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TOWARDS A FRAMEWORK FOR EXECUTIVE DASHBOARD DESIGN IN A TERTIARY EDUCATION INSTITUTION

by

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DECLARATION

I declare that this is my unaided work and has not been submitted to another university for any degree.

26 June 2014

Signature

Date

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Abstract

A lack of accurate and timely decision support information has been prevalent in Unisa over a considerable period. Management has highlighted accurate and timely management information as essential to reinforce planning, accountability and performance management in the institution.

The purpose of this study was to investigate how a framework for the design and development of executive dashboards in tertiary education institutions can be developed. A qualitative approach, using design science research, was used during the empirical work of the research. Data collection was done by means of a literature analysis and semi-structured interviews. The artefacts developed for the design science process were storyboards and exemplary dashboard prototypes in the real environment. Evaluation and refinement cycles were performed to refine the artefacts and adjust design guidelines. The evaluation process was done by means of semi-structured interviews.

The findings are communicated by means of the thesis with the development of the framework for dashboard development and by the deployment of the dashboards to academic managers in the real environment. Further research initiatives can develop comprehensive dashboard frameworks for tertiary education institutions based on business intelligence maturity benchmarks, and can explore how analytics can be incorporated in the dashboards to enhance decision support information.

TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

AIS	Association for Information Systems
BAM	Business activity monitoring
BI	Business intelligence
BICC	Business Intelligence Competency Centre
BPM	Business performance management
CBI	Computer-based instruction
CBIS	Computer-based information system
CEMS	College of Economic and Management Sciences
CEO	Chief Executive Officer
CIO	Chief Information Officer
CISP	Cooperative interactive storyboarding prototyping
CoD	Chair of Department
CPM	Corporate performance management
DCLD	Department of Curriculum and Learning Development
DoE	Department of Education
DSDM	Dynamic systems development method
DSRM	Design science research methodology
DSS	Decision support system
EIS	Executive information system
EPM	Enterprise performance management
ERP	Enterprise resource planning
ESS	Executive support system
ETL	Extraction, transformation and load
FTE	Full-time equivalent
GEM	Gateway to Educational Materials
HCI	Human-computer interaction
HoD	Head of Department
HR	Human resources
IPMS	Integrated performance management system
IS	Information system
ISDT	Information design theory

IT	Information technology
JAD	Joint application development
KPI	Key performance indicator
KSF	Key success factor
MIS	Management information system
NQF	National Qualification Framework
NSFAS	National Student Financial Aid Scheme
OLAP	Online analytical processing
PI	Performance indicator
RAD	Rapid application development
ROI	Return on investment
RU	Radford University
RUP	Rational unified process
TCO	Total cost of ownership
TP	Transaction processes
UCD	User-centred design
Unisa	University of South Africa
URL	Uniform resource link

LIST OF FIGURES

LIST OF TABLES

TOWARDS A FRAMEWORK FOR EXECUTIVE DASHBOARD DESIGN IN A TERTIARY EDUCATION INSTITUTION

1. CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

The University of South Africa (Unisa) is the largest distance education institution in Africa (University of South Africa, 2012; Wikipedia, 2013). It offers a full range of qualifications in higher education to students within and beyond the borders of South Africa. It has a well-established infrastructure that provides quality learning material and effective tuition. Its overall objective is to educate people, enabling them to become skilled and responsible citizens. Unisa was established in 1873 and was one of the world's first distance education universities. Since its establishment, the institution has gone through different phases:

- In the 1940s, the whole concept of Unisa met with resistance, largely because it conflicted with the academic community's perception of what constituted university teaching and learning (the view being that direct contact teaching methods were needed for tertiary education) (Suttie, 2005:99).
- In 1946, the first exclusively distance education institution was established. The resistance gradually dwindled as time passed and the idea gained acceptance (Pityana, 2007:3).
- The third phase, after 1994, was characterised by a decline in growth. During this phase, South Africa became a democratic country and the external environment was in a process of transformation (Pityana, 2007:3).
- A fourth phase, which started in 2004, was marked by rationalisation in the national education system and tightening central control over growth and the related financing of educational institutions in the country by the then Minister of Education, Professor Kader Asmal.

- This phase was also marked by the general capping of enrolments by the erstwhile Department of Education (DoE). It was marked by several mergers of tertiary education institutions of which the merger of the then Technikon South Africa (Technikon SA) with Unisa was one (Jansen, 2004:294; Maharajh et al., 2011:200).

The University started out as a small, educational institution and, over the years, expanded to become the large organisation it currently is. During the course of Unisa's history, radical changes also occurred in the political, competitive and economic environments in which the University operates. Several investigations were conducted with the purpose of gaining insight into the situation and realigning the University with the changed external environment. It was also recognised that the University needed to be "revamped" if it was to meet the challenges it faced. After the merging of the institutions under the scrutiny of the erstwhile Minister of Education, Naledi Pandor, and the erstwhile DoE, the new merged management focused more on the strategic management of the merged institution. During this time, proper strategic and operational planning were performed.

Three investigations that were undertaken by the University are discussed to illustrate how the need for management information grew in the institution. The lack of management information started to feature in the recommendations of the different investigations. The projects are discussed to show how the need for management information increased and, finally, the importance it received in the University's 2015 Strategic Plan (University of South Africa, 2004). The following recommendations and outcomes of the investigations and Unisa's 2015 Strategic Plan are elaborated on:

- Programme Optimum – 1997
- Deloitte & Touche Project – 1997
- Project 2000 by Simeka Consulting – 2000
- Unisa's 2015 Strategic Plan

1.1.1 Programme Optimum – 1997

Programme Optimum's investigation found that the effect of the internet, as well as residential universities and technikons introducing more distance programmes had changed the competitive environment of tertiary distance education over the years. The government reduced the funding per student and Unisa no longer had a monopoly in South African distance education. Other residential educational institutions entered the distance education market by also offering distance education programmes in direct competition with Unisa. It also needs to be noted that Unisa's tuition model was dated and its student support services were subject to a great deal of criticism. The combination of all these factors, plus the fact that the University's cost structure proved to be too high, led to a comprehensive rationalisation programme.

Following a report to Council (Optimum Commitee 1997), Programme Optimum was introduced. It encompassed several projects that aimed to identify, cost, prioritise and rationalise the University's support service activities. The committee recommended that the course database and student support maintained and introduced courses within the parameters of government's new subsidy structure. The committee also recommended the management of cost-effective levels of student support. Management was instructed to convert management structures that were suitable for a small, growing organisation into structures suitable for a very large organisation. Finally, marketing and franchise agreements were compiled to analyse the markets and develop strategies for distance education that would secure Unisa's diminishing market share and ensure its future participation in niche markets. The rationalisation activities required more and more information, which was not freely available at the time, to inform investigations and decisions.

1.1.2 Deloitte & Touche Project – 1997

At the end of 1997, Unisa contracted the services of the Deloitte & Touche Consulting Group. Deloitte & Touche was tasked to review the University's financial position, find out the reasons for the University's financial crisis and evaluate resource efficiency.

Deloitte & Touche was also tasked to make recommendations that would alleviate the University's immediate financial problems. Deloitte & Touche's recommendations focused on generating revenue, reducing costs, establishing budgetary and financial control mechanisms, and improving human resource and industrial relations management. The provision of information on current services and costs to the University was recommended. Deloitte & Touche Consulting Group's Report to Council in 1997 concluded that the University's transformation process required strategic direction. Stakeholder differences would have to be resolved, and the University's processes had to be re-engineered. This included (where appropriate) technological support.

1.1.3 Simeka Consulting – University of South Africa: Project 2000

By the end of October 1998 Simeka Management Consulting Group (Simeka) undertook an investigation as part of a project named Project 2000 (Simeka Consulting, 1998). This project focused on defining the nature of Unisa's core functions, and the structural and strategic implications of these functions.

- Firstly, Simeka recommended that the University addressed the leadership problem and used the new Unisa Act to provide a framework for constructing a new leadership structure and processes. The Council also had to bereconstituted in terms of the new Unisa Act and a new management committee and senate had to be appointed.

- Secondly, in response to the threats and challenges of transformation, declining student numbers, new competition and changes in government funding, the following recommendations were made: Unisa had to strategically reposition itself. The University had to define the core value it would provide to specific target groups and how internal systems would be aligned. Policies and resources to achieve this goal had to be developed and identified, and the University had to explain how existing resources would be optimised. The institution had to become more focused and define its services and the provision of these services more clearly.

- Thirdly, Simeka concluded that it was vital for Unisa to align its internal systems, structures, policies and practices (the aspects that informed its institutional culture) in order to facilitate the necessary change.

Significant change in the institutional alignment of systems and policies in the following areas were identified. Management information systems were among the problem areas to be addressed:

- Human resource management
- Organisational structures and decision-making
- Financial systems
- Application of information technology (IT)
- Management information systems (identified as part of the problem)
- Application of policy

The recommendation was to restructure the University and align its functions and structures with organisational processes, as well as the requirements for transformation. It was found that Unisa's changing context is fundamentally linked to changes in its key stakeholders and the pressures these stakeholders were exerting on Unisa.

Simeka found that the issue of understanding its core functions was central to Unisa's repositioning and transformation process, since it influenced Unisa's role and position in that context. The core functions were seen as the reason for Unisa's existence. These functions included tuition, research, and community participation. The average division of time between these functions was found to be roughly as follows:

- Tuition: 60−70%
- Research : 10−25%
- Community participation: 5−10%

1.1.4 Unisa's 2015 Strategic Plan

The above information shows that, for a number of years, management information has been identified as a strategic issue. In 2004, Unisa merged with Technikon SA. The new management was more aware of strategic management practice and Unisa's 2015 Strategic Plan emerged with the following ten goals (University of South Africa, 2004):

1. Effect a seamless transition to harmonised and coherent structures, policies, systems and practices for the merged institution.
2. Position Unisa as a leading provider of quality distance education programmes through an academic product range that expands on its comprehensive character.
3. Promote research, increased capacity and productivity aligned with national priorities for knowledge development.
4. Utilise the resources and capacities of the University in community development initiatives, and collaborative partnerships.
5. Establish service-orientated, technology-enhanced learner support to increase retention and throughput.
6. Create a nurturing environment to promote student well-being, foster a sense of belonging to Unisa, and mobilise alumni in the service of the University.
7. Establish quality governance, planning, administrative and management systems led by best practices.
8. Manage financial, human and infrastructural resources rationally to monitor expenditure, optimise value, manage risks and ensure financial sustainability.
9. Foster a healthy, secure and stimulating environment for staff, students and visitors, and protect the assets of the University.
10. Establish a performance-orientated approach to management, promote quality assurance, and assess outcomes and reward productivity and excellence.

Strategies to address the above goals were identified in Unisa's 2015 Strategic Plan. A strategy was defined to address Goal 7 above. The strategy aims to position the Department of Information and Analysis as an institutional resource to ensure coordination, coherence, integration and monitoring of planning activities and the provision of timely and relevant management information.

It shows that the management of Unisa considered management information to be strategically important. One of the three targets for Goal 7 was to annually identify, monitor and analyse institutional performance indicators, beginning at the end of 2006. This indicated that the monitoring of key performance indicators (KPIs) should be instituted. According to Wise (2006:2) "Business performance management (BPM) is the use of software to assist organisations to manage their processes and measure their KPIs in order to optimise the performance and to help drive the organisation's strategy as a next generation of business intelligence (BI)."

1.1.5 Discussion

Unisa's historical and strategic background, significant projects undertaken by the University and the relevant strategic information obtained from the projects were considered. Over the period, it became apparent that strategic information became more and more important. It shows the historical lack of management information and the strategic importance of management information systems (MISs), BI and KPIs at Unisa. The reports did not recommend any specific interventions until they had been captured in the 2015 Strategic Plan, which demonstrates that the management of the University considered it an imperative to improve the institution's strategic information situation.

In the next section, the research problem, methodology, outline of the study and limitations are discussed.

1.2 RESEARCH PROBLEM

From the facts above, it can be concluded that Unisa's top management is of the conviction that evidence-based, strategically aligned information is required for decision-making processes at all levels of the institution. During the formulation of Unisa's 2015 Strategic Plan, some of the challenges identified were also related to problems of execution, performance and accountability (Unisa, 2004:11). The following challenges are examples that have relevance to the current study:

- The management practices were not focused on the monitoring and evaluation of processes to improve on delivery, and decision-making information was generally lacking. Phrases such as "line managers are not adhering to due process, planning and deadlines" and "more streamlined decision-making processes" pointed to the lack of responsible management practices and utilisation of management information.

- The absence of a culture of accountability and performance management was identified as lacking when "a culture of accountability and performance management" was listed under the challenges identified by the investigation.
- The lack of management and planning information was identified as a challenge because of constant changes and the complexity in the University: the "dynamic and complex nature of the University makes it difficult to provide accurate and timely management and planning information".

The research problem can be formulated as a problem relating to a lack of accurate and timely management and planning information that supports planning and contributes to a culture of accountability and performance management. It is a formidable task to have factual, analytical information of the right context available when it is required for strategic and operational decisions. This information should also provide a true reflection of the performance.

At the time of the literature analysis, studies about dashboards in tertiary education institutions mainly focused on performance indicators in performance scorecards or dashboards. A limited number of studies focused on executive dashboards concerned with operational monitoring and numerous studies focused on analytics. Only three studies were focused on frameworks for dashboard development in tertiary education institutions. A small number of references of dashboards at South African tertiary education institutions were found, but did not focus on the guidelines for design and construction of dashboards in the institutions.

Although some references of educational institutions were found in electronic journal databases, such as EBSCOHost, Emerald, Google Scholar, Proquest and SpringerLink, no studies focused on defining the guidelines for the construction of effective dashboards or scorecards in tertiary education institutions in South Africa.

The purpose of this study is to do the following:

- Identify the design principles and characteristics of effective dashboards.
- Design and implement dashboards at Unisa.
- Enhance and optimise the dashboards to be effective and practical for tertiary education institutions.

This thesis attempts to address these issues by developing a contextually appropriate dashboard system that provides actionable decision-making information. Part of addressing this issue was exploring the suitability of the information, simplifying the process of attaining it and improving accessibility. The thesis resulted in developing design guidelines to support other designers to develop effective dashboard systems at South African tertiary education institutions.

1.2.1 Main research question

As mentioned above, the research study focuses on finding the design principles and characteristics of effective dashboards, as well as designing and implementing dashboards for managers at Unisa. These dashboards will improve the accessibility to decision-making information and be effective, suitable and practical in addressing managers' information requirements in tertiary education institutions. With the purpose defined in the previous section, the main research question can be defined as follows:

What are the characteristics of a framework to design and implement executive dashboards for portfolio managers at Unisa that will satisfy their decision-making information needs?

1.2.2 Subquestions of the research

i. To be able to answer this question, the following subquestions were identified and presented in Table 1.1.

Table 1.1: Subquestions of the research

Subquestion	Elements
Subquestion 1: What is the general background of executive dashboards?	• Defining the concept of dashboards in general • The difference between a dashboard and a scorecard • Goals and benefits of dashboards
Subquestion 2: How should dashboards be designed and implemented?	• Approach to follow in the planning and design of dashboards • The implementation processes
Subquestion 3: What are the characteristics of metrics on dashboards?	• How are metrics determined? • How are institutional performance indicators strategically aligned? • Leading and lagging indicators • How can the combined effect be portrayed and transformed into metrics easily interpreted for decision-making? • Design characteristics to consider
Subquestion 4: How are metrics presented on dashboards?	• The visualisation requirements of dashboards • Dashboard design • Dashboard layout • Dashboard navigation • Different dashboards for different levels of management and how it relates to the different metrics
Subquestion 5: How is data sourced for dashboard metrics?	• Complexities to overcome when data from different data marts are united into a single dashboard • Which security measures should govern?
Subquestion 6: How should executive dashboards be managed and maintained?	• Where should the management of executive dashboards fit into the reporting structure? • What are the skill sets required to develop and maintain dashboards for executives?
Subquestion 7: How can the return on investment (ROI) of executive dashboards be determined?	• How can the ROI of executive dashboards be determined?

Subquestion	Elements
Subquestion 8: What are the preliminary design guidelines and typical problems found in executive dashboards implementations?	• Conduct thorough user requirements analyses and liaise with users what the measures are • Decide on dashboard design and layout • Consult users about dashboard context and drilldown • Provide intuitive and economic dashboard navigation • Design best-suited metrics
Subquestion 9: How should the preliminary design guidelines for executive dashboards be adapted for the case study of Unisa?	• What are the iterations required to refine the developed intervention from the preliminary design guidelines to suit the specific requirements of managers at Unisa?
Subquestion 10: What are the characteristics and dashboard frameworks for tertiary education institutions?	• Performance dashboards/ scorecards in tertiary education institutions • Executive dashboards in tertiary education institutions • Analytical processing in tertiary education institutions • Technological level in tertiary education institutions • Frameworks for executive dashboard development at tertiary education institutions
Subquestion 11: How can a framework be defined to guide the development of dashboards at tertiary education institutions?	• How can a framework guiding the study be defined?

1.3 RESEARCH METHODOLOGY

Table 1.2 summarises the approach that will be followed according to the descriptors of research design defined by Cooper & Schindler (2001:135). The boxed option is the selection for the current study:

Table 1.2: Design descriptors framework

Category	**Options**
The degree to which the research question has been crystallised	• Exploratory • Formal study
The method of data collection	• Monitoring • Interrogation or communication
The power of the researcher to produce effects in the variables under study	• Exploratory • *Ex post facto* (investigators cannot manipulate outcomes)
The purpose of the study	• Causal • Descriptive
The time dimension	• Cross-sectional • Longitudinal
The topical scope – breadth and depth of the study	• Case • Statistical study
The research environment	• Field setting • Laboratory research • Simulation
The subject's perceptions of research activity	• Actual routine • Modified routine

(Cooper & Schindler, 2001:135)

- The research question has been crystallised and the study can be viewed as a formal study because the research question and purpose for the dashboard study has been identified. The principles of design science research will be the chosen method to structure and evaluate the research and will be discussed in detail in Chapter 3. The identification of formal study elements in the former statement indicates that the study is formal in nature and not exploratory. The research elements and process are unclear from the onset of the study.
- Processes of interrogation and communication will be followed as data collection methods. A literature study (non-empirical) of the subject field will be conducted to define key concepts and define a framework for the research design.

- An investigation into the subquestions of the research and preliminary design guidelines for prototype dashboard components, development process and evaluation will be conducted. Staff members have to respond to questions from the researcher during semi-structured and focus group interviews. The data collection will not be monitoring where the researcher inspects activities without responses from the subjects.
- The researcher's power to manipulate and control the variables in the study is classified as *ex post facto* where the researcher cannot affect the outcomes of the responses. It will not be experimental where the researcher tries to control the variables that influence the outcomes.
- The purpose of the study is descriptive because it is concerned with the design guidelines of the dashboards and processes to follow, which are "who", "what", "where" and "how" elements and it is not concerned with the cause-and-effect of the variables' impact on the study.
- The time dimension of the dashboard study is longitudinal in nature, the prototyping is repeated over an extended period and does not represent a condition at a point in time. The study was conducted over a period of 28 months from 2010 to 2013.
- The topical scope of the dashboard study is a case study in Unisa's environment and it will rely on qualitative data from more than one source. The study will be thoroughly verified through an iterative prototyping process. It does not have statistical breadth drawing inferences from a sample for the characteristics of a population.
- The study will be performed under field conditions in the actual environment. The storyboards will be a form of simulation and the actual dashboard development in the environment will be conducted as field study and will not be conducted in a laboratory or be simulated by mathematical models.
- The perceptions of the researcher and participants are addressed by the selection criteria used to select the participants. The selection criteria aims to select staff members who have experience in performing academic management functions and are able to bring insight into the study without their perceptions being affected. The ideal participants see the study as an exercise

and not as real-world issues. The researcher is a staff member of the business intelligence team at the University.

- Ethical clearance to conduct the study in the real environment was approved by Unisa's research management body, and the University of Pretoria gave ethical clearance was before the study commenced.

1.4 CHAPTER OUTLINE

The chapters in the research study are organised according to the following outline:

1.4.1 Chapter 1: Introduction and background

In Chapter 1, an introduction and background of the study is given. The research problem and research methodology are identified, followed by a chapter outline of the document.

1.4.2 Chapter 2: Literature analysis

The literature consulted for the research will be discussed in Chapter 2. A historical background of executive dashboards and a literature analysis based on the subquestions of the research, as outlined in 1.2.2, are conducted.

1.4.3 Chapter 3: Research methodology and design

Chapter 3 discusses the philosophical foundation of the research, the research methodology elements that will be employed in the research process, the data collection methods and the selection of respondents. In the following section, the principles of design science research and how it would be implemented in the study are explained. The next section explains the application in the actual research design and evaluation as performed in the case of Unisa.

1.4.4 Chapter 4: Empirical results and analysis

The key qualitative results and findings of this study will be presented in Chapter 4, and will be compared to results reached in similar investigations reported in literature. Recommendations, based on the results of the analysis and findings, will be made.

1.4.5 Chapter 5: Design guideline refinement and research methods followed

The findings will be summarised and evaluated against the original problem statement and research objectives. A framework for the development of dashboards in tertiary education institutions will be discussed.

1.4.6 Chapter 6: Framework development and conclusion

The design and development framework is developed by indicating the focus in relation to the system architecture. The design is discussed and how the research questions were addressed. The contribution of the framework to the existing body of knowledge of dashboard frameworks in tertiary educational institutions and the synthesis of dashboard design knowledge with the principles of design science research are explored. Recommendations, from insight gained during the analysis and findings, will be made and additional possibilities for future research will be explored.

1.5 DELIMITATIONS

This study has several delimitations relating to its context, constructs and theoretical perspectives.

Firstly, it is limited to the context of tertiary education institutions in South Africa, and the application of design principles developed by the study are specific to the South African educational environment. The study does not consider the diversity of all the different educational institutions in South Africa or address relevance to all the industries in South Africa.

Secondly, the study is performed in the Unisa environment as the only *bona fide* open distance learning university among many contact tertiary education institutions in South Africa.

The delivery methods and best practices of teaching and learning, the administration practices around, for example, registration methods, class attendance, accommodation and assessment management are vastly different and create very different information cycles.

