system?	No	Yes
16	Is matriculation verification done manually by means of certification identification?	Yes	No
17	Is special admission done automatically against an existing system?	No	Yes
18	Is special admission done manually by the institution staff?	Yes	No
19	Is information received from an electronic application automatically captured on the student system?	No	Yes
20	Is information received from an electronic application manually captured?	Yes	Yes
21	Is course enrolment automatically verified against an intelligent system from the electronic application?	No	Yes
22	Is course enrolment manually tested against the expert system?	Yes	Yes
23	Can students pay student accounts electronically?	Yes	No
24	Can students' accounts be paid automatically and electronically from information received on the application form?	No	Yes
25	Can students make a personal payment at the institution?	Yes	No
26	Can students send a payment through postal systems?	Yes	No
27	Will a student's financial record be updated after payment has been received?	No	Yes
28	Will a student's financial record be updated manually after payment confirmation?	Yes	Yes
29	Can a student send his record profile updates to the institution electronically?	Yes	No
30	Are existing student record profile updates received personally at the institution?	Yes	No
31	Are student profile updates received telephonically / through postal systems?	Yes	No
32	Can existing student record profile updates be done automatically after submitting information electronically?	No	Yes
33	Are student profile updates done manually at the institution?	Yes	Yes
34	Is course material made available to students electronically?	Yes	No
35	Is course material made available to students automatically and electronically?	No	Yes
36	Is course material handed in person to the student?	Yes	Yes
37	Is course material dispatched to students through postal systems?	Yes	Yes
38	Does your institution use a central student system to keep a record of the students' registration profile?	Yes	No
39	Does your institution use an intelligent system to verify for course enrolment?	Yes	No
40	Does your institution use the SAUVCA database to verify matriculation results?	Yes	No
41	Does your institution use a financial system for student accounts?	Yes	No

The purpose was to look at the REGISTRATION process from another perspective and to identify manual processes that can feasibility be converted into electronic processes. I therefore reduced the list to include only the questions that were identified as activities presenting an opportunity to be handled electronically (Table 6.10).

Table 6.10: Activities presenting opportunities for conversion into electronic activities

No	Question	Answer	Link to subprocess
13	Do you assign a student number automatically after the student number application has been received?	No	S_5P_{312}
10	Is the data from the electronic registration form automatically placed in a temporary database, before processing?	No	S_5P_{315}
14	Do you capture information from the registration form manually in the student system?	Yes	S_5P_{312}
15	Is matriculation verification done automatically against an existing system?	No	S_5P_{321}
21	Is course enrolment automatically verified against an expert system from the electronic application?	No	S_5P_{321}
19	Is information received from an electronic application automatically captured on the student system?	No	S_5P_{322}
27	Will a student's financial record be updated automatically after payment has been received?	No	S_5P_{331}
35	Is course material available to students automatically and electronically?	No	S_5P_{341}
5	Are any queries at your institution answered electronically and automatically?	No	None
24	Can students' accounts be paid automatically and electronically from information received on the application form?	No	Not necessary
32	Can existing student record profile updates be done automatically after submitting information electronically?	No	STUDENT SYSTEM
33	Are student profile updates done manually at the institution?	Yes	STUDENT SYSTEM
36	Is course material handed in person to the student?	Yes	S_5P_{341}
37	Is course material dispatched to students via postal systems?	Yes	S_5P_{341}

Each subprocess was mapped to a subprocess in Table 6.3 to pinpoint the subprocesses ideal for re-engineering efforts.

Question 5 focused on electronic enquiries and falls outside the scope of the electronic registration subprocess. Question 24 will be applicable in systems where the registration is completed on-line. Questions 32 and 33 are actually both related to the STUDENT SYSTEM, but if a student is involved in an interactive on-line application, this is important.

In summary, the subprocesses in which there seems to be an opportunity for enhancement, are as follows:

- S_5P_{312} where there is no automatic assignment of the student number.
- S_5P_{315} where the data captured in the application can be available automatically in a temporary database without scanning it again.

- S_5P_{321} where there may be an electronic verification of matriculation results.
- S_5P_{321} where there may be an electronic verification against the Expert System.
- S_5P_{322} where the data captured in P_5 can be moved automatically from a temporary database to the student system.
- S_5P_{331} where the student record should be updated automatically after payment.
- S_5P_{341} where course material is dispatched electronically to a student.

If one compares the subprocesses with the subprocesses with constraints in Table 6.6, the results are similar. Both indicate a problem with subprocesses S_5P_{312}, S_5P_{315}, S_5P_{321}, S_5P_{322} and S_5P_{341}, which confirms that there are constraints in the subprocess chain for which there are feasible electronic solutions.

6.2.4.2 Solution for the constraints in the REGISTRATION process

There is more than one solution for the electronic registration system. Finding a feasible solution for an electronic registration system at a university is a tedious task. The development team may consider the use of existing software that is available or decide to develop in-house software.

The first option may seem ideal, but software available for administrative tasks of this nature is very expensive and it is often not possible to customize it to interact with existing systems. An alternative is to develop the system in-house. This could also be an expensive option, but has the advantage that the software is customized according to the existing legacy systems.

A feasibility study is necessary and because the purpose of my study was to look at how one can manage flow in existing systems, I focus only on the options available for implementing a customized electronic registration system at UNISA. The constraint that the solution should focus on is in the *Application Process* (S_5P_{32}) on the second level. This subprocess is ideal for automation if there is a system that handles the application electronically. A system of this nature will be ideal if it can be a registration management system that handles the application from inception until the final registration of the student. It will therefore not only benefit subprocess S_5P_{32}, but will also focus on the constraints in S_5P_{31}, S_5P_{33} and S_5P_{34}. This is in accordance with the re-engineering procedure, which states that a solution can either focus on a single constraint at a time or focus on a chain of events (section 4.3.2.1.4).

In the *Application Process* (subprocess S_5P_{31}) of an automated system, I suggest the use of an application system similar to the one already in use at UP. I call the proposed solution the

‘Registration Management System (RMS)’, which is graphically depicted in Figure 6.7. For the *Academic Verification* (S_5P_{32}) I suggest the use of the existing UNISA Expert System, but recommend that it be integrated with the central management system. For the *Payment verification* (S_5P_{33}) in the new RMS system I recommend a limitation that the process only makes provision for automatically registered payments. Lastly, for the *Course Material Distribution* (S_5P_{33}) I suggest the use of a system where the student gains access to his course material as downloadable PDF material.

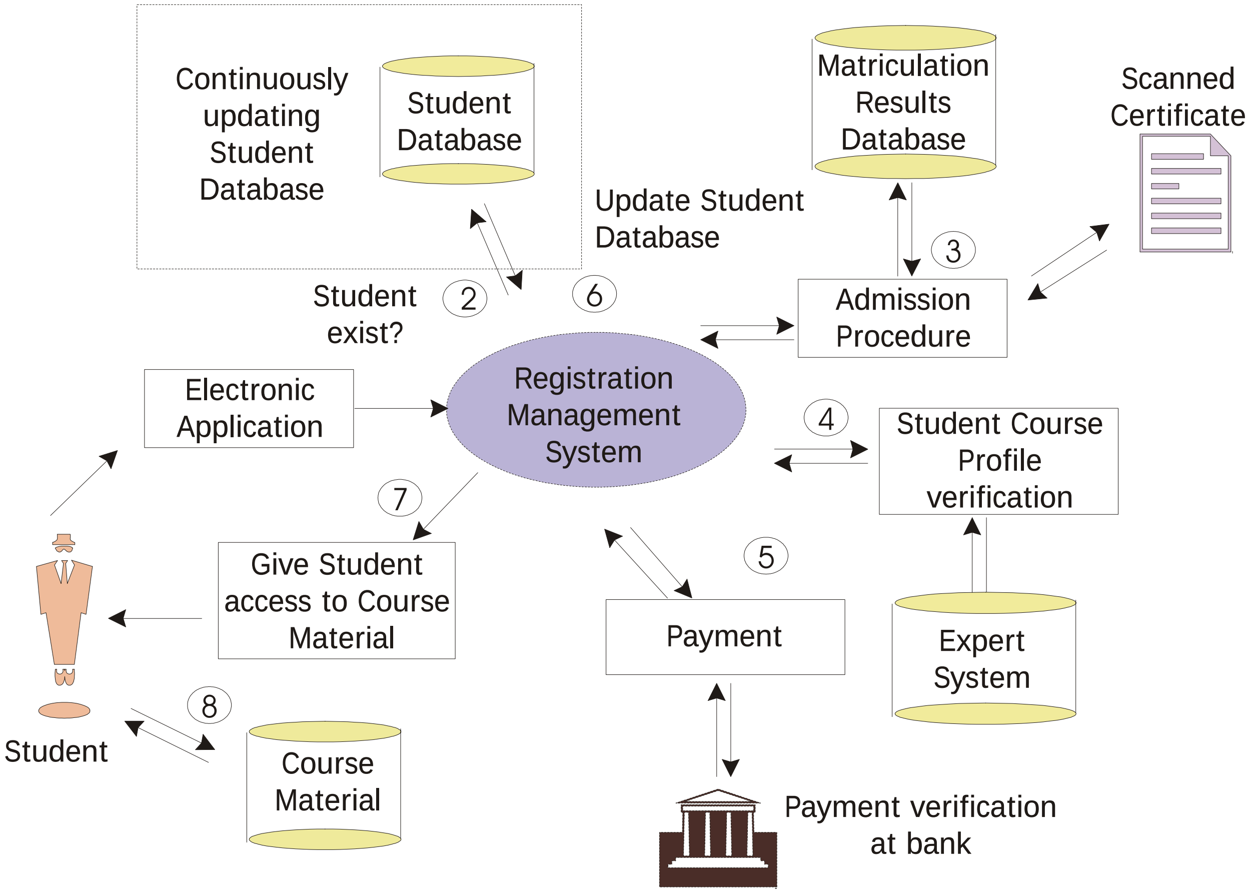


Figure 6.7: Suggested Registration Management System

In the centre of the suggested automated electronic system is the RMS, which is a software management system responsible for managing the application from the moment that the student initiates the application process until the course material is dispatched to the student. The following are the activities managed by the RMS:

1. The student submits his application electronically with all his data, including his personal information, academic record, course to register for and banking, credit or debit card information.

2. The data is captured and kept in a temporary database in the Registration Management System (RMS). The RMS verifies the application information against the Student Database to ensure that the student has not been registered previously. The application is linked to a student number (new or existing).
3. The application goes through an admission procedure where the academic record is verified against the Matriculation database. The RMS uses the student's identification number to compare the marks entered in the application with the marks available in the database. If no match is found, the application is an exception and will be posted to an exception-handling procedure.
4. The RMS uses the suggested course enrolment for a candidate and verifies the courses against the existing Expert System with all the business rules for the different faculties.
5. Electronic payment is made using the student's preferred payment method (credit card, debit card or bank debit order).
6. The data in the application form is captured on the Student Database to reflect the current student enrolment.
7. An e-mail is sent to the student to give him access to his study material on a central course material database.
8. The student downloads the course material.

6.2.4.3 Technical feasibility of the suggested solution

To be able to comment on the feasibility of the proposed solution there are numerous factors that should be considered, such as financial implications, human resources, etc. A full feasibility and impact study of this nature is beyond the scope of this study and was not included as the goal of this study.

The electronic application is feasible; as mentioned previously it has already been implemented at UP. The student number verification can be done automatically if the student types in his national identification number (or passport number). If a previous student number exists the system will return the old number, otherwise the next available student number will be issued. For the verification of results an interface is necessary that matches between the SAUVCA database with the matriculation results and the RMS. Similarly the RMS will need a piece of matching software to compare the application data with the business rules in the Expert System. The electronic payment verification is already used by different business applications and is therefore feasible. Capturing the data and giving access to a database of course material are both feasible. Many of the mechanisms are built into the system to make provision for exception handling; the table with a summary on the feasibility also includes some comments on exception handling (Table 6.11).

Table 6.11: Technical feasibility of the proposed system

Activity	Feasibility of solution	Exception handling
Electronic application	Feasible, already implemented at UP (Lazenby, 2003).	N/A
Verify student number	Feasible – requires unique identification search of maximum two identification numbers and verification on personal data.	There should not be exceptions – an electronic verification is feasible.
Admission procedure	Feasible – SAUVCA database with matriculation results already available.	Exceptions can still be handled manually, e.g. students registering not on the matriculation database.
Student course profile verification	Feasible – an interface is needed between the RMS and the Expert System.	Exceptions can still be handled manually, e.g. students requesting special registration conditions.
Payment	Feasible – many systems are already using electronically registered payments.	Payment done electronically and RMS verifies against bank account – if funds are unavailable it may create a new constraint.
Update student database	Application data is ‘moved’ from temporary database to Student Database.	N/A
Give access to study material	Feasible – already used in electronic courses where students gain access to download material, e.g. the course material at the School of Computing.	N/A

In Table 6.11 I focused on the feasibility of the suggested solution. It is necessary that the solution should address in the current constraints. As triangulation, I focus in Table 6.12 on the technical feasibility of the proposed solution related to the existing subprocesses. In the student application the student accesses the student application database using his identification number. The system immediately verifies the number, which means he will not be able to submit multiple applications. This will help with the constraint in S_5P_{312} where staff had to identify the multiple applications. After completion of his on-line application, the student is immediately placed in the workflow. The on-line application will encapsulate subprocesses S_5P_{311} to S_5P_{315} in one action so that when the student completes his application it is already available in the workflow. For the constraints in the verification processes, interfaces will handle the data between the application and the existing systems. The data capturing is an automatic process and no intervention is needed from the staff. Similarly the payment verification and access to the system can be done automatically.

Table 6.12: Comparison table with technical solution related to subprocesses

Process	Description	Constraint	Technical solution	Comments
S_5P_{311}	Student applies for student number	Yes	Yes	Not possible to submit application more than once – verification on identification number.
S_5P_{312}	Verify student number application and allocate a new number if necessary	Yes	Yes	Verification for previous registrations on identification number. Automatically part of electronic application
S_5P_{313}	Send confirmation with student information to student	No	N/A	Confirmation can still be sent to student to inform him/her of the current status, unnecessary if system performs up to standard and a quick registration is feasible.
S_5P_{314}	Student completes the on-line registration form and submits	Yes	Yes	Automatically part of electronic application
S_5P_{315}	Student application is put on the workflow for processing	No	N/A	Not necessary, the on-line application automatically captures the application data in the RMS. Automatic part of electronic application.
S_5P_{321}	Representative verifies application for legitimate registration	Yes	Yes	If an interface between the RMS and the SAUVCA matriculation results database is created, an automatic verification is possible and exception handling will include only the students not on the matriculation result database.
S_5P_{322}	Student courses are registered on Student Database	Yes	Yes	If an interface between the RMS and the Expert System is created, an automatic verification is possible and exception handling will include only the students who do not fit the course profile, e.g. students who were absent from studies for a long period when business rules changed.
S_5P_{323}	Registration is confirmed and student is notified of payment details.	No	N/A	No notification needed – only after automatic payment does the student receive a letter confirming the registration details.
S_5P_{331}	Receive payment and verify	Yes	Yes	Automatic payment verification
S_5P_{341}	Distribute study material	No	Yes	Students can access course material and download the relevant material.

From the above it seems that there could be an improvement resulting from changing the previous system to the new system. It is therefore possible to claim that it should be feasible to convert the processes previously handled in the REGISTRATION process to automatic processes using the suggested RMS.

6.2.4.4 Findings at UNISA in Phase 4

In Phase 4, I focused on possible solutions for the constraints in the REGISTRATION process. A centralized management system was proposed, which not only solves the constraint within the *Academic Verification* subprocess, but also constraints in the other subprocesses.

A system of this nature has the following advantages:

- Time delays should not be experienced, since almost none of the activities are manual activities and therefore time delays may occur only when systems are down.
- Student does not wait for allocation of student number; application is completed online and static information that will not have an effect may be updated afterwards.
- Using the identification number of the student makes it possible for the RMS to verify previous student allocations to the student and avoid duplication.
- The student's academic record is verified automatically against the SAUVCA matriculation results to verify admission requirements for proposed studies.
- The student's course profile is verified against the business rules of UNISA using an Expert System created by UNISA and updated by faculty.
- Automatic capturing of the data to the Student Database ensures that there are no delays in data capturing activities.
- Payment is handled automatically using the student's credit card information.
- After successful payment the student receives access to his study material automatically.
- Human resources may be used more efficiently – a significant number of students can be accommodated with an automatic system and only exceptions need manual processes.
- The system may address various concerns previously mentioned. In section 6.2.3 a number of concerns were raised with regard to the current REGISTRATION process. In Table 6.13 the constraints are listed and comments are made on how these problems could be addressed by the RMS system:
    - There are two problems that are not addressed, including the fact that the Expert System is not updated by the responsible staff and the awareness of human resources by management. These are human resource problems and should be addressed on another level.
    - The availability of staff is partially addressed. If verification processes are reduced by the RMS system, staff will automatically be available for other tasks such as counter registrations.
    - If the student uses his identification number during his application process, the problem of multiple student number applications will be eliminated.
    - Similarly, for registration information that is not correct, the student will return to the original application data and update the information on the system, and a re-application process is not necessary.

Table 6.13: Problems addressed by the solution

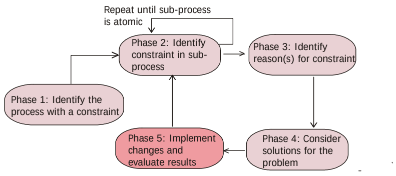
Reason for constraint	Addressed by solution	Comment
Staff members are busy constantly with telephone enquiries on the status of student applications.	Partially	If staff has a smaller role to play in verification process, they may focus on better service with enquiries.
Student application is duplicated in fear of the first application not been received.	Yes	Student cannot submit twice. He has an on-line application, which is updated as he is working – duplication is possible only if he do two separate applications, which can be prevented by making his identification number his application number.
Wrong registration information received from student – re-registration needed.	Yes	Student is responsible for own application. If information is not supplied the application will not proceed.
Limited number of staff members that can assist with exception handling.	Yes	Provided that the Expert System is up to date so that less time is needed on manual verification.
Expert system is not updated by responsible staff – verification is needed by knowledgeable people assigned to degree.	No	Problem
Management does not realize the urgency of lack in resources.	No	Problem
Counter students (65000) visiting UNISA for registration get precedence over electronic / postal students and in busy registration periods staff members are assigned to the counter registration, which causes delays in electronic registrations.	Partially	If an electronic registration exist successfully this will motivate students to rather register on-line and make the counter registrations less. Staff will be available with a more streamline verification process.

However, a system of this nature also gives rise to some concerns:

- The merging of legacy systems is very expensive, both financially and in terms of human resources. Implementing a system of this nature will require a feasibility study, with an impact study that lies beyond the scope of this study.
- There is a 'working system' in place. Implementing automatic electronic systems is a threat to existing staff members and conflict negotiation will need to be included in change management.
- Management need to make it a priority – human resources are focusing on the amalgamation with the Technikon Southern Africa and are therefore not focused on making systems work more efficiently.
- If the Expert System is not updated regularly, it may cause inaccurate results.
- There are some concerns about fraud in respect with credit card payments.

These concerns should be taken into consideration if a system of this nature is implemented at UNISA.

6.2.5 Phase 5: Implementation of changes and evaluation of results



As mentioned previously, the implementation of a project of this nature lies beyond the scope of this dissertation. The focus was only to show that the process models identified can be used in a re-engineering activity. Implementation will need teams from Management, Computer Services, Registration and Financial Services. The recommendations in this report can be used as a starting point in discussions.

However, as part of looking at the feasibility, a small-scale version of the registration system was implemented by a project student at UNISA (Green & Van der Merwe, 2004).

The design overview of the study, as described in Green *et al.* (2004:3) reads as follows:

The Automatic Registration System has been designed for implementation using the Microsoft .NET platform, running on IIS. The development tool to be used to develop the system is Microsoft Visual Studio© v2003, and the language to be used will be C#. The system will interface with the existing UNISA student database. However, for the purposes of testing and evaluation, the system will use a Microsoft SQL Server database, with a schema developed specifically for this project.

The project was not based on the RMS in the sense that electronic payments were accommodated separately from the system. The reason for this design was the feasibility of connectivity to the electronic banking systems for an individual. From the project we learned that an electronic system is feasible, but the complexity of this system was less that that of the UNISA system where legacy systems influence the design and implementation. It is thus possible only to say that an electronic application system is technically feasible without making any claims about how feasible it is at an institution such as UNISA. This is based on the pre-knowledge of successful implementations at other institutions, such as UP, and technical knowledge of the operation of computer-based systems.

6.3 USEFULNESS OF THE PROCESS MODELS

In section 6.2 the implementation of the process management flow procedure was discussed. The experiences during implementation are discussed in more detail in Chapter 8, section 8.3.1. The purpose of Research Question 2 was to discuss the usefulness of the process model structures derived in the first research question. In section 4.3.2.3 some indicators were identified based on ordinal measurement to be used in comments on the usefulness of the process model structure (Table 6.14).

Table 6.14: Rating used to describe the 'extent' of usefulness of process models

Indicators	Description
High	A phase is rated *high* if the process model is used extensively and it is not possible to commence the phase without the process models.
Medium	A phase is rated *moderate* if either the process model or the process list is used as reference in activities in the phase.
Low	A phase is rated *low* if there are one or two references made to the process model.
None	A phase is rated *none* if no reference is made to process models.

In order to discuss the usefulness, I listed the different phases with comments on the usefulness of process models in each phase in Table 6.15. In the last column the indicator mentioned above was used to indicate to what extent the process models were used in the specific phase.

Table 6.15 : Role of process models in different phases

Phases	Documentation	Comments on the role of the process models	Indication of usefulness
Phase 1: Identify main constraint	1. High-level process model 2. Process list	In Phase 1 the high-level process model is used to identify the process list. The process list is then once again used to determine the constraint in each process. Without knowing what the processes are, it is impossible to identify the high-level constraint.	High
Phase 2: Identify constraint in subprocess	1. Subprocess models 2. Subprocess list	In Phase 2, the sub-levels are used to identify the process lists on each level and the constraint on each level. Once again, without knowing what the subprocesses are, it is impossible to identify the constraint on each level.	High
Phase 3: Identification of reason for constraint	Reasons for constraints	Although the process models are not prescribed directly as a tool in this phase, it may be a valuable graphical tool in discussions with role players in the institution to investigate the reasons for constraints.	Low
Phase 4: Consideration of solutions	1. Solution options 2. Feasibility study 3. Process models	The process list is used in Phase 4 to look at alternative chains for a constraint chain of processes or at innovations to enhance the subprocess scrutinized.	High
Phase 5: Implement changes	Adapted process models	After implementation it is necessary to update the existing process models for future reference of the chain of events depicting the flow within an institution.	Medium

The process model and process lists derived from the process model are used on all levels of the suggested re-engineering procedure. In three of the five phases a *high* value is given to 'the extent' that the process models were used. Phase 5 received a *moderate* value for use in the procedure while only Phase 3 received a *low* value. None of the phases received a *none* value.

According to the research design, if most of the phases in a procedure are measured as being *high* or *moderate*, it is rated as *useful to a high extent*, if most phases are *moderate* or *low,* it is rated as *useful to a moderate extent*, if most phases are *low* or *none,* it is rated as a *useful to a low extent.*

It is therefore possible to deduce that the procedure is useful to a high extent if used in a re-engineering activity such as that described in this Chapter. It is useful both for deriving the processes with constraints and also ideal for re-engineering and as a graphical tool in the process.

6.4 SUMMARY

It is very difficult to measure the usefulness of an artefact such as a process model structure. Process models are used in practice in re-engineering efforts as a visualization tool (Van der Aalst *et al.*, 2000; Malone *et al.*, 2003) to understand the processes and the workflow between them. To discuss the usefulness of the process model structure identified in the first research question, a re-engineering procedure was defined for identification of problem processes within the educational application domain. The procedure was used at UNISA and the implementation of the procedure was discussed in section 6.2. So as to be able to comment on the usefulness, an ordinal measurement approach was followed in which indicators are used to show how useful the structures were in the re-engineering effort. The process models were used extensively in the re-engineering effort and were therefore categorized as being highly useful.

7. Evidence and Discussion: Educational process model repository

7.1 INTRODUCTION

In Chapter 5 the first of the three research questions: *What is the process model structure of the higher education institution?* was addressed. The generic educational process model was derived which was used in Chapter 6 to discuss the second research question: *To what extent is the generic process model structure useful in a re-engineering effort?* In this Chapter the last question: *How can the educational process model be preserved and reused?* is addressed.

There are two issues that are addressed in this Chapter relating to the preservation of process models. Firstly, the use of the suggested *educational process model representation* in section 7.2 followed by an investigation in section 7.3 of the *preservation of the models in a repository* such as the Phios repository (graphically depicted in Figure 7.1).

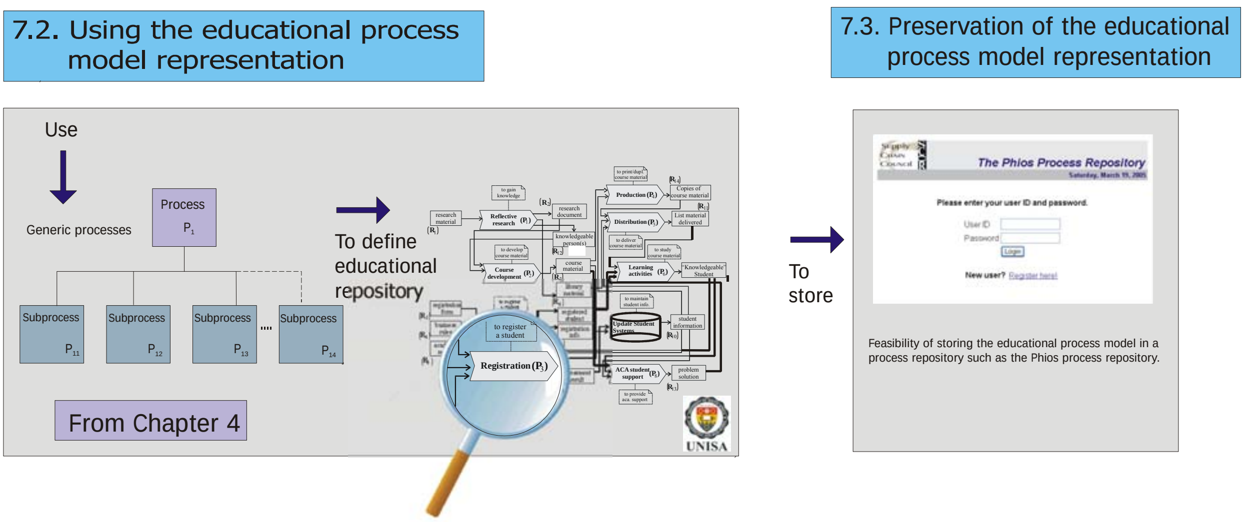


Figure 7.1: Focus on the use of the educational process model in repositories

7.2 USING THE EDUCATIONAL PROCESS MODEL REPRESENTATION

In Chapter 4, section 4.3.3, I suggested the use of an adapted process model representation to denote the generic educational processes and subprocesses. There are different process repositories available, but I preferred the use of a model similar to the Phios Model (1999), which uses a specialization hierarchy. In a specialization hierarchy, the objects (or processes in this case) inherit the features of their parent and modify them incrementally, promoting comprehensibility, maintainability and reusability (Wyner & Lee, 2003). Furthermore, the use of a process hierarchy also supports the generation of design alternatives and suggests an organizational framework where relevant processes could be sought (Malone *et al.*, 1999a). The model is based on specialization and generalization taken from the object-oriented paradigm. I suggested two modifications to the MIT process repository, the use of polymorphism where specializations inherit from the generic base process model and the use of more formal object-oriented notation for defining specialization in the repository model.