Thirdly, the study is not concerned with information delivery system life cycles or classifications, although the relationships are hypothesised in the literature (Pellisier, 2000:73). Dashboards are considered a delivery mechanism of the BI discipline for the purposes of the study.

Fourthly, the study uses a high-level approach and does not evaluate or consider any specific software or hardware requirements or characteristics.

Finally, the study's literature review is primarily limited to literature from the discipline of the design and development of dashboards. Literature from related disciplines, such as strategy development and implementation, general computer system design and development, as well as system design and development in other industries (such as educational systems), are only consulted in passing.

1.6 SUMMARY

In Chapter 1, the background of the case study environment and the context of the research problem were covered. The main research question and subquestions for answering the main question were defined. The research methodology and methods that will be applied were also discussed. The discussion was followed by the structure outline of the thesis and the delimitations of the study were explained. In Chapter 2, the literature will be analysed.

2 CHAPTER 2: LITERATURE ANALYSIS

2.1 INTRODUCTION

Chapter 1 provided an introduction to the study, explained the research problem and research questions, the way the research will be addressed and how the thesis will be structured.

As a first step in the investigation of the executive dashboards for tertiary educational institutions, a literature study (non-empirical) of the subject field will be conducted. The investigation into the subquestions of the research and the preliminary design guidelines for the prototype dashboards will provide a better understanding of dashboard components, the development process and the preliminary design guidelines for the evaluation of the artefact development.

The literature study included a short overview of the historical background of executive dashboards and how it fits into the disciplines of BI and MIS. In the following section, the subject literature is discussed on the basis of the subquestions of the research as defined in Chapter 1.

2.2 BACKGROUND OF EXECUTIVE DASHBOARDS

Executive dashboards fall into the discipline of BPM (Eckerson, 2006b:29). This can be seen as an evolution of BI, which again evolved from MIS, and is related to Executive Information Systems (EISs), Executive Support Systems (ESS) and Decision Support Systems (DSSs) (Eckerson, 2006b; McAuly, 2000; Millet 1991; Wise 2006). This is a representative list, and not at all a comprehensive list of subject areas. In the following paragraphs, an attempt is made to find a definition for BI and BPM. A short overview of the other subject areas of MIS, EIS, ESS and DSS mentioned above is given in Appendix 1 of this report.

2.2.1 Business Intelligence

A few definitions of BI from the literature are given, followed by the view of the current author:

- BI is defined as to "consist of the processes, tools and technologies required to turn data into information and information into knowledge and plans that drive effective activity"; it is also compared to a "data refinery" (Eckerson, 2006b:49).
- BI is defined as "the capability to track, understand and manage information across the organisation" (Malik, 2005:13).
- Gartner Consulting (2007:5) defines BI as "the use and analysis of information that enables organisations to best lead, decide, measure, manage and optimise to achieve efficiency and financial benefit".

BI can be seen as a next generation of MIS. In addition to the processes, tools and technologies described by Eckerson (2006b:49), methodologies are required to analytically and contextually structure institutional information in innovative, user-friendly, actionable ways. The structuring of this institutional information should make the institution more intelligible to itself in support of management, decision-making and planning, building on historical information and developing predictive trends.

2.2.2 Business performance management

From the background above, one of the following progressions of MIS is BPM. Wise, (2006:2) defines BPM as a next generation of BI. According to her, BPM, enterprise performance management (EPM), and corporate performance management (CPM) are terms used for the same concept. It is the use of software to assist organisations to manage their processes and measure their KPIs in order to optimise performance and help drive the organisation's strategy. According to Ariyachandra & Frolick (2008:114), BPM is a business process utilising the IT provided by BI. Kang & Han (2008:473) consider dashboards to be a central component in the business activity monitoring of operational performance management.

Eckerson (2006b:30) defines BPM as “a series of organisational processes and applications to optimise the execution of business strategy”. There is a huge gap between defining a strategy and executing a strategy. BPM processes and tools support good management practices, which are aimed at directing business performance towards strategy execution and assisting the organisation to reach the desired strategic outcomes. BPM provides the analytical perspective to the business, and the BI infrastructure provides the vehicle to distribute the information throughout the organisation (Ariyachandra & Frolick, 2008).

Performance dashboards play a central role in BPM and take operational exception reporting to a next level by building the influence of management practices into the information and providing actionable information to executives (Eckerson, 2006b:30; Brudan, 2010:113). A true BPM is delivered when the information and corporate strategies are aligned by integrating the processes and tools in a cohesive and seamless way. The benefits of BPM are realised through improvements in communication, coordination and control. Some of the prerequisites for BPM are as follows (Eckerson, 2006b:29):

- An advanced level of organisational maturity
- A management philosophy
- An implemented management system aimed at improving business performance

From the above, it is understood that executive dashboards fall into the discipline of BPM and it is imperative that the performance indicators, which measure the performance against targets, should be aligned to the strategic objectives of the organisation. These indicators should also provide actionable information for planning and decision-making. BPM is an evolution from BI and is equivalent to CPM.

2.3 LITERATURE REVIEW OF RESEARCH SUBQUESTIONS

The subquestions of the research study will subsequently be used to discuss the literature.

2.3.1 Subquestion 1: What is the general background of executive dashboards?

2.3.1.1 Defining the concept of dashboards in general

Many articles and books give definitions of dashboards and scorecards. These sources of information will be analysed to learn more about the nature and specifications of dashboards. Descriptions and definitions of dashboards or scorecards are listed alphabetically:

- Bauer (2004:1) defines a dashboard as a customised graphic interface that delivers mission-critical information on a real-time basis to business decision-makers via a variety of visuals. These visuals include gauges, alerts, charts, tables and spreadsheets. He warns that the metrics should be aligned with enterprise goals, strategies and objectives, and are proactively leveraged to optimise enterprise-wide decision-making and collaboration. The key driver in the design and development of the CPM dashboard is that it empowers the user to make fact-based business decisions by providing complete information (and metrics) at the appropriate levels of granularity.

- With the information value chain in mind, performance dashboards can be seen as “powerful tools to transform companies into learning-based organisations that use fact-based decision-making to achieve strategic objectives” (Eckerson, 2006b:49). It is a powerful agent of organisational change. Like a magnifying glass, it focuses an organisation on the key things it needs to do to succeed. It allows managers and users to do the following:

- Monitor critical business processes and activities with business performance metrics that trigger alerts when the business performance reaches an exception.
- The relevant and timely information from multiple perspectives and at various levels of detail allows the analysis of root causes of problems.
- The performance dashboards encourage the management of people and processes to improve decisions, optimise performance and ultimately steer the organisation in the right direction (Eckerson, 2006b:5).

- Griffin (2003:1) provides the following definition: "in short, a dashboard is a one-screen display that enables executives and knowledge-workers to monitor and analyse an organisation's KPIs. It presents actionable information at a glance and up-to-date information on status and forecasts against benchmarks".

- The information on dashboards is presented in a very graphic and intuitive format and users can investigate and explore the supporting information to make timely business decisions. The data from enterprise data resources is prepared according to the business context to present clear, actionable information to users (Kopcke, 2003).

- The elements for building dashboards can be categorised into three broad areas: what is displayed, for whom it is intended, and how it is presented (Malik, 2005:15). The elements are discussed in more detail under section 2.3.3.5.

- Petaschnick (2004:9) refers to how Silvestri describes a dashboard. "A dashboard provides an at-a-glance review, saving hours of digging through reports".

- Rau (2004:1) holds the view that a specialist dashboard can be developed for a Chief Information Officer (CIO) that summarises the KPIs of the IT environment in a graphic format.

- Zurell (2002:39) narrows the audience down to executive management and describes it as a "one-page overview of all critical measurements necessary to make critical executive decisions that will affect the organisation's bottom line".

The general elements of dashboards can be summarised as the following:

- A dashboard is a graphic representation of KPIs.
- It provides customised decision-making information.
- Overview and at-a-glance are prominent qualities of dashboards.
- Most of the definitions require the KPIs to measure critical strategic information for the organisation.

The authors focus on the characteristics, graphic display, overview capabilities and purpose of decision-making and monitoring of business processes. Although all the functionalities mentioned by the authors are valuable, from a development perspective, the automated nature and setup of the system is the backbone and is crucial for the dashboards to update and function properly. The alignment of the information with a business area and the management practice of the business are important to be included as characteristics.

2.3.1.2 <u>The difference between a dashboard and a scorecard</u>

There are similarities between dashboards and scorecards in the literature and the one can be mistaken for the other. One can ask whether they really differ from each other.

According to Eckerson (2006b:13), the primary difference between a scorecard and a dashboard is that a dashboard monitors the performance of operational processes, while a scorecard monitors the progress towards achieving strategic and tactical goals. Eckerson (2006b:69) also mentions that balanced scorecards are strategic dashboards. The following table shows the differences between dashboards and scorecards (Eckerson, 2006b:13):

Table 2.1: Difference between dashboards and scorecards

Criteria	Dashboard	Scorecard
Purpose	Measures performance	Charts progress
Users	Supervision, specialists	Executives, managers, staff
Updates	Real-time feeds	Periodic snapshots
Data	Events	Summaries
Display	Visual graphs, raw data	Visual graphs, text comments

Dashboards and scorecards are related and form part of the wider concept of BPM. Dashboards define a more general concept, "the visual representation of organisational data in real time, strategic, or driven by KPIs, while scorecards can provide an individual view according to a specific focus area of strategic objectives and business goals. It helps to align the performance indicator metrics to long- and short-term goals for the department or organisational unit according to the focus areas of financial, operational, customer and qualitative" (Wise, 2006:2).

A balanced scorecard comprises the knowledge, skills and systems that employees will need (learning and growth) to innovate and build the right strategic capabilities and efficiencies (internal processes) that will deliver specific value to the market (customers) and will eventually lead to higher shareholder value (financial perspective) (Kaplan & Norton, 2000:4).

The term "dashboard" and "scorecard" are often used synonymously, but it can be deducted from the literature sources that dashboards are normally used for monitoring operational processes and exceptions, while scorecards chart the performance of organisations towards strategic objectives and targets. Both dashboards and scorecards present metrics and graphics on a screen.

For the purpose of this research, a distinction will be made between executive dashboards and performance dashboards or scorecards. An executive dashboard is a graphic representation of actionable, decision-making information that is tailored according to the business and management level of a manager. Figure 2.1 provides an example of an operational executive dashboard.

Figure 2.1: Example of an executive dashboard

Performance dashboards will be considered to be equivalent to scorecards, and should represent the implementation of a management system and philosophy that tracks performance against targets for the strategic objectives of the organisation.

Figure 2.2Figure 2.2 shows an example of a scorecard that monitors institutional performance.

Institutional indicators 1

Current Institutional Performance against 2015 Strategic Plan: Scorecard						
Performance Trend	**Performance Indicator**	**Target**	**Target Date**	**Current Performance**	**Current Performance Against Target**	**Prognosis of Meeting Target**
	PI 12: Nett surplus as a proportion of annual turnover, 2004-7	5%	2008	11%	Target exceeded by 6%	Almost certain
	PI 1: Aggregate Course Success Rate, 2004-7	56.0%	2010	54.7%	1.7% below target	Probable
	PI 6: Research outputs/academic against 2015 and DoE targets, 2004-6	Unisa: 1.0 DoE: 1.035	2015 2015	0.44	Below target	Possible
	PI 8: Research outputs increased by 70 points per annum for 2006–2010	70	2006-10	65.89	4.11 below target	Probable
	PI 3: Unisa Student Satisfaction Index, 2005-7	90.00	2015	70.18	19.82 Below	Unlikely
	PI 7: Position among South African universities in terms of research outputs, 2005	Among Top 5	2015	Position 6	Below target	Possible
	PI 11: Personnel expenditure as a proportion of total expenditure, 2004-7	59%	2008	61.7%	2.7% above target	Probable
	PI 4: Headcount Enrolments, 2004-7	258 023	2010	239 851	Already close to target	Impossible
	PI 5: Student-to-Academic Staff Ratio, 2004-7	140	2015	179	Above target	Unlikely
	PI 2: Aggregate Throughput Rate, 2005-7	8.37%	2010	6.45%	1.92% below target	Impossible
	PI 9: Student Support Service Satisfaction Index (SSSSI), 2005-7	90.00	2015	64.63	25.37 below target	Unlikely
	PI 10: Dropout rates, 1998-2003	Decrease 3%	2015	Generally low	Below target	Unlikely
Not yet available	PI 13: Annual Staff Satisfaction Index, 2007	Unspecified	-	Generally low	Baseline	-
	PI 14: Employment Equity Profile, 2004-7	In EE Plans		Severely skewed	Baseline	-

Commentary

From this table, we can see that (apart from the two new targets for which performance trends are not yet available):

1. Only one target (PI 12) is currently being met *(green robot)*, but the trend in this case is sidewards *(horizontal orange arrow)*
2. A further three (PIs 1, 6, & 8) are not being met *(red robot)*, but the trends are in the right direction *(upward green arrow)*
3. Three more (PIs 3, 7 & 11) are not being met *(red robot)*, but the trends are sidewards *(horizontal orange arrow)*
4. Another five (PIs 4, 5, 2, 9 & 10) are not being met but the trends are in the wrong direction *(red robot and arrows – up or down as the case may be)*

Assessing current institutional performance against targets must be seen against the relevant target dates. That is, we need to assess where we are currently in relation to we need to be by when. On this basis, we can see that although several of the targets have not currently been met, the prognosis of eventually doing so:

5. In four cases is almost certain/probable
6. In a further two cases is possible
7. In six cases is unlikely/impossible

Figure 2.2: Example of a scorecard

Since the aim of this research is focused on the design and implementation of executive dashboards for portfolio managers at Unisa, it is primarily concerned with dashboards and not scorecards.

2.3.1.3 Goals and benefits of dashboards

Operational dashboards and performance dashboards have different objectives. The goal of an operational dashboard is to provide users with relevant and actionable information that empowers them to make effective decisions and monitor the efficiency of processes more effectively than they could without a dashboard. The goal of performance dashboards is to align the activities of workers and groups to the strategy so everyone is pulling in the same direction (Eckerson, 2006b:43). Performance dashboards communicate to employees how their work contributes to the strategy and performance of the organisation.

According to McKeen et al. (2005), the benefits of dashboards are the alignment between strategic matters and the accountable persons, improving decision-making and analysis, improving data integrity, timeliness and operational efficiency.

Hall (2003:3) postulates that dashboard systems present complex relationships and performance metrics in understandable formats managers can internalise; these dashboards decrease the learning curve and improve the use of information in decision-making.

The authors focus on the strategic business benefit and operational efficiency, but the replicatability of the dashboards to ensure that the information can be developed for one business area and replicated in similar environments needs to be mentioned. The automated setup and development of the dashboards, like the plumbing of a house, is autonomous if it is properly set up and does not need a lot of human intervention.

If the benefits the authors Eckerson (2006b), McKeen et al. (2005) and Hall (2003) documented will be achieved by dashboard development at Unisa, they will be in line with the main research question to improve evidence-based decision-making and understanding of information.

2.3.2 Subquestion 2: How should dashboards be designed and implemented?

2.3.2.1 How should dashboards be designed and implemented? – Approach to follow in the planning and design of dashboards

According to Zurell (2002:42), an important requirement in the design approach of dashboards is to conduct thorough user requirements analyses and get consensus on what the measures are that represent the performance of the specific line of business. The KPI is identified as the "heart of any dashboard" in the discussion of the backbone of dashboards (Kirtland, 2003:2).

In large organisations, the process of developing a performance measurement process and linking it to the strategic directions of organisations starts with inspecting the business's strategy (Torok & Cordon, 2002:84). In short, it involves a communication plan and identifying objectives with targets and the core business processes and their goals. Performance indicators are identified for the activities in the processes, the improvement of the processes and the targets to reach.

Defining the correct KPIs specific to the intended user is one of the most important design steps, as it sets the foundation and context for the information that will be subsequently visualised within the dashboard. The first step in designing a dashboard is to understand the KPIs for which users are responsible and to identify the KPIs to develop on a dashboard solution that relates to their areas of responsibility (Gonzalez, 2005:1).

Brown (2000:29) offers a scorecard approach that has been proven by implementation in multiple companies in the past. Basic design principles for scorecards are set out in the following three steps:

1) Choose a scorecard methodology (framing).
2) Identify the highest scorecard level.
3) Identify metrics that link back to the organisation's mission and objectives.

Two of the familiar scorecard methodologies to choose from are the Kaplan & Norton model (Kaplan & Norton, 1996) and the Baldrige Award Model (Brown, 2000:31):

1) The Kaplan & Norton Balanced Scorecard consists of four categories (Kaplan & Norton, 2004:30-45):

- Customer measures: lagging indicators, such as buying behaviour, loyalty measures and measures that are important to customers
- Financial measures: lagging financial or accounting measures, such as sales, operating expenses, profits and growth
- Internal measures: leading measures, such as productivity, efficiency, environmental performance and quality, that can be directly impacted on by the business and produce results in the lagging indicators mentioned above
- Innovation/growth measures: leading indicator metrics that focus on new product/service development, research, innovation, employee competencies, etc.

Leading and lagging indicators should be identified and the measures should focus on past and present periods.

2) Secondly, the Baldrige Award Model has five categories of data and is suitable for labour intensive environments with a lot of focus on outside suppliers or contractors (Brown, 2000:31):

- Customer-focused perspective: lagging indicators such as customer satisfaction indices, customer loyalty indicators and internal leading indicators that can impact on customer satisfaction
- Financial and market perspective: lagging financial indicators, such as ROI and market share indicators
- Human resource perspective: employee indicators, such as staff satisfaction survey information, staff turnover, training and measures reflecting the performance of the human resources in the organisation

- Supplier and partner perspective: indicators measuring the performance of suppliers, contractors, distributors or business partners
- Organisational effectiveness perspective: measures of productivity and efficiency, such as unit costs, cycle times and project management measurements

It is important that all levels of the organisation can use the scorecards, even if the individual indicators may be considerably different throughout the organisation.

Eckerson (2006b:198) identifies three types of metrics: leading, lagging and diagnostic. In explanation of these indicators, strategy maps describe the strategic hypotheses by identifying the “activities that are drivers (or lead indicators) of the desired outcomes (lag[ging] indicators)” (Kaplan & Norton, 2001:76). Leading indicators have a significant effect on future performance, while lagging indicators measure the performance of past activity, and diagnostic indicators measure the net margin of product lines, etc. (Eckerson, 2006b:198). Therefore, leading indicators measure the performance of actions that can affect results. Lagging indicators measure the outcome effect of actions. Diagnostic indicators do not measure an outcome as such, but some of the contributing factors to an outcome that can be monitored during the time preceding the outcome. Gonzalez (2005) defines an abstract KPI as a KPI that is made up of other disparate KPIs and their relative performance to specific targets (Gonzalez, 2005:1). It is important to understand the character of the metrics in the design of executive dashboards and scorecards because of the value derived from the metrics.

KPIs are undeniably a crucial element of executive dashboards. The above sources highlighted the important role KPIs play in the success of dashboards. Eckerson (2006b:167) reports that executives at Hewlett Packard’s Technology Solutions Group defined guiding principles to implement the strategic dashboard uniformly with predictable results.

The following guiding principles would contribute to making the initiative a success:

- Executive support and buy-in is important.
- The dashboards should be centrally managed, but the support should be decentralised.
- Metrics should cover information for a number of years and all organisational levels and focus on strategic objectives.
- Only a few indicators should be used, including past, present and future indicators and should be regularly reviewed.
- When appropriate, rewards and incentives should be linked to relevant indicators.
- In general, dashboards should decrease historical standard reports in printed format and provide a richer medium to render information to the users, customised according to their preferences.

2.3.2.2 How should dashboards be designed and implemented? – The implementation processes

In order to be able to find a workable method to develop dashboards, this section is covered in considerable detail with specific steps. Methods by Brown (2000:232) and Kaplan & Norton (1996:300) are listed in the summary in Table 2.2:

Table 2.2: Methods to develop scorecards

Brown (2000)	Kaplan & Norton (1996)
Step 1: Select a starting point for a scorecard implementation According to Brown (2000), the project can be started at any level of the organisation, and if the Chief Executive Officer (CEO) level is chosen to start at, it is advisable to start a level down from the top, since the metrics on the business unit level are often applicable to the others in the organisation.	**Phase 1: Organisational structure to measure** **Task 1**: Determine the highest organisational level for the scorecards. To be at the top level, the business unit must be at the strategic level of the organisation.
Step 2: Kick-off workshop A workshop with proper high-level sponsorship should be conducted to launch the initiative. All important decision-makers should attend the workshop and participants should be taught to evaluate metrics and scorecards.	**Task 2:** Determine how the unit links to the other business units. It is important to know how objectives and measures for different units are related in order to integrate the performance measures.
Step 3: Gather background information and existing indicators Interview the executives who are affected by the project and review strategic documents, such as annual reports to shareholders, strategic plans and operational plans. Interview IT intranet, marketing and communication, market research, finance and human resources staff.	**Task 3:** Conduct interviews for the first level of scorecards. After the executives at the first level have studied the strategic background information about the organisation, their input about measures in the different perspectives is obtained and the executives are informed about the scorecard project.
Step 4: Develop guiding documents This step can be skipped if a vision, mission, key success factors (KSFs), values or guiding principles are already defined. Brown recommends that a draft mission and vision be compiled from guiding documents with the support of executives.	**Phase 2: Strategic objective alignment** **Task 4:** Objectives are compiled from gathered information The list of objectives is discussed with the top management to determine objectives in the four perspectives and causal links among the objectives are defined.

Brown (2000)	Kaplan & Norton (1996)
Step 5: Construct the scorecard for the senior executive It is recommended that a methodology suitable for the industry of the organisation be selected, such as the Kaplan and Norton model with four perspectives, or the five Baldrige perspectives.	**Task 5: First executive workshop** The aim of the workshop is to reach consensus about the scorecards and four or five objectives per perspective are selected.
Step 6: Determine the data collection information Questions can be tested against a checklist of metric attributes. More time is spent on the data collection plan at the highest organisational level, and less time will normally be spent on lower level data collection.	**Task 6: Refine objectives** The wording for the objectives is refined. Measures, data sources and the causal links among the measures are identified.
Step 7: The actual construction of the scorecard The data collection plans are drawn up and used for reference to gather the information through paper surveys, focus groups or capturing systems in collaboration with internal departments.	**Task 7: Second executive workshop** Executives from different levels discuss and refine the scorecard objectives. Executives also and measure and determine targets for the objectives.
Step 8: Collect baseline data, set targets and develop strategies Targets can be absolute numbers or ranges of performance. Target setting is then continued for all the levels of the organisation.	**Phase 3: Building of the implementation plan** **Task 8: Implementation plan** The implementation plan identifies data sources and how the scorecard initiative should be communicated throughout the organisation.
Step 9: Scorecard maintenance Brown (2000:235) recommends that 10–20% of the design and implementation resources can be budgeted for maintenance and revision of the scorecard metrics every year.	**Task 9: Top management approval** Top management approves the implementation plan for the scorecards and initiatives to achieve the targets can be determined and the information system developed.
	Task 10: Finalise the implementation plan Begin to use the scorecards and adjust scorecard measures and information sources accordingly.

The steps and tasks presented in Table 2.2 are not directly comparable. The process of Brown (2000) explained each step in more detail and focused on the promotion and advocacy of the project, as well as soliciting for support and buy-in in the organisation. The process of Kaplan & Norton (1996:300) is divided into three phases: measuring the organisational structure, aligning the strategic objectives and building an implementation plan. The process is also focused on gathering the information required for the balanced scorecard process and not the wider initiative as indicated in the steps presented by Brown (2000).

Both authors determined the highest executive level in the organisation and where to start the information gathering process. Brown (2000) proposed that the project team gathers strategic information from documents, while Kaplan & Norton (1996) proposed that the top executives study the documents to distill the relevant objectives and indicators from the documents. Both authors proposed that executives should be interviewed to gather information about the objectives. Brown (2000) proposed a kick-off workshop at the start of the project, while Kaplan & Norton (1996) proposed that more preparation should be done before the first workshop so that decisions about the scorecards and perspectives can be made at the first workshop. According to the process of Brown (2000), the project team constructed the perspectives and indicators for the highest level. After testing the highest level scorecards with executives, the data collection plans for the lower levels of the organisation are drawn up and collected. Baseline data and targets are determined for strategies to complete the scorecards. Kaplan & Norton (1996) propose that the scorecard components of the highest level be refined at a second workshop. Following that, an implementation plan is compiled and approved by top management. The actual implementation is performed according to the approved implementation plan. A more formal and structured process is proposed by Kaplan & Norton (1996), and approval at top management level is formalised before the process can start, which can be considered an effort to ensure buy-in from all the levels of the organisation.

2.3.3 Subquestion 3: What are the characteristics of metrics on dashboards?

In the electronic media, debates about the difference between metrics, measures, KPIs are ongoing. Table 2.3 compares the views of different authors about the three terms in a general context:

Table 2.3: Comparison between metrics, measures and KPIs

Metric	Measure	KPI
"Standards of measurement by which efficiency, performance, progress or quality of a plan, process or product can be assessed" (WebFinance, 2013).	"A number or a quantity that records a directly observable value or performance. All measures are composed of a number and a unit of measure. The number provides magnitude (how much) for the measure, while the unit gives number a meaning (what)" (The KPI Institute, 2009).	"A selected indicator considered key for monitoring the performance of a strategic objective, outcome or key result area important to the success of an activity and growth of the organisation overall. Typically, KPIs are monitored and distributed in dashboards, scorecards and other forms of performance reports" (The KPI Institute, 2009).
"The term metric refers to measurements of business activity. The only difference between a metric and a KPI is that a KPI embodies a strategic objective and measures performance against a goal" (Eckerson, 2009a).	"A number or quantity that records a directly observable value or performance. All measures have a unit attached to them: inch, centimeter, dollar, liter, etc." (WebFinance, 2013).	"Key performance indicators are quantifiable measurements, agreed to beforehand, that reflect the critical success factors of an organisation. They will differ depending on the organisation" (Reh, 2013).

Metric	Measure	KPI
"Metric is a measurement of the degree that any attribute belongs to a system, product or process. For example, the number of errors per person hours would be a metric" (Answers Corporation, 2013).	"A measurement is an indication of the size, quantity, amount or dimension of a particular attribute of a product or process" (Answers Corporation, 2013).	
"Metric – a value typically derived by a combination of two or more measures, for example, financial ratios or total revenue over time. Metrics provide the notion of whether the values are good or bad" (Forman, 2012).	"Measure – anything that is measured, for example, number of customers or total revenue. The key thing is that there is nothing inherently good or bad with a measure" (Forman, 2012).	"KPI – brings in the business context. Metrics within a particular organisational or industry context are KPIs. However, you need to distinguish between KPIs and PIs (performance indicators). Most companies have far too many "KPIs". KPIs are derived from the strategy and value drivers of the organisation; they are few in number. The rest might be important, but not strategic and should not be defined as KPIs" (Forman, 2012).

From the above comparison, it can be seen that there are many different views to define metrics, measures and KPIs. The lens used by the individual who defines the term, affects the definition. The current author concurs with the view of Forman (2012) to capture the essence of the difference that a metric combines more than one measure and that a measure is anything that is measured.

From the above, the viewpoint taken for the dashboard study will consider the terms "metrics" and "KPI(s)" to be generally correct for dashboards in a business context, because the values refer to a status or performance that aligns with the intention of dashboards to deliver intelligent decision-making information, as can be seen from the following definitions related to KPIs.

Metrics used in performance dashboards are usually called KPIs. Depending on what the metrics measure, they indicate how well the organisation or individual performs operational, tactical or strategic activities that are critical for the current or future success of the organisation. According to Gonzalez (2005:1), “a KPI can be defined as a measure (real or abstract) that indicates relative performance in relationship to a target goal”.

Alexander & Walkenbach (2010:13) see KPIs on dashboards as measures of drawing attention to problem areas and signifying the performance of an essential task in the operations or processes.

The balanced scorecard recommendation is to create leading indicator metrics rather than lagging indicators, as well as having cross-referencing indicators in the operational and tactical levels to monitor the effectiveness of metrics. Eckerson (2009b:198) highlights that 80% of the effectiveness can be achieved by the design of a KPI, while the other 20% only comes from deploying the KPI and experiencing the impact of the behaviour and performance.

The well-known “SMART” characteristics for KPIs were identified by Doran (1981) as follows:

- Specific – The indicator should be specific to an area.
- Measurable – The indicator should be quantifiable or measure progress.
- Assignable – A responsible person should be assigned to provide data.
- Realistic – What results are achievable?
- Time-related –When can results be achieved?

The SMART characteristics are still generally used, but many authors contributed their insight and the list grew, as Table 2.4 shows. This is not an exhaustive list, but illustrates the combined characteristics of KPIs.

Table 2.4: KPI characteristics

KPI	Description and authors
Aligned	KPIs have to measure performance that is in line with the strategic direction and objectives of the organisation (Eckerson, 2006b:201; Mind Tools Ltd., 2013).
Owned	A manager or group should be accountable to reach the outcome of a KPI (Eckerson, 2006b:201; Barbuio, 2008:7; (Parmenter, 2010:4; The KPI Institute, 2009; Mind Tools Ltd., 2013).
Predictive	KPIs have to be leading indicators, therefore the organisation can steer it towards the desired direction (Eckerson, 2006b:201; Mind Tools Ltd., 2013).
Actionable	KPIs on performance dashboards should be carefully defined, refined and updated timeously in order to enable owners to apply corrective action in time to impact performance (Eckerson, 2006b:201).
Few	A few focused and carefully selected KPIs are required to direct the organisation's efforts (Eckerson, 2006b:201; Mind Tools Ltd., 2013).
Easy to understand	Owners should be able to understand how to influence the performance of KPIs and have to be involved in the construction of KPIs (Eckerson, 2006b:201; Parmenter, 2010:4; The KPI Institute, 2009).
Balanced and linked	KPIs should interactively support other KPIs to create balanced and aligned sets that do not counteract each other and neutralise or negatively impact other processes (Parmenter, 2010b:4).
Trigger changes	KPIs should be actionable and activate a sequence of positive changes in the organisation (Eckerson, 2006b:201; The KPI Institute, 2009).
Standardised	Generally accepted business rules, norms and definitions should be used to define KPIs to facilitate standardisation across the organisation (Eckerson, 2006b:201; Mind Tools Ltd., 2013).

KPI	Description and authors
In context	Owners should be able to logically understand how to effect and monitor progress KPI performance in relation to targets and thresholds (Eckerson, 2006b:201; Mind Tools Ltd., 2013).
Reinforced with incentives	When incentives and remuneration are connected to stable and tested KPIs, they can boost the influence of KPIs (Eckerson, 2006b:201; Mind Tools Ltd., 2013).
Relevant	To ensure that KPIs remain relevant, they should be periodically reviewed and tested (Eckerson, 2006:201; Barbuio, 2008:7; The KPI Institute, 2009; Mind Tools Ltd., 2013).
Verifiable	It should be possible to verify data accuracy and calculations (Barbuio, 2008:7; The KPI Institute, 2009).
Quantifiable	KPIs should be measurable and possible to summarise (Barbuio, 2008:7).
Cost-effective to collect	The cost to institute the data capturing and sourcing of a KPI should be considered against the KPIs value (Barbuio, 2008:7; The KPI Institute, 2009).
Accessible	If KPIs cannot consistently be updated due to access restrictions, or updates that happen irregularly (Barbuio, 2008:7).
Timely	The update cycle of the KPI should suit the business cycle involved to inform decisions (Barbuio, 2008:7; The KPI Institute, 2009).
Non-financial measures	Non-monetary measures should be used (Parmenter, 2010b:4).
Measured frequently	Measured as frequently as is viable (Mind Tools Ltd., 2013 Parmenter, 2010b:4)

KPI	Description and authors
Acted on by CEO and senior management	Senior management should act regularly on KPIs (Parmenter, 2010b:4).
Have a significant impact	Key success factors should be affected by KPIs. (Parmenter 2010b:4)
Comparable	The context of KPIs should be stable and KPIs should remain comparable (The KPI Institute, 2009).
Allow innovation	KPIs should limit innovative processes (The KPI Institute, 2009).
Statistically valid	Valid statistical methods should be used in KPI calculations (The KPI Institute, 2009).

The above qualities will be different depending on the context of the metrics. For the dashboard application, it is important that the data should be electronically available for all the measures involved in determining the metric and for the supporting business processes to be operational. To be effective, source data should be captured according to the cycles of the business for all the measures involved in an automated metric. If data is not updated in accordance with the relevant business process, the metric is rendered unusable.

2.3.3.1 Metrics on dashboards: How to determine metrics on dashboards

In the context of the dashboards of cars and cockpits of aeroplanes, metrics are often referred to as gauges, but for the purpose of this research, the researcher will use the term metric or indicator. To define the metrics that should capture the motive of the objective on the scorecards, the scorecard development team will not be in a position to define the metrics in isolation from members of the business. Teams are required to determine the metrics or gauges on dashboards, which can consist of ratios, comparisons, as well as composite measures, called indices. These gauges can combine more than one measure in the form of scores, percentages, actual amounts etc. (Brown, 2000:41). An expert group can be assembled to identify the metrics for objectives. This group should be composed of members who have different contributions to add in the form of expertise and insight.

Members of the executive teams, who work with subgroups, are crucial to determine the metrics that accurately measure the purpose of the objectives (Kaplan & Norton, 1996:304).

Brown (2013) suggested that dashboards' metrics should be introduced to users in small incremental steps and the users should carefully evaluate their definition, presentation and measurement. His view is that when users can understand their own contribution to strategic goals, they will become advocates and promote adoption.

The metrics should convey the strategic alignment and if the metrics that are used as gauges on dashboards do not accurately translate the organisation's strategy and goals, the organisation will be efficient, but ineffective (Eckerson, 2006b:197).

From the above, it is clear that users and relevant managers should be closely involved in the development of the metrics. Although users can seldom design metrics, they can give input when they begin to understand the message conveyed through the metric. Their input is indispensable for interpreting the relevance and performance of the metrics.

2.3.3.2 Metrics on dashboards: How institutional performance indicators are strategically aligned

Performance dashboards are the implementation of a performance management system (Eckerson, 2006b:4; Alexander, 2007:6). They provide an information system that helps executives communicate key strategies and goals to all employees on their level of the business on a daily basis. Strategy is the way for an organisation to move from its present position to a future desirable, but uncertain position. What organisations really need is a performance dashboard that translates the organisation's strategy into objectives, metrics, initiatives and tasks customised for each group and individual in the organisation. They communicate and enable business people to measure, monitor and manage the key activities and processes needed to achieve their goals.

Because it is uncertain, the pathway consists of a series of linked hypotheses. Strategic themes are a combination of the critical processes for creating and delivering value to selected customer segments. Intangible assets should support strategic themes. Kaplan & Norton (2001:11) defined five principles embedded in the balanced scorecard methodology for organisations to become strategy-focused organisations. They postulate that the strategy can be described through simultaneous complementary themes. The five principles are detailed in Table 2.5.

Table 2.5: Five principles to become strategy-focused

Principle	Description
Principle 1	**Translate strategy into operational terms** A strategic dashboard is a description of an institution's strategy. Strategy maps are cause-and-effect linkages among the objectives in the four perspectives of balanced scorecards. They represent executives' perspectives about resources and processes that drive financial results and/ or customer value.
Principle 2	**Align the whole organisation to the strategy** A top-down approach is usually followed to implement the strategic dashboard. This approach starts at the top executive's office and serves as a template and reference for levels lower down in the organisation. A framework of cascading scorecards is developed. As suggested by Brown (2013), users should be involved to brainstorm the presentation and measurement of KPIs to help facilitate their understanding of their own contribution to strategic goals and promote adoption of the initiative.
Principle 3	**Motivate the organisation to make strategy everyone's job** The purpose and benefits of the scorecards are communicated to the organisational community. Users define the most suitable objectives and metrics for their scorecards. Linking scorecards to compensation and incentives reinforces the importance and relevance of the scorecards. Brown (2013) proposes that staff members or departments should have customised views of the KPIs and goals relevant to their jobs.
Principle 4	**Learn and adapt to make the strategy a continual process** The scorecards should be used to prioritise and allocate funds and resources. The interpretation of the scorecard results should become a standard part of the agenda for management meetings of monthly performance. Parmenter (2007:91) proposed that KPIs should be available 24 hours a day and should be discussed at continuous process improvement meetings.

Principle	Description
Principle 5	**Mobilise change through executive leadership** A strategy is a destination an organisation strives to reach, but has not yet reached. The scorecards should be devised to steer the organisation to the vision of the future. The leadership team should make informed decisions from the scorecards and should make bold structural and directional changes in the way the organisation is run. In agreement with Principle 2, Parmenter (2007:21) proposes that the best way to determine KPIs is to ensure that the top management team is committed, involved and informed.

(Kaplan & Norton, 2001:11)

Olve et al. (1999:12) consider the balanced scorecard to be a strategic controlling method. The art of strategy is to identify the most important processes that should receive special attention and focus. De Geuser et al. (2009) empirically found that the balanced scorecard methodology translated the strategy into operational terms. If the strategy is continuously considered, greater alignment of units, processes and resources is achieved.

Generally, in the balanced scorecard methodology, strategy maps describe the flow of value creation from the perspective of employees to customers to profits, as described in 0. A strategy map consists of the cause-and-effect relationships that describe how intangible assets, such as skilled and satisfied staff, will affect tangible (financial) outcomes, such as cash, revenue and profit (Kaplan & Norton, 2001:11). For every strategic theme, one or more processes that will focus on achieving the desired results within operations management, customer management, innovation, and the regulatory and social domains should be identified.

Strategy maps are graphic representations of objectives per theme, describing the logic of the strategy (Kaplan & Norton, 2004:9). According to Cokins (2013), a strategy map is a diagrammatic display of strategic objectives and their cause-and-effect links with the purpose of guiding the implementation of the strategy.

The balanced scorecard methodology translates the strategy map into measures and targets to monitor progress and performance to achieve the overall objectives.

The best way to build strategy maps is to use the results-driven approach. Start with the desired strategic objectives and then determine what the operational levels contribute to the strategic levels (Kaplan & Norton, 2004:8). Armitage & Scholey (2006:3) compiled guidelines to develop strategy maps because they found the implementation guidelines difficult. Ariyachandra and Frolick (2008) confirm the challenge to implement these guidelines. Parmenter (2012) questions the value of strategy mapping and prefers the relationship mapping of critical success factors.

The strategy maps provide a plan that describes the logical cause-and-effect progression through the perspectives to be followed in the strategy implementation process (Kaplan & Norton, 2004:9).

During the strategy mapping process, the organisation's mission and core values are reviewed to formulate the reason for the organisation's existence, as well as its beliefs. The vision is a definition of what the organisation wants to become and is developed, and the strategy is the logic of how to get to that destination.

Therefore, the building of strategy maps starts with defining the objectives of the financial/stakeholder perspective. Then, a lagging indicator, followed by the other lagging indicators of the customer perspective, is defined. Subsequently, the leading indicators from the internal processes, as well as learning and growth perspectives, which are under the organisation's control and influence, are addressed. Authors, such as Parmenter (2010b), question the success companies have had with the implementation and execution of the strategies defined in strategy maps. Barrows (2010) also postulates that the activity system mapping by Porter (1996:73) and success maps by Neely et al. (2002) should be considered.

2.3.3.3 Metrics on dashboards: leading and lagging indicators

Three types of indicators or metrics are identified: leading, lagging and diagnostic (Eckerson, 2006b:198; Kerzner, 2013). Strategy maps describe the strategic hypotheses by identifying the "activities that are drivers (or lead indicators) of the desired outcomes (lag indicators)" (Kaplan & Norton, 2001:76). Leading indicators have a significant effect on future performance, while lagging indicators measure the performance of past activity, and diagnostic indicators measure current performance, such as the net margin of product lines (Eckerson, 2006b:198; Kerzner, 2013). Therefore, leading indicators represent actions that can have an impact on results, while lagging indicators represent the change the actions effected. Diagnostic indicators represent some of the other factors contributing to an outcome that can be monitored during the time preceding the outcome.

Parmenter (2007:1) identified the following three types of indicators:

1. Key result indicators measure the results of actions and are measured over a longer period. Key result indicators can be compared to the lagging indicators discussed above.
2. Performance indicators are the other possible result indicators among which the KPIs are the critical few.
3. KPIs are the few performance indicators that are critical for the current and future success of the organisation. These indicators should be monitored daily, weekly or in real time. This will allow the relevant people to notice changes in the performance it measures so that interventions can be effected. They can be compared to the leading indicators that are discussed above.

From the literature sources, it is evident that the metrics or indicators play a key role in the dashboard design. The discussion about leading, lagging and diagnostic or supporting indicators is aimed at creating an understanding of indicators or metrics, which can be seen as a critical success factor in the design of dashboards.

2.3.3.4 Metrics on dashboards: How the combined effect can be portrayed and transformed into metrics easily interpreted for decision-making

The most difficult part of designing a dashboard is determining the best-suited indicators (Petaschnick, 2004:9) and to avoid the information overload of executives. The high-level indicators have to be properly designed (Krell, 2003:14). In order to add significant value, performance indicators have to be presented in the context of comparable standards, such as benchmarks, historical trends or goals, and they should be in line with other indicators that contribute to the same goals (Rau, 2004:13).

Executives require an enterprise-wide information perspective that is aligned with the enterprise objectives and strategies. It should be highly summarised, with an external and internal view on business drivers. KPIs should be designed to provide a picture that portrays the "health of the organisation". Depending on the level of the employee that needs the information, the KPIs can be supported by additional graphic representations of extra information and drill-through capability that a user can use to diagnose the status of KPIs (Bauer, 2004:2). Supporting information, such as charts, tables or lists that add insight into a KPI's condition, can be provided to properly contextualise a KPI's design to assist with interpretation and insight (Gonzalez, 2006:2).

The literature sources highlight the fact that different metrics should be used to ensure that information is understood correctly. It is evident throughout that the aim should be to provide information that is contextualised and supported by additional information to ensure that it is interpreted correctly. The current study investigated information requirements for the different management levels that can be addressed by drill-through to operational detail for lower levels, or supporting metrics at strategic management levels.

2.3.3.5 Metrics on dashboards: design characteristics to consider

In order to address critical questions of the business area, these questions should be identified and mapped to KPIs, as well as hosted on the dashboards to facilitate insight and answers. In paragraphs 2.3.2.1 and 2.3.2.2, the process to determine KPIs on dashboards is discussed. Alexander & Walkenbach (2010:9–22) propose that the process involves creating an understanding of the audience and purpose of the dashboard, determining the measures and their data sources, as well as identifying the dimensions and filters, drilldowns and refreshment cycles of data.

A good understanding of the business processes and information requirements should be collected, in collaboration with subject specialists, data analysts and information technology divisions (Alexander & Walkenbach, 2010:9–22). A good understanding is created by understanding the physical elements, thresholds, alerts of KPIs, and hierarchies for the granularity dimensions. More detail about these elements is provided in sections 2.3.3.5.1 to 2.3.3.5.4 below:

2.3.3.5.1 Physical elements

Malik (2005:17) described the physical elements as “what”, “for whom” and “presentation”. The groupings are used to investigate the characteristics of the physical elements.

- What?

The term refers to what information should be displayed, how the characteristics can be classified, where it is sourced from, what level of detail is displayed, and how it should be calculated. An elaboration of the different categories proposed by (Malik, 2005:17) follows:

Table 2.6: Classification of characteristics

Categories	Description
Data sources	The following information is required to source data for a KPI: database, data mart or data warehouse identification, online analytical processing (OLAP) sources (specific cubes), data files (from legacy systems or external sources) and existing reports with the supporting source identification, such as universes and objects. Transformation detail is required to prepare data for the dashboard software. This is often consolidated and transformed from multiple (disparate) data source locations (Malik, 2005:17). Alexander & Walkenbach (2010:15) also stress that the availability of and access to data sources can cause dashboard projects to fail. Alexander & Walkenbach (2010:14) recommend verifying that data for metrics exists that can be accessed, how often it is refreshed and maintained, and that the process involves in-sourcing data. Kopecky & Raghavendra (2010:5) postulate that dashboard success depends on a data warehouse, data scrubbing and heavy analysis performed in the data warehouse, instead of by the dashboard tools.