The MIT process repository is built on the notion of generic process model structures (Malone *et al.*, 2003). In order to illustrate the concepts within the education process model representation and to compare the adapted model to the MIT process repository, the generic process models are needed as input.

7.2.1 Mapping of the generic high-level process model structure

On the highest level of the educational environment, the high-level process model (Figure 7.2) consists of 8 generic processes.

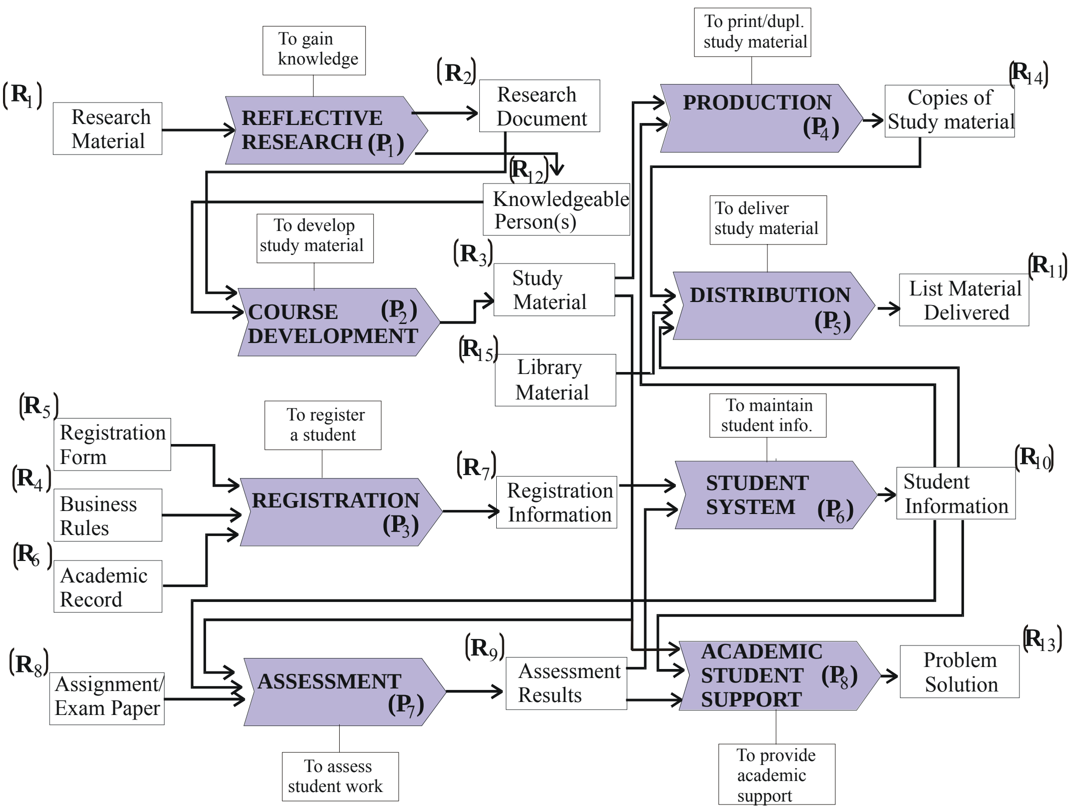


Figure 7.2: Higher education process model

The generic higher education process model can be mapped to an educational process model representation, with the eight processes listed as generic processes, as illustrated in Figure 7.3.

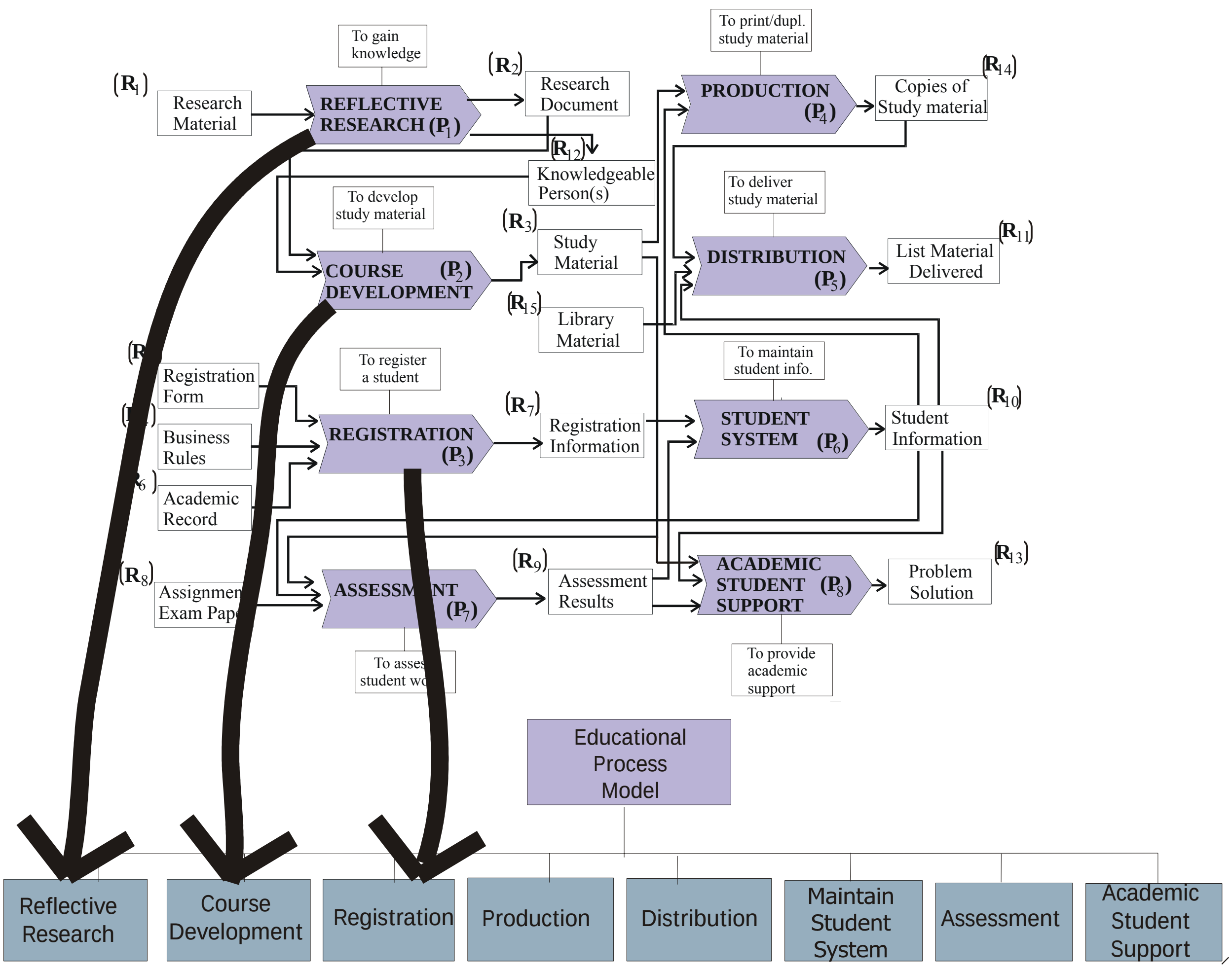


Figure 7.3: Generic educational process model

These generic processes are considered to be the main processes in the educational process model, and similar to the main processes identified in the business application domain (Herman & Malone, 2003) stored on the highest level of the educational process model representation.

The REGISTRATION process was selected to illustrate and discuss the educational process model representation on lower levels. REGISTRATION was used as an example in the first two research questions and to support uniformity is also used as an example for the third research question. The generic subprocess model for REGISTRATION consists of four generic subprocesses, including the *Application Process, Academic Verification, Payment Verification* and *Course Material Distribution* (discussed in section 5.4). The generic structure of the high-level processes and the subprocesses for REGISTRATION is illustrated in Figure 7.4 (with the generic subprocesses emphasized in green).

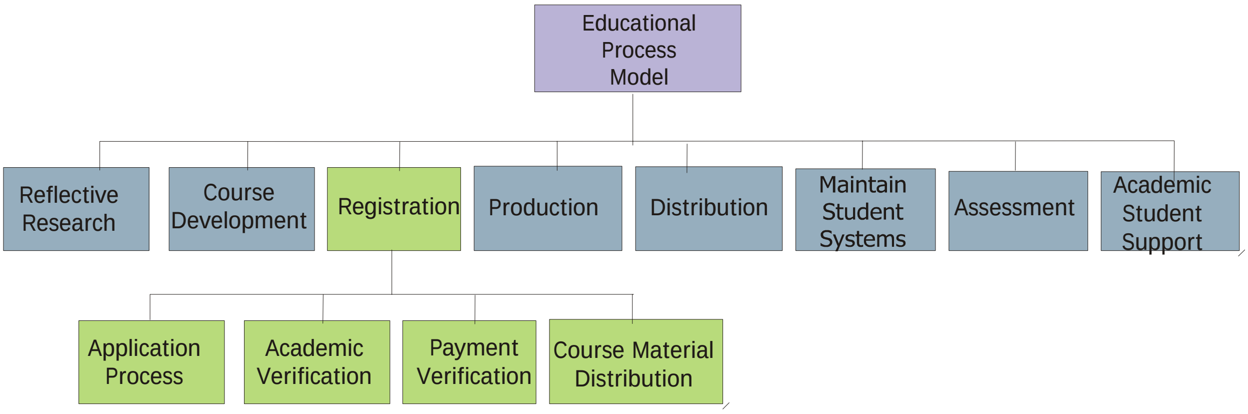


Figure 7.4: Generic subprocesses for the REGISTRATION process

To illustrate the specializations on the second level, the instance of REGISTRATION at UNISA is considered. These specializations are derived from the different scenarios available at an institution and may differ from institution to institution.

7.2.2 Specializations for REGISTRATION on the second level (UNISA instance)

There are six different scenarios for the REGISTRATION process at UNISA (identified and discussed in section 5.2.1.5). The six scenarios and the subprocesses for the second and third level are summarized in Table 7.1. In this section I focus on the specializations in column 2.

Table 7.1: Scenarios for REGISTRATION in UNISA instance

Scenario : Mail existing student (S_1)		
REGISTRATION S_1P_3	*S_1P_{31} Application Process*	*S_1P_{311} Application form completion*
	S_1P_{32} Payment Verification	*S_1P_{321} Register & verify student payment*
	S_1P_{33} Academic Verification	*S_1P_{331} Scan application & put on work flow* *S_1P_{332} Course profile verification* *S_1P_{333} Course data capture.* *S_1P_{334} Print confirmation to despatch & student*
	S_1P_{34} Course Material Distribution	*S_1P_{341} Course material distribution*
Scenario : Mail new student (S_2)		
REGISTRATION S_2P_3	*S_2P_{31} Application Process*	*S_2P_{311} Application form completion* *S_2P_{312} Capture student information and issue stud number* *S_2P_{313} Send confirmation of actions to student.*
	S_2P_{32} Payment Verification	*S_2P_{321} Register & verify student payment*
	S_2P_{33} Academic Verification	*S_2P_{331} Scan application & put on work flow* *S_2P_{332} Course profile verification* *S_2P_{333} Course data capture.* *S_2P_{334} Print confirmation to despatch & student*
	S_2P_{34} Course Material Distribution	*S_2P_{341} Course material distribution*
Scenario: Counter existing student (S_3)		
REGISTRATION S_3P_3	*S_3P_{31} Application Process*	*S_3P_{311} Application form completion*
	S_3P_{32} Academic Verification	*S_3P_{321} Course profile verification* *S_3P_{322} Course data capture.*
	S_3P_{33} Payment Verification	*S_3P_{331} Register & verify student payment.* *S_3P_{332} Print confirmation to despatch & student*
	S_3P_{34} Course Material Distribution	*S_3P_{341} Course material distribution*
Scenario: Counter new student (S_4)		
REGISTRATION S_4P_3	*S_4P_{31} Application Process*	*S_4P_{311} Application form completion* *S_4P_{312} Capture student information and issue student number*
	S_4P_{32} Academic Verification	*S_4P_{321} Course profile verification* *S_4P_{322} Course data capture.*
	S_4P_{33} Payment Verification	*S_4P_{331} Register & verify student payment.*
	S_4P_{34} Course Material Distribution	*S_4P_{341} Print confirmation to despatch & student* *S_4P_{342} Course material distribution*
Scenario: Electronic new student (S_5)		
REGISTRATION S_5P_3	*S_5P_{31} Application Process*	*S_5P_{311} Student number application* *S_5P_{312} Student number allocation* *S_5P_{313} Send confirmation of actions to student.* *S_5P_{314} Application form completion* *S_5P_{315} Put on work flow*
	S_5P_{32} Academic Verification	*S_5P_{321} Course profile verification* *S_5P_{322} Course data capture.* *S_5P_{323} Send confirmation of actions to student.*
	S_5P_{33} Payment Verification	*S_5P_{331} Register & verify student payment.*
	S_5P_{34} Course Material Distribution	*S_5P_{341} Course material distribution*
Scenario: Electronic existing student (S_6)		
REGISTRATION S_6P_3	*S_6P_{31} Application Process*	*S_6P_{311} Application form completion* *S_6P_{312} Put on work flow*
	S_6P_{32} Academic Verification	*S_6P_{321} Course profile verification* *S_6P_{322} Course data capture.* *S_6P_{323} Send confirmation of actions to student.*
	S_6P_{33} Payment Verification	*S_6P_{331} Register & verify student payment.*
	S_6P_{34} Course Material Distribution	*S_6P_{341} Course material distribution*

For all six scenarios $\{S_k\}_{k=1}^{6}$, $k \in \mathrm{N}$, the four subprocesses on second level (S_kP_{31}, S_kP_{32}, S_kP_{33} and S_kP_{34}) map to the four generic subprocesses given in Figure 7.3. For example, *Application Process* (S_3P_{31}) in scenario S_3 maps to the first generic subprocess in Figure 7.3. This is illustrated in Figure 7.5.

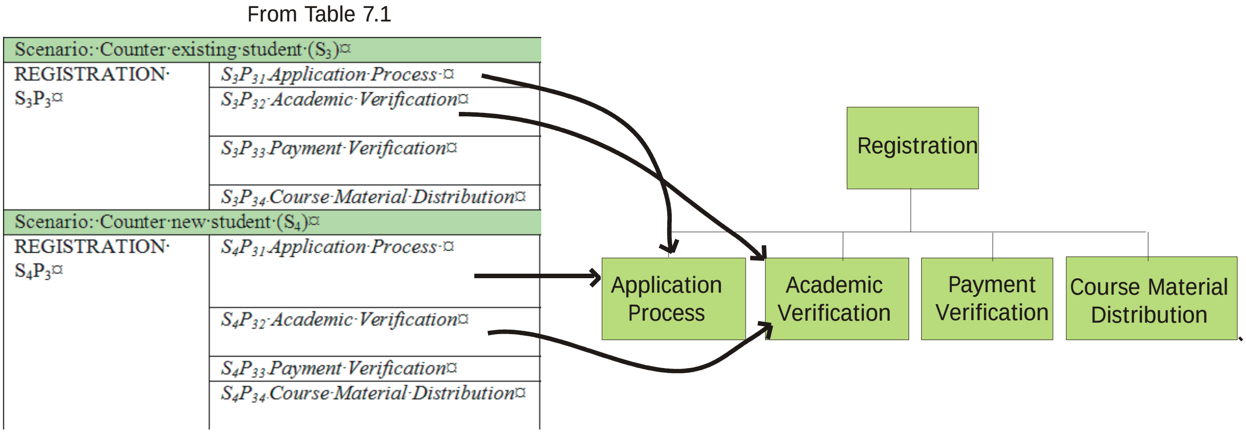


Figure 7.5: UNISA scenarios mapped to generic REGISTRATION subprocesses

Each of these scenarios represents a specialization in the educational process model representation for UNISA instance. Using the notation specified in section 4.3.3 for the educational process model representation, the subprocesses are represented as in Figure 7.6.

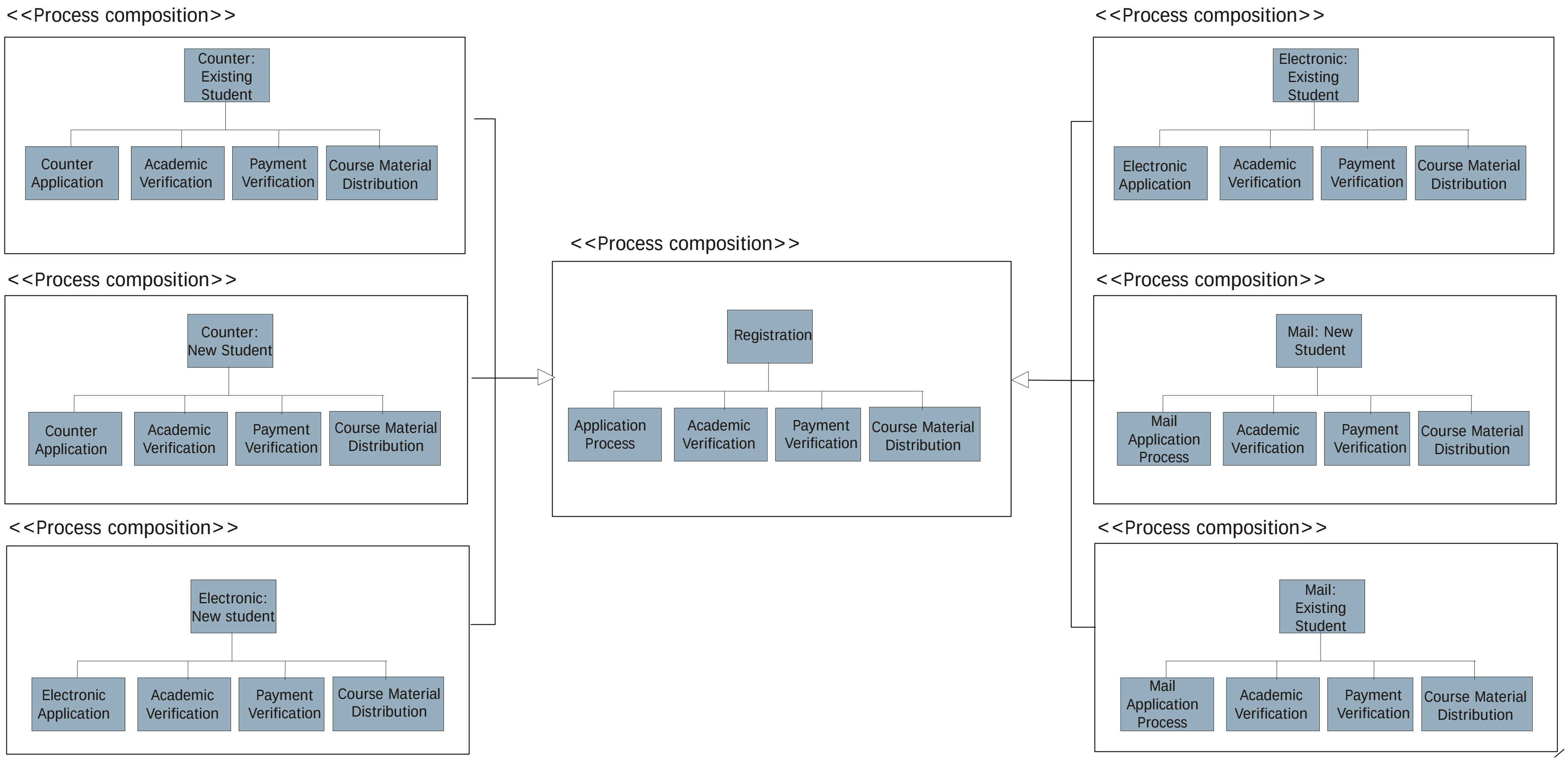


Figure 7.6 : Representation of the six UNISA REGISTRATION scenarios

7.2.3 Specializations for REGISTRATION on the third level (UNISA instance)

The third-level subprocesses for each of UNISA REGISTRATION scenarios are also given in Table 7.1. For each of the scenarios it is possible to draw an educational process model representation. The six representations of UNISA scenarios are given in Figure 7.7a to 7.7f.

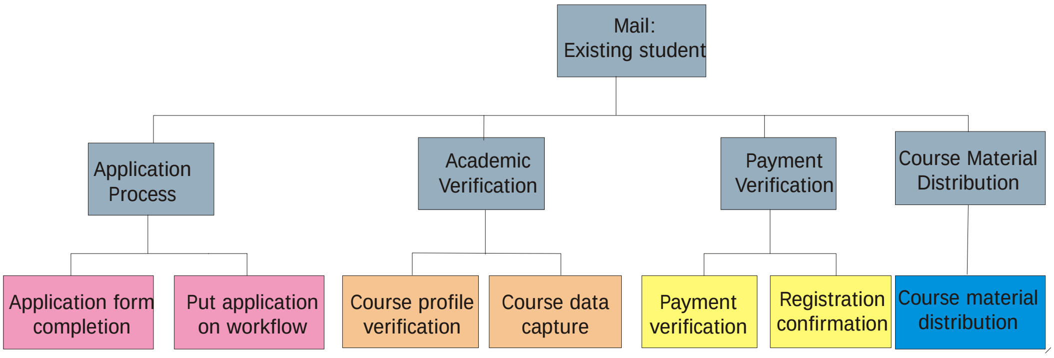


Figure 7.7a: Representation of an existing student using mail registration

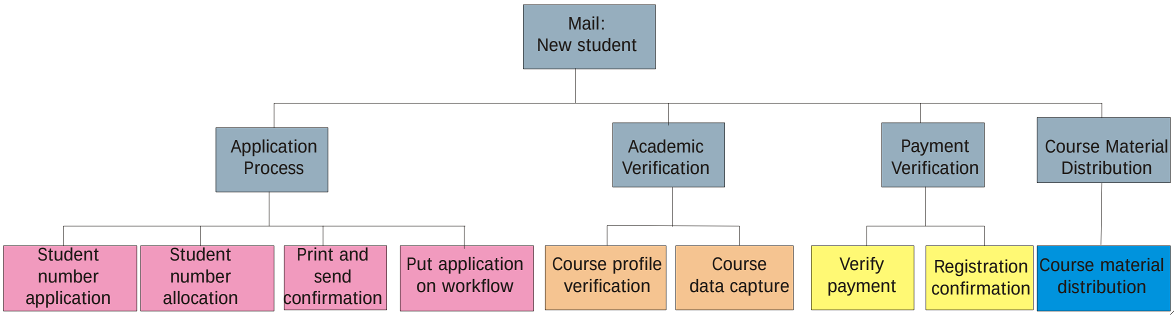


Figure 7.7b: Representation of a new student using mail registration

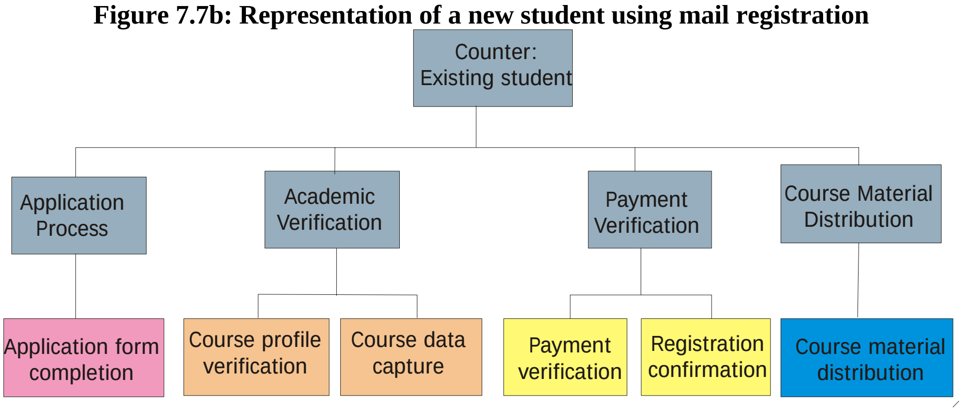


Figure 7.7c: Representation of an existing student using counter registration

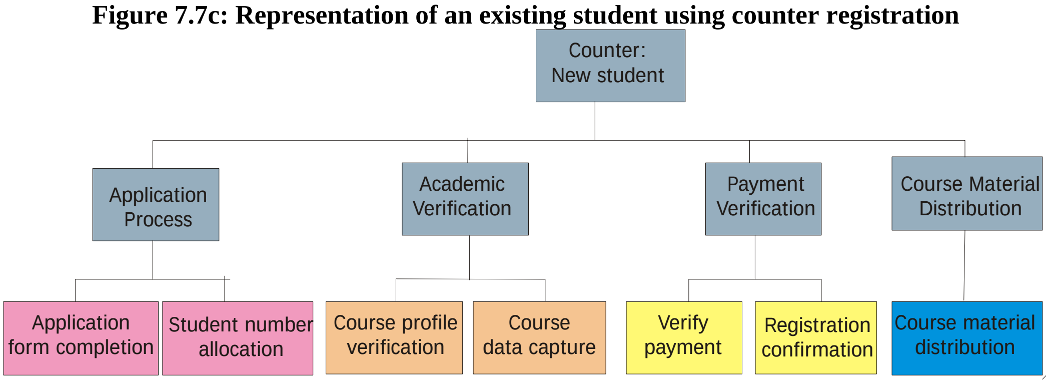


Figure 7.7d : Representation of a new counter registration

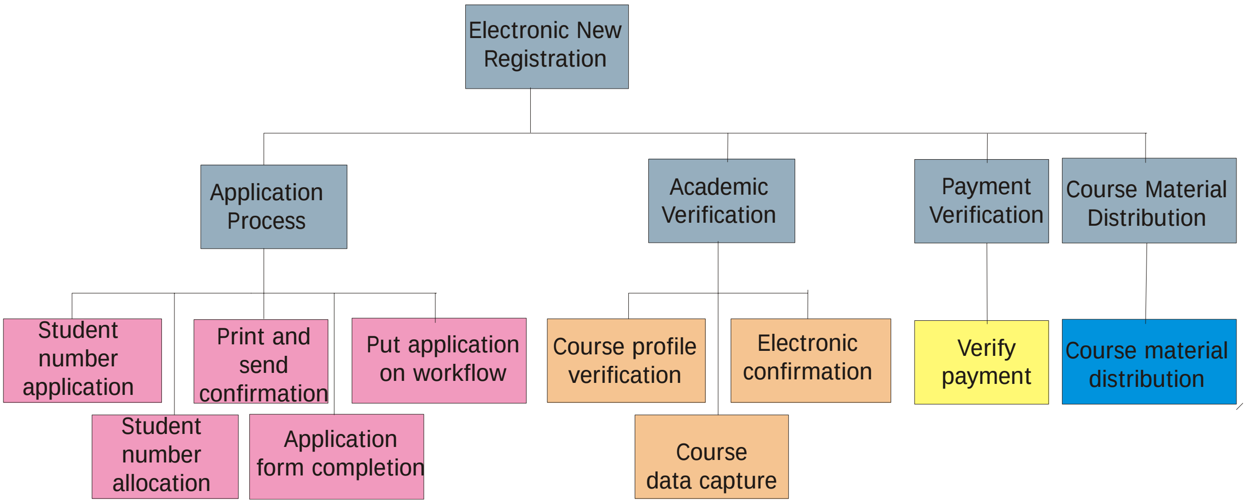


Figure 7.7e: Electronic new registration - a specialization for the generic Registration process

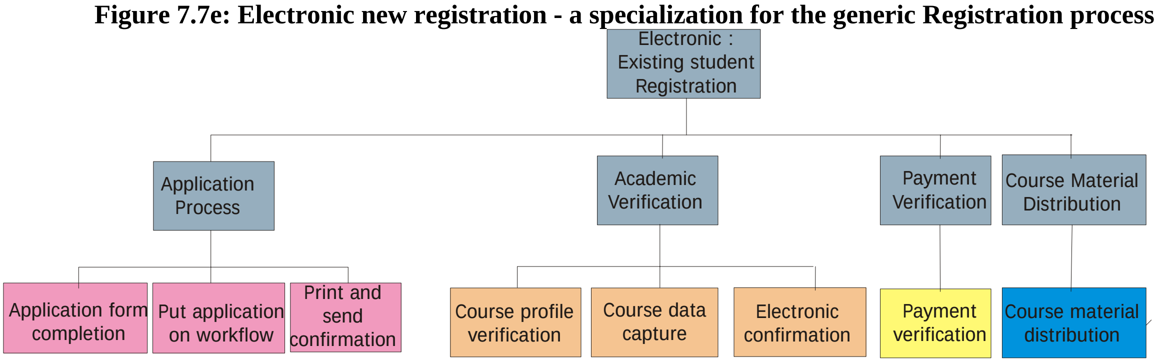


Figure 7.7f: Representation of an existing student using electronic registration

To be able to derive UNISA specializations from the different scenarios, it is necessary to find the common subprocesses for each scenario on the third level. I used a table listing all the possible subprocesses on the third level and showed in which of the scenarios each subprocess is used (Table 7.2).

Table7.2: Third-level subprocesses

Activity	**Scenarios**					
	Mail		Counter		Electronic	
	Existing	New	Existing	New	Existing	New
1. Application form completion						
2. Student number allocation.						
3. Put application on workflow						
4. Send confirmation to student.						
5. Course profile verification						
6. Course data capture						
7. Register & verify student payment						
8. Print confirmation to despatch & student						
9. Course material distribution						
10. Student number application						
11. Electronic confirmation of registration						

Application Process *Academic Verification* *Payment Verification* *Course Material Distribution*

For the *Application Process* (marked in pink in Table 7.2), only the *Application form completion* subprocess is common to all the scenarios and can be used in a specialization (Figure 7.8).

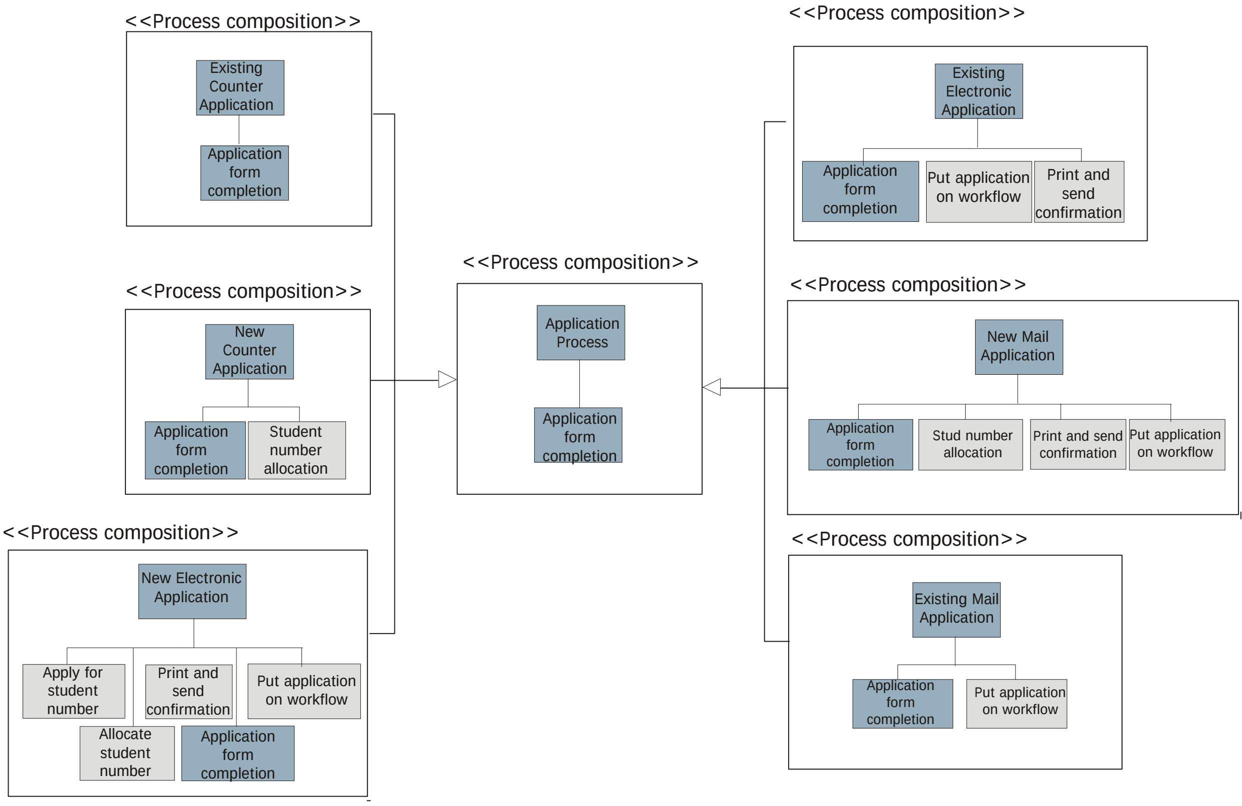


Figure 7.8 : Specializations for UNISA *Application Process*

Similarly it is possible to derive the specializations on the third level for the remaining second level subprocesses by looking at the subprocesses that are common to all the scenarios. For the moment, the given specialization in Figure 7.7 can only be generalized for UNISA instance and as discussed in section 5.4, more research is needed to determine the core for this instance on lower levels. For illustration of the specialization concept it is, however, sufficient to use UNISA instance in Figure 7.7.

7.2.4 Discussion: using the educational process model representation

The educational process model representation introduced polymorphism and suggested stricter rules with regard to the notation. In this section a discussion on the enforcement of stricter polymorphism rules is given in section 7.2.4.1, followed by a discussion of the suggested use of the notation in section 7.2.4.2 and concluding with some notes in section 7.2.4.3 on discussions with two object specialists on the adapted notation.

7.2.4.1 Discussion: polymorphism in the educational process model representation

In object technology, generalization is defined as the relationship between a more general element and a more specific element (OMG, 2001b). The term 'polymorphism' is used when something achieves the same result even when the mechanism for achieving it differs from object to object (Bennett, McRobb & Farmer, 2002).

In the Phios process model representation, generalization and specialization concepts are introduced where a specialization inherits the processes and subprocesses from the main process model without enforcing polymorphism. For example, for the specialization *Sell Product* there are two specializations, *Sell in retail store* and *Sell by mail order* (section 4.3.3). The specializations inherit the same number of subprocesses. But in the *Sell in retail store* specialization, the desired result for the second subprocess *Wait on customers* was changed. It is no longer the same as the base process model which was to *Inform potential customer* (Figure 7.9).

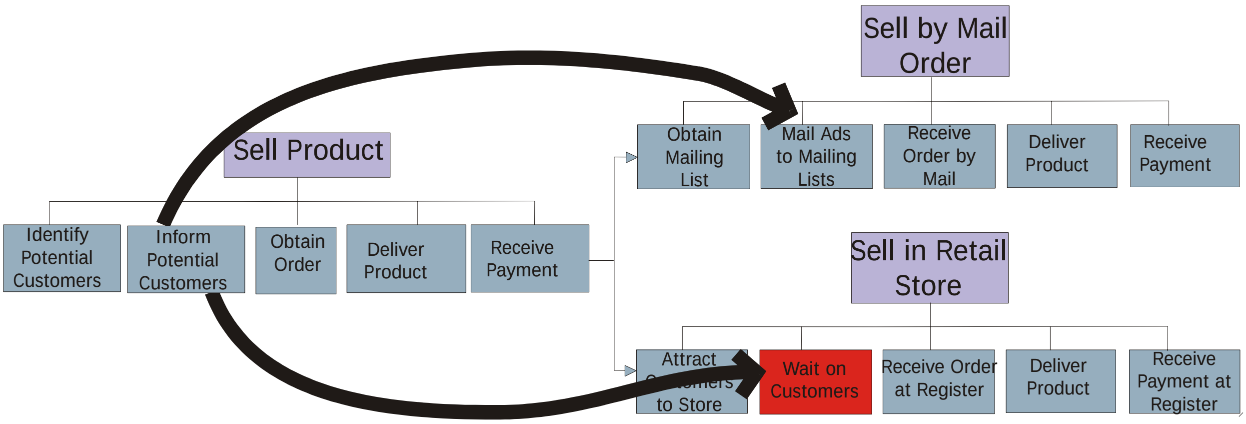


Figure 7.9: Specialization *Sell in Retail Store* changing the output of one of the subprocesses

In the educational process model representation this is not allowed. I suggested an adapted model where subprocesses inherited by the specialization must produce the output specified on the higher level (section 4.3.3.1).

For the example in Figure 7.8[22] the implication will be that the base model will have fewer subprocesses and all subprocesses in the specialization will abide by the rule that the format of

[22] For the moment the notation used for *Sell Product* is the same as the notation used in all the resources referring to this example. More discussions follow on the notation in section 7.2.4.2.

the output must be the same as the original process model representation. Enforcing the rule to the example in the MIT process repository, the *Sell Product* representation will change to the suggested model in Figure 7.10. Note that I excluded the process *Wait on Customers* for the *Sell in Retail Store* specialization because there is no output generated by the process and I believe it is not necessary in the specialization.

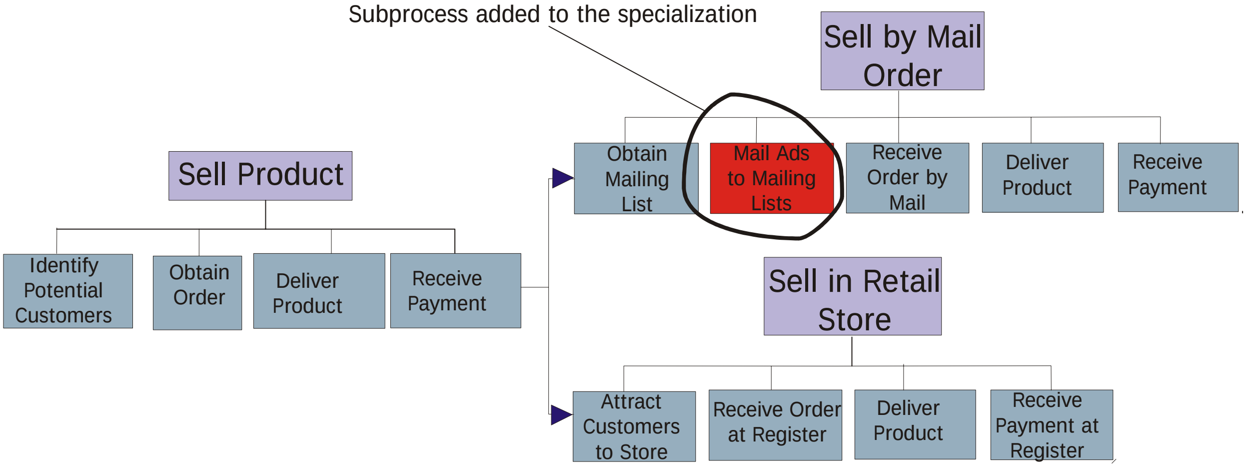


Figure 7.10: Implication of using the adapted model on *Sell Product*

The implication is that there will be fewer processes in the generalization *Sell Product* and that all subprocesses in the specialization either map to the generalization with the same output or that they are added subprocess in the specialization.

To relate this to the REGISTRATION instance at UNISA discussed in section 7.2.3, six specializations were given in Figure 7.7 for the *Application Process*. The educational process model representation encapsulated only one subprocess, *Application form completion.* However, in the specializations the educational process model representation provides for additional subprocesses. For example, for the *New Counter Application,* the *Application form completion* was inherited but *Student number allocation* was added to the specialization. The output for the *Application form completion* in the model and in the specialization is the same; it may not be changed by the specialization (Figure 7.11).

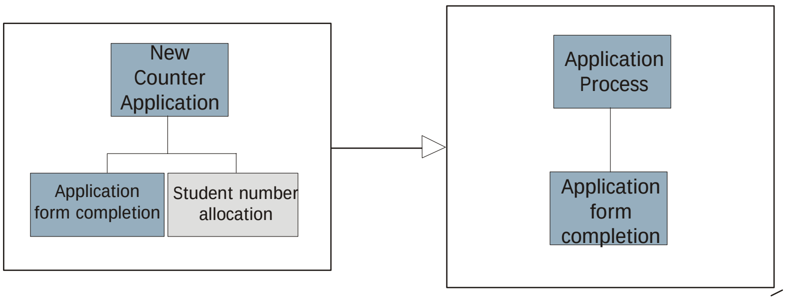


Figure 7.11: *New Counter application* as a specialization for *Application process*

Introducing stricter rules and enforcing polymorphism (to include the rule that the goal for an inherited subprocess in a specialization must stay the same), has the implication that the development team should enforce stricter rules in defining the generalizations, but the advantage is that they know that in any specialization the subprocesses used from the generalization will produce the same output.

7.2.4.2 Discussion: notation in the educational process model representation

In object notation, specializations are modelled with an arrow pointing from the child object to the parent object (Firesmith & Eykholt, 1995). The MIT process repository uses the specialization concept but does not support the notation for specialization in examples (discussed in section 4.3.3.2). I suggested the use of stereotypes to formalize the notation of specializations in the educational process model representation.

In the MIT process repository representation (Figure 4.17), the arrows point towards the specializations. Using the stereotyped notation suggested in section 4.3.3.2 will change the representation to what is deciphered in Figure 7.12. Note that the changes to the specializations suggested in section 7.2.4.1 are included in this representation.

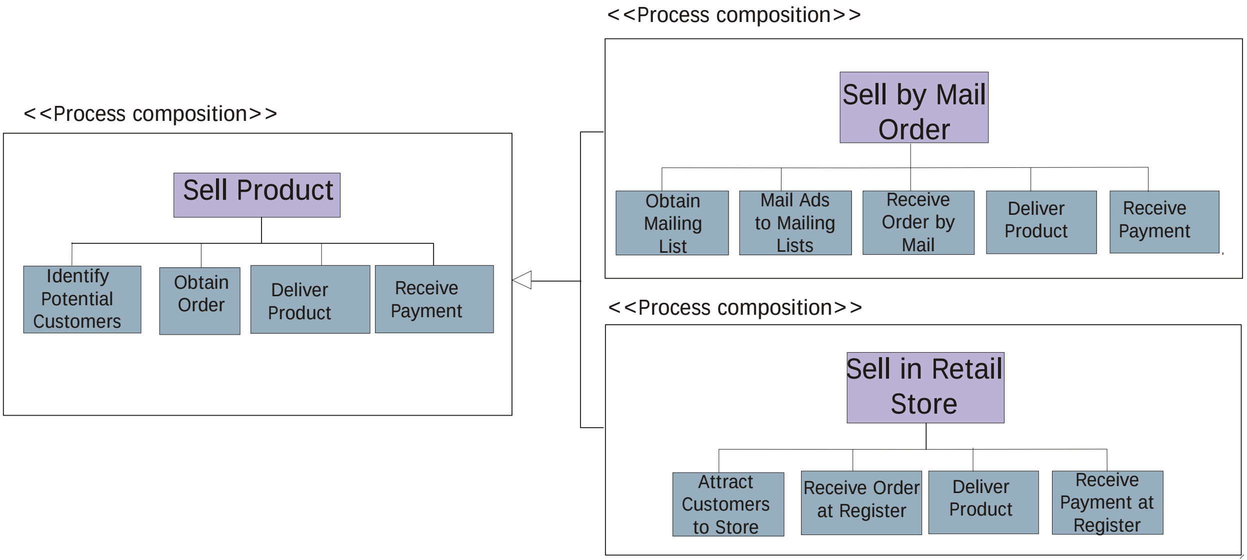


Figure 7.12: Adapted notation for specializations

7.2.4.3 Discussion: notes on discussions with object specialists

In sections 7.2.1 to 7.2.3 the educational process model representation suggested in section 4.3 was used to derive the specializations for UNISA instance of the REGISTRATION process. Section 7.2.4.1 and 7.2.4.2 discussed the implication of using the suggested adaptations on the MIT process repository presentation. As a triangulation exercise I wanted to know how the adapted model would be perceived by peers. I wanted comments from someone in practice and someone in academia and therefore identified two people who fitted this description. The first Interviewee (Interviewee 1) is a software engineer involved in the development of very large systems. The second (Interviewee 2) is a staff member at the School of Computing who was involved previously in curriculum development for the object-oriented modules at UNISA and also has some practical experience in the development of systems.

The adapted model with the implications (Figure 7.13) was used in information interviews to discuss the notation and the limitation on specializations.

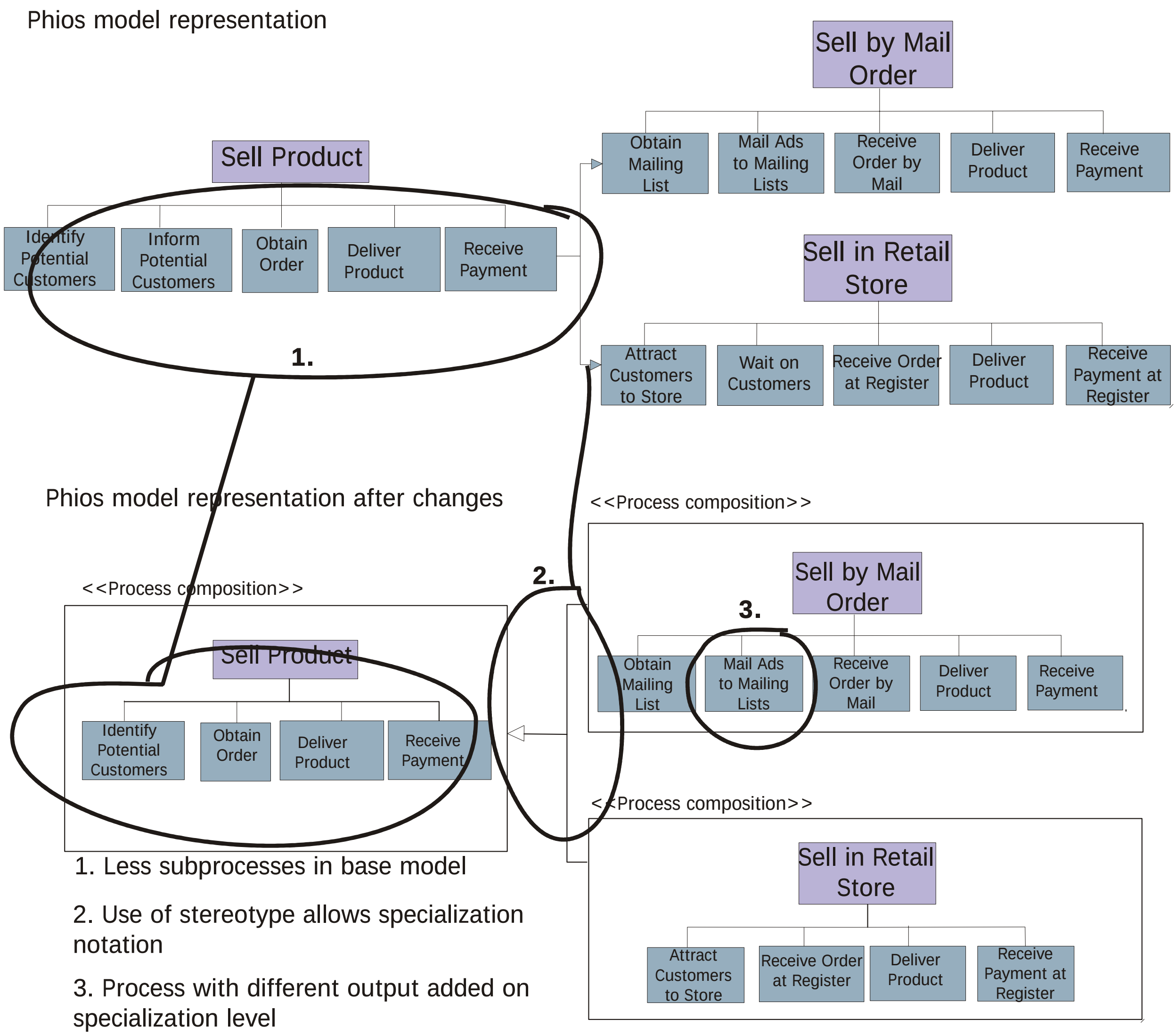


Figure 7.13: *Sell Product* in the MIT process repository and using the suggested adaptations

First the Phios process model representation was discussed with the interviewees. The results from both interviews were the same and therefore I give a short summary on the findings:

- The use of process models in the object paradigm is an unfamiliar concept.

- If one wants to use concepts from the object paradigm such as specialisation and generalization it is necessary to select a notation (preferably a standard notation such as UML) and define the way in which concepts will be used.
- The stereotyped notation defined and the enforcement of the polymorphism rule with regard to the output of subprocesses in a specialization are only a move in the direction of a more formal notation of the environment. More research is needed on sequence of execution and information lost in the diagrams such as the input and outputs associated with each process.
- Some comments were made on the nature of the implementation of polymorphism in applications. Interviewee 1 claims that it is possible to change the output of a specialization when used in combination with dynamic bounding. The problem is that this is not true to the object paradigm. He did agree that this is an advanced topic and should be handled as an exception rather than a rule. Therefore, this should not be enough reason to be lenient when using object notation such as specialization and generalization in this application domain and it therefore does not apply to the abstract level of process models as suggested by the adapted model.
- The concerns raised by the respondents were the same as my own which was the motivation for suggesting the adaptations to the Phios process model representation. This confirms the proposition that the suggested notation is a better representation in an object environment from both a theoretical and practical perspective.

Although no implementations were made within a repository such as the Phios repository, it is possible to comment on the way that the specializations can be stored in a similar repository. This issue is addressed in section 7.3.

7.3 PRESERVATION OF THE EDUCATIONAL PROCESS MODELS REPRESENTATION

In section 2.5 an overview was given of the storage of business process models. In this section the feasibility of the preservation of the educational process model representation in the Phios repository is investigated.

7.3.1 The Phios process repository

There are three routes that can be followed in discussing the feasibility of storing the educational processes in a repository environment similar to the Phios process repository. These include:

- The creation of a repository similar to the Phios process repository and testing the feasibility of storing the educational process model representation and instances thereof.
- The use of the existing Phios process repository to store the educational process model representation and instances and comment on the working thereof.
- An investigation into the similarities between an existing business process specialization in the Phios repository and an education specialization, in order to be able to comment on the preservation possibilities for the educational process model representation in the repository.

The creation of a repository similar to the Phios process repository would need a dedicated development team and this is beyond the scope of this study. For the second option, the use of the Phios repository, it would be necessary to purchase the software tools developed by the Phios corporation (Phios, 1999). An alternative is option three where access can be gained to the Phios process repository through a web interface to compare the specializations of the educational model to those in the business model. This would enable me to comment on the feasibility of the specializations discussed in section 7.2.3 with little or no financial implication.

I selected the *Sell Process* in the Phios process repository as an example to show how a process is stored in the Phios process repository. This process was selected because it is the process used as an example in all the discussions on the MIT process repository and the structure is known from the theory (Phios, 1999).

Each process in the Phios repository is viewed from four different perspectives using the Compass Explorer defined for the Phios repository (Figure 7.14).