Categories	Description
Granularity	Granularity establishes the level of aggregation and summarisation required per KPI (Malik, 2005:17). Chin & Chanson (1991:96) define the granularity of software objects as the amount of processing involved on different scales of "large grain", "medium grain" and "fine grain". The Geckoboard team (2012) suggests that data should be logically grouped, and departments and functional areas should be used often. The total number of elements for a KPI can become large if each of the dimensions has large sets of values. It is important to determine the total number of data elements required per dashboard. Multiple hierarchies often exist for the same granular dimension, such as different time hierarchies within a department. The most common are different grains across unique combinations of three basic dimensions: time, geography and product (Malik, 2005:17): • Time grain determines the time attributes for a given KPI, such as quarterly, monthly, daily or weekly. The quarterly grain then operates with hierarchy levels such as quarter, month and day. • Geography grain determines aggregation per geographic attributes, such as world, region, country, city and outlet type. This grain has hierarchy levels such as worldwide, region, country, city and customer. Product grain determines product attributes, such as total for product, division, product category and item group. This grain has a hierarchy such as organisation, category, brand and product item.
Calculation	The calculation is any operation required to derive a given KPI, mathematical calculation, with sum, average and percentage being the most often used, and minimum, maximum, moving or weighted average as more examples. It also refers to the aggregation of a KPI and roll-up characteristics from lower levels. The aggregation calculation for non-aggregate KPIs and roll-ups must be pre-computed for each granular level. When a KPI is extracted from multiple data sources, the calculations may require complex joins across data sources with conditional computations (Malik, 2005:17).

Categories	Description
	Parmenter (2007:81) suggests Pareto's 80/20 rule so that the effort to calculate KPIs should not exceed the benefit derived from the KPIs.
Variance	Diverse calculated measures, such as ratios, trends over years and rate of change, can provide better insights into business functions (Kopcke, 2003). The idea is to design presentation formats that display variations that require action to be easily noticeable, and lower level detail to investigate if the variance is an anomaly or a trend (Pappas & Whitman, 2011:251).

For whom?

In order to provide role-based information and security customised for the end-user, the information is categorised according to user groups and hierarchies, privilege domains and content domains (Malik, 2005:17). The categories are discussed in more detail under research objective 0.

- Presentation?

  The way the information is presented on the dashboard is an important characteristic of the dashboard. It is categorised according to design, layout and navigation, and is discussed in more detail under section 2.3.4.

2.3.3.5.2 Thresholds

The thresholds of KPIs are parameters set by the organisation to evaluate performance through BPM or business activity monitoring (BAM) systems to stimulate action. Defining the thresholds will assist in determining whether the performance is good, bad or acceptable. A threshold may be different for the same KPI for different product grains, time periods and geographic dimensions (Malik, 2005:17). Business activity should vary within a performance band, allowing for acceptable variance in the process, and the performance should be managed within the threshold band (Hill, 2010; Pappas & Whitman, 2011:254).

Popular graphic formats to visualise thresholds and relative performance are speedometers, dials or robots. The colour bands on the dials and speedometers represent the threshold levels, and the needle represents the actual data values. In the robots, the colour indicates the relative performance (Malik, 2005:17; Eckerson, 2006b:7). Conditional formatting should be standardised across the system, so that the categories of above target, on target and below target translate to the same colour coding. The boundary lines between the ranges are the thresholds. The threshold ranges make it easy for users to assess the status of business processes at a glance. For example, the graphic representation of the KPI changes from yellow to green when performance exceeds the threshold (Eckerson, 2006b:7).

2.3.3.5.3 Alerts

Alerts for KPIs warn when KPIs show poor performance. Alerts must be accompanied by automatic emails or visual blinking animation on the dashboard to attract attention. Alerts are elements of management by exception practices. They ensure that a red flag or negative exception in a KPI is not overlooked and that the relevant role-players receive the warning, or that appropriate actions are taken. Alerts deliver insight by graphically highlighting exceptional conditions and allowing users to drill into more detailed information to diagnose the causes of the conditions (Eckerson, 2006b:5; Kopcke, 2003:3).

2.3.3.5.4 Hierarchies for granularity dimensions

The hierarchies for the granularity dimensions discussed in 2.3.3.5.1, namely, time, geography and product, affect the dashboard layout and navigation, user profiling and customisation of the dashboarding process. In order to present a dashboard customised to a user's profile, the dashboard architecture should be designed so that the KPIs applicable to the granular cross-section are presented to a specific user (Gonzalez, 2005:2).

The menu items should be built to suit the hierarchies of the business. Each menu item may represent a geographic region or product category according to the desired navigation that is required.

The drill paths are important, as is determining what information is most relevant to the user and what information is displayed when a user clicks on a chart (Malik, 2005:17).

Two important factors in this regard are privilege and relevance. Depending on the level of the user in the organisation, the user's access to information may be different. Information architects have to ensure that users have access to the right information (Kirtland, 2003).

2.3.4 Subquestion 4: How are metrics presented on dashboards?

According to Pappas & Whitman (2011:253), "a dashboard is meant to be viewed at a glance" and the display should allow all the elements to be in view without scrolling or navigating to other pages. When developing dashboards, general visualisation guidelines can be considered. For example, that of Kirtland (2003:7), which considers a three-dimensional display to be excess "chartjunk [that detracts] from the story you're trying to tell".

Nielsen & Tahir (2002:33) provide a summary of guidelines for home page usability. These guidelines are applicable to web design in general and assist with prioritisation. The guidelines can also ensure continuity and consistency. Nielsen & Tahir (2002:33) also recommend features for home pages that could be equally applied to dashboards. These features include download time that should not exceed 10 seconds, a logo in the upper left-hand corner to provide a search facility with specific features, navigation with left-hand rails, tabs, links across the top of the screen or categories in the middle of the page, a section about the organisation, no auto-playing music, and relative text sizes. With regard to date- and time-sensitive information, Nielsen & Tahir (2002:33) recommend using a date and time format that all users will be able to translate to their local time. It should also show the time zone. They recommend using standard abbreviations such as p.m. or P.M., spelling the month out or using the abbreviations instead of numbers for the month. When information is updated, it should be indicated as "Updated<date time>".

2.3.4.1 Presentation of the metrics on a dashboard: the visualisation requirements of dashboards

Drawing from the literature the researcher engaged with for this study, it becomes apparent that the visual presentation of the information on dashboards plays a vital role in the information and intrinsic intelligence a dashboard will convey. According to Gonzalez (2005:Part 2), there are two main categories in dashboard visualisation: KPIs and supporting analytics. In both cases, it is important that the visualisation suits the user's needs in terms of the areas they monitor and manage.

Few (2006:124) distilled a "library" of display media for dashboards. The main requirements for using specific display mechanisms is that it must be the best display method generally used on dashboards for the type of information and it should not lose any functionality when used in the small space available on a dashboard. His "library" contains graphs, images, icons, drawing objects, text and organisers.

A way to validate the design is to view the screen with an out-of-focus perspective by stepping back from the dashboard and relaxing one's focus until the dashboard becomes blurry and one can no longer read words or distinguish finer details. In this way, the most attention-grabbing elements can be identified to ensure that they correspond with the most important KPIs the dashboards would have to address (Few, 2006:124).

Malik (2005:45) also contributes to visual intelligence and divides the presentation of data on dashboards into three broad categories: dashboard design, layout and navigation. His approach provides a practical framework for discussing the dashboard elements that will be used for the following discussion.

2.3.4.2 Presentation of the metrics on a dashboard: dashboard design

Screen graphics and colours on dashboards should not distract attention from the primary message and intended information. In order to focus the attention on the main message, charts and message delivery elements should have their own colour scheme to differentiate them from the background, aesthetic and functional elements.

Logos and brand elements should not be too prominent, but light and neutral in colour. Light blue, grey and beige are good choices for banners, navigation tabs or borders (Nielsen & Tahir 2002:22). They also recommend the use of graphic design to attract the user's attention to the most important elements and display complex information graphically. Realistic photos and graphics should be used to convey information. More details of relevant presentation characteristics and the representation of KPIs are provided below:

- Colour: Colour can also be used to separate content and to differentiate certain areas from one another, but the researcher finds the data-to-ink ratio of Few (2006:101) to be useful. The "data-ink ratio = data ink / total ink used to print the graphic" is a formula used to assess the redundant ink in a graphic that can be done away with without distracting from the real information conveyed by the graphic.

- Different colours for visited and unvisited links are recommended. Nielsen & Tahir (2002:22) also recommend the use of different hues of the same colour to make it possible for colour-blind people to distinguish between differences. Some sophisticated software packages allow users to customise colour schemes according to their own preferences.

- Chart types: The selection of chart types depends on the information presented. Generally, pie charts are used for relative shares, line charts for trends and bar charts to compare two metrics. At the time of the literature study, other contemporary chart types were traffic lights, speedometers, dials, thermometers, donuts and bubble charts. The availability of space constrains the choice of chart types. The advice of a graphic designer may even be sought if the target audience is large. More specific detail should be studied when a dashboard system is developed. Few (2006:124) discusses the pros and cons specific to dashboards and the suitability of particular types of charts for the limited space available on screens, while still considering the visual experience of the user.

- Text: Nielsen & Tahir (2002:23) have a number of tips for the text used on websites. Dashboard developers should avoid uppercase letters and be careful with punctuation that can cause ambiguous messages and incorrect emphasis, or can “shout”. If font formatting, such as size or colour, is too busy or capitalisation and style standards are inconsistent, they can distract from the intended message being communicated. Generally, high contrast between text and background makes it more understandable. According to Malik (2005:45), a given element’s colour or contrast to its background will contribute to the order in which the user focuses attention on elements on a display and contrast can be the primary influence on the user’s eye movements. When displaying numbers, Nielsen & Tahir (2002:22) recommend using the percentage of change when figures changed and not just the points gained or lost, using thousand separators for five or more digits and aligning decimal points when showing columns of numbers.

- Animation with relevance: When the mouse pointer hovers on a pie chart for an area, the related performance metrics are also highlighted. Nielsen & Tahir (2002:19) warn that animation can have an impact on download times. Limiting content is the most important principle of dashboard layout (Malik, 2005:50). Overloading a dashboard screen can overwhelm the user and good dashboard software would normally allow the user to make his or her own selection of KPIs, as well as performing limited customisation.

Some of the most common representations of KPIs in dashboard solutions are given by Gonzalez (2005:Part 1) in Table 2.7:

Table 2.7: Common presentation of KPIs

Representation	Description
Alert and traffic icons	Gonzalez (2005:Part 1) proposes using different colours or shades for alerts and traffic icons to convey the message the shapes intend to convey. Normally, this requires other supporting information for message conveyance to be effective. The traffic light icons require a large percentage of the available space on the dashboard screen. Pappas & Whitman (2011:254) also hold the view that speedometers and dials take up too much space. Few (2006:153) prefers simple shapes such as circles●, squares ■, ups ▲ and downs ▼, and triangles in red and green or × and ✓.
Trend icons	Trend icons represent performance indicators that change over time. Arrows or numbers suitably portray the status of the three states, moving towards a target, away from a target or remaining static (Gonzalez, 2005:Part 1). Line graphs and coloured up or down arrows are suitable to portray trends (Pappas & Whitman, 2011:254).
Progress bars	A progress bar represents more than one dimension of information about a KPI via its scale, colour and limit through a visual representation of progress along an axis (Gonzalez, 2005:Part 1).
Gauges	Gauges convey positive and negative values along a relative scale and can represent dynamic data that can change over time in relationship to underlying variables (Gonzalez, 2005:Part 1). The same can apply as in the case of traffic lights and alerts above.

Gonzalez (2005:Part 1) relates that support analytics is information that provides more detailed information to assist the user in better understanding the KPI performance. Support analytics could normally be in the form of charts, tables or lists. When support analytics are graphically presented, it is important to keep in mind how the end users will use the information. The visualisation forms for support analytics by Gonzalez (2005:Part 1) and the viewpoints of Few (2006:124–160) on the suitability of different types of graphics are integrated to compile the following summary in Table 2.8 of how graph types and features should be applied.

Table 2.8: Suitability of graph types

Graphic	Summary
Pie charts	Pie charts depend on colour or pattern to discern differences and can be used for small data sets with six and less elements (Gonzalez, 2005:Part 1). According to Few (2006:135), when values of “parts of a whole” are displayed, a pie chart would usually be used, but according to him, a bar graph would be a better mechanism to display the “parts of a whole” information as long as the title indicates that it forms part of a whole. Pappas & Whitman (2011:254) think the pie chart visualisation is less efficient because little information is provided in relation to the space occupied by the round element.
Bar charts	Pappas & Whitman (2011:254) state that comparisons are visualised effectively by line, bar and bullet graphs. (Gonzalez, 2005:Part 1) considers bar charts to be best suited for visually showing the relationship of data elements in categories, for example, sales per product group. Few (2006:113) postulates that categories can have the following scales: 1) nominal scales normally differ in name such as product groups; 2) ordinal scales have an intrinsic order, but do not correspond to quantitative values, such as small, medium and large; while 3) interval scales have an intrinsic order and quantitative values, such as age groups or months of the year.
Line charts	Line charts are used to display data elements side by side over time and allow for comparative trend analysis if multiple series of data are stacked into one chart. As defined above, line graphs are suitable for interval categories and not for nominal or ordinal scale categories (Few, 2006:120 114).
Bar and line graph combination	The bar and line combination is used when the data of one measure is comparable against categories in a bar graph and another measure where the overall shape of the information is important in a line graph. A Pareto is a special case of the line and bar graph combination. It displays the values of a category in a bar graph and the cumulative total of the values as a line graph. It clearly shows along the bar graph what the top-performing categories were and how much their combined contribution was, against the line graph, for example, the top 3 out of 10 sales people were responsible for 75% of the total sales for a period (Few, 2006:118–119).

Graphic	Summary
Bullet graph	Bullet graphs display a key measure's performance state against ranges and a comparison against a target (Few, 2006:107). Users can compare line lengths easier than comparing differences in angles as in pie charts (Pappas & Whitman, 2011:255).
Stacked bar graphs	Stacked bar graphs are used for multiple instances of parts of whole information and comparing the "wholes" (Few, 2006:116; SAP (Design Guild), 2001:4).
Sparklines	A "word-size" graph to fit alongside text is instantly available and conveys a trend or historical shape (Pappas & Whitman, 2011:254; Few, 2006:120).
Area charts	According to Gonzalez (2005:Part 1), the area under or above a line chart can be shaded or coloured and it can be used for simple comparisons of multiple series of trends over time. However, Few (2006:151) warns that they are often incorrectly interpreted or that one area can be completely or largely hidden by another graph.
Radar plots	Few (2006:153) suggests that radar plots are successful when the data could be intuitively viewed against a circle, such as the hours of a day, but generally, he feels that bar graphs would be more effective.
Labels of charts and graphs	Gonzalez (2005:Part 1) points out that the more a user views a chart, the simpler the labels and context can be. The more distinctive the labels, the more it will distract the user's attention from the actual data presented in the chart. Few (2006:178) agrees that the "prime real estate of the screen should be used for important data", and should be "simply, clearly and quickly" understood (Few, 2006:201).

2.3.4.3 Presentation of the metrics on a dashboard: dashboard layout

The layout can be considered as part of the design, where aspects such as the number of frames on the screen, symmetry and proportions, computer resolution and context are discussed (Malik, 2005:50):

- Number of frames or windows: Multiple frames can be created on a dashboard screen and independent charts and reports can be inserted into the same window. Four and, optimally, six frames per window are recommended so as not to overload the user and create areas that are less accentuated (Malik, 2005:50). According to Nielsen (1996), frames cannot be bookmarked and pages cannot be printed easily.

- Symmetry and proportions: Frames that are uniform in size and shape are better to use (Malik, 2005:50). As indicated under the previous bullet, Nielsen (1996) is not in favour of using frames in general web interface design.

- Computer resolutions: At the time of writing, Malik recommended that best practice is to design dashboards for 1 024 x 768 screen resolution, since the majority of desktop monitors and laptop screens used that resolution setting. The resolution used for computer screens is currently much higher. His recommended resolution eliminated the need to scroll for higher resolutions and important KPIs requiring user attention should not be placed in the viewing area that requires scrolling (Malik, 2005:50). Nielsen (2006) recommends optimising development for 1 024 x 768 screen resolution, but not to design only for 1 024 x 768 screen resolution.

- Context: Dashboards provide a view into the business and only users can advise on how interrelated charts and reports of critical business information should be viewed. Therefore, it is advisable to involve users early in the design phase to get their inputs and feedback (Malik, 2005:50; Pappas & Whitman, 2011:257; Ein-Dor & Segev, 1978).

2.3.4.4 Presentation of the metrics on a dashboard: dashboard navigation

Malik (2005:46) describes navigation to be related to the way charts and screens are linked and how the user can drill down into more detailed reports or charts. Key considerations are information grouping and hierarchy, and position. He recommends the involvement of users to determine the grouping of information according to the business context, and the hierarchy levels on which the dashboards should focus.

Two levels are fairly standard and the first level will have tabs or links to second-level dashboards. Large lists of non-numeric data or data with relationships are not easily visualised, and data that cannot be numerically analysed is best displayed by tables and lists, such as the line items within an organisation's balance sheet. The following dashboard design mechanisms can be considered (Malik, 2005:46):

- Context grouping: Placing elements in visual proximity to each other and grouping them by colour or lines give an implied context and relationship between the elements. According to Gonzalez (2005:Part 1), it is a good technique to establish the association between supporting analytics and the related KPI. Few (2006:157) also find tables, spatial maps and "small multitudes" useful to organise information on dashboards, where tables present data in columns and rows, and spatial maps graphically display the categories according to the relative space they occupy on a map. "Small multitudes" repeat the same basic graph a number of times for different variables.

- Tabs and pivots: Tabs and pivots are used to navigate across the dashboard groups. Tabs are links that are presented horizontally or vertically with a brief title on which the user clicks to branch to other corresponding dashboards. Nielsen (2007) compiled guidelines for using tabs and postulates that tabs should be arranged horizontally and that only one row should be used. Pivots are drop-down lists that allow users to select any of the listed dashboards for viewing (Malik, 2005:46). In general web design, Nielsen (2000) summarises the use of pivots or drop-down menus as being troublesome and often confusing because they are applied for different purposes. When users can scroll, they are prevented from seeing all their selection options.

  Context drilldown: Malik (2005:46) views context drilldown to be an extremely important aspect of the navigation design, since it facilitates investigation for analysis. The context drilldown adds the intelligence of the data point on a chart that the user clicked on. There are two components to a drilldown: the source and the destination. The source captures the specific point within the chart or report that was clicked on, which then serves as a parameter to filter the detailed report or chart supporting the user's investigation.

The filtered chart or report is the destination. The source also serves to store the point of origin. It is important to carefully consider the context drilldown in terms of source and destination pairing and it is good practice to get the users' input to optimise and customise the drilldown to suit their management style, as well as the way they conduct their business (Malik, 2005:46).

Whitenton (2013) supports the recommendations above and suggests using breadcrumbs (links from the source to destination) and site maps (providing the structure of the site) to help users with site navigation.

2.3.4.5 Presentation of the metrics on a dashboard: Different dashboards for different levels of management and how they relate to the different metrics

Executives and managers need to see different information and are not necessarily interested in the same information or KPIs. Depending on the procedures of the organisation, some information may be required to be screened from particular users. This requires access control and an understanding of what information users need. Access control needs a dual-purpose approach in securing personalised information and protecting the site (Kirtland, 2003). A more detailed discussion of the issue of security follows in section 2.3.5.2.

Popp (2008:1) gives a well-defined explanation of the characteristics of dashboards at different levels of management. He stresses that the information should be customised according to the users' needs and should be refreshed in time for the decisions managers are required to make.

The levels of management are categorised as operational, tactical and strategic. The information provided on the dashboards for the different levels of management are as follows:

- Operational level: At this level, operational processes are monitored and the data has to be refreshed as close to real-time as possible. Emphasis at this level is on monitoring processes more than analysis or management.

- Tactical level: The purpose is to analyse performance of processes on departmental and project level rather than monitoring or managing processes. The dashboards are deployed through portals and source data from data marts or data warehouses.

- Strategic level: The nature of the dashboards is more sophisticated at this level. The purpose is to monitor business performance against strategic objectives and there is more emphasis on management than on monitoring or analysis. The information often supports the balanced scorecard methodology.

The presentation of the metrics should contribute to understanding and usability for the users. The users have to engage with the presentation on a regular basis to be able to experience the diffence in visualisation, design, layout and navigation. By using the information, the level of detail can be experienced in day-to-day management.

2.3.5 Subquestion 5: How is data sourced for dashboard metrics?

Four elements constitute the facets of a KPI: data sources, granularity, calculation and variance (Malik, 2005:17), as discussed in 2.3.3.5. Information pertaining to each of these facets has to be gathered and compiled to effectively source a KPI on a dashboard.

Eckerson (2003) refers to the extraction, transformation and load process of data preparation as archaeology and analysis when integrated data is loaded into a data warehouse, where the data is optimised for query processing and report generation. Subsets of data, called data marts, can be prepared to make the data more user-friendly and allow users to slice-and-dice.

Malik (2005:17) calls the collection of data sources in an organisation the “information biosphere”. In order to present properly integrated information on dashboards, numerous information sources should be accessed seamlessly by dashboard software to facilitate smooth navigation and contextualisation.

Data sources, such as relational databases, multidimensional databases and OLAP cubes, vendor-specific reporting and enterprise resource planning (ERP) systems, may form part of the data sources of dashboards.
It is important that the variance of a specific KPI is consistent across all its possible grains to establish a uniform performance benchmark across the organisation (Malik, 2005:25). Therefore, change in revenue across all geographies, brands and time periods would always be calculated as a percentage change for the same time a year ago for corresponding geographies and brands.