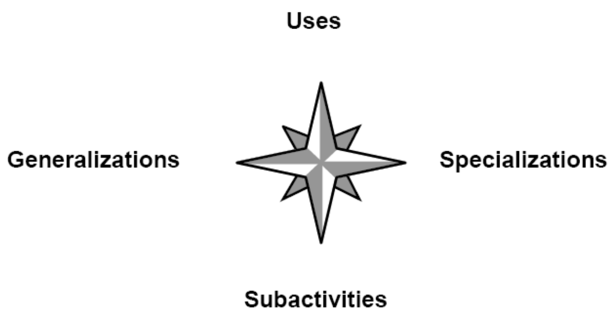


Figure 7.14: MIT process repository compass explorer (Phios, 1999)

A process is described in terms of its *specializations, generalizations, uses* and *parts (subactivities)*. The following questions apply to each:

- Specialization: What other way can this activity be done?
- Generalization: What other activity is like this one?
- Uses: In what larger activities is this one used?
- Parts: What are the different parts?

I obtained a login to the Phios repository used for preservation of business models at http://repository.phios.com/SCOR/Search.asp where the repository is open for public viewing (after registration). Under the open license, users may comment on process representations but cannot add or change existing structures. The *Sell* process was viewed from the four perspectives mentioned above and the results are given in Table 7.3.

Table 7.3: *Sell Process* in Phios process repository

Characteristic	Question	*Sell* product in Phios process repository
Specialization	In what other way can this activity be done?	There are a number of ways in which the *Sell Process* can be done, in the Phios repository some of these include: ⊟Sell to whom? ⊞Sell to businesses Sell to consumers ⊟Sell what? ⊞Sell service Sell product ⊟Sell how? ⊞Sell via other direct marketing Sell via face-to-face sales ⊞Sell via store
Generalization	What other activity is like this one?	The direct ancestor for *Sell* is *Exchange*, meaning that *Sell* is a specialization of *Exchange.* Other specializations for *Exchange* are *Barter* and *Buy.* The following is a description of each: - 'buy something' and 'sell something' imply an exchange of money for a product or service. - 'barter things' implies an exchange of products and/or services between two or more participants. The following is the ancestor tree described in the repository: ⊟Modify Modify - views ⊞Modify what? ⊟Modify how? ⊞Improve ⊞Prepare ⊞Process ⊟Move Rotate ⊟Exchange ⊞Exchange - views ⊟Exchange how? ⊞Barter ⊞Buy ⊞***Sell***
Characteristic	Question	*Sell* product in Phios process repository
Uses	In what larger activities is this one used?	There are a number of processes that use the *Sell Process*, including *Produce as a business, Produce as a landlord, Produce as a Service Provider, Provide transportation service,* etc, for example, in *Produce as a business* the following is the given description: This all-encompassing process provides a basic model of an entire business. It is intended to apply to businesses that produce products or services, to non-profit organizations as well as to for-profit corporations, and to large and small organizations.At the first level, this model includes five basic activities: • Design • Buy • Make • Sell • Manage a business
Parts	What are the different parts?	The parts defined for *Sell* include: - Identify potential customers - Identify potential customers' needs - Inform potential customers - Obtain order - Deliver product or service - Manage customer relationships.

To discuss the feasibility of defining the REGISTRATION process in a repository similar to the Phios process repository, I focused on the *Application* process in REGISTRATION and compiled Table 7.4 using the characteristics from Table 7.3.

Table 7.4: *Application Process* mapped to the Phios process model repository

Characteristic	Question	*Sell* product in Phios process repository

Specialization	In what other way can this activity be done?	There are six specializations for the *Application_Process*. There is more than one way to define the specialization in the process repository. The following is one definition that relates to the definition of the example in section 7.2.3:
		⊟ **Application**
		    ⊟ Apply how?
		        ⊟ Postal
		            New student
		            Existing student
		        ⊞ Counter
		        ⊞ Electronic

Generalization	What other activity is like this one?	Generalizations refer to the parent processes of which the subprocesses are a specialization. The *Application* may be a specialization of *Receive document*. *Student record request* is also a specialization of the *Receive document* process.
		⊞ Send document
		⊟ **Receive document**
		    ⊟ Application
		        ⊟ Apply how?
		            ⊞ Postal
		            ⊞ Counter

Uses	In what larger activities is this one used?	The *Application Process* may be used in: - *Undergraduate studies* - *Postgraduate studies* - *Certificate course registration.* The *Application Process* is on the same level as four other basic processes, including: - Application - Academic Verification - Payment Verification - Course Material Distribution
Parts	What are the different parts?	*Application Process* includes only: -Application form completion. The specializations include more parts, e.g. for the specialization where a new student applies through postal systems, the following are parts for *Application Process* and will be included in the repository: - *Student number application* - *Student number allocation* - *Print and send confirmation* - *Put application on workflow*

7.3.2 Discussion: feasibility of using the process repository

The specializations, as discussed previously, accommodate the three different scenarios for a new and existing student. There will be six specializations in total for the *Application Process*. The generalization is limited to the REGISTRATION process and as mentioned has the potential to grow when the model is extended. Similarly the uses may also be extended to other kinds of registrations, e.g. postgraduate registration or registration of certificate students. Lastly, the parts are limited to one subprocess, namely the *Application form completion*.

It is possible to define the *Application Process* with the structures available in the Phios process repository and therefore it is possible to say that there is enough evidence to maintain that it is feasible to store the defined structure in a repository similar to the Phios process repository.

A concern with the Phios repository is that the repository includes different sell processes which are duplications of one another. I believe that this duplication may lead to problems within the repository and therefore does not support generic structures. For the implementation of the educational process model repository, I suggest that stricter rules are enforced and that duplication of subprocesses is not allowed. The model does provide for different specializations and it is not necessary to duplicate processes in order to accommodate different scenarios.

7.4 SUMMARY

In this Chapter the preservation of the generic structure model representations was investigated. The formalization used in the MIT process repository representations in reference to the model did not use general object notation and to move towards a more formal notation some suggestions were made in the formal notation of the educational process model representation. In section 7.3 the feasibility of the preservation of the process model structures in a process repository was investigated, where it was shown that it is feasible to store the scenarios described in section 7.2, using the adapted model.

8. Evidence and Discussion: Contribution

8.1 INTRODUCTION

The contribution of this study lies in the *identification, usability* and *preservation* of educational process model structures. The different views are illustrated using a graphical picture with the three views represented in a pie graph, (with no significant value attached to the portions represented), as in Figure 8.1.

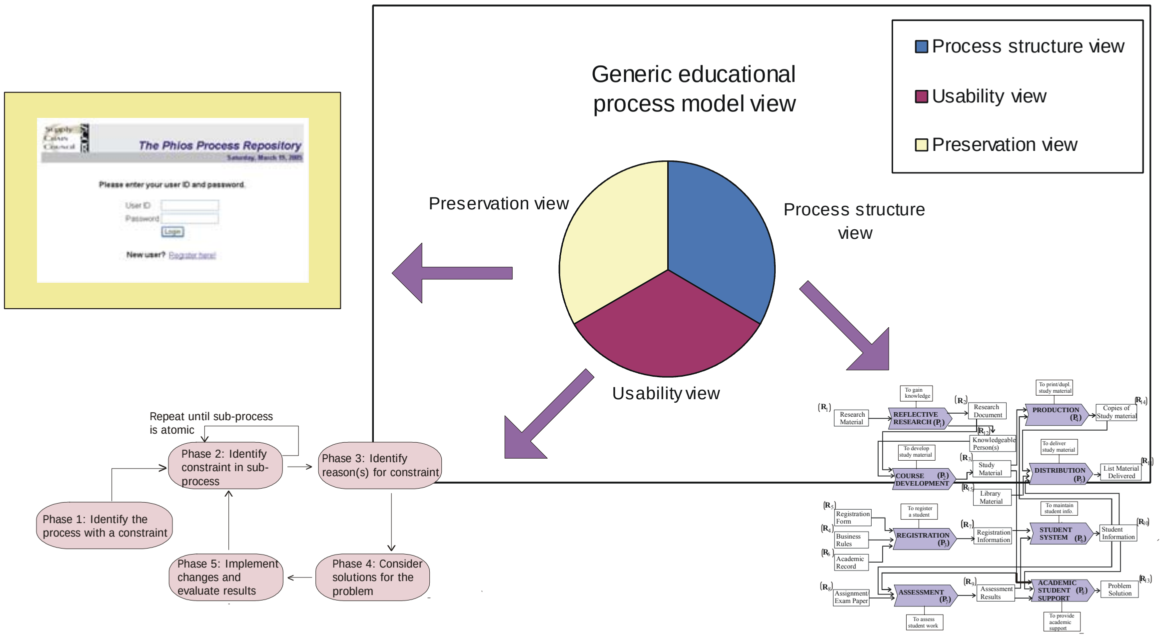


Figure 8.1: Process model view

This study addressed all three views in the three given research questions:

1. Process structure view: What is the process model structure of the higher education institution?
2. Usability view: To what extent is the generic process model structure useful in a re-engineering effort?
3. Preservation view: How can the educational process model be preserved and reused?

In this research I drew upon the concepts in design research where the researcher contributes to building an artefact via the methods, tools and techniques used during the design and building process (Association for Information Systems, 2005). I also used development research during the data-gathering, where the focus was on building theory through practice (Van den Akker, 2004). In most studies the researcher focuses only on contributions through product or through theory. This research was a combination of both, the product being built and the contribution made towards the theory. Therefore, in this Chapter the contribution concerning each of the research questions is discussed in section 8.2 to section 8.4, from both a product and a scientific perspective.

8.2 CONTRIBUTION: PROCESS STRUCTURE VIEW (RESEARCH QUESTION 1)

The focus of the first research question was on the identification of the process model structure of the higher education application domain (Figure 8.2).

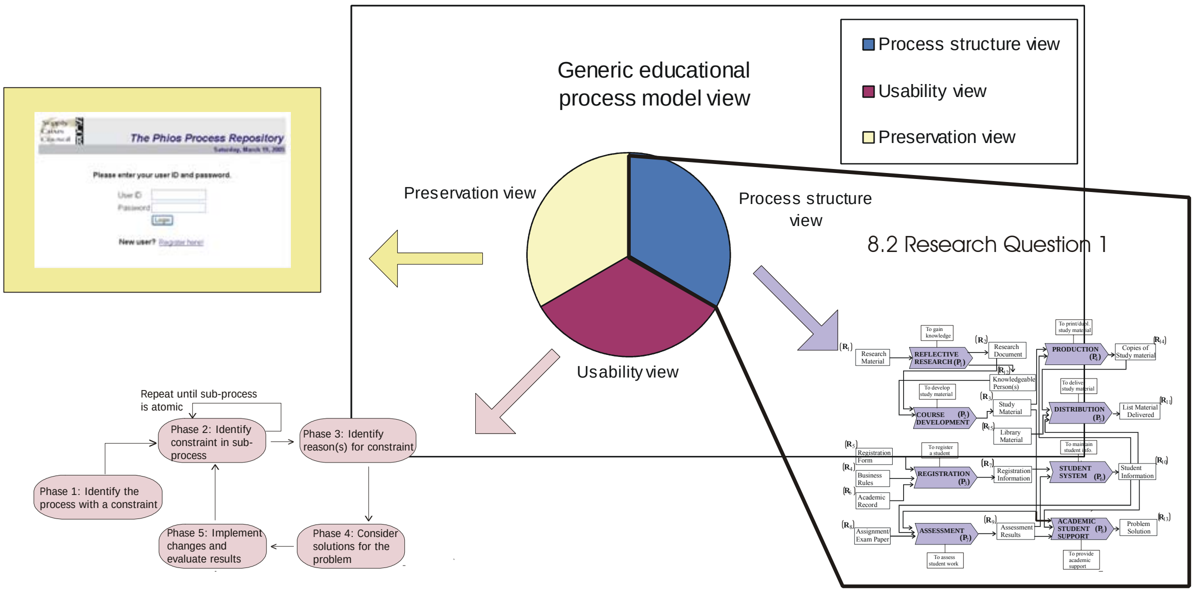


Figure 8.2: Focus of Research Question 1 – the process structure view

For identification of the process model structure, I could not find an adequate procedure that focused on the retrieval of process model structures in the higher education domain, and therefore developed a requirements elicitation procedure at UNISA, using theory from existing business requirements elicitation procedures. After developing the procedure and using it at different institutions, it was possible to reflect on what was learned from the data gathered in the research effort. (When referring to phases in section 8.2 one is talking about a phase within the requirements elicitation procedure, except when explicitly stated otherwise).

A conclusion on the contribution made in establishing the product is given in section 8.2.1. This included the development of a procedure to derive generic process model structures, using the requirements elicitation procedure in data-gathering, the characteristics of the procedure and the output, the high-level process model structures and the subprocesses (second level) for the REGISTRATION process. This is followed by a summary in section 8.2.2 on the scientific contribution that reflects on what knowledge was gained on the procedure for the identification of process model structures.

8.2.1 Product contribution: Research Question 1

There are four issues addressed in this conclusion that relate to the identification of the process model structure, namely:

- The development of the requirements elicitation procedure (section 8.2.1.1).
- Applying the requirements elicitation procedure (section 8.2.1.2).
- The characteristics of the requirements elicitation procedure (section 8.2.1.3).
- The educational process model structure (section 8.2.1.4).

8.2.1.1 Development of the requirements elicitation procedure

Development of the requirements elicitation procedure commenced in January 2002, when the existence of procedures was investigated to determine process models in the application domain. To my knowledge, no requirements elicitation procedures were available at that stage and a bottom-up approach was used to identify the process model structures in the institution. This was not very successful or efficient and I realized that I needed a step-wise procedure to identify the process models in the HEI, which led to the development of the requirements elicitation procedure described in section 4.3.1.1. The following factors were significant during the development of the requirements elicitation procedure:

- Many procedures are available for doing process modelling in the businesses domain. These procedures were not developed with the focus on the higher education domain and often included a number of business processes, which was not the focus of the requirements elicitation procedure that was needed (Davenport, 1993; Hammer & Champy, 1993).
- The focus of the procedures available was not to identify the higher-level process model but rather to investigate the current problem and find a solution to it (Figure 8.3). In contrast, the aim of the requirements elicitation procedure is first to provide you with an overview of the institution and only then to identify a problem (or more than one) and seek solutions to this specific problem (Figure 8.4).

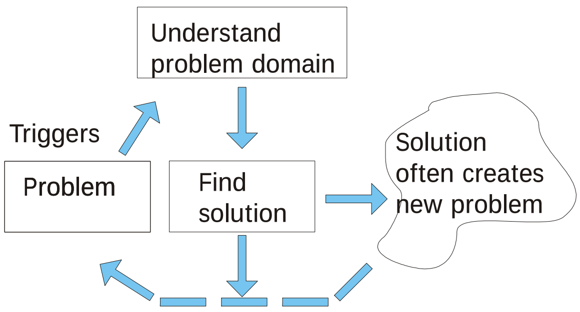


Figure 8.3: Problem triggers solution

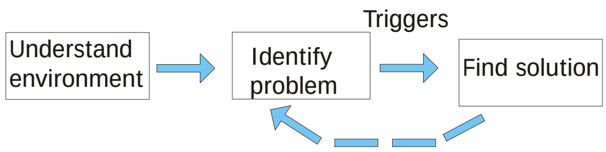


Figure 8.4: First understand the environment and then look for problems

- The development of a procedure of this magnitude took much longer than envisaged. During development and application much time was spent on investigating best practices from different development environments. This gave me the opportunity to look at requirements elicitation from different perspectives and to implement best practices. The following are a few of the best practices that were included in the requirements elicitation procedure:
  - *The inclusion of a goal statement*: The proposed first phase of the requirements elicitation procedure (defined in section 4.3.1), where the goal statement is the deliverable of the phase, gives the rationale for identification of the process models. This is valuable especially when the reason for identification of the process models is not only to understand the environment, but to find a solution to a specific problem.
  - *The use of a cyclic approach:* There are various approaches to development cycles (Avison & Fitzgerald, 2003). I suggested the requirements elicitation procedure as a spiral model in which knowledge on the application domain 'grows' every time the phase is revisited.
  - *Use of a standard notation:* I suggested the use of a standard notation in building the process models, including provision for the process itself, its goal, input and output (Eriksson & Penker, 2000).
  - *Atomic breakdown*: The procedure states explicitly that, during Phase 5 of the requirements elicitation procedure (defined in section 4.3.1), the deliverable is process models with atomic processes at the lowest level. If the developer uses the structural breakdown suggested and proceeds until the atomic level is needed, the likelihood of missing important actions is reduced.
  - *Stepwise approach*: The notion of using a stepwise approach with clear deliverables at the end of each phase, establishes order in the identification of processes and subprocesses. Development teams using a systematic approach tend to be more

successful, as has been demonstrated more than once in different studies (Whitten *et al.*, 2000; Schach, 2002; Pressman, 2005).

- *Use of mathematical notation*: For the construction of the process models I suggested a mathematical model that links the processes using input and output resources. Although this may seem unnecessary for a limited number of processes, for process models with a large number of processes it assists in the building of the tools to access the process model.

As mentioned previously, best practices often drive the development of methodologies (Avison & Fitzgerald, 2003). Different methods were used to find solutions to problems and later document the 'ideas' and 'best practices'. As soon as a solution was needed for a similar problem, the previous documentation was used as a guideline. These guidelines later evolved into methodologies that even became available commercially. There were no 'recipes' with guidelines on how to develop a procedure. I believe the reason is that procedures or methodologies are based on the documentation of best practices and there is not really a set of rules for creating them, except to say that they must produce the desired result rapidly, efficiently and cost-effectively (Frese & Sauter, 2003).

The requirements elicitation procedure produces an information-rich model. From one model it is possible to see what the different processes are and how they relate to one another. At a glance it is possible to see what is needed by a process (the input) and the deliverable produced (the output). The procedure is paper-based at this stage, which makes it difficult to show when processes are atomic. The way that Errikson and Penker (2000) do this is by using different notation for a process at different levels. Using computer-based tools could make it more visual and easier for the developer to 'see' that it is not on the lowest level yet. It could also give a level indicator so that the developer can easily establish the number of levels in a model.

8.2.1.2 Requirements elicitation procedure applied

For the question: *what did I learn from applying the requirements elicitation procedure?* it is possible to comment on issues within the institution concerned (section 8.2.1.2.1), human resources (section 8.2.1.2.2), personal views (section 8.2.1.2.3), and comparisons between the way that 'things' are done at the different institutions (section 8.2.1.2.4).

8.2.1.2.1 Comments on experiences at institutional level

One of the reasons why the requirements elicitation procedure was developed was the lack of generic process models at institutional level. The following experiences were significant at institutional level:

- At unit level within institutions there were often good descriptions of processes within the unit, but the institutional process model structure was badly described.
- Understanding the environment is one of the most important issues in re-engineering efforts and at institutional level, the process model depicts graphically the processes and the flow between these processes, making it a valuable tool. It was therefore believed that the high-level process model, as confirmed by the University of the Freestate, has value as a representation of the structure of the HEI.
- The use of the web as an information tool is expanding in institutions. With the growth in users of web-technology, HEIs realized the worth of web pages in attracting students to their own institution. An intranet also plays a bigger role in ‘sharing’ information within the institution, making it a valuable resource not only for researchers, but also as a communication tool amongst staff. The web pages were used extensively for the purpose of this study, after I discovered how much information is available regarding the web on the structures of the different units in the institutions. The advantage was that it simplified the process of identifying the units during Phase 2 of the requirements elicitation procedure (defined in section 4.3.1). The only disadvantage of using web pages as a resource is that some of the pages are static and therefore contain outdated information, or information that does not correlate with the current structure.
- A valuable set of documentation was created during the requirements elicitation procedure. The high-level process model was defined and valuable information on the institutional units, resources and flow between processes was documented. Often developers neglect the documentation of ideas and of ‘what is going on’ and this is identified as one of the reasons why systems fail (Whitten *et al.*, 2000; Pressman, 2005).

8.2.1.2.2 Comments on experiences at human resource level

Much has been written on data-gathering when working with people, e.g. how one should conduct interviews and what to ask and what not to ask (Seidman, 1991; Leedy, 1993). From my experience of conducting interviews during this research, I found the following to be significant:

- At UNISA people were very approachable. I believe this was because they did not feel I was from the ‘outside’ and in most cases I did not even have to explain why I was doing this research. This was in contrast to the other institutions where people were more careful in answering questions, as if there were wrong and right answers. I had to use negotiating skills which I did not realize were going to form part of the research. In some interviews it took me longer to explain the reason for doing the research and make the person comfortable than it took to do the interview itself.
- At UNISA people felt threatened the moment they were asked why something was done in a certain way. I had to be very careful not to sound as if I was criticizing the way in which it was done, especially in cases where alternative procedures, such as the use of automatic electronic processes could easily replace the worker. Some interviews did lead to the uncovering of frustration with current practices. A few such instances mentioned during interviews are that:
    - Streamlining processes is not a priority with management.
    - Resources are not always used in the best interests of the unit.
    - Staff changes imply crisis management.
    - Amalgamation is causing unnecessary re-engineering of activities that previously were considered to be effective.
- At institutional level, I believe that being an outsider at UP and TechPta meant that people were more aware when answering questions. However, because the respondents were more clinical in answering questions on the working of units, I believe this created a balance since staff at my own institution could sometimes have been rather emotional.

8.2.1.2.3 Comments on personal experiences

I learned a great deal about interviewing techniques. I had to be careful not to make my own deductions, especially at Pretoria University and TechPta where I ‘thought’ I knew the processes after doing the case study research at UNISA. The following are personal recommendations on conducting a research effort where data is gathered at different institutions:

- Identify a key person at the institution. This person should be in upper management and support your research. Weicher *et al.* (1995) support this notion and emphasize that when resistance is encountered, the leader must be willing to ‘drive’ change.

- Use this key person to refer you to other key persons in subunits. Use the name of the key person in conversations. People being interviewed are more positive if they realize management supports the research being conducted (Weicher *et al.*, 1995).
- Remember that people may easily feel threatened during interviews, especially if you ask them for reasons why something is done in a certain way. This substantiates findings on what BPR lacked in the early 1990s (Davenport, 1995a), causing later procedures to focus more on change management (Bruno *et al.*, 1998).
- Listen carefully to what is said. Sometimes respondents say what they think you want to hear. Ask the same question again but in a different manner. Seideman (1991) supports this notion in discussing interview techniques.
- Consider using staff on the development team who are familiar with the environment in which the requirements elicitation procedure will be used. Much time was spent at UNISA on gaining an *understanding of the environment* due to my own lack of knowledge on the processes within an HEI. The advantage is that this makes you more persistent in trying to find out how things work (Christel & Kang, 1992).
- At UP and TechPta, being an outsider gave me a more clinical perspective on the processes. A disadvantage was that I had to be careful not to use my pre-knowledge and not to 'decide' how things were working. Once again, documenting findings and going through a step-wise refinement assisted me in this procedure. This is confirmed by Bergey *et al.* (1999), who emphasized that one of the reasons why re-engineering efforts fail is the lack of an strategy.

8.2.1.2.4 Key issues in the institutions

The issues discussed in Chapter 5 are summarized in Table 8.1. The key persons for each institution are listed with a comparison of the development cycle. As discussed previously, the longest cycle was at UNISA where the procedure was developed. At UNISA, respondents had a positive attitude towards interviews. A single negative interview response was experienced at UP, with three negative responses at TechPta. The high-level process model was similar at the three institutions. The difference between the models is at responsibility level. A unit is responsible for the production and distribution of course material at UNISA, while at UP and at TechPta the responsibility for the same activities is at lecturer level.

Table 8.1: Summary – key issues at different institutions during data-gathering

Issue	University of South Africa	University of Pretoria	TechPta
Key person - approval	Project approved as a PhD study at the University, management approval. Project initiated from Prof. Elsabe Cloete's involvement in technological innovation research in education at UNISA.	Prof. N Grove	Prof. P van Eldik
Time	Procedure completed in longest time period (±246 hours). Included procedure development.	Procedure completed in significantly shorter time (±82.9 hours). Phase 5 included only the breakdown of REGISTRATION with the electronic scenario.	Procedure completed in shortest period of time (±54.8 hours). Phase 5 included the breakdown for REGISTRATION with the counter scenario.
Cost	No significant cost – only time used to do data-gathering.	No significant cost – only time used to do data-gathering.	No significant cost – only time used to do data-gathering.
Interviews	All respondents were positive about the queries directed to them.	Only one person interviewed was uncomfortable with the interview.	Three people interviewed felt uncomfortable. I decided not to pursue the interviews and selected alternative resources.
Response from interview	People felt threatened in positions where they knew a process in the unit is not efficient.	People were more careful about answering questions. In cases where respondents felt uncomfortable, I had to assure them that the investigation was not a threat.	People were more careful about answering questions. In cases where respondents felt uncomfortable, I had to assure them that the investigation was not a threat.
High-level process model	Eight primary processes. STUDENT SYSTEM, which is actually a support process, is included as a primary process – forms the glue between all the processes.	Eight primary processes. Lecturers are responsible for PRODUCTION and DISTRIBUTION of most of the course material related to a specific course. The responsibility shift does not influence the resulting structure.	Eight primary processes. Lecturers are responsible for PRODUCTION and DISTRIBUTION of most of the course material related to a specific course. The responsibility shift does not influence the resulting structure.
Subprocess: New Electronic registration	No application payment required. Registration forms available on-line.	An application procedure is used and students pay an application fee before registration.	Students pay an application fee before registration but no electronic registration process available. Students can retrieve the registration form from the web, complete it and send it or take it to the Technikon.
	Course enrolment is verified against an expert system.	Application is verified at faculty level.	Course modules are verified against an expert system
	Only exceptions are handled at faculty level.	Student is selected according to UP rules.	Student is selected according to results, or a test or an interview.

8.2.1.3 Characteristics of the requirements elicitation procedure

The purpose of the requirements elicitation procedure was to answer the question: *What is the process model structure of the higher education institution?* The deliverable was a high-level process model consisting of eight high-level processes. The subprocesses for the randomly selected REGISTRATION process were derived and discussed. One can argue that the goal was reached in determining the structure of the higher education process model. But the question remains, how efficient were the derived models? In this section, an overview is given of the efficiency of the elicitation procedure developed to determine the process model (and subprocesses). The requirements elicitation procedure was measured against a set of requirements elicitation characteristics.

A set of fifty-eight indicators was identified as characteristic of requirements elicitation (Van der Merwe *et al.*, 2004a). The indicators were retrieved from authors who commented on the characteristics of requirements elicitation and modelling procedures. Some were also extracted from other domains, such as elicitation or modelling in software engineering (Sommerville, 2000) and business process re-engineering (Christel & Kang, 1992; Macaulay, 1996). The theory gave some indication of good practices during requirements elicitation, but lacked a comprehensive list like the one identified during this research (section 4.3.1.2).

The potential applications of the result can be discussed from both a research and a practice perspective. Researchers may use the instrument as a guideline during the development of similar requirements elicitation procedures. Practitioners using procedures that adhere to a set of defined characteristics can clearly do so in the knowledge that the procedure is well-defined, and that it adheres to standards that are used in different application domains.

In further work, I plan to use the instrument to see how other requirements elicitation procedures within the educational domain adhere to the suggested indicators. According to various sources (Finkelstein, Ryan & Spanoudakis, 1996; Maiden & Ncube, 1998), we shall in future see the development of reference models for specifying requirements. If this is so, the effort involved in developing requirements models such as ours will be reduced. This may assist in the move from projects being creative designs to being normal designs, and may facilitate the selection of commercial off-the-shelf (COTS) software. Further research into this domain is necessary in education studies.

In comparing the requirements elicitation procedure developed with the set of characteristics, it was found that the procedure adheres strongly to most of the characteristics. In summary, for the set of characteristics identified that refer to activities across phases, the procedure adheres strongly to *standards, techniques* and *documentation*. For elicitation the procedure adhered strongly to *specification*, *boundaries, problem analysis, data-gathering* and c*ustomer involvement*. In the remaining set, modelling, the procedure also adhered strongly to all but two characteristics, including *user involvement* and *modelling.* The characteristics that the procedure adheres to or does not adhere to, are discussed in more detail in section 5.3.1

In conclusion it is possible to claim that based on the set of characteristics that the procedure does adhere to, it is an efficient requirements elicitation procedure and does adhere to the modelling and elicitation characteristics identified from the relevant literature.

8.2.1.4 The educational process model structure

The rationale behind the first research question: *What is the process model structure of the higher education institution?* was to determine the process model structure. To determine the structure that is generic for different institutions, a requirements elicitation procedure was developed to assist in the data-gathering at three different institutions, and used to determine the process model structure. After data-gathering activities at the three institutions, a high-level process model was presented with the REGISTRATION process decomposed further. The components of the high-level process model are discussed in section 8.2.1.4.1, followed by some comments on generic subprocesses on lower levels (section 8.2.1.4.2). Another way of presenting generic processes is by using a value chain (Porter, 1985). In section 8.2.1.4.3 an overview is given of how the processes map to an educational value chain, using Porter's (1985) value chain concepts.

8.2.1.4.1 High-level process model components

After completion of the data-gathering at the different institutions, the high-level process model representation consisted of 8 high-level primary processes. The eight processes and the flow between the processes are illustrated in Figure 8.5.

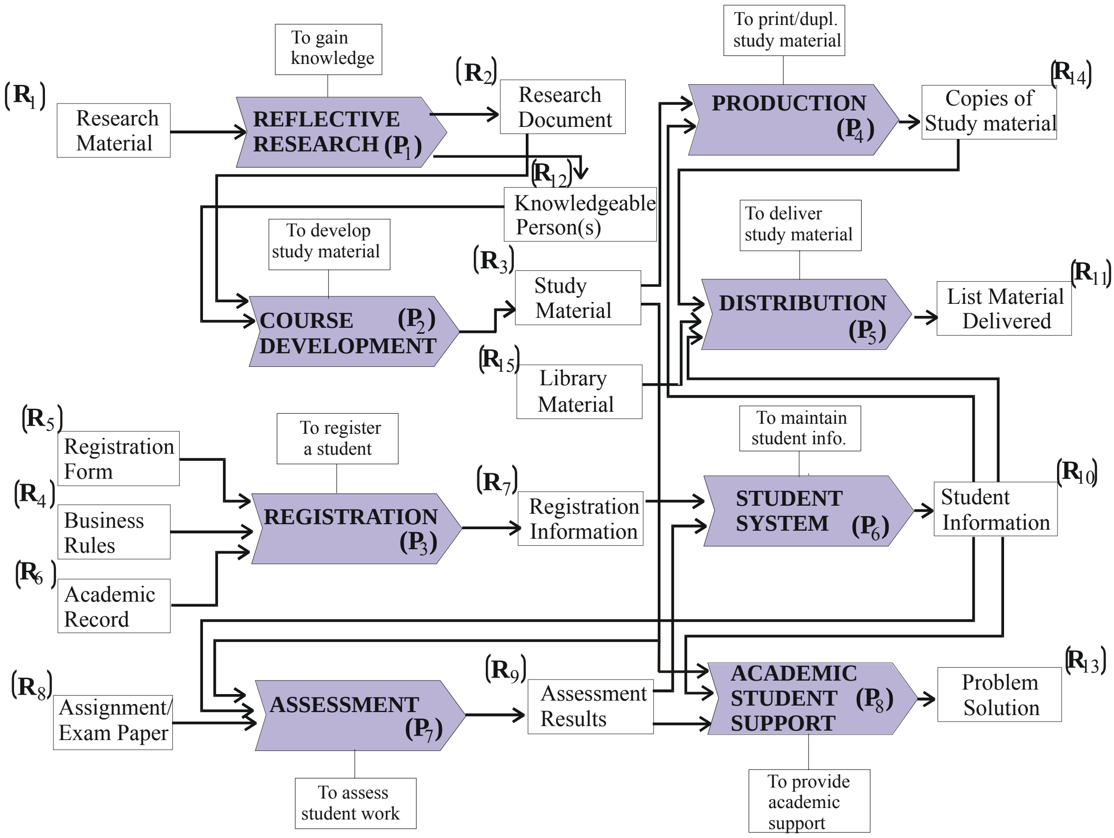


Figure 8.5: High-level process model

In this representation of the HEI structure, the flow between processes is supported by thirteen resources. The input for the first process, REFLECTIVE RESEARCH, is the research material used to conduct the research. This includes prescribed books, journals, publications, web-resources, etc. The output for this procedure is a staff member who can be seen as knowledgeable on the research topic and / or a written report on the findings of the research activity. Both these can be input resources for COURSE DEVELOPMENT where the output is a piece(s) of study material, including tutorial letters, study guides, examination papers, video, audio etc. These source documents needed for duplication are sent to the PRODUCTION process where the printing is started based on the number of students in the course (retrieved from STUDENT SYSTEM). The DISTRIBUTION process sends course material to students based on student information retrieved from STUDENT SYSTEM. Material could also be distributed from other resources, e.g. from the library (books). REGISTRATION is done using an application form received from the student, his academic record and the rules of the institution for registration. The data is captured and stored on the STUDENT SYSTEM. ASSESSMENT is done based on the assignment / examination paper received by the students (once again the student information is retrieved from STUDENT SYSTEM). For ACADEMIC STUDENT SUPPORT the lecturer needs the student information (if it is relevant to marks obtained), the course material (if it is course related) or / and the assessment results to assist successfully in answering queries.

Both UP and TechPta felt that the DISTRIBUTION and PRODUCTION processes are not primary processes at their institutions. This may be the argument if you assume that the lecturer is responsible for production and distribution of course material. But this is not always the case. For web material there may be a developer responsible for the publishing of the material on the web. This is once more a responsibility shift. Also, the distribution of audio material may not necessarily be the responsibility of the lecturer. After discussions we agreed that the processes should be represented on the high-level process model. This was confirmed at the University of the Freestate.

For future research, the inclusion of human resources on the process model level could be investigated. A model including human resource responsibility may prove to be a useful reference tool in re-engineering efforts (discussed in future research in section 9.4).

8.2.1.4.2 Generic processes on lower levels

The REGISTRATION process was used in Phase 5 of the requirements elicitation procedure as an example of refinement of a high-level process. From this refinement it was possible to deduce that there are generic processes on lower levels of the high-level process model. For example, the counter registration scenario, for a new and existing student, in the REGISTRATION process, has four generic subprocesses that were identified (section 5.4). These generic subprocesses include *Application Process, Payment Verification, Academic Verification* and *Course Material Distribution.* Note that the sequence of execution on second level and the subprocesses on third level may differ in the subprocess model structure. The indication that there are generic procedures on lower levels contributes to the knowledge of the nature of process model structures on different levels.

8.2.1.4.3 The educational value chain

The value chain is a systematic approach to examining the development of competitive advantage. It was introduced by M. E. Porter in his book, *Competitive Advantage* (Porter, 1985). Value chains are an accepted means of identifying the sequence of key generic activities that businesses perform in order to generate value for customers. The chain consists of a series of activities that create and build value. Over the past two decades, value chains have been used in different fields for the purpose mentioned, including telecommunication (Li & Whalley, 2003), wireless communication (Sabat, 2003) and in health services (Unknown, 2003). Although the identification of the educational value chain is not the focus of this study, I included it to show the relationship between work done in the business domain and the educational domain.

The activities within the business domain are divided into *primary activities* and *support activities,* as illustrated in Figure 8.6 (Porter, 1985).

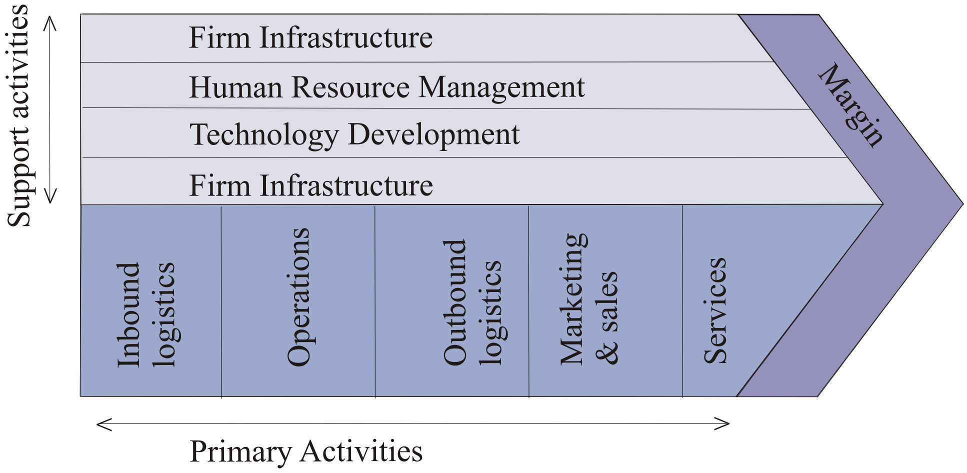


Figure 8.6: The generic value chain (Porter, 1985)

Primary activities are the activities involved in the creation of the product, the sale of the product, the transport to the buyer and the service provided to the client afterwards. The support activities are the activities that support the primary activities and one another.

It is possible to map the generic process model structure to an educational value chain. According to Porter's model (1985), the processes included in a value chain should be the high-level essential processes necessary to achieve a predetermined outcome. In the educational environment there are two primary outcomes, the *course material development* and the *course presentation*. The one is embedded within the other and can be depicted graphically as illustrated in Figure 8.7.

The support processes include those identified by Porter (1985), with a new focus on the student system, which are the driving force behind technology innovations such as e-learning. The student system and general operational systems within the university are the technology that adds value to the educational value chain, even if not seen as a primary activity within the chain. One may even argue that it is not really only a support activity, but a binding of the whole system from an e-learning perspective.

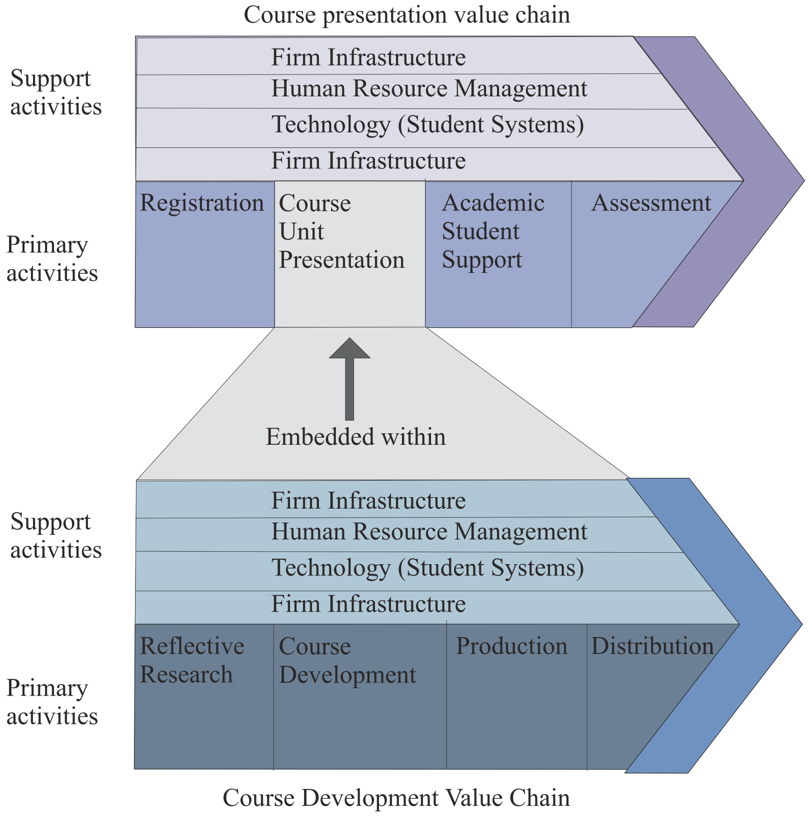


Figure 8.7: Educational value chain

Concluding thoughts on the educational value chain: in a world where e-learning is increasingly penetrating the higher education environment, it is becoming necessary for university administrators to consider the processes that can be streamlined and the points at which value can be added. Using modelling tools, such as value chains, to identify key processes that add value in an application domain, has already proved to be a successful strategy in business re-engineering efforts. A value-chain approach to higher education will go some way towards determining those areas of the system where bottlenecks are likely to occur, as well as providing a route to follow when determining the value that can be added by technology. This alternative way of presenting the educational process model structure was also presented at the ISICT conference in 2004 (Van der Merwe & Cronje, 2004).

8.2.2 Scientific contribution: Research Question 1

The focus of this research was on the procedure used in the identification of educational process models that are reusable and preservable. The first research question focuses on the identification of the educational process model structure:

What is the process model structure of the higher education institution?

The scientific contribution focuses on what was added to the intellectual knowledge. For this research question the intellectual focus is the *procedure* used for the identification of generic educational process model structures. The intended audience for this procedure is developers involved in the identification of generic process model structures. The main reasons for identification of generic process model structures are to use the models in future process re-engineering, to identify new processes and to share the knowledge about the educational institution.

From a methodological perspective, method engineering refers to the process of designing, constructing and merging methods and techniques to support information systems development (Avison & Fitzgerald, 2003). The development of this procedure can be mapped to a Type I method in method engineering. The goal of a Type I method is to bring order to an environment using data modelling or process modelling (Avison & Fitzgerald, 2003).

The scientific contribution of this research question therefore lies in the method used to derive the educational process model structures. The procedure that focuses on the identification of process model structures can be generalized to comprise five phases:

1. The definition of the scope.
2. The identification of a procedure to derive the process model structure.
3. The data-gathering at different institutions.
4. The comparison of the results.
5. A verification technique to ensure that the procedure that you use is a sound procedure.

The phases are sequential and graphically depicted in Figure 8.8.

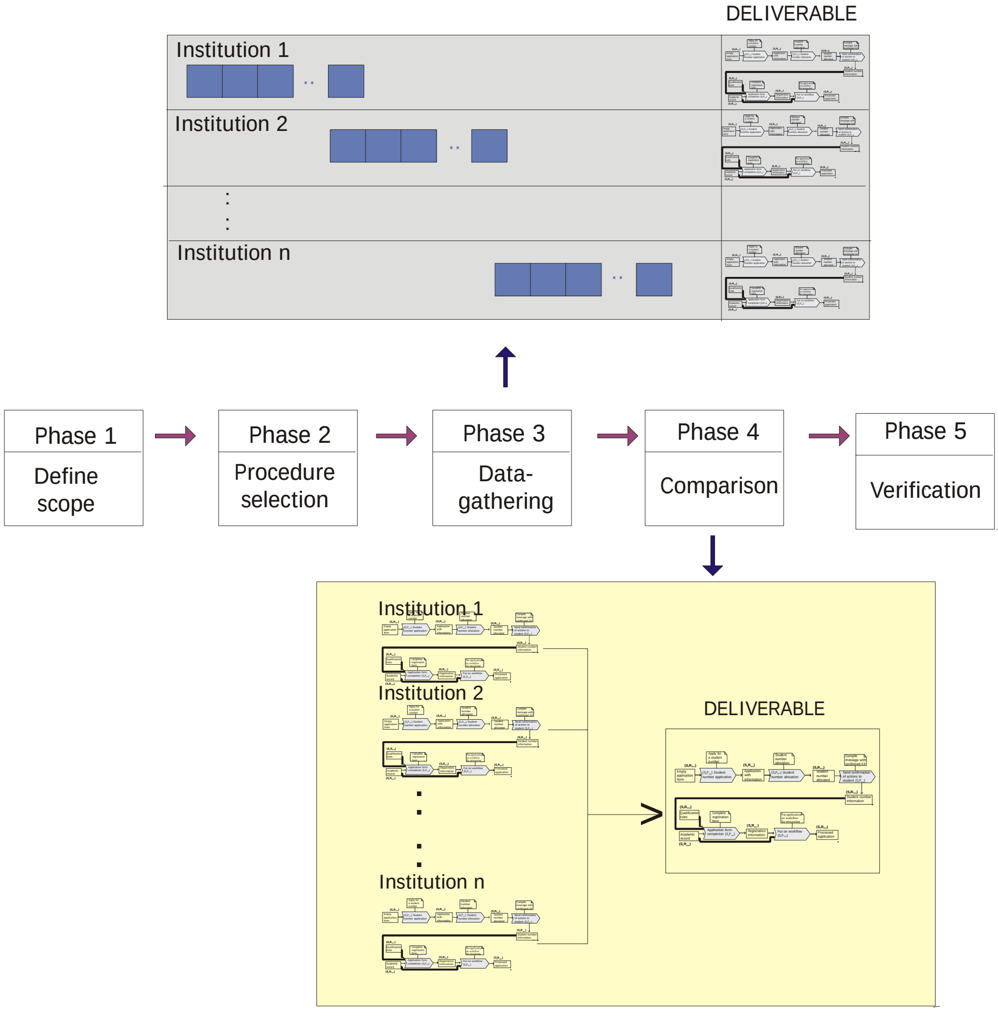


Figure 8.8: Procedure for identification of generic educational process model structures

For each of the phases there are different issues that the development team should consider. The contribution of this study lies not only in the identification of the phases in the procedure, but also in the capturing of 'best practices' during the identification process (which is the *intent* of Type I movements in Method Engineering (Avison & Fitzgerald, 2003)). In-depth discussions were given in sections 5.3 and 5.4 on the requirements elicitation procedure used and the product derived. In section 8.2.1 an overview was given of experiences during the development of the procedure, the application of the procedure, the characteristics of the procedure and the product, and the generic educational process model structure. These experiences are generalized into 'best practices' for identification of generic educational process model structures, and combined with the steps used to identify the process model structure into a procedure, which is graphically presented in Figure 8.8. Table 8.2 gives the considerations, role players, deliverables and recommendations for each phase.

Table 8.2: A framework for the identification of generic educational process model structures

Phase	Considerations and recommendations	Role players	Deliverable
Phase 1: Define scope	• Role players determine the focus of the identification process. • Identify key persons responsible for the development team. • Do a feasibility study with regard to time, human resources and financial implications. • Select the institutions involved in the data-gathering activity. o Consider the different teaching models in selecting institutions, e.g. distance-based and residential. o A guideline is to use at least three institutions in identification activities. o Consider including different types of institutions, e.g. universities and colleges. • Get management approval from the selected institutions.	o Development team (analyst) o Management (feasibility) o Management representative in institution	Scope document
Phase 2: Procedure selection	In considering a procedure, use the following guidelines. Select a procedure: • that supports a model with a diagrammatic presentation to represent the processes and the flow between them. • where the focus of the techniques and tools is on process modelling. • where the method focuses on identification of existing processes with the goal to create reference models for organizational activities such as process re-engineering. • that supports the clear definition of deliverables after each phase. • that is not too costly (the IDEF3 (2004) process modelling methodology is well-known for the identification of process models with supporting tools such as ProSim and ProCap). • that use existing procedures (Van der Merwe *et al.*, 2004b) or derive your own procedure. If you want to derive your own procedure, consider inclusion of the following best practices: o Steps that are cyclic to revisit different units in identification of processes within the unit. o Mathematical notation for the definition and categorization of the sets of processes. o Steps that eliminate any process duplication. o Definition of deliverables at the end of each phase. o A procedure that supports a standard process model notation. o Identification of quality control mechanisms, e.g. a characteristic list to see how far the procedure adheres to the good practices (Van der Merwe *et al.*, 2004a). o The identification of techniques and guidelines to construct the process model.	o Development team (analyst) o Management (financial implications)	Selected procedure and tools to assist in the data-gathering activity
Phase 3: Data-gathering	Data-gathering for the different institutions is done using an incremental model (Avison & Fitzgerald, 2003) where each institution is visited and the procedure selected in Phase 2 is used to derive the process models for the specific institution. During data-gathering, the following should be considered: • the data collection techniques that are applicable for the specific institution. Many of the interviews could be conducted telephonically to save costs but for production environments where a product is the output such as in the printing process, this may not be a consideration.	o Analyst o Key persons involved in educational units	Process model(s) focused on during this data-gathering activity

Table 8.2 (continued) : A framework for identification of generic educational process model structures			
Phase	Considerations and recommendations	Role players	Deliverable
Phase 3: Data-gathering (continued)	• the identification of contact persons in the different units who have a positive attitude towards the data-gathering process. Many respondents may feel threatened, especially during data-gathering conducted at institutions where the analyst is not a member. • to include phase-checking to validate the deliverable for each phase. • the use of CASE-tools to support the data-gathering technique if available for the selected procedure • during data-gathering it is essential to document all interviews and documents used during the activity not only for future reference but also to use in comparative studies if needed for clarification on discrepancies. • the analyst should be careful of using pre-knowledge after the first increment of data-gathering at the second and third institution. If financially feasible, the use of an alternative analyst is suggested.		
Phase 4: Comparison study	For Phase 4 the analyst should compare the different models retrieved in Phase 3 to derive the core or generic process model structure for the focus area. The following should be considered: • at most a process model consists of 10 to 15 processes to complete one single function. If more than this, the analyst should consider the detail on the single process model and investigate the possibility of a 'hidden' level above the current level. For many processes on one level the analyst should consider the use of a reasoning model to compare the models. • A comparison table should be sufficient to identify the core or generic processes on a level for a specific scope. • A high level of skills may be required. Some interpretation may be needed where similar processes are called different names in different environments. • On higher levels the 'set' of processes that are generic on one level should be larger while on the lower levels, where processes become atomic, one ends up with single generic subprocesses. This is natural because the identification of subprocesses for lower levels consists of decomposition of processes on higher levels.	Development team (responsible for comparative study)	The generic process model
Phase 5: Verification	The last Phase consists of verification at an institution not included in the data-gathering activities. The following should be considered: • This acts as a triangulation exercise where results obtained from previous institutions are confirmed. The analyst is not involved in data-gathering within the organization but rather discusses the results with key persons at the institution. • The profile of the selected institution should match the profile selected for generic process model structure identification.	• Development team (responsible for comparative study) • Key persons in selected institution	The generic process model confirmed

8.3 CONTRIBUTION: USABILITY VIEW (RESEARCH QUESTION 2)

The goal of Research Question 2 was to investigate the usefulness of the process models in re-engineering efforts in a higher education application domain using a process management flow procedure (Figure 8.9).

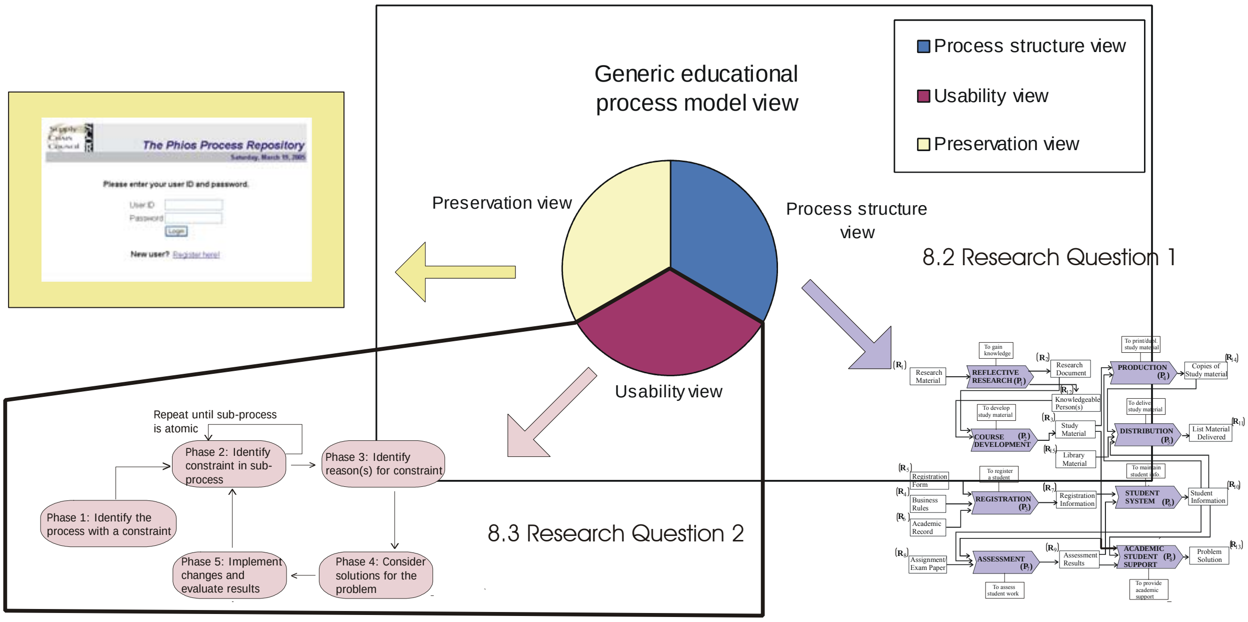


Figure 8.9: Focus of Research Question 2: the usability view

This investigation included:

- The investigation of existing re-engineering procedures and the role of process models in institutions (section 2.4).
- The suggestion of a re-engineering procedure called 'the process management flow procedure', which includes steps that focus on the process model (procedure suggested in Chapter 4).
- The application of the procedure at UNISA to determine constraints and to suggest a technical solution for a selected constraint (Chapter 6).