A single KPI could require multiple variance calculations. For example, the revenue may be required to also reflect quarter -ago percentage change and month-ago difference. The variance of KPIs plays a key role in defining business rules to configure alerts and triggers for dashboards. The following framework can be used to gather supporting information to consolidate the relevant details of the four elements data sources, granularity, calculation and variance:

Table 2.9: Framework to map the KPI details required for building dashboards

KPI	**Data source**				**Granularity**		
Name	Report	Universe/Cube	Database	Other	Time	Geography	Product

Calculation		**Variance**		**Threshold**			**Alert**	
Formula	Additive			Lower	Middle	Upper	Action	Recipient(s)

(Malik, 2005:25)

2.3.5.1 Sourcing of data for metrics: complexities to overcome when data from different data marts are united into a single dashboard

When data sources for KPIs are identified, gaps in information delivery are often exposed. This poses a challenge to integrate the numerous sources of information so that they can seamlessly communicate with dashboard software in presenting all information in a fully integrated manner.
Lack of data integrity, data redundancy and a lack of well-defined business rules are examples of the loopholes that are often exposed. According to Malik (2005:17), it is a common occurrence that the process of defining KPIs triggers a parallel process of data standardisation, validation, data warehouse enhancement and extraction, and transformation and loading.

Eckerson (2003) describes that data from multiple transaction or operational systems is extracted, integrated and stored in a data warehouse. According to him, the matching and merging of data from different sources and formats turn data into information.

The KPI initiative can lead to a gap analysis between the requirements and the capabilities of the software. It is imperative that the dashboard software is able to communicate and interface with the different disparate data sources. If the software falls short of directly linking to specific data sources, it should be possible to develop practical workarounds that are not difficult to maintain.

A single KPI may involve multiple data sources, for example, the market share of an organisation’s product may require the sales data from the enterprise data warehouse and the total sales per category as reported by an external vendor who tracks the industry. Malik (2005:20) maintains that dashboards require additional efforts, manipulation and massaging of data to consolidate data from different sources into seamless dashboard software communication. He refers to this as “the harmonisation of the information biosphere”. This view corresponds with the view of Eckerson (2003) and Kirtland (2003:2) that the data needs preparation for dashboards, reports and slicing-and-dicing.

Internal staff members, who understand data preparation, are required to interpret and prepare data for dashboard use. Skilled data management team members are also required, because the data preparation is crucial before presentation can be developed.

2.3.5.2 Sourcing of data for metrics: what security measures should govern?

Dashboard personalisation is an intersection of three dimensions: user groups and hierarchies, content domain and privilege domain (Malik, 2005:35).

- User groups and hierarchies

  User groups and hierarchies allow the allocation of a set of privileges and access to groups and through inheritance. The privileges are allocated to all the sublevels in a hierarchy. User groups and hierarchies in a database context enforce access to tables, views, columns and database commands, while dashboard groups control the access and privileges related to dashboard functions, features and KPIs. Dashboard privileges are similar to roles and hierarchies of users of a report distribution system and are related to the business requirements, the organisational hierarchy and the domain of responsibility of each level of the hierarchy with its information needs.

- Privilege domain

  Privileges apply to a set of functions a user may perform with the software and are generally grouped as roles. The business user role is normally the lowest level, the power user or analyst role uses the dashboard software more effectively, and the administrator role manages the environment with all the functionality of the lower roles. An inverse relationship usually exists between the software's capability and the user's required proficiency level.

- Content domain

  Content domain involves the management of "what data and KPIs a user can see on a dashboard" and is classified into security and relevance of information. Security and relevance contribute to the delivery of personalised content management. It is imperative to consider the entire user community and to develop a structured framework for personalised dashboard deployment. Security refers to the restriction of information delivery to users who are allowed to access information at different levels of confidentiality. The security framework should be defined with the help of the user community during dashboard deployment. Relevance refers to the control of the most relevant content per dashboard user. The levels of control for security and relevance involve the control of access at different levels (Malik, 2005:35):

Table 2.10: The control of access at different levels

Level	Access
Dashboard level	Access is controlled per dashboard group or individual dashboard according to the management level of the user. For example, the set of dashboards for senior management may consolidate high-level, organisation-wide KPIs, which are only deployed to top management executives.
Report level	It is common practice to have embedded reports and links to reports on dashboards. These reports can also be restricted per group or individual user.
Chart level	Chart level control is data displayed by the chart to which the user gains access or not.
KPI grain level	KPI grain level provides the main control over relevance. A regional manager may have access to his or her regional information, but links and reports can provide access to other regions' information, as well as historical information, depending on the predetermined access privileges.
Subject area level	Subject areas can be defined as a collection of dashboards, reports, charts or KPIs. Therefore, subject area control facilitates the allocation of access collectively to predefined groups rather than the individual assignment of access.
Alert level	Alerts are used to alert the user to exceptions and any unusual change or threshold level of a KPI that is reached. The users who have to act on the exception indicated by the alert have to be identified and assigned at the alert level.

If a complex security hierarchy is required, careful planning is needed, as well as dedicated staff mambers to perform the security management. Designing the different roles and levels can also be quite complicated.

2.3.6 Subquestion 6: How should executive dashboards be managed and maintained?

The purpose of the dashboards is to provide actionable information. The day-to-day maintenance and application of dashboards in practice require monitoring and discussion of variances to give insight. Monthly reviews of the dashboards can be used to inform discussions of problem areas (Petaschnick, 2004:11).

According to Dresner et al. (2002), business, analytical and IT skills are required in BI competency centres. Business skills include understanding the business communication on executive level and making business-related decisions. Analytical skills include analysing data and patterns, applying statistical and analytical techniques, and collaborating with IT staff to identify data for specific analyses. IT skills are required to understand the infrastructure and implications of business and analysis decisions on infrastructure, proficiency with tools, technologies and data extraction, translation and manipulation techniques, and how to access and manage data.

2.3.6.1 Management and maintenance of executive dashboards: where the management of executive dashboards should fit into the reporting structure

Dresner et al. (2002) state that the position of a BI department in the organisational structure will vary from industry to industry, but it should not be located in a line function such as the IT or Finance departments because it cannot focus on only one discipline.

In a study performed by Eckerson (2006b), information management departments provided centralised BI and data warehouse services to other units in the organisation. BI competency centres were applied in decentralised environments where different business units would perform their own BI and data warehousing functions.

The view of Boyer et al. (2010:49) is that the structure of organisations changes and matures, and the position of BI competency centres in organisations also changes.

BI competency centres are functionally focused, centralised in enterprises or federated and distributed across regions or divisions. Their observation is that BI competency centre changes are linked to the implementation and development life cycle of the BI tools. Safeer et al. (2011:268) propose that organisational change and review phases are performed in the implementation of BI competence centres to manage the organisational change and reconsider the operations and configuration of the competency centre as it evolves.

From the discussion above, the position of BI competency centres in organisations varies and does not have a specific position in organisational structures. According to Boyer et al. (2010:49) and Safeer et al. (2011:268), organisational structures change as the maturity of the competency centre and the software change. Safeer et al. (2011:268) concluded that the presence of a BI competency centre contributed to the success of BI projects and ensured better adoption of BI on different levels in organisations.

In order to efficiently manage the business intelligence, the position in the organisation needs to change with the changing technology or organisational environment. Changes in information technology operational systems affect the business intelligence functions directly, therefore the management should also be resilient to adjust to changes.

2.3.6.2 Management and maintenance of executive dashboards: What are the skill sets required to develop and maintain dashboards for executives?

“Successful dashboard deployment is such as a team sport requiring the pooling of diverse skills toward the common goal” (Malik, 2005:87). The pooling of resources from diverse skill sets and various areas of expertise are required for the implementation of dashboards.

The typical mix of resource skills and expertise required in a dashboard team are as follows:

- Dashboard software expert
- BI expert
- Business analyst
- Department/business unit subject matter expert
- Database administrator
- IT manager
- Project manager

(Malik, 2005:87)

In his study, Hammond (2006) found that project manager, data analyst, data modeller and systems analyst are the roles most commonly involved in projects, and are the roles in which team members performed more than one function. The involvement of the various resources differs in the different phases of the projects, but it is recommended that all the team members are actively informed and involved in the implementation phase.

There is a risk that shortcomings are not detected early enough. Individuals may fulfil more than one role and/or groups may perform the roles. Assembling the right team and keeping them fully involved throughout the dashboard process is extremely important (Hammond, 2006).

A really critical requirement is to co-opt end users. It is important during the early deployment phase to assess the full scope of users' information requirements and to elicit their input during the storyboarding process (Hammond, 2006).

2.3.7 Subquestion 7: How can the ROI of executive dashboards be determined?

Four ways of creating business value with information are through minimising risks, reducing costs, creating new reality and adding value with customers in markets (Marchand, 2000). If these four elements are measured, the information can help with a framework to measure to what degree a dashboard satisfies information needs. From the experience related by Wettemann (2002), it is apparent that companies achieve significant ROI by integrating existing data sources through BI to provide a better view on operations and performance.

According to Malik (2005:173), there are two sources of returns in any ROI calculation: cost savings and additional business opportunity. The cost savings factors are related to efficiencies, and are simpler to determine, but the real winning initiatives are those with a significant component of increased business opportunity, and of which the initiatives are supported by strategy and vision. The challenge remains in the ability to quantify the relevant benefits and associated monetary value. Once that is done, it can be divided by the cost factors to determine the ROI. Typical ROI factors of a dashboard initiative are the following (Malik, 2005:173):

Table 2.11: Typical ROI factors

Cost savings	Additional business opportunity
• Reduction or elimination of efforts for consolidating disparate reports • Reduction of time wasted in reviewing an overwhelming amount of data and reports	• Better decision-making with more current or live information • Better business insight due to improved data visibility through enhanced visualisation
• Reduction of time in coordinating and monitoring complex processes • Reduction of effort enforcing regulatory compliances • Elimination of redundancies within the organisation for processing similar data	• Proactive and timely decision-making with exception management and alerts • Greater democratisation of information, empowering the front line of the organisation • Better customer service and enhanced value delivered to customers and/or vendors

In calculating the ROI, the cost factors directly related to the dashboard initiative are as important as the sources of return. The total cost of ownership (TCO) for an extended period should be considered.

According to Malik (2005:168), the main cost factors to be considered for a successful dashboard implementation are the following:

- Software cost
- Annual support cost
- Additional hardware cost
- Initial deployment cost
- User training cost
- Ongoing support personnel cost

Malik (2005:171) gives a useful basic framework that can be applied when calculating the TCO:

Table 2.12: Framework for calculating TCO

Cost factors	1st year	2nd year	3rd year	4th year
Software cost CPUs Named users Concurrent users Department/enterprise license Developer license				
Prerequisite software Prerequisite 1 Prerequisite 2 Prerequisite 3				
Annual support cost Dashboard software support Prerequisite software support				
Additional hardware cost Production server(s) Test/developer server(s) Additional storage				
Initial deployment cost Infrastructure readiness – extraction, transformation and load (ETL), etc. Dashboard development – internal resources Dashboard development – external				

Cost factors	1st year	2nd year	3rd year	4th year
resources				
User training cost IT administrator(s) training Power user(s) training Business user(s) training				
Ongoing support personnel cost IT support personnel Business analyst support Dashboard developer support				

2.3.8 Subquestion 8: What are the preliminary design guidelines and typical problems found in executive dashboards implementations?

From the preceding literature review, the following preliminary design guidelines are formulated to guide the design and formative evaluation of the dashboard implementation at Unisa. Many of the preceding discussions included guidelines for scorecards and performance management, and were not used to compile the initial guidelines. Five initial design guidelines and six "wicked problems" are presented below.

2.3.8.1 Conduct a thorough investigation of user requirements and liaise with users about the measures

According to Zurell (2002:42), important requirements in the design approach of dashboards is the thorough assessment of user requirements and getting consensus on what the measures are that represent the performance of the specific line of business.

2.3.8.2 Decide on dashboard design and layout

According to Malik (2005:45–56) the presentation of data on dashboards can be divided into three broad categories: dashboard design, layout and navigation.

2.3.8.3 Users should be consulted about dashboard context and drilldown

The dashboard context and context drilldown are separated from the previous design guideline, because of its importance in the usability of the dashboard. Dashboard context is discussed in the next section and context drilldown in section 2.3.4.4 above. Users have to be consulted on how information interrelates and suits the management style. Context drilldown is an extremely important aspect of the navigation design, since it facilitates the investigation for analysis (Malik, 2005:56).

2.3.8.4 Provide intuitive and economic dashboard navigation

Dashboard navigation is discussed under section 2.3.4.4. The grouping and hierarchy of the information should be consulted with the users to reflect the relevant context and importance of information in the business context (Malik, 2005:56).

2.3.8.5 Design best-suited metrics

The most difficult part of designing a dashboard is to determine best-suited indicators or metrics (Petaschnick, 2004:9). In order to add significant value, performance indicators have to be presented in the context of comparable standards, such as benchmarks, historical trends or goals, and it should be in line with other indicators contributing to the same goals (Rau, 2004:13).

2.3.8.6 Typical problems found in executive dashboard implementations

In section 3.5.9 of Chapter 3, six “wicked problems” are discussed. Designers have to design and envision elements that do not exist in an undefined environment full of wicked problems without knowing what the outcome will be. The six “wicked problems” will serve as the draft problems found in dashboard implementations.

2.3.9 Subquestion 9: How should the preliminary design guidelines for executive dashboards be adapted for Unisa?

Design guidelines for the development of dashboards in the literature were investigated in Subquestion 8. These design guidelines, which are drawn from the literature discussed in Subquestion 8, will serve as the preliminary design guidelines for the prototype development conducted in Chapter 4. During the design science process followed in the empirical work of Chapter 4, the preliminary design guidelines, as defined in Subquestion 8, will be adapted and refined according to the requirements for the case of Unisa.

2.3.10 Subquestion 10: What are the characteristics and frameworks for dashboards in tertiary education institutions?

In general, literature sources about dashboards in tertiary education institutions focused on the following five main areas:

- Scorecards with performance indicators
- The internal monitoring of operational processes with operational dashboards
- The kind of analytics involved in the processing of information for dashboards
- Technology levels
- Investigating frameworks for dashboard development particular to tertiary institutions

The following sections provide a closer look at these five areas.

2.3.10.1 Characteristics and frameworks: performance dashboards/scorecards in tertiary education institutions

Volkwein (2010:13) identifies that the dual purposes for the assessment of higher education institution effectiveness consist of inspirational internal improvement and pragmatic external accountability. The difference identified between executive dashboards and performance dashboards/scorecards in section 2.3.1.2 resonates with this view of Volkwein (2010:13).

Executive dashboards monitor the performance of operational processes, while performance dashboards/scorecards monitor progress against targets (Eckerson, 2006b:13). The classification of the purpose of institutional assessment provides a practical guide to distinguish between the differences found in the literature sources about dashboard and scorecard development in tertiary education institutions. It also relates to the balanced scorecard model of Kaplan & Norton (2001:76) where internal processes contribute to the outwardly focused strategic level of institutional outcomes.

References to scorecards were found in Stanley (2010), Minnesota State Colleges (2010) and Institutional Research Reporting and Assessment (2005).

South African references to performance dashboards or institutional performance indicators were also found. The Council on Higher Education Higher Education Quality Committee (2007:5) refers to dashboards at the Central University of Technology in the Free State and a “Balanced Scorecard of performance indicators” at the University of Pretoria. The Council on Higher Education Quality Committee (2008:12) also refers to an “institutional dashboard” at the University of the Witwatersrand.

Looking at the performance indicators, it can be observed that the classifications in most cases include indicators focused on improving internal efficiencies (leading indicators) (Kaplan & Norton, 2001:76), as well as indicators that are externally focused (lagging indicators) (Kaplan & Norton, 2001:76) and concerned with the outcomes produced by the effect of the initiatives often measured by the leading indicators.

In the example of the Minnesota State Colleges (2010) a “board of trustees accountability dashboard” was launched with indicators such as the ratio of tuition fees to median income, student success rates, student throughput and the employability of graduates, which are outcome focused.

With regard to the performance indicators in the South African higher education system, Bunting et al. (2008:4) divided performance indicators into systemic (externally/nationally focused) and those focused on the profiles of higher education institutions (internally focused). Bunting et al. (2008:5) defined the following categories for the institutional profiles:

- Student enrolments and outputs, including headcounts
- Success rates
- Graduation rates and growth in enrolments

- Staff ratios compared to national averages
- Research performance compared to national targets
- Financial income
- Subsidy and expenditure compared to national averages

Similar categories were found for the “RU Dashboard” of Radford University (RU) (Institutional Research Reporting and Assessment, 2005). Other authors also found similar categories for South African institutions (Stumpf, 2013; Nel, 2013).

A number of references to scorecards in tertiary education institutions in South Africa were found, although nothing was found in the particular case of Unisa at the time of the literature analysis.

The references to the international sites of tertiary education institutions, such as Minnesota State Colleges (Minnesota State Colleges, 2010) and Radford University (Institutional Research Reporting and Assessment, 2005), were links to live dashboard systems. Direct links to live South African tertiary education institution dashboards could not be found. Often references were links to documents where the words “dashboard” or “scorecard” formed part of the headings or were used in the narrative of the documents. No access to dashboard systems at tertiary education institutions could be found, although reference was made to dashboard systems in some of the documents.

2.3.10.2 Characteristics and frameworks: executive dashboards in tertiary education institutions

The main threads found in the literature sources about executive dashboards monitoring the performance of operational processes were the analytical processing involved in the delivery of dashboard information and designing frameworks for dashboard development.

Next, the role of analytical processing in higher education and its role in dashboard design will be discussed, since analytics play a major role in monitoring operational processes in higher educational institutions. Several literature sources concerned with dashboard development also focused on the role of academic analytics in institutional effectiveness and the academic domain as one of the core functional areas in tertiary education institutions.

2.3.10.3 Characteristics and frameworks: analytical processing in tertiary education institutions

Ganesan & Wellesley (2011), Watson (2011) and Van Barneveld et al. (2012) all share the view that the term “analytics” is used for an overall concept of decision-making supported by the analysis of data. Bach (2010:1) postulates that, in general, the insight from historical data is used to determine probabilities for the sample population under investigation, often to determine resource allocation targets focused on improving returns.

The view of Watson (2011:5) is that analytics has different meanings to different people. In general, it involves statistical and mathematical techniques. Examples of analytics are the multidimensional processing required to deliver performance indicators, statistical segmentation analysis in marketing businesses and mathematical processing in financial reporting. According to Bach (2010:1), the main aim of segmentation analytics is to divide the data population into subsets that have similar behavioural patterns according to profile parameters or that behave significantly differently with similar characteristics. Segmentation involves cluster and categorisation analysis.

According to Bach (2010:1), the main purpose of predictive analytics is to determine the propability that a subset of the population will perform in a specific way or make a specific decision and logistic regression. Neural networks, decision trees, support vector machines and survival analysis form part of forecast analysis. Watson (2011:5) also sees decision trees and neural networks as predictive analytics and adds survival and biometrical methods to the list. Van Barneveld et al. (2012:1) consider the purpose of predictive analytics as being to analyse reporting data and inform intelligent action from the analysis. It is similar in business and higher education. For Bach (2010:2), the purpose of predictive modelling is to identify the attributes in the data that serve as drivers of the desired outcome. Some techniques, such as logistic regression and decision trees, identify combinations of factors and relationships among variables that drive an action, while techniques such as neural networks and support vector machines determine scores, but do not provide the relationships among variables that drive an action.

To Van Barneveld et al. (2012), the purpose of analytics is similar in business and academic environments when compared with present performance indicators on management decision support dashboards that reflect business or institution performance. They consider learning analytics in a training organisation to focus on learning effectiveness and operational excellence, while in an academic institution, it focuses on students and their learning behaviours, as well as interventions to manage student success. According to Bach (2010:2), finance, operations, advancement, enrolment planning, marketing and educational effectiveness are the areas that contribute significantly to institutional effectiveness. In these areas, analytics were used to inform decisions.

Bach (2010:2) indicates that educational effectiveness consists of student support, learning, retention and incoming student analytics as the main factors of institutional effectiveness in higher education institutions. Historically, graduation rates, graduate school acceptance rates, graduate employment rates and input measures, such as the scores of incoming students, were used to measure educational effectiveness. More recently, educational effectiveness is assessed by assessing learning outcomes.

Learning outcomes assessment involves identifying measurable learning outcomes, identifying where the outcomes are supported, identifying methods of assessing the outcomes and using the gathered assessment data to improve instruction, curriculum and learning practices. Van Barneveld et al. (2012:6) distinguish learning analytics from academic analytics, which focuses on the monitoring of academic processes and is similar to business analytics. On the other hand, learning analytics focuses on the learning behaviour of students and gathering data from course management and student information systems to develop early warning systems and triggers for corrective interventions.

The following table summarises the analytics that are relevant to dashboards in tertiary education institutions. It combines views of statistical and mathematical analytics with system analytical processes as defined by different authors.

Table 2.13: Types of analytics

Term	Explanation	Sources
Optimisation analytics	Linear and integer mathematical programming and simulation	Watson (2011:5)
Predictive analytics	Logistic regression, neural networks, decision trees, support vector machines, survival analysis, biometrical methods	Bach (2010:1) Van Barneveld et al. (2012:1) Watson (2011:5)
Descriptive analysis	Reporting, such as visualisation, dashboards and scorecards, drillable and multidimensional reports, SQL queries and reports	Watson (2011:5)
Segmentation techniques	Clustering and categorisation analyses	Bach (2010:1)
Learning analytics	The use of analytic techniques to help target instructional, curricular and support resources supporting the achievement of specific learning goals	Van Barneveld et al. (2012:1) Bach (2010:2)
Academic analytics	To run the institution's business, the academics – similar to BI in other industries	Van Barneveld et al. (2012:1)
Action analytics	Improving productivity processes, innovation, performance, cultivate behaviours and build capacity for change	Van Barneveld et al. (2012:1)

Goldstein (2005:2) conducted a study on 380 institutions to investigate the uses of MIS and technology in higher education institutions in the USA and Canada.

In the study, the stages of analytical processing in higher education institutions were grouped into the following hierarchy of sophistication levels as they were performed in the institutions involved in the study (Goldstein, 2005:5):

1) Level 1: Extraction and reporting of transactional level data
   The reporting at this level was from operational system transactional data.
2) Level 2: Analysis and monitoring of operational performance
   The operational processes, such as turnaround times, compliance and monthly deadlines, were monitored.
3) Level 3: What-if decision support (scenario building)
   Historical data was used to perform what-if scenarios to determine whether specific situations might occur in future scenarios.
4) Level 4: Predictive modelling and simulation
   The analytical processing as identified in Table 2.13 is performed. Examples are logistic regression, neural networks, decision trees, support vector machines and survival analysis.
5) Level 5: Automatic triggers of business processes (such as alerts)
   At this level, the results from prior analysis were implemented in an automated system to manage workflow and business process and data management.