As in section 8.2, I first give a discussion on the contribution on product level in section 8.3.1 and then discuss the scientific contribution in section 8.3.2.

8.3.1 Product contribution: Research Question 2

Research Question 2 focused on the usability view of the generic process models. To investigate the usefulness a process management flow procedure was developed with re-engineering as the scope. This was used at UNISA where the constraints were identified including steps from Davenport's (1993) and Hammer's (1993) process re-engineering initiatives and Goldratt's (1992) theory of constraints. A solution was suggested to eliminate bottlenecks in the REGISTRATION process. In section 8.3.1.1 a summary is given on the findings after the application of the procedure at UNISA, followed by a short discussion in section 8.3.1.2 on the usefulness of the process models in the re-engineering effort.

8.3.1.1 Findings after the application of the procedure at UNISA

Although the focal contribution of this study was not the data gathered during the application of the procedure, there are some comments on experiences that are worth mentioning. These include comments on *conflict negotiation, pre-knowledge, triangulation, legacy systems, data-gathering at UNISA, the RMS system* and *constraints created by the solution.*

8.3.1.1.1 Conflict negotiation

Conflict negotiation is one of the areas that requires much investigation and dedication in implementing any electronic solution at UNISA. The solution suggested includes the automation of manual processes. In any discussions referring to automation, staff felt threatened by any hint that the way in which work was currently being done was not an efficient way of doing it. It was not the object of this study to consider how staff felt about change, but from the reaction experienced during investigation of the REGISTRATION process, it is possible to make the claim that some staff involved in registration at UNISA feel threatened by change and have a negative attitude towards technological implementations. Reasons for this were not investigated, but from the reactions noted, I believe that this phenomenon is due to the current unstable work market and staff being afraid that they may be replaced by alternative systems. I agree with the remark made by Grotevant (1998) on re-engineering and staff: 'Pursuing technological potential without exploiting human potential will not yield the outcomes sought from Enterprise Engineering efforts'.

8.3.1.1.2 Pre-knowledge

In this specific study, the pre-knowledge gained about the HEI application domain was very valuable. In re-engineering efforts, understanding the processes within the environment is one of the most important prerequisites and is mentioned as an activity in re-engineering methodologies (Malhotra, 1996; Muthu & Whitman, 1999). In Phases 1 and 2 of the process management flow procedure, the process models identified in the application of the requirements elicitation procedure at UNISA were used. In Phase 4 of the process management flow procedure, the knowledge on the processes and flow between processes assisted in the formation of different solutions. The knowledge acquired on the UP application process made it possible to include best practices from the institution in the proposed solution. It is believed that no re-engineering activity should be initiated without involving the people who understand the business of re-engineering efforts.

8.3.1.1.3 Triangulation

Triangulation was used in this research effort, where I looked at the registration constraints from two different perspectives. The two views revealed similar results. I first focused on the subprocesses from a throughput perspective, and then a checklist was used to indicate which subprocesses promote opportunities for conversion to electronic processes.

To conclude the *triangulation,* the data from Table 6.7 were used to investigate which of the questions in the checklist should be addressed in the suggested solution. This is accomplished by a comparison in Table 8.3 of the questions and the solution.

Table 8.3 : Comparison between checklist questions and solution

Question	Previous Answer	Technical solution	Comment
Do you assign a student number automatically after the student number application has been received?	No	Yes	In activity two of the proposed solution a student receives a new student number if it does not exist.
Is the data from the electronic registration form automatically placed in a temporary database, before processing?	No	Yes	The RMS captures the information in a temporary database.
Is matriculation verification done automatically against an existing system?	No	Yes	The existing SAUVCA matriculation result database is used.
Is course enrolment automatically verified against an expert system from the electronic application?	No	Yes	The RMS tests the application data against the business rules.
Is information received from an electronic application automatically captured on the student system?	No	Yes	The RMS captures the information in a temporary database.
Will a student's financial record be updated automatically after payment has been received?	No	Yes	After an electronic payment the data is captured automatically.
Is course material available to students automatically and electronically?	No	Yes	It is feasible to distribute the material electronically.

The comparison table indicates that the questions previously not covered (discussed in section 6.2.4.1) by the mechanisms included in the REGISTRATION process, are now covered in the suggested solution. Each question is listed with a comment on how the question is addressed in the prototype.

8.3.1.1.4 Legacy systems

During conversations at UNISA, it was realized that some of the processes are done using familiar old procedures without questioning their efficacy or appropriateness. There is a great deal of resistance to change not only on a process level, but also to change in existing systems. The notion of 'if it is working, don't change it' is sometimes used to justify a reluctance to accept change. A danger where technology is suggested as an innovation is that UNISA tends to follow the route that Grotevant (1998) warns us against: that is to use technology in existing work processes, 'rather than adapting the work to take advantage of technological opportunities' (Grotevant, 1998).

8.3.1.1.5 Data-gathering at UNISA

During Phase 1 of the process management flow procedure, four constraints were identified: REGISTRATION, COURSE DEVELOPMENT, PRODUCTION and DISTRIBUTION. The REGISTRATION process was selected at the end of Phase 1 of the process management flow procedure as the constraint to be scrutinized in the remaining four phases of the procedure. However, re-engineering and process improvement should be an ongoing activity in any institution (Goldratt & Cox, 1992; Davenport *et al.*, 2003). Although this study is only a proof of concept with regard to the procedures used to determine the usefulness of a process management flow procedure, it is suggested from a practical point of view that for future technological innovations the three remaining processes not scrutinized in this study should also be analysed.

The first two phases of the process management flow procedure used the process models derived in Chapter 5 (section 5.2.1). Telephonic interviews were conducted in order to verify constraints in Phase 2, in subprocesses S_5R_{31} and S_5R_{32}. For the solutions suggested in Phase 4 of the process management flow procedure, the data gathered previously for both UNISA (section 5.2.1) and UP (section 5.2.2) was used and best practices were included in the solution. Mrs. Esterhuizen (UP) was consulted to confirm the use of the automatic application process at UP, which is included in the proposed RMS.

Unfortunately, for Phase 5 of the process management flow procedure, the implementation of the procedure was beyond the scope of this thesis. The documentation should, however, be valuable as reference documentation for activities such as re-engineering, to build new processes, or to use in conflict negotiation in future.

8.3.1.1.6 The suggested Registration Management System

Investigating the feasibility of a technological innovation, such as an electronic registration system, involves different feasibility studies. It is necessary to look at the impact on current systems, human resources, infrastructures, financial implications and the technological feasibility. Although some comments are made in this study on the impact on human resources, the technical feasibility of the system was the real focus of attention.

All of the facilities suggested in the solution were technically feasible. The new application procedure is already in use at other institutions. For example, UP has successfully implemented an on-line web-based application system (Lazenby, 2003). The facilities needed for verification with the SAUVCA matriculation database for academic verification and the Expert System for course enrolment are possible. The database already exists and the Expert System is already in use at UNISA. For the Matriculation database, it is necessary to develop an interface which can do a search on the identification number and the year that a student obtained his qualifications. It is then necessary only to carry out verification for exceptions. This should immediately minimize the current workload in the Undergraduate Section. At UNISA, an advantage in working towards a solution was that an Expert System that assists in the verification of business rules is already in existence. The Expert System also needs an interface in order to verify the proposed enrolment. The electronic payment proposed by the system is feasible. There are well-known e-commerce systems that use electronic payment successfully (e.g. Amazon.com and Kalahari.net). Lastly, access to electronic study material should not be a problem. The mechanisms for making material available in PDF format are easy to implement and feasible. Students at the School of Computing can already access study material for downloading on a server (www.cs.unisa.ac.za).

8.3.1.1.7 Constraints created by the solution

It is inevitable that a solution may also create new constraints. In a feasibility study it is necessary to look at problems caused by the suggested solution (as was done in section 6.2.4 regarding Goldratt's theory of constraints (1992)). Most of the problems mentioned are not process-specific but institution-based. An example is the concern about the merger being a priority. Inevitably, the focus of attention is on merging and selecting between systems and this will remain a priority until the merger with the old Technikon Southern Africa is complete.

- For payment verification one may argue that an automatic banking verification is beyond the scope of the student profile at UNISA. A study is needed on the profile of the students with access to electronic mechanisms (see further research in 9.4.1).

The next section, section 8.3.1.2, reports on the usefulness of process models in the process management flow procedure.

8.3.1.2 Usability of the process model structure

The process model was used in a re-engineering effort at UNISA. Although no physical implementation of the suggested solution took place at UNISA, a technical feasibility study was done. During identification of the constraints, the theory of constraints was used in combination with the high-level process model. This was done both on the highest level (Phase 1 of the process management flow procedure) and on sub-levels (Phase 2 of the process management flow procedure). The models were also used in Phase 4, where a solution was suggested. The subprocess models were of assistance when the individual constraint process was analysed and also when the chain of events was viewed in a triangulation activity. According to the indicators identified for usefulness in section 4.3.2.3, the process model structures are useful for deriving the processes with constraints and also ideal for re-engineering where they are used as a graphical tool in the process.

8.3.2 Scientific contribution: Research Question 2

For this research question, the intellectual focus is on the *procedure* used for process re-engineering in an educational domain. The research question was stated as follows:

To what extent is the generic process model structure useful in a re-engineering effort?

Focusing on the usability view from a process re-engineering perspective is one way of looking at things. The usability could also be described from another perspective, i.e. sharing knowledge about organizational practices (Malone *et al.*, 2003). In section 9.3.1.2, there is a discussion on alternative approaches and how they may have influenced the study.

My goal was to show that the process model structures are valid and can be used as reference models in re-engineering. The motivation for using process re-engineering is that it relates to the current trend in higher education towards including technological solutions to manual processes and the impact of the Internet on the rethinking of higher education organizations (Allen & Fifield, 1999; Educause, 2003).

The intended audience for this procedure is the re-engineers involved in process re-engineering where information technology is investigated as a solution to constraints in the application domain. Like the scientific contribution for Research Question 1, the contribution lies in the method used to establish the usefulness of the process model structure through a re-engineering effort.

The procedure that focuses on the establishment of the usefulness of the process model structures in re-engineering can be generalized into five phases, including the:

1. Definition of the scope.
2. Identification of a re-engineering procedure.
3. Definition of a measurement strategy.
4. Re-engineering activity.
5. Measurement of the process model structures in the re-engineering activity.

The phases are sequential and graphically depicted in Figure 8.10.

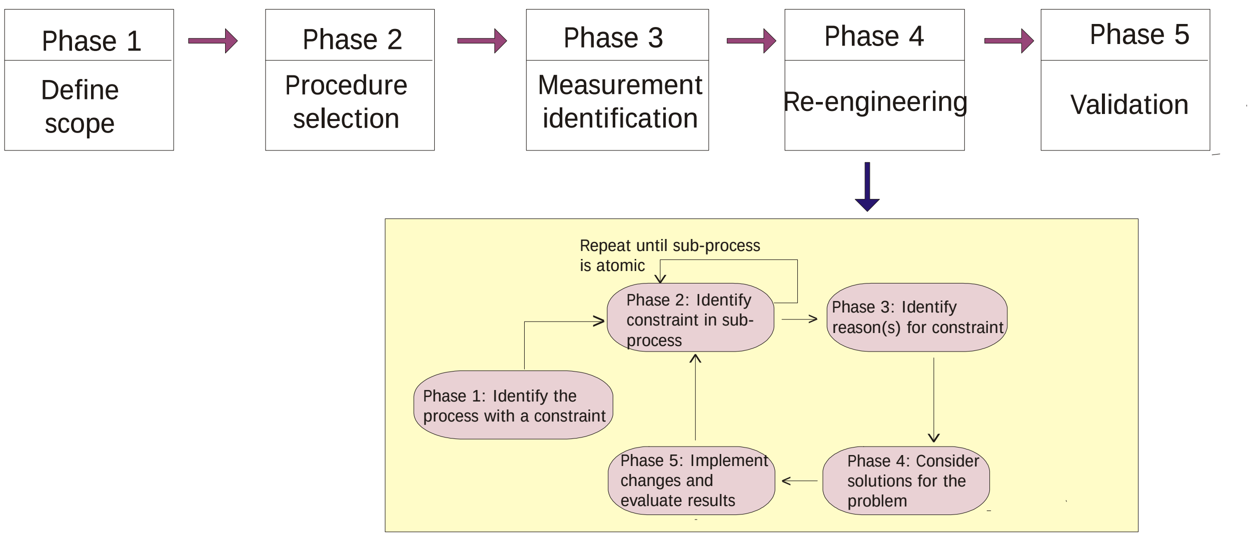


Figure 8.10: Procedure for investigation of the usability of process model structures

As in Research Question 1, I also reflect on some best practices for each phase of the re-engineering activity at UNISA. As discussed in section 6.1, UNISA was selected because I was already familiar with the structure of the institution and the resources were easily accessible due to my involvement as a lecturer in that institution. These experiences are generalized into 'best practices' with different considerations and recommendations for the investigation of the usability of process model structures. For each phase described above, a list of considerations and recommendations is given as well as details of the role players and deliverables. In Phase 1, the scope defined is that the development team should consider management commitment and determine financial constraints. For Phase 2 of the usability procedure, the team should consider the use of existing procedures, or develop a new procedure. The use of existing procedures may create a financial burden but reduce development time, in contrast with the development of a new procedure, which may take more time but is custom-made for the environment (Whitten *et al.*, 2000). In the third Phase, the development team needed to consider the types of measurement techniques necessary to comment on the usefulness of the procedure. For Phase 4 some re-engineering considerations regarding the options of using a new procedure or an existing procedure are listed in Table 8.4. For either consideration, an impact study is vital in order to investigate the danger of fixing something that is not really broken (Davenport, 1995a). Lastly, for Phase 5, validation techniques should include the use of the measurement instrument defined in Phase 3. The considerations are summarized in more detail in Table 8.4.

Table 8.4: The usability of process model structures during process re-engineering

Phase	Considerations and recommendations	Role players	Deliverable
Phase 1: Define scope	One of the first tasks that the investigation team and management will be involved in is to define the scope of the investigation. The scope is broadly defined as the investigation of the usability of process models, specifically in process re-engineering, but this is not enough. It is necessary to refine the scope where the following are considerations during this phase: • the level of management commitment. If management is not involved during this phase the project may be doomed from the start. • how urgent is the re-engineering activity? If the focus is only on the testing of the usability, then defining a prototype during re-engineering activity is sufficient. However, if the re-engineering is the main focus, an implementation is also needed as part of the re-engineering activity. • is the constraint that needs re-engineering already identified? If so, document the reasons for the constraint, e.g. user dissatisfaction. This will influence the kind of procedure selected in Phase 2. • identify re-engineering team members. • the financial implications of the investigation. Even an investigation without any implementation involves time and money and this should be considered by the investigation team.	o Management o Investigation team	Scope definition
Phase 2: Procedure selection	During the selection of a procedure to do the re-engineering, the team should decide between the use of: • existing re-engineering procedures available for the educational domain as defined in section 4.3.2, or by Bruno *et al.*. (1998). • the development of your own procedure where the following should be considered: o use existing process re-engineering procedures as a guideline (Davenport & Short, 1990; Hammer, 1990; Davenport, 1993) where process re-engineering steps include the (1) the development of the business vision and process objectives (2) identify the processes to be redesigned (3) understand and measure the existing process (4) identify the IT levers (5) design and build a prototype of the new process. o the design of a procedure with phases and with deliverable(s) after each phase.	o Investigation team o Re-engineering team	Selected procedure
Phase 3: Measurement identification	In this phase, the following are important issues: • To be able to comment on the level of usefulness it is necessary to determine the way in which the measurement will be conducted. • To comment on the level of usability is a quantitative exercise where an ordinal measurement is suggested. • If the focus of the study is to give any statistical evidence of the level of usability, then alternative measurements such as nominal measurements should be considered.	o Investigation team o Re-engineering team	Measurement indicators

Table 8.4 (continued) : A framework for investigating the usability of process model structures during process re-engineering			
Phase	Considerations and recommendations	Role players &	deliverable
Phase 4: Re-engineering	During the data-gathering for selection of a process to be re-engineered in the educational application domain, the following should be considered: • the impact on interviews with respondents. People easily feel threatened during re-engineering activities, especially if technological change is involved. • to what extent is a feasibility study needed that relates to the budget for re-engineering processes? This will influence the purchase of available solutions in contrast to development of a new system. • what are the triangulation measurements that the re-engineering team will put in place to look at the constraints from different perspectives? The following should be considered in the implementation of a new process: • an impact study is needed where the financial implications, effect on human resources, units, data, hardware, applications and existing processes are considered. • how does the business strategy relate to the suggested technical strategy? • what are the best practices used in other institutions? • what is the impact of the implementation on the existing flow? Will new constraints be created?	Investigation team	Prototype of solution or implemented solution
Phase 5: Validation	Use the measurement method identified in Phase 2 to determine to what extent the process model structures are useful in the re-engineering activity.	Investigation team	Level of usefulness

8.4 CONTRIBUTION: PRESERVATION VIEW (RESEARCH QUESTION 3)

The goal of Research Question 3 was to investigate the preservation of the process models in a process repository. This was accomplished by suggesting an educational process representation in section 7.2 and investigating the feasibility of the representation in an environment such as the Phios process repository in section 7.3. The preservation of process model structures relates to the preservation view of the process model view discussed in section 8.1, and is highlighted in Figure 8.11.

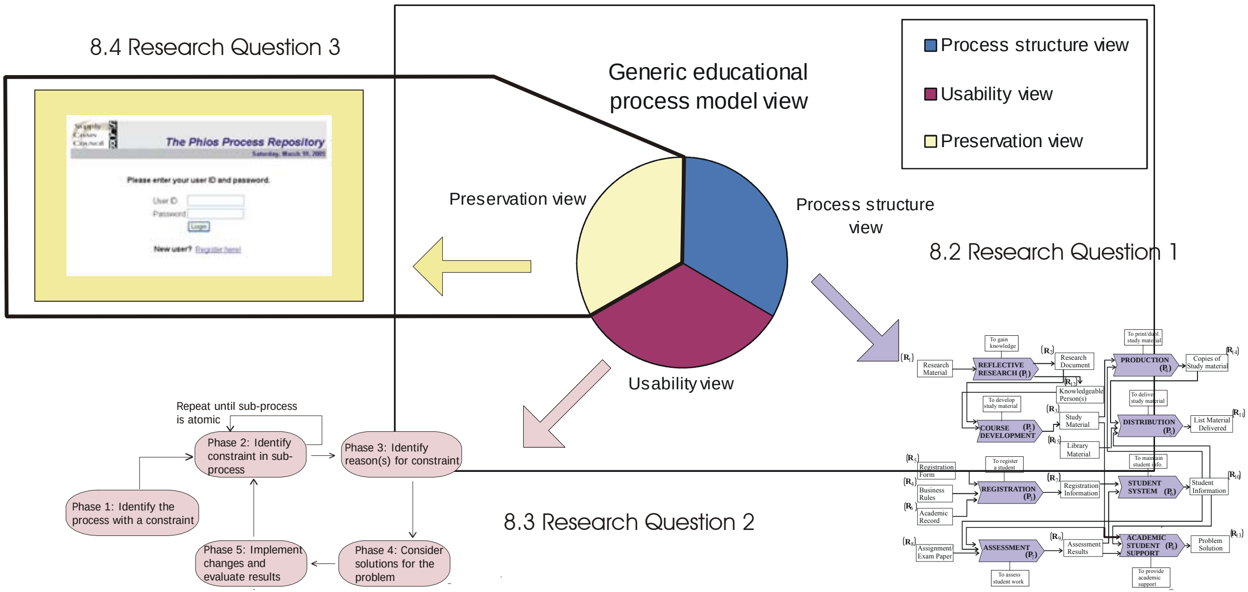


Figure 8.11: Focus of Research Question 3: the preservation view

The contribution in focusing on the process model from a preservation view was made on the product level, where an adapted model (described in section 4.3.3) to the MIT process repository (Malone *et al.*, 1999a) was used at UNISA, and in the options available to the development team. The contribution on product level is addressed in section 8.4.1 and the scientific contribution regarding Research Question 3 is addressed in section 8.4.2.

8.4.1 Product contribution: Research Question 3

In Chapter 7 the last of the three research questions was addressed. The educational model derived in Chapter 5, and verified as useful in Chapter 6, was used in Chapter 7 where a method to retain the model for future reuse was discussed.

The research question addressed was: *How can the educational process model be preserved and reused?* I suggested the use of a model adapted from the MIT process repository to store the process models for future reference. In this section, I will first discuss the educational process repository model and then offer comments on the feasibility of a repository for educational models, concluding with some insights on doing the relevant research at UNISA.

8.4.1.1 Discussion: educational process model representation

The educational process repository suggested was based on the MIT process repository developed by MIT's Sloan School of Management in the early 1990s. The advantages of using the adapted model do not all stem from the suggested adaptations, but some of these are experienced because of the use of the MIT process repository, which was developed after extensive research in this area.

One of the biggest advantages is the *extensibility* of the model. Any user of the model may extend it to include new subprocesses according to new specializations. For example, our examples were based on undergraduate studies; if the user wants to add a registration that is for postgraduate students only, it could be implemented easily by adding a new specialization for the generic REGISTRATION process. This specialization will then inherit the four generic subprocesses defined for the REGISTRATION process. The developer only needs to map these processes according to his pre-knowledge on the application domain and decide whether the processes are sufficient or whether an additional process is needed. This emphasizes another characteristic of the repository model, namely its *reusability*. The specialization of a generic process model enables the developer to *reuse* what has already been identified previously and extend only if needed.

The *maintenance* of the process model repository is uncomplicated. Processes can be added at any time to describe a specific specialization. A problem that should be addressed is the sequence of execution of processes on the same level. It is assumed that the sequence of processes is from left to right in the representation of the educational process model. If a set of processes is inherited for a new specialization, there may be a process that is added between two existing processes. If the developer is not aware of the sequence of process execution, a model that is not a real representation of the real world could easily be created.

The use of an accepted *object-oriented notation* for presentation of the specializations enhances the usability of the models (section 7.2.4.2). If a notation is used that is accepted generally as a standard notation by different role players in development, the 'language' for discussions is the same and the developers can focus on the solutions and not on what the current environment actually looks like. In implementing the adaptations of a more formal way of representing the specializations through stereotypes and the use of polymorphism, this model moves in the direction of supporting a standard notation. The use of accepted standard notation implies that this model supports more characteristics of the object notation than the previous model does.

In the object-oriented paradigm, the models used should be easy to understand, easily maintained, support object-oriented modelling concepts, be information-rich to model different concepts and be reusable (Harmon, 1993; Booch *et al.*, 1998; OMG, 2001a). As a triangulation exercise involving discussions with object specialists, I confirmed that the adapted model conforms to these characteristics insomuch as it:

- *is understandable*: The goal of models is to make the 'picture' clearer for the reader using it as a reference tool. Both respondents agreed that the model is clear and tells the user what the representation is for a real-life situation (as it was intended to do).
- *is easily maintainable*: Using the generic process with specializations allows the user to add processes on lower levels if the higher level neglects a needed process. Both respondents agreed that the model could easily be extended.
- *supports object-oriented modelling concepts:* I suggested the use of polymorphism and stereotypes to make the model more object-oriented. The creators of the MIT process repository suggested the use of generalization and specialization from the object-oriented paradigm without using the object-oriented notation in their own models. From the interviews it was confirmed that the adapted model supports more object notation than the initial model does.
- *is information-rich:* The adapted model gives information on the parts and the specialization of the environment. Using the model will enable the reader to derive logical arguments on the generic process models and on the parts represented in different scenarios. This was not added to the model but only confirmed as being an advantage of the model in general.
- *is reusable:* The generic process model and the specializations thereof can be used and reused because of the generic characteristic of the models. Simply by discussing the models with the respondents I was already involved in an exercise of using the process models for something different to re-engineering, as a reference model. This confirms that the model can be used as a reference model in discussions.

The triangulation confirmed the findings gleaned from the implementation of the educational process model representation for the UNISA instance in using the REGISTRATION process. The model is reusable, information-rich, understandable, supports object notation and is easy to maintain.

8.4.1.2 Discussion: reuse of the educational process repository model

In 2003, there were already more than 5000 activities stored in the Process Handbook (Malone *et al.*, 2003). The repository is maintained by the Phios Corporation and may be viewed but not changed at the Phios website (http://repository.phios.com/SCOR/). Partners gain access to the repository and may add their own specializations to the existing specializations. This makes the repository extensible so that it grows according to the different users that expand it.

The development of software to maintain and access a repository of this nature is feasible (proof is in the existing repository). The question is therefore not whether it is feasible to develop this repository, but whether or not it is useful. Some businesses have already used the repository successfully (Malone *et al.*, 2003) and it may be a good idea to investigate the experiences of these businesses before the development of a similar model is considered.

In discussions in section 7.2 the *Sell Process* and *Application Process* were compared with regard to the representation of the different components in the Phios repository. Storing the *Application Process* is feasible because the elements are comparable to the elements in the *Sell Process*, which is already saved in the repository and it should therefore be feasible to store the *Application Process* in a repository similar to the Phios repository (representations in Table 7.3 and Table 7.4).

The identification of generic processes is time-consuming. A concern is that the *flexibility* of the repository will lead to developers becoming ‘lazy’ about the classification of generic processes and instead of spending time on the identification of generic process models, perhaps enforcing duplication. The danger of duplication is that if a process is really generic and stored as more than one generic process, maintenance will be an issue. Changes to the generic process will not be inherited everywhere, which may lead to false representations of the specializations.

8.4.1.3 Insights at UNISA

The generic high-level educational process model and subprocess models for the REGISTRATION process were established for the first research question, during an in-depth analysis at three different institutions. For the second research question, the generic REGISTRATION process from UNISA was used to show how the specializations could be represented and stored for future reuse.

The adapted MIT process repository was used to represent the different specializations for UNISA REGISTRATION instance. During the construction of the different models, analysis was needed to build the different models. Once again, the four subprocesses identified previously as the generic subprocesses for REGISTRATION were emphasized as the important activities in all the REGISTRATION specializations. This acted as a *triangulation* where information that had previously been gleaned from a different perspective was confirmed.