2.3.10.4 Characteristics and frameworks: technological level in tertiary education institutions

In the study by Goldstein (2005:4), a hierarchy of six sophistication levels were also identified in the institutions' use of technology in MISs. The lowest level was on the transaction level and the highest level employed multiple technologies, such as an enterprise-wide data warehouse and an ETL reporting tool. Goldstein (2005:4) structured the levels as follows:

- Level 1: Transaction system only
- Level 2a: Operational data store or single data mart, no ETL reporting tools
- Level 2: Operational data store or single data mart in conjunction with ETL reporting tools

- Level 3a: Warehouse or multiple data marts, no ETL or OLAP reporting tools or dashboards
- Level 3b: Warehouse or multiple data marts, with ETL reporting tools, no OLAP reporting tools or dashboards
- Level 3: An enterprise-wide data warehouse or multiple data marts used in conjunction with ETL reporting tools, executive dashboards or alerts

2.3.10.5 Characteristics and frameworks: frameworks for executive dashboard development in tertiary education institutions

Three frameworks for dashboards in higher education institutions were found in three different studies that focused on the internal monitoring of operational processes. In the first study, Muntean et al. (2010) investigated how performance dashboards supported decision-making in Romanian universities. In the second study, Mohd et al. (2010) developed a framework for higher education institutions at the University of Malaysia. This framework provided insight through visual overviews of the data behaviour generated by clustering and vector feature techniques.

The third study, a framework by the Santa Barbara City College, proposed that portal technology played a pivotal role in the knowledge management systems implemented in the college and included a decision support component (Pickett & Hamre 2002). The three frameworks are discussed below.

2.3.10.5.1 Framework 1: Romanian universities

In the first framework study of how performance dashboards supported decision-making in Romanian universities, it was proposed that information in the performance dashboards for the university management should be classified into the following groups (Muntean et al., 2010:208):

1) Student, teaching and learning
2) Faculty dashboards
3) Finance dashboards
4) Research dashboards
5) Staff and workplace satisfaction dashboards

6) University business processes and operations dashboards

The reporting architecture to support this framework consists of the following layers:

- A raw data warehouse
- Ad hoc query and transactional reporting
- Analytical multidimensional, data mining and predictive modelling reporting
- A monitoring layer with personalised dashboards and scorecards with performance indicators
- A university level portal

The reporting layers are centrally hosted on the University's web portal.

The technical environment data resides in a data warehouse that is populated from various internal transactional systems, such as student, staff, research, finance, academic administration, library and external data from other institutions, labour and employment, financial and national sources. The data includes current and historical information.
When a secondary evaluation with information from the Romanian report on dashboard technology and analytical levels against the two frameworks proposed by Goldstein (2005:3) is performed, the Romanian dashboard technology can be classified at Level 3 of the Goldstein framework technology hierarchy. Level 3 consists of "data warehouse and/or several data marts, with ETL, query and reporting tools, executive dashboards and alerts". The Romanian dashboard technology included current and historical data, performed analytical multidimensional data mining and predictive modelling reporting, which require ETL and several data marts.

The analytical level of the Romanian dashboard can be classified on Level 4 of the Goldstein framework analysis hierarchy. This hierarchy consists of predictive modelling and simulation as was demonstrated by "predictive modelling reporting" in the Romanian dashboard summary.

Comparing the dashboard technology and analytical levels to the Goldstein levels, Framework 1 proved to be sophisticated. The areas addressed by Framework 1 might not be exhaustive, but covered a wide range of areas in the academic management of universities. The variety of reporting types also proved to be sophisticated and varied. It consisted of raw data warehouse information, ad hoc query and reporting, analytical multidimensional data mining and predictive modelling, and monitoring and evaluation with personalised dashboards and scorecards with performance indicators hosted on a university-level portal. It is a high-level technical environment with raw data warehouses, data marts and multidimensional information. The analytics consisted of descriptive, multidimensional data mining and predictive modelling, which is also at a sophisticated level.

From the previous paragraph, it can be concluded that Framework 1 provides comprehensive guidelines of dashboard framework elements at universities.

The level of sophistication is high compared to other institutions, as demonstrated in the previous paragraph. However, the study did not document the empirical process that was followed to develop the components in sufficient detail to enable other institutions to follow the guidelines to develop dashboards for academic managers.

2.3.10.5.2 Framework 2: University of Malaysia

The study by Mohd et al. (2010:55) developed a framework for higher education institutions at the University of Malaysia. This framework consists of a dashboard model, prototype and technical infrastructure design. The dashboard system aims to be more user-friendly than the current reporting system. It also aims to provide insight through visual overviews of the data behaviour generated by clustering and vector feature techniques.

The dashboard system comprises the following three layers:

- The first layer provides an institutional overview dashboard that visually presents the performance of the main subjects in the management of an institution.
- The second layer is a clustering engine that clusters different objects, such as students, lecturers or courses according to behavioural attributes in the data, and allows experts to interact with the system to fine-tune the clustering process.

- The third layer presents the characteristics of the clusters in "feature vector" views, which can be used to design interventions to improve object performance.

The institutional overview dashboard consolidated the clusters into a single view that was easier to read and understand. Domain experts' interaction with the system will allow the users to select performance indicators and, in doing so, re-execute and fine-tune the clustering process. The dashboard also provides a drilldown functionality to facilitate investigation into the causes of the trends observed in the graphic presentation.

The cluster layer employed a data mining "MaxD K-means" clustering technique that clusters data without any input parameters.

The size and distance among items in a cluster, as well as size and distribution among clusters, are graphically illustrated. The technique explores the unknown data and presents student performance according to the categories "excellence", "less excellence", "medium" and "not performing" in graphic clusters. The categories are derived from the process and are considered to be more explorative than fixed categories of traditional reporting systems. Cluster characteristics, which are graphically presented by "feature vectors" in star format, allow further investigation into the nature of the clusters.

The study of the cluster behaviour enables the institutional management to identify interventions for action to improve the performance of the clusters presented in the analyses. For example, by comparing the characteristics of clusters in the "excellence" group with the characteristics of the "not performing" clusters, possible actions can be identified.

The technical environment of the system consisted of custom-developed programmes and database functionality. The system was custom-developed for the purpose and used web-enabled programming and database functionalities to perform the clustering and forecasting for the data processing, and web development for the visualisation and trend analyses features in the dashboards.

The functionality, as indicated in the framework discussion, is indeed novel and very dynamic with the on-the-fly processing without any predefined parameters. The sophistication level of the analytics is advanced and the input of tacit knowledge contributes to a sophisticated model for learning analytics, as discussed in the section about predictive modelling and clustering techniques. The analytical level of the Malaysian framework can be classified on Level 5 of the Goldstein analysis framework hierarchy, which consists of user involvement with automatic clustering recalculation and reporting.

The approach could be very suitable in an academic, student-related environment that is concerned with student behaviour patterns as proposed in the study.

In terms of the Goldstein technology framework, the Malaysian technology environment can be classified at Level 1, 2 or 2a of the technology hierarchy, which consists of a transaction system or operational data store with no ETL.

The analytical level of Framework 2 is very high, advanced and complex to understand for non-statistical users. The technology level is low when compared to data warehousing standards, since it consists of a transactional system or operational data store with no ETL, as indicated above.
Advanced training will be required to train users to a reach a self-help level. It is specific in its application and will not be easily replicated in other environments. The customised analytical programming, performing the data mining clustering technique, will not be easy to understand and will require an advanced level of statistical programming experience to interpret and understand. Will power and perserverence will be required to reproduce the system in another environment.

The reporting format is also not intuitive and end users will require a considerable level of training to understand and interpret the reporting and develop a level of self-sufficiency. The customisation is adjustable according to user input parameters, but users need an advanced level of understanding and skill to operate the system. The system seems to be customised for the specific environment and is not easily replicated in other environments. The reporting format is suitable for students and courses, but the significance in the staff and research domains would not have a wide application. The approach could be very suitable in an academic, student-related environment concerned with student behaviour patterns as proposed in the study.

The university summary level of information and the user input into the system makes it very sophisticated and advanced, but not easily generalised and implemented without specific assistance by the designers. The principle of using a course as the currency in the system has the potential to serve as a guideline for dashboard development.

2.3.10.5.3 Framework 3: Santa Barbara City College

Santa Barbara City College proposed that portal technology played a pivotal role in the knowledge management systems implemented in the college (Pickett & Hamre, 2002). The portal comprised four main components: decision support and data warehousing, document management, website management, and content communication. The decision support component is relevant to the current discussion, while the document, website management and content communication components are not considered in the current context.

The decision support system focused on academic programme review and planning, ranking of college staff, institutional performance and accreditation. The role-based customisation of the decision support information, tailored to the needs and responsibilities with drilldown functionality, was considered as the most important feature, as supported by the following statement: “The key premise underlying this concept is that customers want on-demand access to information that is tailored to their needs and preferences.”

The analytical processes can be categorised on Level 2 of the Goldstein framework analysis hierarchy and include the operational performance monitoring of turnaround times, compliance and monthly deadlines. It can be interpreted that the system focused on operational processes and planning. The role-based customisation, tailored to the needs and responsibilities with drilldown functionality, addressed the users’ needs and requirements.

The technology level cannot decisively be categorised, but portal technology and a data warehouse is mentioned. Therefore, it is categorised on Level 3 of the Goldstein technology framework.

Good academic management components, such as programme review, peer reviews and ranking, and institutional performance indicators are addressed by the decision support system. The data warehousing environment that is mentioned with role-based customisation and drilldown functionality provides proof of a good level of sophistication.

However, not enough detail and guidelines about the decision support component were documented to be evaluated against the other two frameworks and it does not offer a good framework to replicate in another environment.

Table 2.14 provides a summary, in tabular format, of the features of the three frameworks discussed in the sections above.

Table 2.14: Summary of Romanian, Malaysian and Santa Barbara City College framework features

Feature	**Framework 1:** **Romanian universities** **(Muntean et al., 2010:208)**	**Framework 2:** **University of Malaysia** **(Mohd et al., 2010:55)**	**Framework 3:** **Santa Barbara City College** **(Pickett & Hamre, 2002)**
Areas	Performance dashboards areas: 1) Student, teaching and learning 2) Faculty dashboards 3) Finance dashboards 4) Research dashboards 5) Staff and workplace satisfaction 6) Business process and operations	The dashboard system comprises the following three layers: 1) An institutional overview dashboard that visually presents the performance of the main subjects to the management of an institution. 2) A clustering engine that clusters different objects, such as students, lecturers or courses according to behavioural attributes in the data and allowing experts to interact with the system to fine-tune the clustering process. 3) The characteristics of the clusters in “feature vector” views, which can be used to design interventions to improve object performance.	Decision support and data warehousing is part of portal technology. The decision support system comprises the following: 1) Academic programme review 2) Planning 3) Ranking college staff 4) Institutional performance 5) Accreditation

Feature	**Framework 1: Romanian universities (Muntean et al., 2010:208)**	**Framework 2: University of Malaysia (Mohd et al., 2010:55)**	**Framework 3: Santa Barbara City College (Pickett & Hamre, 2002)**
Functionality	1) Raw data warehouse 2) Ad hoc query and transactional reporting 3) Analytical multidimensional, data mining, predictive modelling reporting 4) Monitoring layer with personalised dashboards 5) Scorecards with performance indicators 6) University level web portal	1) Performance indicator selection and fine-tuning clustering 2) Drill down into trend causes	Role-based customisation with drilldown
Analytical	1) Ad hoc query and transactional reporting 2) Analytical multidimensional, data mining, predictive modelling reporting 3) Monitoring layer with personalised dashboards and scorecards with performance indicators	1) Data mining “MaxD K-means” clustering technique without any input parameters 2) Clustering and forecasting 3) Web development for the visualisation and trend analyses features	
Technical	Data warehouse populated from various internal transactional systems with current and historical information with several data marts and ETL	Technical environment of custom-developed programmes and database functionality	Data warehouse and web portal

A critical review of the three frameworks is discussed in terms of the features provided in the first column of Table 2.14:

- Areas
- Functionality
- Analytical
- Technical

Framework 1 (Muntean et al., 2010) is the most comprehensive of the three frameworks. It catered for all the combined features that were identified in the frameworks. Different functional areas like students, staff, research and financial information were catered for. A wide range of functionalities were covered, consisting of ad hoc querying, dashboards and scorecards, multidimensional granular and overview views as well as data mining. The analytical components included data mining and predictive analytics. The technical environment had automated ETL functionality with a data warehouse with multidimensional data marts populated from source systems containing current and historical data.

Framework 2 (Mohd et al., 2010) monitors student performance by using clustering techniques. The framework is mainly focused in one area, the functionality is sophisticated and can be used to design interventions and perform root cause anaylsis and interventions can be identified to improve object performance. The analytical features of the framework is sophisticated including clustering, forecasting, web development visualisation and trend analyses features. The technical environment consisted of custom developed programs in a database environment and there was no evidence of a data warehousing environment with OLAP software and development or ETL automation. The framework will not be easy to replicate or generalise.

Framework 3 (Pickett & Hamre, 2002) consisted of the decision support module of the portal and did not provide enough information to equally compare to the other two frameworks. Several areas were covered such as academic programme review, planning, ranking of college staff, institutional performance and accreditation but the observation was that there were fewer areas than in framework 1. Role-based drill down functionality was mentioned, but not discussed which was considered as less sophisticated than framework 2 and not as comprehensive as framework 1. There was no mention of analytical components. There was a data warehouse and web technology in the technical environment.

2.3.11 Subquestion 11: How can a framework be defined to guide the development of dashboards in tertiary education institutions?

In the previous subquestion, the literature sources about dashboards in tertiary education institutions were analysed and three frameworks for dashboard development were discussed.

Framework 1 provided comprehensive guidelines of the elements of a dashboard framework, but no empirical detail was provided for the development of the components. Framework 2 provided considerable detail of the data mining "MaxD K-means" clustering and vector feature techniques. The focus of the framework is mainly on the second and third layer functionality. It does not provide a general broad framework like Framework 1 and can be seen as providing guidelines for the mentioned techniques, rather than providing a comprehensive dashboard framework. Framework 3 provides a framework for portal development. Decision support is a subcomponent of this framework. The decision support component is not explained comprehensively enough to qualify as a full decision support dashboard framework.

The current study focuses on the guidelines for general dashboard development. The study also investigates how to approach the development and design of a dashboard in the academic management environment. Therefore, it compares with Framework 2, which does not provide comprehensive details of the wider architecture of a full solution, but is focused on detailed characteristics and customising development and design according to the academic management levels and requirements. The empirical work addressed the exemplary module of a full academic dashboard solution as a prototype that can be replicated and does not address a complete solution with all the required components and functionality. A framework will be developed by combining the knowledge from the literature study, the frameworks reviewed in section 2.3.10.5, the refined design guidelines, and the results of the empirical work. It will provide an approach to general dashboard design and development in tertiary education institutions, addressing decision support information for academic management.

2.4 SUMMARY

In an effort to sketch the background to address the research problem, definitions for BI and BPM were discussed. The importance of performance indicators, aligned to the strategic objectives of the organisation, to facilitate actionable decision-making were highlighted.

The subquestions of the research elaborated on the factors characteristic to dashboards, and elements to bear in mind in the development of dashboards. It covered an overview, design and implementation factors, visualisation and presentation factors, metrics used in dashboards, data sourcing, management and maintenance, and cost factors. The preliminary design guidelines were investigated and the characteristics and guidelines for dashboards in tertiary education institutions were pursued.

The next chapter addresses the research methodology and design of the dashboard study.

3. CHAPTER 3: RESEARCH METHODOLOGY AND DESIGN

3.1 INTRODUCTION

The purpose of this chapter is to provide background information about the research design used in the study. A qualitative approach was followed as the research methodology. The research method is used to explore the main research question and subquestions. Design science research is used to structure the research study. The philosophical position of the research study and research methodology elements that will be used include case study and data collection methods. Subsequently, design science research, as well as how participants are selected and triangulation applied are discussed.

3.2 PHILOSOPHICAL UNDERPINNING OF THIS STUDY

Several authors have argued that researchers have to make certain assumptions about the philosophical underpinnings in their research. In order to consider appropriate research methods, it is important to know what these assumptions are (Myers, 1997; Creswell, 2003:4; Hirschheim, 1992). The major assumptions are those on how knowledge is obtained. This forms the underlying guiding epistemology for the research according to Hirschheim (in Myers, 1997).

Oates (2006:283) and Myers (2009:37) argue that case studies can have positivist, interpretive or critical perspectives and, according to Myers (1997), the choice of a specific qualitative research method, such as a case study, is independent of the underlying philosophical assumptions.

Qualitative research can be classified according to a three-fold classification based on the underlying research epistemologies: positivist, interpretive and critical research (Myers, 1997:5). The research epistemologies are described below.

3.2.1 Positivist research

Positivists generally assume that reality is objectively given and can be described by measurable properties that are independent of the observer (researcher) and his or her instruments. Positivist studies generally attempt to test theory, to increase the predictive understanding of phenomena.

In positivist research, the positivist researcher, instruments and the subject are unrelated. The research aims to test theory in order to explain similar incidents with dependent and independent variables, as well as to increase the predictive understanding of phenomena (Myers, 1997; Myers, 2009; Oates, 2006). Myers (2009:37) and Oates (2006:283) describe positivist research as the approach used in the natural sciences. It aims to find laws and patterns all around the world, usually by performing experiments to prove cause-and-effect evidence.

3.2.2 Interpretive research

In interpretive research, human interpretation, such as the perceptions and experiences of the researcher, as well as the views of people who are subjects of the research, play an important role. Myers (2009:39) refines it as follows: “Interpretive researchers focus on meaning in context.” He continues with the following: “They aim to understand the context of a phenomenon, since the context is what defines the situation and makes it what it is” (Myers, 2009:39). Hermeneutics and phenomenology are the philosophical bases of interpretive research according to Boland (in Myers, 1997). This does not predefine dependent and independent variables, but focuses on the full complexity of human sense-making as the situation research develops (Kaplan & Maxwell, 1994).

Oates (2006:293) states that “interpretive research in information systems (IS) and computing is concerned with understanding the social context of an information system: the social processes by which it is developed and construed by people and through it influences, and is influenced by, its social setting”.

Oates (2006:293) summarises the following criteria for good interpretive research:

1) The research should inspire confidence.
2) The evidence should be reliable.
3) The research should involve well-captured processes and verifiable results.
4) The research should be convincing.
5) Could the research be replicated in another study?

3.2.3 Critical research

The main task of critical research is one of social critique. Critical researchers assume that social reality is produced by people and that it is historically formed and affected by social, cultural and political limitations. It focuses on bringing the limiting and alienating conditions of the status quo to light and finding ways to eliminate the causes of alienation and domination (Myers, 1997).

According to Oates (2006:295), “critical research in IS and computing is concerned with identifying power relations, conflicts and contradictions, and empowering people to eliminate them as sources of alienation and domination”. The major contribution of critical research is the appraisal of the social conditions of a specific group of people, the uncovering of limiting factors and the recommendation of liberating advice (Myers, 2009:42). Oates (2006:295) focuses on the IS environment and specifies the criteria for assessing the research. These criteria are fair data collection, improving understanding of issues around subjects, adding to lessons learnt, and providing actionable information. Myers (2009:42) stresses the “emancipation” from legal, social or political restrictions as an important requirement.

The scientific position of this study is rooted in the interpretive and prescriptive knowledge claims. It will start by identifying the problems to be solved, formulate the research questions and identify suitable research methods relevant to obtaining valid and reliable answers to these questions. The research will be geared towards the best understanding of the research problem. Myers (2009:39) argues that interpretive research is focused on meaning in context and that it will not be based on the researcher’s reality and understanding, but on what worked in the research.

March & Smith (1995:252) consider understanding information technology performance as using knowledge and corresponding to design science with a prescriptive knowledge claim.

For this reason, users will discover for themselves how to operate the dashboards and build up their own “reality” of how they function and satisfy their day-to-day information requirements. The research aims to test theory in order to explain similar incidents and increase the predictive understanding of phenomena. It will be achieved by developing design guidelines for dashboards in tertiary education institutions through an iterative process of refinement and assessment, as well as considering measurable properties that are independent of the observer.

3.3 CASE STUDY

In his discussion of qualitative research design in business and management, Myers (2009:29) lists action research, case study research, ethnography and grounded theory as the most commonly used research methods in business and management. He compares two types of case studies: teaching and research case studies. He explains that teaching and research case studies are the two most generally used types of case studies. Each type of case study has a different purpose. Myers (2009:70) explains that teaching case studies are used in education to demonstrate how theoretical principles apply in practice. On the other hand, research case studies are used to test empirical evidence in research studies and the case study can be used in various stages of the research study (Myers, 2009:72). Teaching case studies are not relevant to the current discussion. Therefore, the rest of the section focuses on research case studies.

According to Cooper & Schindler (2001:135), case studies focus on a full context, with smaller samples of data. Their view corresponds with a classification provided by Mouton (2001:10), which indicates that case studies are normally suitable for detailed studies on small samples of a qualitative nature, such as a case study of an organisation. A case study would have less cause-and-effect incidences and would not aspire to prove hypotheses from a representative sample of a population or community, which would belong to the category of statistical or participant observation studies (Mouton, 2001:143).

Oates (2006:76) defines a case study as “an empirical study that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are clearly evident”.

Myers (2009:77) states that “case study research in business uses empirical evidence from one or more organisations where an attempt is made to study the subject matter in context. Multiple sources of evidence are used, although most of the evidence comes from interviews and documents”. Both the definitions of Oates (2006:76) and Myers (2009:77) point out that it is particularly important to carefully consider the context when conducting case studies. This view corresponds to the view of Cooper & Schindler (2001:135). Myers (2009:77) focuses on case studies in business and adds that multiple sources of evidence should be applied. For the current study, which will be done in the real business environment, both definitions apply. Keeping the context in mind is crucially significant.