The model was shown to two specialists involved in the software engineering field and the new way of representing the model as a more object-oriented model contributes to the 'clear' description of concepts in the model. It may be argued that people ignorant of notation could understand the models easily, but as demonstrated before, when a model is used where 'meaning' is added to the links and the arrows between the objects, a standard notation is the best way of presenting of these concepts.

To conclude the findings in this Chapter, it is possible to confirm that the educational process model repository with the adapted model is *feasible, reusable, maintainable, flexible* and lends itself to the use of *standard notation.*

This research opens up a new field of research related to the storing of process models in the educational domain and researchers could continue this work in the areas of:

- Extending the existing educational process model.
- Implementing the model without the duplication allowed in the current MIT process repository.
- Developing graphical tools to view the different models.

8.4.2 Scientific contribution: Research Question 3

The focus of this research is on the procedure involved in the identification of educational process models that are reusable and preservable. The last research question, Research Question 3, relates to the preservation view and was stated as follows:

How can the educational process model be preserved and reused?

In this section, the preservation of the educational process model structure was discussed where an educational process model representation was identified and the feasibility of the preservation of the process model structures in a process repository was established. To establish a procedure that developers can use during the preservation of educational process model structures, I used the investigation of the preservation of the educational process model structures and the generalization of best practices in the approach.

The suggested procedure for the preservation of educational process model structures, as illustrated in Figure 8.12, includes steps to

1. Identify collaborators.
2. Identify a process model representation.
3. Select a process repository environment.
4. Build the educational process repository.
5. Maintain the educational process repository.

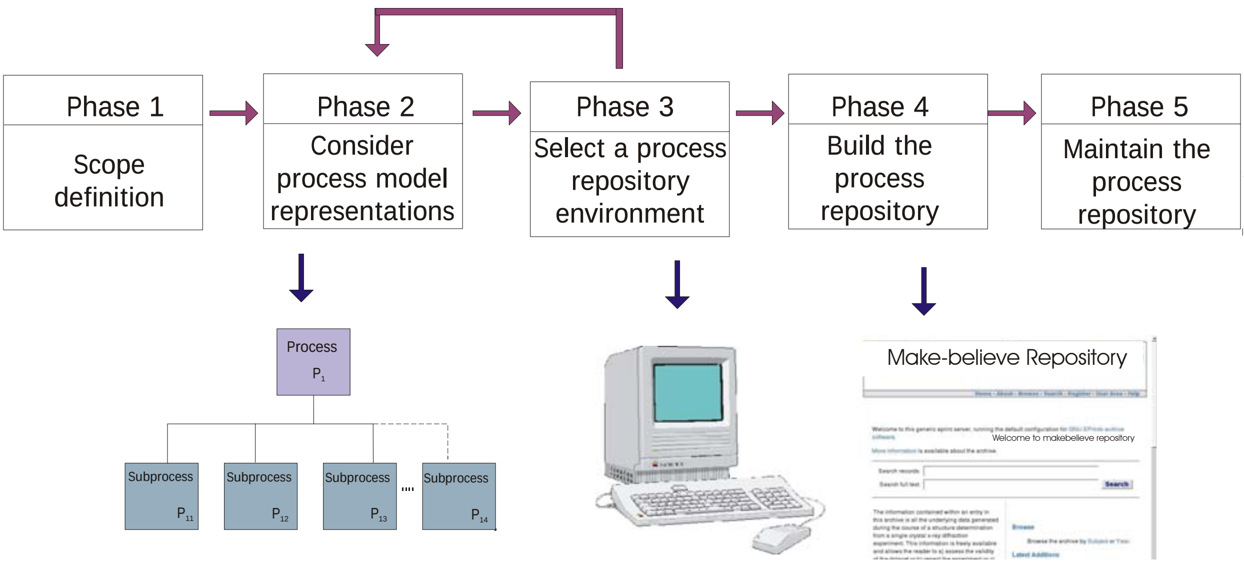


Figure 8.12: Preservation of process model structures

The focus of the procedure is first on the scope where the main activity is the identification of the collaborators involved in the repository environment. Knowledge sharing on process models at an organization level can only be for use by staff in the organization, or it can be for general use by different institutions. The process model representation selected in Phase 2, defines the format in which the process models will be stored. This is important in Phase 3 when the role players decide on the mechanisms for storing the process model structures. If the investigation team decides that the process model representation selected in Phase 2 to be stored in Phase 3, cannot be represented efficiently in a process repository environment, the investigation team may return to Phase 2. In Phase 4, the process repository is built using the available knowledge on current generic process model structures and maintained in the last phase, Phase 5. Table 8.5 provides more detail on these phases.

As in Research Question 1 and Research Question 2, I also reflect on some best practices for each phase from the preservation activity at UNISA (discussed in section 8.4.1). These experiences are generalized into 'best practices' with different considerations and recommendations for the preservation of process model structures. The different role players are listed as well as the deliverable for each phase. In Table 8.5, for the first phase, the issues related to the scope definition are listed where collaboration is significant. The developers need to consider who the role players are and what the contribution of each will be. During Phase 2 the development of the process model representation is considered where one option is to consider

During Phase 3, as indicated in Table 8.5, the development team should consider the use of existing repositories or the building of a new repository. If the development team considers the use of existing repositories, issues such as suitability and feasibility should be considered. If the development team considers the development of a new repository, responsibility will be more permanent. During Phase 4, the development team is involved in repository-building activities in which process model structures are identified and added to the repository. Duplication is an important issue and the team needs to consider responsibility for the management of the repository. Open source has advantages, but as previously mentioned duplication may be a danger as was observed in the Phios Model (discussed in section 1.3). This phase relates to the last phase, Phase 5, where the issues relate to the maintenance of the repository.

Table 8.5: A framework for investigating the preservation of process model structures

Phase	Considerations and recommendations	Role players	Deliverable
Phase 1: Scope definition	An investigation of this nature can be initiated by a single institution but would be more feasible if it were a joint collaboration between institutions. The initiator of the project needs to consider the following in selecting the scope: • Who will the collaborators be? • What are the responsibilities of the different institutions? • What is the budget for the project? • How will the financial responsibilities be shared between the different collaborators? • How will the information be shared? • Who will be responsible for the maintenance of the process repositories? • Where will the repository be stored physically?	o Management of collaborating institutions o Investigation team	Scope definition
Phase 2: Consider process model representations	During Phase 2 the investigation team should consider the available process model representations. The following should be considered: • Consider existing process model representations with a formal notation. • Select a presentation that is extendable. • Select a presentation that is ideal for reusability. • Consider a model representation that is easy maintainable. • Select a model based on existing models established in the process model representation application domain such as the MIT process repository (Phios, 1999) or the adapted model suggested in section 4.3.3.	Investigation team	Selected process model representation
Phase 3: Select a process repository environment	A process repository can either be developed or selected from existing process model repositories. Should the team consider purchasing an existing repository, the following should be considered: • Is the repository developed for the educational process model representation selected? • Does the repository support the selected process model representation? • Can the scenarios in the educational domain be preserved in the selected repository? • How does the cost compare to the cost of developing your own repository? • Is it necessary to return to Phase 2 to reconsider the process model representation? • Is the budget sufficient for the purchase? • Is there training available for using the process repository? • Who is using the repository successfully? Should the team consider developing the process repository structure, it will be necessary to do a full software development cycle including the analysis, design, development and implementation of the system. Furthermore, the following should be considered: • What are the best practices in system development that will be included in systems development? What are the best practices used in other repositories? • Who will be responsible for the development and how will the financial burden be distributed? • Which institute will be responsible for the development and who will be in the development team?	o Investigation team o Development team (if development is selected as an option)	Measurement indicators

Table 8.5 (continued) : A framework for investigating the usability of process model structures during process re-engineering			
Phase	Considerations and recommendations	Role players &	deliverable
Phase 3: Select a process repository environment (continued)	• What are the hardware components for distribution and how will the data be accessible to different collaborators? • What tools will be built to support the environment? • What are the components of the interface through which the users will access the repository? • What are the access mechanisms? • What is the project plan (including time schedules, deliverables and responsibilities)? • Consider the use of guidelines given by software engineers (Sommerville, 2000; Pressman, 2005)		
Phase 4: Build the process model repository	In Phase 4 the process data are added to the process repository. The following should be considered: • mechanisms to ensure that duplication is limited in the process model repository. • access mechanisms to the process repository. Who will be allowed to add to the repository? • will the repository be available for viewing by non-collaborators?	Responsible members	Physical process repository with data
Phase 5: Maintain the process repository	The maintenance of the process model repository includes both the maintenance of process model data and identification of errors in the software system. • If the system was developed by the collaborators, it will be necessary to return to Phase 3 where the system was developed and investigate changes to the repository if necessary. • If the system was purchased, the problems should be discussed with the vendors. • Maintenance is an ongoing process and the maintenance team should consider quality control mechanisms so that the repository remains a true representation of the different processes within the institutions.	Maintenance team	Process repository maintained by responsible members.

8.5 CONCLUSION: CONTRIBUTION

In considering the generic educational process view that this research addresses, it is possible to step back from what was done in this study and to generalize it into five actions that are needed if a researcher wants to describe the structure of another application domain. These steps include:

- An identification phase where the structures are determined.
- A classification phase where the generic structures are determined.
- A preservation phase where the storing of the structures is investigated.
- A development phase where support tools and techniques are investigated.
- A transfer phase where the information is made available to interested parties.

8.6 SUMMARY

Chapter 8 is the conclusion on the three research questions namely:

1. What is the process model structure of the higher education institution?
2. To what extent is the generic process model structure useful in a re-engineering effort?
3. How can the educational process model be preserved and reused?

These three questions address three different views of the generic educational process model view, including the process structure view, usability view and the preservation view. In the different views there are procedures applicable to the identification of the process model structure, the investigation of the usability and the feasibility of preserving the structures.

This Chapter contained a conclusion based on the data-gathering commenced within the higher education domain, and a scientific perspective in which the best practices were included in the procedures suggested for the identification, preservation and usability of process models.

9. Conclusion

9.1 INTRODUCTION

The goal of this Chapter is to give an overview of the findings of this research project. A research project of this nature begins with the motivation for the research, the theoretical foundation, the research methodology and the evidence of what was found. The study needs to reflect on what was found, what was learned and what is recommended.

In this Chapter, this is addressed as follows:

- Section 9.2 provides a summary of the thesis with discussions on the results for each of the research questions.
- Section 9.3 gives an overview of what can be learned from this research, focusing on methodological, substantive and scientific reflection.
- Section 9.4 discusses recommendations for policy and practice, further research and further development work.

9.2 SUMMARY

In South Africa, the re-engineering of processes within the HEI application domain is unavoidable due to the restructuring enforced on national level (discussed in Chapter 1). The driving force behind this study was the identification and preservation of the higher education process model structure, where these structures can be reused by institutions involved in re-engineering initiatives. Over the years, a number of approaches have evolved in different disciplines to represent the processes in organizations. For example, one of the best known tools to represent data flow between processes is the data flow diagram used in systems analysis and the design of software systems (Whitten *et al.*, 2000). Some organizations developed database storing concepts, such as the best practices and process maps of generic processes (Malone *et al.*, 1999b).

The usefulness of process models has been established in different application domains. In Chapter 2 the theory related to this study was given. The Chapter contains a detailed description of the rationale of the study, and showed the shortcomings experienced in the theory that led to the definition of the research questions. Where the concepts related to the research questions were addressed, the underlying theory was discussed in more detail.

This project was initiated as a result of my own interest in two diverse fields, software engineering and the application of software engineering concepts to the educational application domain. In the late nineties I was involved in numerous projects relating to the implementation of technological innovations at UNISA. This included being the course leader in an online web-based certificate course, acting as departmental representative for web innovations, and being involved in a UML focus group. After identification of the research questions for this study, I was also involved in a structured analysis activity with the aim of studying at the institution from a human, product and process perspective. These activities, which contributed to my need to do the study, and my understanding of the application domain were included in Chapter 3 as contextual analysis.

In Chapter 4 the tools and techniques used to answer the research questions were described. The study was identified as a qualitative study using questionnaires, observations, structured interviews and contextual analysis as tools during data-gathering efforts. These tools were used in combination with a requirements elicitation procedure developed to identify the process model structure. The different research methods available in information systems were explored and a matrix was constructed to identify the approach needed to answer the different research questions. The research approach was classified as being a combination of development research and case study research.

The research questions addressed in this study were as follows:

1.	What is the process model structure of the higher education institution?
2.	To what extent is the generic process model structure useful in a re-engineering effort?
3.	How can the educational process model be preserved and reused?

The evidence and findings for the first research question were presented in Chapter 5. The findings were in the form of a requirements elicitation procedure with five phases, an evaluation list discussing the characteristics of a requirements elicitation procedure, and a discussion on the findings after using the procedure at three different institutions. The deliverable, the high-level institution structure, was presented as a process model, and the concept of presenting it as an educational value chain, was also introduced. For the second research question, the findings were presented in the form of a re-engineering procedure developed to identify constraints within the process model structure. The data gathered during the application of the procedure was used to show the feasibility of the procedure, and an evaluation list was used to discuss the usefulness of the process models in a re-engineering procedure of this nature. The findings from Research Question 3 were in the form of a feasibility study in which the REGISTRATION process was used to discuss the feasibility of preserving the generic process model structure in the adapted educational process repository.

9.2.1 Summary: Research Question 1

The first research question focused on the educational process model structure of the HEI. The research question was as follows:

What is the process model structure of the higher education institution?

Before a process model can be claimed to be generic, it should first be confirmed that it repeats or exists in a significant number of environments. Therefore, in order to answer this question on what the educational process model structure is, it was necessary to look at different institutions, identify the high-level process model for the different institutions and compare the results. However, there was no formal requirements elicitation procedure available for the identification of the process models. Therefore, I had to:

- Develop a requirements elicitation procedure.
- Apply it at different institutions to identify the high-level process model.
- Identify a set of requirements to show that it is a sound requirements elicitation procedure.
- Compare the result from the different institutions to comment on the generic structure of the HEI.

The requirements elicitation procedure was developed at UNISA as a five-phase procedure (Van der Merwe, 2003). The procedure was developed as a *cyclic* procedure where phases may be revisited more than once to gather all the data at a specific institution. Furthermore, the procedure was developed using theory available and best practices available at the time of the application of the procedure at the three institutions. This emphasizes the use of development research as a research approach where theory meets practice with the goal of enhancing the theory. In the procedure the Erikkson and Penker (2000) UML notation was used during the definition of the process model structures. Stepwise refinement was introduced in the theory of the requirements elicitation procedure to ensure that a top-down process is followed in which the development team first look at the ‘bigger picture’ before the processes are decomposed into smaller pieces. The procedure also ensures that the unit and the processes are separated, therefore providing a global view of the process structure and not just a unit-dependent process flow. For the sake of clarity and also to simplify the implementation mathematical notation is supported in the definition of the different sets. The use of an ordered procedure based on best practices enabled the development team to decrease the time needed to do data-gathering at the three institutions significantly. Lastly, the procedure produces a set of documentation that can be used as reference documents (Table 4.16, section 4.3.1.1.3).

Prior to this study, there was no guidelines were available for developers involved in the development of a requirements elicitation procedure to enable them to ‘know’ whether the procedure could be considered a good procedure or not. As part of this study I identified a set of requirements elicitation characteristics (Van der Merwe *et al.*, 2004a) from resources reporting on the use of requirements elicitation in order to be able to comment on the characteristics of the requirements elicitation procedure developed. The procedure adheres to 75% of the characteristics identified for a requirements elicitation procedure (report on in section 5.3.1) and the characteristics that it did not adhere to provide opportunities for future research (section 9.4.2).

With regard to the data-gathering activity at the different institutions, the procedure derived a generic set of processes on the highest level of an institution, which may be regarded as the high-level structure of an educational environment (Van der Merwe *et al.*, 2004b). For the second level, it is possible to deduce, from decomposition of the REGISTRATION process at three different institutions, that there is a subset of generic subprocesses with the extendibility possibilities of processes on the second level (more processes may be added), and also with no limitations to the sequence of execution. The respondents at the University of the Freestate commented during verification that the process model structures could be valuable in their own process re-engineering efforts and requested copies of the structures. Staff members at Technikon Pretoria and the University of Pretoria were also interested in obtaining the structures for their own use. This emphasized the fact that the study is *relevant, needed* and *important.*

With regard to the presentation of structures, one of the well-known generic structures used in businesses today is the value chain of a business, as proposed by Porter (1992). It is possible to convert the process model structure to be presented as a value chain for an educational environment (Van der Merwe & Cronje, 2004). The educational value chain is therefore an alternative to the process model structure presented in this study. Information on the flow between processes and the goal of each process is, however, lost if the value chain is the only source of reference. It can be argued that in cases where one only wants to refer to the high-level process models, the educational value chain is a more compact structure, in contrast to the more complex process model structure that includes flows. This is a matter of preference and the user may select whichever one is appropriate for the current need.

With regard to my own experiences at institutional level, human resource level and personal level, the following were issues that are worth mentioning:

- From my experience at the three institutions it is possible to report that process model structures are poorly described at higher institutional levels. On lower levels, within operational units, process model structures have a higher priority and are developed to depict the working of units graphically. The problem with this is that the process models are based on operational units and therefore report on the workings within a specific operational unit, without reflecting any processes that influence the structure from other operational units. The requirements elicitation procedure separates the operational unit and the process model structures, so that a global view can be presented.
- From a human resource perspective, I found that respondents were approachable in interviews where I discussed the processes in which they were directly involved. UNISA members of staff were more spontaneous in discussions, in contrast to UP and TechPta where more clinical answers were received. I believe that this was because the staff at UNISA did not feel threatened by another staff member asking about details on processes within the institution, in contrast to the other two institutions where the respondents had the perception that that there were ‘wrong’ answers, or that they were giving out confidential information.
- The identification of key persons in data-gathering activities of this magnitude was of great value. Whenever I was not sure of how to represent data or needed more information, the key persons in the units that I identified, directed me to the correct sources required. I also had to reflect on my own interviewing skills in order to retrieve data from respondents in such a way that they did not feel threatened. Lastly, I experienced the value of having

background knowledge, by reaping the benefits of a much shorter second and third cycle when applying the procedure at the second and third institution.

9.2.2 Summary: Research Question 2

The second research question focused on the identification of constraints in the educational application domain using the process models identified in the first research question. The research question was as follows:

To what extent is the generic process model structure useful in a re-engineering effort?

A process model provides the user with an information-rich model on the flow between processes. It is intended to be a graphical tool that enables developers to 'see' what the processes involved in a specific environment are, what is needed by each process (input), what is produced (output) by each process, and what the goal of each process is. A process model also gives information on the sequence of events. The focus is on the usefulness of the process models and, more specifically, in a re-engineering activity. In order to reflect on the aspect of usefulness I had to:

1. Define the steps for a process management flow procedure.
2. Identify the way in which the usefulness of the procedure would be 'measured'.
3. Use the procedure in a re-engineering effort.
4. Discuss the usefulness of the procedure according to the indicators specified.

The suggested process management flow procedure was defined in terms of five phases. The procedure is cyclic in nature with the development team returning to investigate whether the solution created any new constraints or to focus on previous constraints after a solution was implemented. The process management procedure suggested uses Goldratt's theory of constraints (1992), which focuses on the demands and throughputs in a chain of events in order to identify constraints. The procedure uses a top-down approach where the processes on the highest level of the institution are first considered, constraints are identified and the process is selected on which the remainder of the procedure will focus. In the second phase the procedure focuses on the second level of subprocesses where the actions of identification are repeated. This selection process is repeated until the problem is identified without 'hidden' subprocesses that may cause a problem. In the third phase the reasons for solutions are considered, which may be used as guidelines in finding solutions in the fourth phase. Phase four involves feasibility studies on the suggested solutions and could be an expensive phase. This is inevitable, as implementing the wrong solution could cost the institution more than selecting the solutions carefully. The last phase, Phase 5, focuses on the implementation of solutions.

With regard to measuring the usefulness of the process models during implementation of a re-engineering procedure, an ordinal measurement method was used and four indicators were identified that refer the frequency of use. The indicators proposed (Table 4.30) to measure the ratio of use include the values of high, medium, low, and none. If most of the phases in a procedure are measured as being high or medium, it is rated as being highly useful, if most phases are medium or low, it is rated as moderately useful, or if most phases are low or none, it is rated as not useful.

The data-gathering was done at UNISA where the first four phases were implemented and a proof of concept (Harley Green 2004) was done for the last phase, namely implementation. In the first phase, four constraints was identified and REGISTRATION was selected for further investigation. In the second phase, constraints were identified in subprocesses *Course profile verification* and *Course data capture*. The two significant reasons for the problems experienced in the REGISTRATION process include the lack of human resources during the registration period and the priority placed by management on converting to automated processes. In finding solutions it was possible to look at the two processes and give a solution to each, or to look at the chain of events and suggest a single solution that will have an impact on all the processes. In Phase 4, the latter was selected, where a single Registration Management System (RMS) was suggested to manage the actions involved in student registration. A system of this nature will act as an interface between the existing systems, and has the advantage that changes only focus on the constraints and that it is not an entirely new system. Significant changes will however be necessary in the application procedure.

The RMS system suggested is technically feasible and has a number of advantages, including the elimination of the two problem subprocesses (*Course profile verification* and *Course data capture*) in the REGISTRATION process. It also acts as a solution for the three other subprocesses with constraints (*Student number application, Student number allocation* and *Register & verify student payment*), by automating the application and payment process. The suggested solution is based on best practices (incorporating the application process from UP and the electronic payment system used in e-commerce systems) and also suggested the use of access to the course material which, although not a constraint, may have financial advantages for the institution in terms of printing and distribution costs. There are a number of concerns regarding the solution that should be addressed if a RMS of this nature is implemented. These include the concern related to change management and the financial implications of implementing a system of this nature. Extended feasibility studies will be necessary, including provision for change management procedures.

With regard to my own experiences during the data-gathering activity, the following were significant aspects:

- The guideline on reasons for constraints (Table 4.27) was a useful tool in interviews as a point of departure in discussions on why a constraint may be experienced.
- Respondents at UNISA were feeling more threatened when information was gathered for the second research question, than respondents during data-gathering for the first research question. In the first case, the information was on how it was currently done without questioning the way in which it was done. For the second research question, more attention was devoted to why a process was being done in a certain way. In such a case people often feel as if they are being judged, even if this is not so.
- The familiarity with the environment after data-gathering for the first research question, assisted me in data-gathering for the second research question. The process models derived were used in the first two phases to determine the constraints, which meant that it was not necessary to identify the processes since the data was already available. Therefore, familiarity with the environment and the availability of the process models contributed to the reduction in the time needed to complete Phase 1 and Phase 2.
- Using the communication checklist (Table 4.28) as a triangulation exercise confirmed that the process management flow procedure successfully identified the constraints in the REGISTRATION process.

With regard to the usefulness of the procedure, the measurement indicators were used to indicate that in Phases 1, 2 and 4 there was a high use of the process models, medium in Phase 5 and low in Phase 3. Overall, the usefulness of the process models in the procedure was rated as *useful to a high extent.* For future research, one might consider elaborating the procedure to include visual tools such as CASE tools to assist in the decomposition of the different process models and also to show where the constraints are. Furthermore, the inclusion of conflict negotiation tools such as Core Conflict Cloud and Current Reality Tree (Patrick, 2001) should be considered in a re-engineering effort where changes will affect a number of staff members at the institution.

9.2.3 Summary: Research Question 3

The third research question focused on the preservation of the process models identified in the first research question and used in the second research question. The research question was as follows:

How can the educational process model be preserved and reused?

To ‘preserve’ in this context refers to ’keep in safety and protect from harm, decay, loss, or destruction‘(Wordnet, 2005). In computing, the concept of reusability is used in object-oriented programming and system analysis and design to refer to concepts that are stored for reuse. In storing process models, some work has been done on storing process models in the business domain (Malone *et al.*, 1999b; Phios, 1999). In order to reflect on the preservation of the process model structure, I had to investigate the use of process model repositories in the educational domain.

After considering different options, the Phios repository model, described by the Massachusetts Institute of Technology (Phios, 1999), was suggested as a starting point for storing educational process models (discussed in section 4.3.3). The suggested educational process model repository used the same concepts, with some minor adaptations to the representation of specializations and the enforcing of polymorphism in generic process model representations. Furthermore, a more formal object-oriented notation was suggested in referring to the process model structure, by suggesting the use of stereotypes.

The feasibility of the adapted model was investigated at UNISA using the REGISTRATION process. Using the suggested educational process repository, the processes for the three levels identified during Phase 5 of the requirements elicitation procedure (Table 5.12) were modelled. Polymorphism was enforced where a generic process is specialized for different scenarios, with each specialization producing the same output but with different techniques. *Application form completion* is a process in both the electronic scenario and in the counter scenario. Although the form is completed online in the first scenario and is in a physical paper form in the second scenario, the output is the same: the form is completed with the relevant information. A more formal object notation was also enforced with the use of the stereotyped notation defined in section 4.3.3 for modelling the six scenarios for the REGISTRATION process (Figure 7.7). It was found that it is feasible to model educational processes with the educational process repository model (section 7.4.1). Furthermore, two respondents involved in using object technology confirmed that the suggested object notation is a better way of modelling the concepts within the educational process model, when object concepts such as specialization and generalization are used.

With regard to the feasibility of storing the educational process model structure in a physical repository, the Phios repository was used as guideline and a feasibility study was done, comparing the structure of the *Sell Process* and the *Application Process*. It was found that it is indeed possible to store the *Application Process* in the current Phios repository structure, which means that it is feasible to store processes represented by the adapted educational process model.

9.3 DISCUSSION AND REFLECTION

This section focuses on the lessons learned during the study.

This has been a qualitative study based on facts and perceptions; there is a possibility that there was data to which I did not have access. All assumptions made were based on my personal perception and the data that I gathered at the time of research using sound methods as described in Chapter 4. As stated by Katie Fraser (2003):

> *If I discovered an apparent causal relationship within my research, it would be impossible to establish it as a 'true' relationship. No matter how many times the same relationship is discovered, its appearance may be context-specific and it would never be truly possible to be sure that my perception of the world accurately mirrored the real world. However, a casual relationship that constantly generalizes across individuals, time and space, is a better and better candidate for a true representation of the objective world (Fraser, 2003:5).*

In section 9.3.1 the focus is on the methodological reflection, followed by the substantive reflection in section 9.3.2 and the scientific reflection in section 9.3.3.