Oates (2006:143) classifies case studies into exploratory, descriptive or explanatory case studies. An exploratory study seeks to investigate and identify the factors, questions and hypotheses arising from a particular case. A descriptive case study documents a real-life phenomenon and how it is experienced by people. An explanatory study explains why things happened as they did, what the influencing factors were and how they can be explained by existing literature. Myers (2009:72) focuses on the exploratory and explanatory case studies for the business management discipline. He refers to the exploratory research as a phase in the study that considers the features and impacting factors. He also refers to explanatory research that is generally done when existing literature covers the topic widely and the case is used to test or compare theories, or to find cause-and-effect explanations for questions.

Different authors cover the same requirements, with Mouton (2001:150) adding that the researcher may possibly be subjective in his or her approach and that the analysis of a case study might not be thorough enough.

When case study research is conducted and research methods chosen, the philosophical perspective, which is applied in the corroboration of qualitative research, and the relevant assumptions that are made have to be considered (discussed under 3.2).

3.4 DATA COLLECTION METHODS

As this is a qualitative study, observations, focus groups and interviews can be applied as data collection methods to source qualitative data. Observations are time consuming and impractical in this context and the standardisation of the diverse observations of individuals is not a viable option. Focus groups and interviews have been integrated as the method of semi-structured group interviews. Literature review and group interviews are the two sources of data and evidence in this study. Data will be collected at three points during the study. The first data collection is during the analysis of background information and compilation of design guidelines for the dashboard development during the literature review. The second point is during the formative evaluation of the artefact prototype development. The third is during the final semi-summative assessment of the artefact development.

Research studies are exploratory or formal. In exploratory studies, the research guidelines are not strictly defined and the purpose of the study is to identify questions or hypotheses for further research, while the aim of formal research is to test a hypothesis or find answers to a research question. Depending on whether a study is exploratory or formal, data collection methods are classified as monitoring, interrogation or communication (Cooper & Schindler, 2001:135). Monitoring is the observation of the researcher without the interactive interrogation of the research subject.

During an interrogation study, the researcher interrogates subjects to gather responses using methods such as telephone or personal conversations, self-administered methods, or responses before or after stimuli. According to Krathwohl (in Herrington et al., 2007:7), the methods are determined by the necessity of meeting triangulation criteria such as various data collection sources, times, places and participants, different research methods, and different researchers and helpers.

Participants are clients, end users and researchers who partner as co-researchers or teachers, lecturers or other educational staff who perform research of their own work (De Villiers, 2005:11).

3.4.1 Semi-structured interviews

In order to understand differences and illustrate why semi-structured group interviews were considered most appropriate for the study, different instruments and methods are discussed.

In research, measuring instruments, such as questionnaires, interviews and observation schedules or psychological tests, are used to collect data about a sample population. Mouton (2001:100) draws a parallel between the actual measuring instruments in natural and health science experiments conducted in laboratories and the measuring instruments used in human sciences. Questionnaires and interview schedules completed by the participants are categorised under "participant observation" (Mouton, 2001:105). According to Oates (2006:221), respondents complete self-administered questionnaires, with the advantage that they do not feel intimidated to provide specific answers. With researcher-administered questionnaires, the researcher asks the questions. The advantage is that better response rates are achieved, questions can be probed or the sequence of the questions can be changed. The interview guide approach is summarised by (Patton, 2002:349) as follows: "Topics and issues are specified in advance, in outline form; interviewer decides sequence and wording of questions in the course of the interview". The guide is a checklist to keep the process on track and ensure that all issues are covered.

The method of data collection will be influenced by the kind of interaction with the respondents and the information required (Cooper & Schindler, 2001:332). According to Myers (2009:122), the research method, research topic and data availability will affect the data collection method. He points out that interviews are often used in the case of studies in business and management research. Oates (2006:187) also confirms that interviews are often applied to collect data in case and ethnography studies.

Myers (2009:122) elaborates that data collected through the interviews, fieldwork, documents and in minutes of meetings constitute primary data. Primary data is unique to the study it is used for, while secondary data comes from published sources such as books and articles. The following types of interviews are mentioned: structured, semi-structured, unstructured, individual and focus group interviews.

Oates (2006:187) and Myers (2009:124) have corresponding views about structured, semi-structured and unstructured interviews. In structured interviews, the researcher's role is limited and the consistency across the interviews is higher. The same, standard questions, which are prepared in advance, are used in each interview. The researcher reads the predefined, standard questions to the interviewees and captures the responses. In unstructured interviews, the interviewee is encouraged to talk spontaneously with little focus on consistency. In semi-structured interviews, the researcher asks predefined questions and consistency across the sample is better than in unstructured interviews, but new issues can be introduced and probed, and elaboration is allowed. The approach corresponds with the interview guide approach mentioned earlier (Patton, 2002:349). Interview schedules are predefined questions asked in a specific sequence, while focus groups can be guided by focus group guides.

Oates (2006:189) recommends planning interview questions aimed at an organisation's staff members by investigating background information on the interviews and the related organisational context. A list of interview questions or areas that will be covered can be distributed to the interviewees beforehand so that they can prepare for the interview (Oates, 2006:189).

All the authors provide practical guidelines and Bak (2004:136) provides general guidelines for interview design, focus groups and observation. These guidelines will be useful in the design of measuring instruments for the current research, addressing the purpose of the interview or focus group, and keeping in mind who will be involved, why they will be involved, and how many members should be involved. The full list taken from Bak (2004:136) is provided in Appendix 2.

Oates (2006:195) and Myers (2009:125) also provide practical tips on how to organise the interviews. Individual interviews are normally conducted one-on-one and group interviews normally consist of seven to 12 interviewees to allow the interviewer to probe ideas further and have better control over the interview (Myers, 2009:125). Oates (2006:195) differs slightly from Meyers when he proposes three to six interviewees for similar reasons.

Both authors recommend note-taking and recording the interview on tape or video. Bak (2004:136) recommends introductory, administrative and rules sections for the interview and Oates (2006:222) distinguishes between factual questions used to collect facts, and questions collecting respondents' opinions. Cooper & Schindler (2001:333) explain that the introduction, layout of questions and conclusion will vary with the method used to collect the data and group the questions into the following three categories:

- Administrative questions are used to identify the interviewee, interviewer and location.
- Classification questions are usually demographic, and sociological groupings are used to identify patterns.
- Target questions are aimed at gathering information about the study.

Oates (2006:221) provides prescriptions for question design, such as using questions with no more than 20 words, using words related to the questions and questions related to the research, not using ambiguous words, using specific questions and not using leading questions. Oates (2006:226) recommends checking the questions with experts and even conducting a trial run of the questions with a test focus group to iron out obvious problems in the question design. Furthermore, he recommends using more open than closed questions. Open questions encourage the respondent to elaborate, while closed questions require a “stop” answer such as the following (Oates, 2006:222):

- Positive and negative response questions: “yes” or “no”.
- Quantitative questions: How many interviews were conducted?

- Agree and disagree statements, such as using the scale: agree strongly, agree, neutral, disagree, disagree strongly.
- Scale questions: excellent, good, medium, bad, very bad.
- List questions: “Please list three most urgent complaints.”
- Rank order: “Please rank the following criteria in order of importance from 1 to 5 (1 being least important and 5 being most important)”.

Semi-structured interviews were selected as a data collection method because managers in Unisa have limited time to engage with the evaluation of the dashboard prototypes and would be able to provide valuable feedback about the design of practical and effective dashboards in tertiary education institutions. The semi-structured interviews were conducted with managers to determine their experience of the dashboard presentation and to determine to what degree information needs are met. The interviews were conducted in a longitudinal process over a period of time, where the display and access of metrics are tailored and the suitability of indicators are adjusted and tested iteratively.

Questions were formulated according to the following predefined factors that do the following:

- Measure the suitability of the information presentation in a longitudinal process.
- Identify the dimensions identified by the focus groups to measure to what degree of satisfaction managers’ information needs are met.
- A qualitative method was used to construct a measuring instrument that measures the following:
    - How well the indicators per responsibility area represent the underlying contributing drivers according to a portfolio’s unique characteristics.
    - The suitability of the best presentation method for the information and the most intuitive delivery.

3.4.2 Focus groups

The participation of the members of staff is an important component in the facilitation of the current research process and therefore it is important to discuss focus groups and their nature.

From a conventional research perspective, Mouton (2001:105) provides broad frameworks on research methodologies and designs. He divides data collection methods into four high-level groups: observation, interviewing, testing, selecting and analysing texts.

He categorises semi-structured focus group interviews as “interviewing” and when interviewees of individual or group interviews actively participate in the exercises, the data source is classified as self-reporting, alternative to observation, documentary or physical sources of data (Mouton, 2001:99). Myers (2009:125) also distinguishes between individual and focus group interviews. Focus group interviews are used to gather the collective view of the group and can be used in any discipline.

The advantages of focus group interviews are that the group’s views can be explored and probed, and the interviewer can guide the discussion (Myers, 2009:126). The group’s reaching of consensus, stimulation of ideas by other members, wider responses, as well as the definition of themes, are also advantages as Oates (2006:195) pointed out. According to Myers (2009:126), disadvantages are that the process is time consuming and expensive, some individuals can dominate and all interviewees might not participate. Oates (2006:195) lists the same disadvantages and adds that the group might not accept some members’ views. He provides practical tips to encourage more discussion by prompting the participants to say more, probing for more detail on information offered by participants, or checking with the participants that the interviewer interprets the information correctly (Oates, 2006:193).

More than one participant attended some of the semi-structured interviews and therefore focus groups are discussed as a data collection method. As postulated by Myers (2009:125), the self-reporting characteristic of Mouton (2001:99) and the group's collective view could be probed, but more diverse views were also possible and cross-stimulation of ideas, as proposed by Oates (2006:193), could be explored.

3.4.3 Sampling

In the application of measuring instruments, such as interviews or questionnaires, it is relevant to discuss sampling methods. Sampling is the application of measuring instruments to a subset of a population to draw conclusions for the whole population. It is the selection of a subset of the total population of objects that could have been included in the research. A census is the count of all the elements of the population. The elements include people and documents. Instead of using the entire population, sampling is done for the sake of time efficiency, cost-effectiveness, availability of population elements and accuracy. To qualify as a valid sample, it should be representative of the entire population. Instead of the full population, the sample is studied (Cooper & Schindler, 2001:163).

The method of probability sampling randomly selects elements, minimising any bias in the selection process. On the other hand, in non-probability sampling, the elements are selected according to certain control criteria. Table 3.1 demonstrates the high-level classification of Oates (2006:96). Although it contains less detail, it largely corresponds with the classification of Cooper & Schindler (2001:166).

Table 3.1: Probalistic and non-probalistic sampling based on Oates (2006:96)

Probabilistic	Non-probabilistic
Random	Purposive
Systematic	Snowball
Stratified	Self-selection
Cluster	Convenience

Probabilistic and non-probabilistic sampling methods are discussed below on the basis of the subelements listed above by Oates (2006:96).

Probabilistic:

- Random sampling selects the sample elements randomly using simple or complex sampling techniques and often involves statistical software to assist with the process.
- Systematic sampling applies a system to perform the selection, for example, selecting every third person.
- Stratified sampling applies the same distribution proportions of the population, such as age, gender or geographical location, in the selection of the sample.
- Cluster sampling chooses natural cross-sections to cluster the population, for example, by region, province or primary schools. Valid criteria determine the number of elements in the clusters.

Non-probabilistic:

- In purposive sampling, the elements are chosen for their close connection to the aim of the research (Oates, 2006:96). Cooper & Schindler (2001:166) subdivide purposive sampling into judgment and quota sampling. Judgment sampling is used for a specific criterion, such as women experiencing a gender-specific disease. Quota sampling chooses elements from all the multidimensional cross-sections of the population. As a result, the entire population is covered. Another example of quota sampling would be to select elements from two gender groups, 11 home language groups or nine province categories. Arguments against judgment sampling are that it assumes that the different categories are equally representative of the population under study, that only a limited number of categories can be applied simultaneously and that the bias of field workers can have an impact on the responses.
- Snowball sampling relies on referral networks to identify respondents. They are again used to refer more respondents from whom a random sample can be selected.
- Self-selection sampling is done when respondents react to a researcher's advertisement inviting respondents to volunteer their feedback about a particular topic.

- Convenience sampling selects respondents who are convenient to the researcher for some or other reason.

The perspective of Mouton (2001:150) corresponds with the above discussion and provides a classification of design types, indicating that the sampling method for case studies would typically be theoretical or judgment sampling. Judgment sampling is defined by criteria such as staff in specific departments in an organisation, while quota sampling would be chosen for certain dimensions, such as gender, race or class level, which is in proportion to the larger population. The view of Oates (2006:96), explained above, corresponds with the view of Mouton (2001:150), while Cooper & Schindler (2001:166) hold a similar view, but divide purposive sampling into more specific detail. It is clear that an inference can be drawn between the above discussion and the characteristics of the current research setting.

Leedy & Ormrod (2005) postulate that qualitative researchers intentionally do not select participants or objects randomly and their sampling is purposeful, in order to select participants or objects that will yield the most information about the topic under investigation.

3.4.4 Literature review

The second data collection method is literature review. The group interviews are the empirical study's primary data source, while the literature review collects secondary data.

The view of Mouton (2001:87) is that different sources of literature should be examined to investigate how well the topic is covered by literature and to what extent the area has been investigated and studied. A literature review should convey the researcher's ability to find and organise relevant and applicable information on the research topic and substantiate how the new research will add new insight to the existing body of knowledge or give a critical assessment of another study. Bak (2004:53) concurs with this view and adds that the literature study should be a "scholarship review" of the most recent, as well as historical sources of information on the topic, covering the evaluation methods and instruments and ensuring that the

new study is unique and relevant. Oates (2006:34) holds the same arguments as Mouton (2001:87) and Bak (2004:54) and adds that the literature review serves to conceptualise the blueprint and factors playing a role in a research study. He also points out that the literature review helps to form an approach for the research and the output it will produce. It clarifies how current research is related to existing theories, what relevant research elements are and how to process and analyse the data the research generates. It can help with ways to evaluate the output and the contribution it makes to the existing body of knowledge. The above recommendations will be relevant to understand the theoretical background of the current research, to organise the information and to ensure that the study adds unique value to and identifies the contribution it will make to the field of study.
Primary and secondary sources of information can be studied. Primary sources are from the original authors and secondary sources reference and engage with the information from the original authors (Bak, 2004:135).

Although she recommends the utilisation of search engines to look for information related to a topic, it should be noted that search engines, such as Google, Google Scholar and Yahoo, are generally available on the internet and libraries subscribe to online databases and catalogues that provide access to academic books, articles and conference papers, such as EBSCO Host and ProQuest. Oates (2006:77) points out that gateways provide links to websites on specific subjects, such as business and economics (Biz/Ed) and education (GEM). Different information sources, such as books, journal articles, newspapers, magazines, reports, theses and dissertations, can be applied in the investigation, as well as co-opting the help of subject librarians where necessary (Bak, 2004:52; Mouton, 2001:88; Oates, 2006: 73–77). The literature review for the current research covers the existing literature sources and services, as mentioned above.

Referencing and quoting sources are important elements for the literature study, as well as throughout the research documents. Researchers and students have to adopt a referencing method, and referencing software packages can be applied to ensure consistency in the referencing methodology.

Care should be taken to acknowledge every contribution of information or help in any form, and to ensure that sources are properly referenced and that ideas are not presented as the researcher's original ideas.

The assistance of the supervisor and software packages can be applied to avoid plagiarism (Bak, 2004:53; Mouton, 2001:15).

Herrington et al. (2007:6) postulate that the literature review is continuously necessary when conducting design science research in education. The literature review is essential to compile the first version of the intervention development's design principles by providing an understanding of the problem and assisting with the design principles for the iterative refining of the intervention solution.

The investigation into the subquestions of the research and the preliminary design guidelines for the prototype dashboards provided a better understanding of dashboard components, the development process and its draft design guidelines for the evaluation of the artefact development.

3.5 DESIGN SCIENCE RESEARCH

3.5.1 Introduction

Design science research is considered in the next section. This is followed by an exploration of how design science research will be employed to address the research questions in this study.

Vaishnavi & Kuechler (2004) of the Association for Information Systems (AIS) see design science research in IS as consisting of research and design. Research is defined as "an activity that contributes to the understanding of a phenomenon" and all or part of the phenomenon is created and consists of a "set of behaviours of some entities" that the researcher or research community finds interesting. The intention of design science research in IS, according to Vaishnavi & Kuechler (2004), is to investigate the characteristic of "what it means is what it does". The implementation of an artefact will investigate the "knowing is making" in practice.

"Design science addresses research through the building and evaluation of artefacts designed to meet the identified business need. The goal of behavioural science research is truth. The goal of design science research is utility" (Hevner et al., 2004:82). According to Hevner et al. (2004:82), the difference between design science and design lies in the fact that the intervention should address an unsolved problem or provide a more efficient or effective solution to a specific problem. Gregor & Jones (2007:331) caution that design theory should be developed by the design science research process and should not only be an instantiation or created artefact, which would make the effort a craft-based exercise.

The discussion of design science research will consider the following elements:

- Research outputs
- Research activities and processes
- Design guidelines and characteristics
- Research evaluation that converged from the work of the different authors
- The overall conceptual structure of design science research

3.5.2 Design science research outputs

March & Smith (1995: 255) provide a framework for design science research in IS, consisting of outputs and activities. The outputs are defined as constructs, models, methods and instantiations. Constructs constitute the documentation and definition of elements according to discipline-specific guidelines and models define how elements are related and behave. Methods specify how to perform the steps constituting processes and procedures. An instantiation is the constructed instance of constructs, models and methods, and the research output referred to as an artefact is the product of a research activity in the form of a construct, model, method or instantiation.

Hevner et al. (2004:82) also developed a framework where the artefact is the product or output of the research in the form of a construct, model, method or instantiation. The instantiation represents the creation of an output and these authors add that it should be for a specific domain and should create functionality for a specific problem. The building of an artefact is the main output of the exercise. Both frameworks require thorough evaluation. Hevner et al. (2004: 87) add the quality of novelty, which requires the artefact to solve an unsolved problem, or provide a more effective solution for an existing solution.

Vaishnavi & Kuechler (2008:3) considered several contributions to design science research in information systems and concluded that design theory is prescriptive and is the most significant requirement of design science research. This view is refined in a framework on theory development in design science research by Vaishnavi & Kuechler (2012:397). Three potential outputs are proposed. An artefact, an information systems design theory (ISDT) and a design relevant explanatory/predictive theory (DREPT). The artefact is considered mandatory and ISDT and DREPT are optional.

An artefact is defined to include software, combined software systems, system and user processes, and organisational information systems and components. An information systems design theory consists of statements prescribing how a class of artefacts should behave. A design-relevant, explanatory, predictive theory explains why the artefact functions as it does and produces the effect that it does.

In the preceding discussion, research outputs were considered for their relevance to the current study. Alturki et al. (2011:117) compiled a holistic summary and comparison of design science research outputs, as defined by various authors, which provides a more comprehensive overview.

Table 3.2 summarises the outputs of design science research by different authors and the criteria that should be considered during the evaluation phase.

Table 3.2: Summary of design science research outputs and criteria by the different authors

Output	Description	Evaluation criteria
Construct	Constructs constitute the documentation and definition of elements according to discipline-specific guidelines (March & Smith, 1995; Gregor & Jones, 2007:320).	Construct evaluation involves completeness, simplicity, ease of use, elegance and understandability (March & Smith, 1995). The specifications can be represented by physical constructs, in narrative or as diagrams, and can be in generic terms without the finer detail (Gregor & Jones, 2007:320).
Models	Models define how elements are related and behave (March & Smith, 1995).	Models should display internal and real-world consistency, completeness, robustness and understandability (March & Smith, 1995).
Methods	Methods specify how to perform the steps constituting processes and procedures (March & Smith, 1995).	Methods should have operationality, efficiency, generality and ease of use (March & Smith, 1995).
Instantiations	An instantiation is the constructed instance of constructs, models and methods (March & Smith, 1995).	Efficiency, effectiveness, impact on the environment and users, and significant improvement (March & Smith, 1995).
Better theories	Effective design science research in IS must provide clear and verifiable contributions in the areas of the artefact design, design foundations and/or design methodologies (Hevner et al., 2004:82).	Clear and verifiable contributions.
Proposal	Identification of the problem and how to solve and improve performance in the problem area (Vaishnavi & Kuechler, 2004; Gregor & Jones, 2007:320).	Problem identification and proposal of solution.

Output	Description	Evaluation criteria
Tentative design	An artefact is proposed based on the theoretical background of the problem as solution to the problem (Vaishnavi & Kuechler, 2004).	Building the first model, method, instantiation if artefact has utility for an important task (March & Smith, 1995).
Artefact	Artefact is the product of a research activity in the form of a construct, model, method or instantiation (March & Smith, 1995).	How well the artefact works (March & Smith, 1995).
Design guidelines	The goal is not to perform a critical evaluation of the quality of the research contributions, but to show how design science guidelines are satisfied (Hevner et al., 2004:82).	Design guidelines should be compiled and conceptualised in a logical and coherent way (Hevner et al., 2004:82).
Information systems design theory (ISDT)	The ISDT contains design information for the class of artefacts of which the specific artefact under consideration is an illustration and proof of concept of the design theory (Vaishnavi & Kuechler, 2012:397).	The implementation serves as an implemented example of the class of artefacts (Vaishnavi & Kuechler, 2012:399).
Design-relevant, explanatory, predictive theory (DREPT)	DREPT is an explanation of how and why the designed artefact features function the way they do (Vaishnavi & Kuechler, 2012:397). DREPT is more broadly applicable than ISDT above.	DREPT provides an explanatory and predictive knowledge base for multiple classes of artefacts, resulting in the increased trustworthiness and believability of information (Vaishnavi & Kuechler, 2012:400).

3.5.3 Design science research activities and processes

Nunamaker et al. (1991:98) summarised system development in IS processes. Their work served as a source for several other design science researchers in IS (March & Smith, 1995; Hevner et al., 2004; Gregor & Jones, 2007).

Table 3.3: The system development research process

System development research process	Explanation
Develop a conceptual framework.	Define a research question. Investigate system requirements, development and possible improvements.
Design the system architecture.	Design the architecture modules, functionality, components and relationships.
Design the system components.	Develop the elements of the system, such as the data sources and information processes.
Develop the prototype system.	Engage in the system-building process.
Evaluate the system.	Observe and evaluate the use of the system, refine iteratively in practice and capture design principles.