9.3.1 Methodological reflection

The methodological reflection refers to the extent that the research approach influenced the results obtained in the study. The main research method used in this study was qualitative research. In this section I reflect on the various research approaches used in each of the three research questions respectively.

9.3.1.1 Methodological reflection: Research Question 1

For the first research question, development research combined with case study research was used to derive the process model structure. This included the development of a requirements elicitation procedure as a data collection instrument. The requirements elicitation procedure as a data collection instrument included the other data collection instruments, including the questions asked of respondents, observations and contextual analysis. A mistake often made in information technology, is falling into the trap of seeing the product (i.e. a piece of software or technique) as 'the research'. Some might therefore say that the requirements elicitation procedure is the 'research product' and not a data collection instrument, but this is not the case. The research is not the creation of the new artefact; the research is the use of and reflection on findings during the application or development of the artefact.

For the first research question my goal was to identify the generic institutional structure. It was not sufficient to focus on one institution and then give feedback on a single case. I had to look at more than one institution in order to compare the results from the different institutions, before I could argue that the structure derived is generic. This made it necessary to use different environments or *case studies*. To ensure that the results are scientifically sound and comparable, it was necessary to use the same procedure at each institution. There was no procedure available with the scope of identification of process model structures in the educational domain, and I therefore developed the requirements elicitation procedure at UNISA. After application of the procedure at one institution, the theory used in the procedure was adapted to include best practices, or what was learned during the application of the procedure. This indicates that the research done was *development or action research* where research is of a cyclic nature, adapting the theory according to what is learned in practice. I also used some concepts of *grounded theory* in the research in cases where the research reflects on what already exists in practice. However, this is not a purely grounded theoretical study, since I did not retrieve theoretical models or frameworks from practice. I only reflected on the existing structures in practice, which involves a small shift in emphasis.

Interviews, observations and contextual analysis were included in the data-gathering as data collection techniques used during application of the requirements elicitation procedure. An alternative would have been to use *joint requirements planning (JRP)*, which is a process whereby group meetings are conducted to analyze an environment and define requirements (Whitten *et al.*, 2000). JRP embraces the active involvement of system owners, systems analysts, system users, and some system designers and builders, in jointly performing systems analysis. This was not feasible because the study was a research project initiated as research, and not an institution-based development project. Sessions of this nature will only be feasible if the project is defined as an institutional development project and approved by management as part of a re-engineering or development initiative.

An alternative to interviews is the use of structured questionnaires. Questionnaires are used in cases where the researcher needs to collect facts from a large number of people while maintaining uniform responses. For my research it was necessary to reflect on what is happening in different units, where the initial questions to interviewees were the same, but the responses were based on different actions and were not uniform. Therefore, although questionnaires could have been used, face-to-face or telephonic interviews were appropriate to retrieve information in different environments. Interviews also had the advantage that, after each interview, a piece of the 'puzzle' of understanding the nature of the environment was added to the researcher's knowledge on the domain, which enabled the researcher to use the information in the interviews conducted thereafter. Questionnaires, in contrast, give all the information in one set of data, and different methods are needed to build up the information on the application domain.

Observation was used in data-gathering for both the Production Unit and course development at UNISA. The Production Unit has a physical procedure in which one can 'see' how course material proceeds from one subprocess to another. The observations were combined with interviews with staff members involved in the unit, in order to gain an understanding of how the course material is handled from inception until the printed material is produced at the end of the production line. Similarly, in course development I was an active participant involved in the development of course material for a number of course modules, and therefore understood the processes.

Contextual analysis was used to study existing documentation on the processes within the institution. On a high level there was not much material available and the contextual analysis procedure was used to derive the process model structures. On lower levels in units, there was some material available on the working of the unit, but not on the interaction with other units. The requirements elicitation procedure provided for this lack of information and prescribed that the units within the institution should be identified (Phase 2), that the activities within the units should be identified (Phase 3), and that this information should be used to construct the process models (Phase 4 and Phase 5). The web and telephone lists were used in the identification of the different units in Phase 2, while interviews were used as main the data collection technique to determine the activities in units in Phase 3.

After the three cycles of data-gathering at the different institutions it was necessary to reflect on what was learned. Some *interpretation* was needed. The techniques from interpretive research were used in which the structure derived from the first three institutions was compared and verified at a fourth institution, the University of the Freestate. An alternative was to use the data from the first cycle, derived at UNISA, and only verify the results at the three remaining institutions. This would have been a faster way of verifying the high-level structure, which is generic, but could have caused problems lower down. For the structure on the second and third level, the possibility exists that the researcher may rely on pre-knowledge and not replicate the processes as-is at the other institutions. A more detailed analysis was therefore an advantage, and a small price to pay, in deriving conclusions on the generic nature of process models in the higher education domain.

9.3.1.2 Methodological reflection: Research Question 2

For the second research question the research focused on the management of flow within the process model structure. The reasons for studying and managing the flow within institutions differ, but are mostly to do with re-engineering purposes. To illustrate the use of process models in a re-engineering effort, a re-engineering procedure was developed using a combination of existing re-engineering process modelling knowledge (Hammer, 1990) and theory of constraints as suggested by Goldratt (1992).

For the second research question, the main approach was a case study approach, in which the focus was on the constraints within UNISA. A single case study was sufficient because the goal was not to compare the results with other institutions, but rather to study the usability of the process models derived in a re-engineering effort in the educational domain. Furthermore, although some characteristics from development research were present (Table 4.3), the focus was not on enhancing the existing theory, and therefore a cyclic approach was not necessary. Similarly, interpretation was needed in the selection of solutions, but this also did not contribute to the existing theoretical knowledge. There was therefore no alternative but to use a case study approach for demonstrating the usefulness of process models in an activity such as the management of the flow within institutions.

For data-gathering the existing process models derived in the first research question were used as resources in Phase 1 and Phase 2 of the process management flow procedure to derive the process list and to identify the constraint processes. Interviews were used in all the phases to determine the constraints. For the throughput in the *Course data capture,* subprocess in REGISTRATION, SQL queries were used to determine the rate of throughput. For the solution selected in Phase 4, an automated electronic registration system was used as proof of concept and used in Phase 5 as documentation in discussions related to the feasibility of the solution. A list with reasons for constraints in the high-level process model was suggested (Table 4.27) and used in data-gathering as a starting point in discussions on the reasons why the constraint was being experienced. As a triangulation exercise, a checklist (Table 4.28) was used, which confirmed the constraints identified in the process management flow procedure (Phase 2). To measure the usefulness of the process models, an ordinal level of measurement was selected to indicate to what extent the process models were used in the different phases of the procedure.

The decomposition of the REGISTRATION process was selected as an example in the case study in Phase 1. This limited the results to the constraints identified in this process. However, the procedure is cyclic in nature where Phase 2 is repeated so that the selection process was not conducted on one scenario only but on different levels of the REGISTRATION process. This was done successfully, which is an indication that if it is possible to repeat the selection process for different levels (even within the same process), it should also be possible to repeat it for other processes.

One advantage of using the existing process models in data collection was that it shortened the time needed to complete Phase 1 and Phase 2. This emphasizes the fact that the models are reusable in activities such as re-engineering. For an institution involved in re-engineering activities for which there are no process models, the time required to establish the constraints within the institution will be much longer, because the chain of processes or subprocesses in which the constraint is being experienced, would first have to be identified. This once again emphasizes the importance of seeking for solutions that the third research question asks, i.e. how can the educational process models be preserved so that institutions that need to refer to them, can use them without doing an in-depth analysis, or at least have a set of process models available that may be used as a starting point or as reference models.

One concern about the formalization of the management flow procedure is that although it seemed to be ideal to use Goldratt's (1992) theory of constraints in processes where the Throughput is easily measurable, such as in a production system, the existing theory does not make provision for systems where the Throughput and Demand are difficult to compare, which in fact applies to the educational domain. A constraint was identified in COURSE DEVELOPMENT based on the fact that material is sometimes received late, but it is difficult to focus on one constraint and pinpoint that as the problem area without going through a decomposition procedure. In a manufacturing system it is easier to determine the constraint because the problem area is easier to 'see'. The data flow management procedure was adapted to make provision for this concern by using not only numeric values for the Throughput and Demand, but also three other indicators to indicate no constraint, a possible constraint or a satisfactory situation.

9.3.1.3 Methodological reflection: Research Question 3

The third research question focused on the preservation of the process models for the future. This study consisted of interpretive research with some characteristics taken from development research where the existing theory was adapted to be used as an educational repository model. The alternative to this approach was to investigate the feasibility of using the theory exactly as was defined by the MIT process repository (Phios, 1999). In comparing the examples used in the MIT process repository with examples from the educational domain, it is possible to deduce that it is feasible to represent the examples using the existing model. In enforcing a more formal object-oriented approach by introducing polymorphism and the use of more formal object notation in the model representation, the existing theory is enhanced and 'truer' to the object-oriented paradigm.

For data collection on the feasibility of the proposed model, the existing process models were used in combination with the adapted theoretical model derived from the MIT process repository. This was mainly a theoretical study where the theory from an existing model was used and according to contradictions and interpretations, adapted. It was then applied using the REGISTRATION process as an example to drew conclusions about the feasibility of the adapted model. Interviews were conducted with two field specialists on the nature of the adapted model. It was not necessary to discuss the model with more respondents because even if the adapted model was new, it used theory from the object-oriented paradigm. This simplified the comparison activity between the existing and new model, where the new model supported more object-oriented concepts in both the specialization of processes and the notation used to model the examples.

9.3.2 Substantive reflection

In this section, the focus is on the substantive reflection where the goal is to compare the results of this research with other related research in the same area. This study was initiated as a result of my own interest in the potential change within higher education owing to technological innovations. As noted at the beginning of this thesis, several authors emphasized the need for strategic planning and innovative plans in re-engineering the existing structures of the higher education application domain to make provision for the implementation and use of IT (Laurillard, 1993; Allen & Fifield, 1999; Oblinger & Katz, 1999; Bates, 2000; Luker, 2000). For the last fifteen years, strategic planning for IT has been an important issue in institutions and the rapid change in technology and the urgent need to stay competitive will force institutions to keep on introducing policies that provide for constant change management (Darwin, 2005). In 2004, according to a survey done by the EDUCAUSE Core Data Service at 645 institutions, strategic planning for IT was still one of the most important issues in the changing university (Spicer & DeBlois, 2004). It will also be necessary to have a clear focus on ‘what’ has to be changed and ‘how’ to change it (Scott, 2003a).

Changing existing systems is unfortunately not an inexpensive exercise. According to two publications released in late 2002, higher education has spent five billion dollars over the past decade on enterprise resource planning (Lawson, 2003). This is one of the reasons why HEIs in general have successfully resisted the influence of new technologies, where funding is still the top current IT issue in such institutions (Spicer & DeBlois, 2004). Institutions are faced with a dilemma where, on the one hand, there is a rising frustration with higher education’s slow transformation efforts (Barone, 2004) and on the other, the fear that the institution will not really save money by investing in information technology (Hawkins & Oblinger, 2005).

Re-engineering processes have been identified as a solution that will reduce the cost of education, increase access and improve quality (Heterick, 2004). A strategy is surely one of the most important issues in re-engineering the university (Duderstadt, Atkins & Houweling, 2003), but institutions need cheaper 'short-cuts' to assist in the conversion process. A positive contribution in this arena is the new openness and sharing culture created by many researchers, such as the open source phenomenon (Wheeler, 2004). Software developers, software users and even businesses now realize the value of, and support, the idea of sharing and reusing concepts. In the software implementation domain, reusability is incorporated as one of the main concepts in the new programming paradigm, called 'object-oriented programming'. The reuse of concepts is also supported in the unified software development process (Jacobson *et al.*, 1999). Early in the 1990s, MIT also realized the value of extending the reusability of processes, supporting object concepts with the creation of the Phios repository for business processes (Phios, 1999). Incorporating the concept of reusability of process models into the re-engineering strategy of an institution may contribute to savings in feasibility studies.

In this study the focus was on what the reusable generic process structures are and on how they can be preserved for reuse in re-engineering efforts. For business processes a similar study was initiated at MIT where a reusable repository was created based on structures in the business application domain. However, the university is not a business (Greenberg, 2004), and therefore the process models applicable in a business may overlap in certain areas, for example in support structures such as financial systems, but will be totally different in other areas. Since the primary processes of a business are different from those of an HEI, the current ongoing research at MIT on the notion of a process model repository (Malone *et al.*, 2003) should not be ignored, but should only be considered as a guideline during identification of the processes unique to the educational domain.

In software engineering there is a new movement supporting the idea of building experience repositories, where the experiences recorded in previous activities are reused for activities such as the anticipation of reaction to changes or the acceptance and impact of improvement activities (Scott, Carfalho & Jeffery, 2002; Schneider & Von Hunnius, 2003). With regard to learning objects, the current research focuses on the building of object repositories to support online course construction. Some repositories are available as open courseware, including Merlot (www.merlot.org), MIT Open Courseware Free (http://wcw.mit.edu/), and World Lecture Hall (www.utexas.edu/world/lecture). Some research is also currently being done on the creation of environments needed for the object repositories (Krishnaswamy *et al.*, 2004).

According to a report published by CAUSE on the re-engineering of higher education environments, institutions do not manage through structures anymore, they manage through processes (Ernst *et al.*, 1994). The authors elaborate and argue that it is necessary for the 21st century to promote easy access to information needed to make decisions, including the workflow within the university structure. Bruno *et al.*. (1998) reported on a practical process engineering project initiated between Glendale Community College and Oklahoma City Community College. The focus was on systems engineering related to process engineering, where the selection of processes and a change approach were addressed (Bruno *et al.*, 1998). This work is related to the work addressed in the second research question, where the focus is on re-engineering the environment. Although a process engineering approach was used, the focus was not on the process models, but rather on the re-engineering procedure.

In a report on an investigation into techniques for business process modelling and their application to an audit of current business processes at the University of Natal, the authors did a thorough investigation into the use of process modelling (Buller, Gerritz & Petkov, Unpublished). They used Porter's (1985) idea of the value chain and identified the primary processes and secondary processes applicable to an audit effort. In my research, the educational value chain was also identified using Porter's (1985) value chain and presented as part of the conclusion in Chapter 8. The difference is that my focus is on the processes important in creating an educational environment, in contrast to the work of Buller *et al.* (unpublished), which that focuses on the audit and therefore includes quality control and public relations as primary processes. The differences in the two chains identified emphasize that in referring to any chain and in making any claims about the generic nature thereof, it is very important to emphasize the context or the focus of the chain.

Identifying processes within an environment is not easy (Nikols, 2003). The reorganization of higher education through IT requires an in-depth understanding of the processes within the organization and the definition of structures (Prupis, 1992). My research is a move forward in the classification and presentation of structures in educational environments.

9.3.3 Scientific reflection

The scientific reflection focuses on what this research has contributed to the 'scientific body of knowledge', including what we have learned with regard to the product, process and methodology.

The scientific contribution of this study can be depicted graphically using the educational process model view constructed in Chapter 8, as illustrated in Figure 9.1.

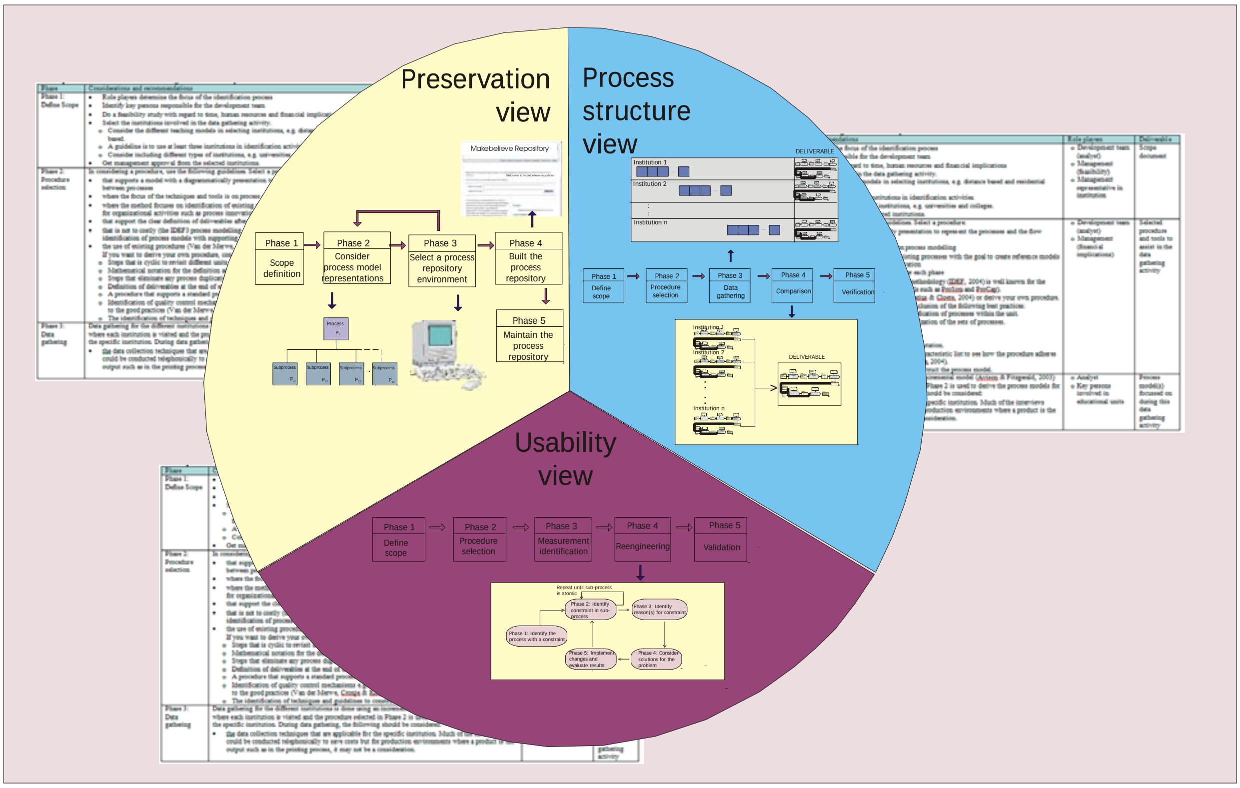


Figure 9.1: Educational process model view

The educational process model structure was the primary focus of this study. The structure was first identified and contributes to the process structure view. Section 8.2 discussed the product and the procedure recommended for identification of the educational process model structure.

With regard to the product, the following contributions are of importance:

- The identification of the process model structures in the educational environment where no procedure available was previously available to identify generic educational process model structures (section 8.2.1.1).
- The measurement of the characteristics of requirements elicitation procedures with the identification of a requirements elicitation list (section 8.2.1.3).

- The product produced by the first research question is the generic high-level process model structure identified at three different institutions and confirmed at a fourth one (section 8.2.1.4).

With regard to the knowledge gained about the process structure view, a procedure was derived from the best practices during the development of the product. This procedure consists of five phases. These are as follows:

1. The definition of the scope.
2. The identification of a procedure to derive the process model structure.
3. The data-gathering at different institutions.
4. The comparison of the results.
5. A verification technique to ensure that the procedure that one uses is a sound one.

A list of recommendations and considerations was described for each phase (section 8.2.2).

The *usability view* was addressed in Research Question 2 and focuses on the usability of the process model structures. There are different ways of testing the usability of the process model structures. I decided to use them in a process re-engineering activity owing to the motivation for this research, the availability of new technological innovations and the reaction of HEIs to the opportunities provided by these innovations. For the application of a process re-engineering activity, a process management flow procedure was defined using best practices from process re-engineering described by Davenport (1990) and Hammer (1990). The procedure was adapted for the higher education domain and forms part of the product contribution in this study. Theory of constraint concepts were included in the procedure, but I found that this is only ideal in cases where the Demand and Throughput are easily measured. Furthermore, an ordinal measurement was defined to discuss the usability of the process model structures in process re-engineering.

With regard to the methods used in the usability view, the best practices from using the process flow procedure at UNISA were incorporated into the definition of a procedure for discussions on the usability view. The procedure that focuses on the establishment of the usefulness of the process model structures can be generalized into five phases, including the:

1. Definition of the scope.
2. Identification of a re-engineering procedure.

3. Identification of a measurement strategy.
4. Re-engineering activity.
5. Measurement of the process model structures in the re-engineering activity.

A list of considerations that the re-engineering team may use in process re-engineering was included in section 8.3.2.

For the *preservation view* the research question addressed the reuse of the process model structures. The existing Phios process repository was adapted to support more object-oriented concepts and used in a feasibility study at UNISA to investigate the preservations of the process model structure. The contribution on product level was an adapted educational process model representation, which can be stored in existing process model repositories.

Furthermore, the best practices were incorporated into a procedure suggested for the preservation of process model structures suggested in section 8.4.2. The procedure for the preservation of educational process model structures includes steps to:

1. Identify collaborators.
2. Identify a process model representation.
3. Select a process repository environment.
4. Build the educational process repository.
5. Maintain the educational process repository.

For each of the phases, some considerations were listed in section 8.4.2, with provision for the development of either a new system or the adoption of an existing repository.

The combination of the three research questions into an educational process model view, adds a new view of educational process models to the current body of knowledge on the subject. Furthermore, it is possible to step back from what was done in this study and to generalize it into five actions that are needed if a researcher wants to describe the structure of another application domain. These steps are as follows:

1. An identification phase in which the structures are determined.
2. A classification phase in which the generic structures is determined.
3. A preservation phase in which the storing of the structures is investigated.
4. A development phase in which support tools and techniques are investigated.

5. A transfer phase in which the information is made available to interested parties.

9.4 RECOMMENDATIONS

The recommendations issuing from this study are presented as recommendations for policy and practice, further research and further development work.

9.4.1 Recommendations for policy and practice

During verification at the University of the Freestate I did come across any formal re-engineering procedures. Each project is assigned to a project leader who is responsible for management of the project. This approach proved to be successful, but as in other environment, there have been projects that have not been successful. This may, however, not necessarily be due to the lack of a methodology. Further research might be appropriate in which the researcher could ask the following questions:

- What are the factors that contribute towards the successful re-engineering of higher education environments?
- What are the factors that militate against the successful completion of re-engineering in higher education environments?

Related to this are the guidelines on conflict negotiation in a changing educational environment in terms of which the researcher asks the following question:

- What are the considerations related to human resources when a HEI considers the improvement of systems through technological innovations?

The high-level process models were derived by means of the requirements elicitation procedure during data-gathering at three different institutions. These three institutions use different teaching models (distance-based and residential) and consist of two universities and one technikon. These are complex environments and it is possible that the findings may be generalized to other environments than the HEI domain. Some of the research questions that the researcher might ask in another environment, for example the business environment, include:

- What are the procedures involved in establishing the process model structures for the new environment?

- What tools and techniques established in this research can be generalized for this new application domain?
- How should the tools and techniques established in the educational environment be adopted for use in the new domain?

For payment verification during REGISTRATION one could argue that an automatic banking verification is beyond the scope of the student profile at UNISA. A study is needed to determine the profile of the students with access to electronic payment mechanisms. Some of the questions that need to be addressed in this further research include:

- How many students who prefer electronic registration have access to banking facilities?
- Is it feasible to expect students to open a bank account if they prefer to use the electronic registration facilities?
- What are the support structures necessary if an institution decides to use only credit card payments for on-line registrations?

9.4.2 Recommendations for further research

The requirements elicitation procedure developed for Research Question 1 *adheres* to 75% of the characteristics identified for a requirements elicitations procedure. The procedure may be changed to adhere to the remaining 25% of the characteristics. The question that the researcher might ask is:

- What are the techniques necessary in a requirements elicitation procedure for data-gathering in the higher education domain so that the procedure adheres to all the characteristics identified for a requirements elicitation procedure?

Prof. Peter van Eldik from TechPta commented that it may be valuable to consider a graph with responsibilities. This could enable the user to see that even if processes are generic at different institutions, the shift lies in the responsibilities. This could be considered for future research if included in a study where one of the questions is: what are the elements in a process model structure that reflect on the responsibilities in the institution?

There are different research opportunities to enhance the process model representation relating to process model preservation. I only addressed the specialization in this research. Future research could address other components such as the use of UML notation in coordination theory. For this research topic the researcher might want to consider the following:

- What is the notation in the preservation of structures related to coordination theory?
- How could the educational process model structure be formalized to include the ‘uses’ and ‘parts’ defined in the Phios compass?

9.4.3 Recommendations for further development work

For the construction of the process models I suggested a mathematical model that links the processes using input and output resources. The notation simplifies the development of tools that might assist in the requirements elicitation procedure. Furthermore, the identification of atomic processes can also be assisted by tools. The researcher could include the following questions as part of a design research project:

- What are the components of a system that supports the identification of process model structures in the educational application domain?
- What are the guidelines in establishing the atomic processes on the lowest levels of the process model structure?

The suggestion of the establishment of process repositories for the educational domain opens up a number of research opportunities. For development work this includes the development of software to support the educational process model repositories. The questions that the researcher might ask are:

- What are the components for the representation of the educational process model structure?
- How could the process model repository be implemented so that duplication is not allowed?
- What graphical tools are necessary and how should these be represented to the customer for modelling the higher education process model structures?

9.5 CLOSURE

Thus, this study supports the hypothesis that *a generic educational process model structure for higher education institutions can be established; a process management flow procedure can be used to manage the flow within an educational process model; and that an educational process model can be stored and reused in re-engineering efforts.*

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CD Content: Appendices and publications

The attached CD consists of the Appendices A to C and the conference and journal papers published from this research. The following seven papers are available on the CD:

ICTE 2000.pdf	Structures and Techniques used in a Distance Virtual Learning Implementations
IDPT 2003.pdf	A process modelling approach to requirements elicitation to incorporate e-learning as a core learning strategy
ICICTE 2003.pdf	A requirements elicitation methodology for educational process modelling
ISICT 2004.pdf	The Educational Value Chain as modelling tool in reengineering efforts
SAClLA 2004	The Functionality of a Requirements Elicitation Procedure Developed for Process Modelling within the Higher Education Application Domain
SDPS 2004	A requirements elicitation process modelling technique for incorporation of e-learning as a core learning strategy
SACLA 2005	Selecting a Qualitative Research Approach for Information Systems Research

The CD has a user-interface that will guide the reader towards the material of interest.