According to Nunamaker et al. (1991:101), system development as an IS research methodology has to comply with the following five criteria:

- The purpose of the system development is to study elements of system development through the building process.
- The outcomes should contribute to the system development domain.
- The stated requirements and objectives can be tested.
- The development is an improvement on the existing solution.
- The experience and learning gained through the process is suitable for future use.

The activities involved in the design science research in IS processes, as formulated by March & Smith (1995:255) are building, evaluating, theorising and justifying. The activities produce the research outputs explained in the previous section.

The “build” activity builds or produces an artefact. When an instance of an artefact is completed, it should be evaluated to determine how successful the instantiation was. Well-defined metrics are needed to measure whether the instantiation achieved the required results.

The “theorise” activity consists of the consideration of the factors that played a role in the creation of the research output. This is followed by the “justify” activity, focusing on explaining and proving the theory that was formulated in the previous step.

Hevner et al. (2004: 87) add the quality of novelty, which requires the artefact to solve an unsolved problem, or provide a more effective solution for an existing solution. They require proper definition and presentation of the artefact, which corresponds with the view of Vaishnavi & Kuechler (2004) and the process of searching for an optimal solution. Lastly, they require that the results are evaluated technically and managerially and that the suitability is tested. Vaishnavi & Kuechler (2004) view the outputs of design science research as a proposal, a tentative design, artefact, measures and results. They expand on the research outputs and activities described by March & Smith (1995:256) to include more generic research-related elements and activities, such as proposal, performance measures and results, as well as the process phases of problem awareness, suggestion, development, evaluation and conclusion. They included knowledge flows that illustrate the iterative nature of the process and finding a solution by iteratively adjusting the artefact.
Vaishnavi & Kuechler (2004) built on the design process steps of Tadeka et al. (1990:12) to produce the following process phases of design science research in IS and the corresponding research outputs. Vaishnavi & Kuechler (2004); Kuechler & Vaishnavi (2011) and Vaishnavi & Kuechler (2012) used the same phases in their discussions.

The design science research phases correspond to the phases of the design science research methodology (DSRM) of Peffers et al. (2008:46). In Table 3.4 below, the phases of Vaishnavi & Kuechler (2004), Kuechler & Vaishnavi (2011) and Vaishnavi & Kuechler (2012), with the corresponding phases by Peffers et al. (2008:46) in brackets, are indicated:

Table 3.4: Phases of design science research in IS and the corresponding research outputs

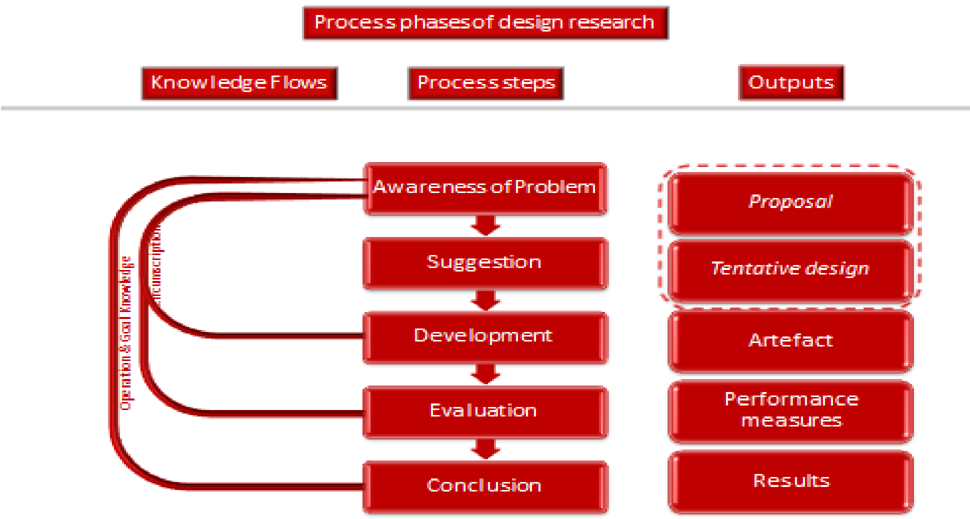
Phase	Output	Explanation
Awareness of the problem (problem identification and motivation)	Proposal	Identification of the problem and how to solve and improve performance in the problem area.
Suggestions (solution objective definitions)	Tentative design	An artefact is proposed based on the theoretical background of the problem as a solution to the problem.
Development (design and development)	Artefact	A complete or partial artefact is developed according to the design guidelines defined in the suggestion phase.
Evaluation (evaluation)	Performance measures	The partial or completed artefact is evaluated and the development, evaluation and suggestion phases can be iteratively repeated.
Conclusion	Results	The process comes to an end.

Vaishnavi & Kuechler (2004)

The last phase of Peffers et al. (2008:46) is a communication phase where the problem and its importance, the artefact characteristics and use, learning gained, research rigour and solution effectiveness are communicated to researchers and relevant audiences. Vaishnavi & Kuechler (2004) added that the research problem and findings should be communicated to managerial and technical audiences. Peffers et al. (2008:46) also required a demonstration phase. This involved demonstrating that the artefact solves instances of the identified problem, and experimentation, simulation, case study, proof or other appropriate activities could be applied in the demonstration. They also defined different entry points into the research process, namely, problem-centred initiation, objective-centred solution, design- and development-centred initiation and a client- or context-initiated initiation. Depending on the change required, the refinement cycles are repeated from the entry points as mentioned above. In the phases of Vaishnavi & Kuechler (2004), Kuechler & Vaishnavi (2011) and Vaishnavi & Kuechler (2012), as indicated in the diagram below, the phases can also be repeated from different stages.

Alturki et al. (2011:117) compiled a holistic summary of design science cycles, activities, steps or tasks defined by various authors that provide a good comprehensive overview.

Vaishnavi & Kuechler (2004)
Figure 3.1 visually presents the design science research phases as defined by Vaishnavi & Kuechler (2004), Kuechler & Vaishnavi (2011) and Vaishnavi & Kuechler (2012), and shows the refinement cycles (indicated by the arrows) involved in the process.



Vaishnavi & Kuechler (2004)

Figure 3.1: Design science research phases

3.5.4 <u>Design science research guidelines and characteristics</u>

Hevner et al. (2004:82) defined seven guidelines for a research study to be classified as design science research in IS. The knowledge and understanding of the design problem grows during the development and use of the artefact. Alturki et al. (2011:107) are of the view that the guidelines might be to abstract to apply or not clearly defined. The current author thinks that examples explaining how to apply the guidelines would assist in making them easier to understand (Gregor & Jones, 2007:320) and includes the “thick descriptions” of Carlsson et al. (2011:11).

Table 3.5: Design science research in IS guidelines

Guideline	Description
Guideline 1: Design as an artefact	Design in IS research must produce a viable artefact in the form of an original, focused intervention, such as a construct, a model, a method or an instantiation.
Guideline 2: Problem relevance	The objective of design science research in IS is to develop technology-based solutions to important and relevant problems and domains.
Guideline 3: Design evaluation	The utility, quality and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods and if the intervention addresses the specific problem.
Guideline 4: Research contributions	Effective design science research in IS must provide clear and verifiable contributions in the areas of the artefact design, design foundations and/or design methodologies. (The difference between design science and design lies in the fact that the intervention should address an unsolved problem or provide a more efficient or effective solution to a specific problem.)
Guideline 5: Research rigour	Design science research in IS relies on the application of rigorous methods in both the construction and evaluation of the design artefact. Design guidelines should be compiled and conceptualised in a logical and coherent way.
Guideline 6: Design as a search process	The search for an effective artefact is developed and refined iteratively, while satisfying laws in the problem environment.
Guideline 7: Communication of research	Design science research in IS should be communicated to technical, managerial and practitioner audiences.

Hevner et al. (2004: 83)

Gregor & Jones (2007: 320) reviewed the evolution of thinking in design science research from the previous contributions to the research theory in IS design of Dubin (1978) who had a logical approach, but did not include explanations in the research.

Simon (1996:49) promoted the building of artefacts, but theory was not connected to the building of the artefact. Walls et al. (1992) considered elements of Dubin (1978) and Simon (1996:49) to define an information design theory (ISDT). Considering the prior work, Gregor & Jones (2007:320) compiled the following eight components of the anatomical skeleton of design theory:

Table 3.6: Components of the anatomical skeleton of design theory

Components	**Explanation**
The purpose and scope	The purpose and scope component is aimed at defining specifications to develop a class of artefacts. It can be used to specify categories, comparisons and improvements.
Constructs	The specifications can be represented by physical constructs, in narrative form or as diagrams, and can be in generic terms without the finer detail.
Form and function guidelines	This is a design guideline to explain the components and their functionality, how they are organised and related.
Artefact mutability	The dynamic nature of the artefacts has to be captured by describing how their characteristics are refined and changed according to changing requirements and environments.
Testable propositions	The artefact is developed according to the design guidelines to be functional or improve an existing artefact or method. Propositions how the artefact can be evaluated to measure if the design guidelines and requirements are met
Justificatory knowledge	The component justifies and explains how the artefact functions and why it is developed the way it is.
Implementation guidelines	Guidelines for the implementation of models and system components in the real environment
Example of instantiation	The development of the artefact provides a practical demonstration of the design in the real environment. Problems can be identified and it is better than written specifications.

Gregor & Jones (2007: 320)

Gregor & Jones (2007: 322) see the main goal of the design theory to be a methodology (such as a system design life cycle) or a product (such as a decision support system). Six elements of design theory should be included in a research study: purpose and scope, constructs, principles of form and function, artefact mutability, testable propositions and justificatory knowledge.

Gregor & Jones (2007:320, 321) categorised the components of design science research into the following insight hierarchy:

- Material artefacts or instantiations, such as hardware or software, that have physical qualities that can be observed or experienced.
- Theories or abstract artefacts, such as picture and diagram representations constituting constructs, methods and models, that require insight into the problem and solution qualities to be developed.
- Human learning and insight, such as design guidelines, frameworks and theories extracted from instantiated artefacts, require a more complex level of interpretation and engagement with the artefact to gain this kind of insight than the previous two categories.

3.5.5 Design science research evaluation

The DSRM requires the designed artefact to be evaluated. Hevner et al. (2004: 84–85) postulate that the functionality, completeness, consistency, accuracy, performance, reliability, usability, fit with the organisation and other relevant quality attributes of IT artefacts can be evaluated. Gill & Hevner (2013:5–2) added that the evaluation of artefact fitness in the landscape and utility is complementary to the previous evaluation attributes.

In the formative evaluation phase, refinements to the design process or artefact are suggested and implemented. The design of the artefact is complete and effective when it satisfies the requirements and constraints of the problem it was meant to solve. In Table 3.7 Gregor & Jones (2007:320, 315) provide examples of how the anatomical skeleton of design theory is applied to evaluate research contributions. In the example below, the “anatomical skeleton of design theory” is applied to the research of Codd (1970; 1982) to show how the framework is applied in evaluating the research work.

Table 3.7: Example of the anatomical skeleton of design theory

Article details	The design theory anatomy
The introduction says better database technology is needed to increase human productivity. (Motivation is also provided: this need is significant because current approaches are failing.)	The purpose and scope of the theory are stated.
The relational database model has principles such as "the order of rows in the tables is arbitrary and irrelevant."	Artifact mutibility is addressed.
Statements are made such as " A relational database can perform as well a non-relational database."	These statements are testable propositions.
It is shown how the relational model works, by reference to underlying set theory and also human cognitive processes.	Justificatory knowledge (kernel theory) is provided.
Guidelines are given on how to produce a relational database through normalization procedures.	Principles of implementation are given.
An illustration of working relational databases is provided.	An expository instantiation is given.

Gregor & Jones (2007:320, 315)

Table 3.8 presents earlier criteria by Burstein & Gregor (1999:128) to evaluate system development, which Gregor & Jones (2007) referenced in next evolutions of their research work and that are evaluated in the same way as the example above:

Table 3.8: Evaluation criteria of system development

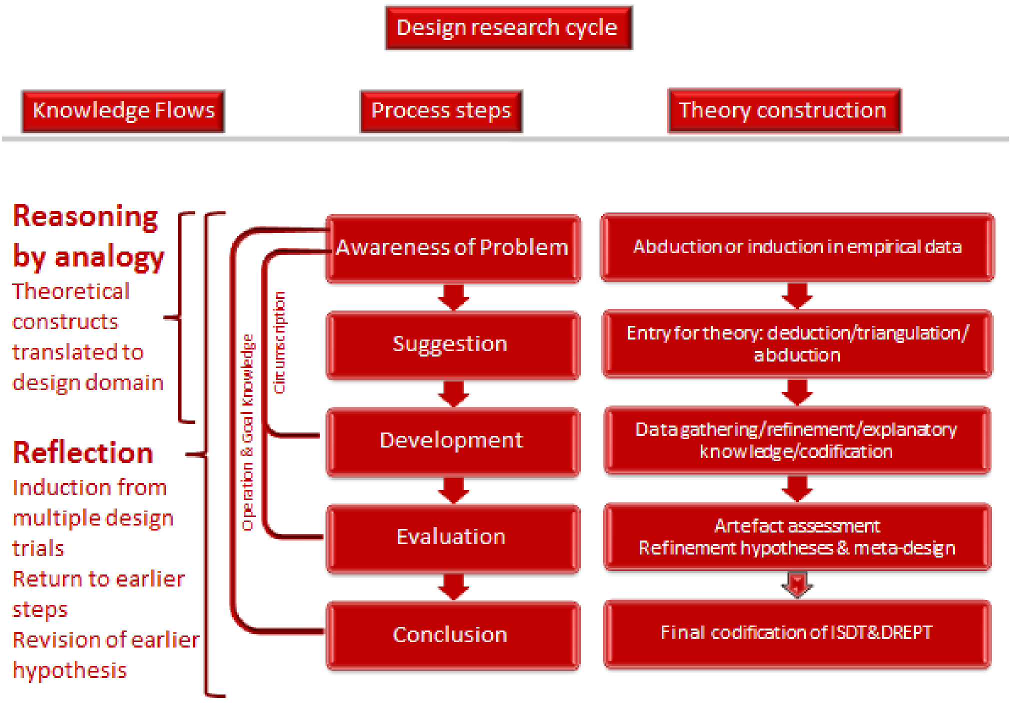
Criterium	Criteria
Significance	The research study should be significant for the knowledge domain and the practice. Does it provide better solutions to problems? Is it faster, more efficient, elegant or superior in any way?

Criterium	**Criteria**
Internal validity	Are the arguments logical and relevant? Does the development work and does it meet the requirements? Do the findings of the study make sense? Is the study believable?
External validity	Are the findings general and suitable for future use?
Objectivity and confirmability	Is the construct validity confirmed by understandable guidelines of methods and procedures? Is the researcher reasonably unbiased and are the assumptions explained?
Reliability, dependability and auditability	Was the study conducted with reasonable research quality? Are the questions, specifications and roles clearly defined? Have things been done with reasonable care and quality?

Burstein & Gregor (1999:128)

The design science research evaluation focuses on structuring the contribution the design of artefacts makes to the field of design and development research in order to elevate the effort above the level of merely being craft-based exercises.

As mentioned earlier, Vaishnavi & Kuechler (2012:397) postulated that artefact development and theory building are integral to design science research. They proposed that an artefact, an ISDT and DREPT are outputs of the research effort. An ISDT consists mainly of prescriptive statements describing how a class of artefacts should behave. DREPT augments ISDT with explanatory information explaining why the artefact has the effect it has. Figure 3.2 is an adjustment of Figure 3.1 above to include the reasoning and knowledge flows in theory construction.



Vaishnavi & Kuechler (2012)

Figure 3.2: Reasoning in the design research cycle

The theory construction, as indicated on the right-hand side of the diagram, runs parallel with the process steps to indicate that theory induction or abduction can originate from the empirical data or similar cases across the organisation. Deduction or triangulation is possible from multiple similar cases. During development, data gathering ensues, and refinements, conclusions and the codification of design knowledge starts. During evaluation, artefact performance data can inform the hypotheses and the meta-design of the class of artefacts. ISDT and DREPT can be formulated during the conclusion process.

Gregor (2006:614) developed a taxonomy for classifying ISDT, which consists of five different theories. The theories are interrelated and can include components of all the types of theories that hgave been distinguished. Traditionally, natural and physical science theories provide explanations and predictions, and can be tested. The five theories include a theory for analysing, a theory for explaining, a theory for predicting, a theory for explaining and predicting, and a theory for design and action.

1) Analysis theory includes analysis and description and does not include causal relationships or predictions.
2) Explanation theory explains how, why, when and where, and does not include prediction.
3) Prediction theory explains what is and what will be, including testable propositions and without causal explanations.
4) Explanation and prediction theory explains what, why, when, where and what will be. It includes predictions and causal relationships, and is testable.
5) Design and action theory explains how to do something with prescriptions for the construction of an artefact.

In the example below, the “theory for design and action” is applied to the research of Markus et al. (2002) by Gregor (2006:630) to specify a design theory for knowledge management systems.

Table 3.9: Example of theory for design and action (Gregor, 2006:630)

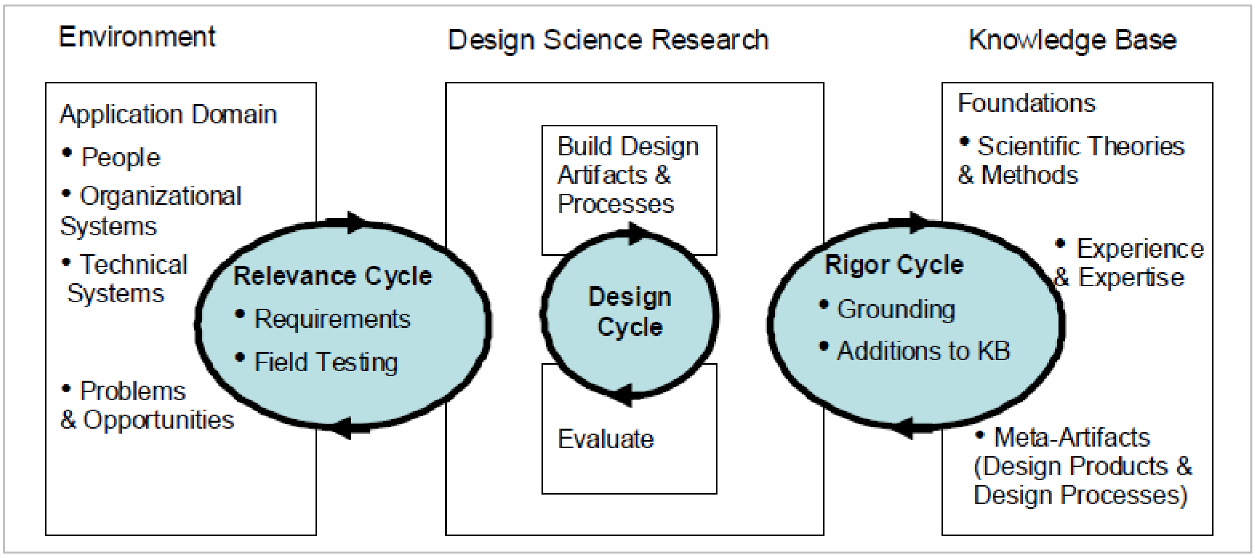
Example of a theory for design and action	
Theory overview	
Theory component	**Instantiation**
Means of representation	Words, tables, screen shots, diagrams.
Primary constructs	Users, work context, information requirements, system architecture, system processes (and more).
Statements of relationship	An example: Design for customer engagement by seeking out naïve users (Markus, 2002:188). That is, involvement of naïve users leads to a greater degree of customer engagement.
Scope	Systems that support emergent knowledge processes.
Causal explanations	Underlying micro- or kernel theories that explain the design include an understanding of the nature of emergent knowledge processes. One requirement of these processes is that general expert knowledge must be contextualised when making decisions, something that familiar expert systems are unlikely to supply, so that supplementation by personal

Example of a theory for design and action	
Theory overview	
Theory component	**Instantiation**
	communication systems should be considered.
Testable propositions	The claim is made that the design theory will assist designers of other systems with similar requirements.
Prescriptive statements	The design theory specifies the meta-requirements addressed by the theory and gives a set of system features and a set of system principles for system development to meet these requirements. The user requirements include a need to translate expert knowledge into actionable knowledge for non-experts. One development principle is that knowledge translation requires radical iteration with functional prototypes.

Gregor (2006:634) recommends the consideration of causality, explanations, generalisation and prediction in the framing of theory and that stronger theory building is possible by combining different theory types.

3.5.6 Overarching structure of design science research

Hevner (2007:87) divided the research activities of design science research into three overarching cycles that should be present for a project to qualify as design science research. These cycles are relevance, design and rigour (Hevner, 2007:88) Figure 3.3 is followed by a discussion of the elements in the diagram as postulated by Hevner (2007:88).



(Hevner, 2007:88)

Figure 3.3: Design science research cycles

The view expressed by Hevner (2007) unites the outputs, activities and processes discussed in sections 3.5.1, 3.5.2 and 3.5.3 above.

The application domain consists of people, organisational systems and technical systems that work together towards a common goal. The relevance cycle connects the environment of the research project with the design science activities and initiates the design science research in the application environment and defines the acceptance criteria of the research outputs corresponding with how March & Smith (1995:255) and Hevner et al. (2004: 82) viewed the research outputs.

According to Hevner (2007:89), the results of the field testing determines additional cycles in the relevance cycle and a restatement of the research requirements determined through actual experience, which corresponds with the iteration process in the evaluation phase proposed by Vaishnavi & Kuechler (2004).

Hevner et al. (2004: 82) proposed contributions of better theories as an output of design science research, and the rigour cycle of (Hevner, 2007:88)
Figure 3.3 (Hevner, 2007:88) connects the design science activities with the theories and methods for constructing and evaluating the artefact. Identifying different sources for ideas from existing artefacts, parallels, comparisons and theories are

ways of the theory building in the research process. The design cycle in (Hevner, 2007:88)

Figure 3.3 (Hevner, 2007:88) represents the primary component of the design science research project and iterates between the constructon of the artefact, evaluation and feedback, and the refinement of the design. The nature of the design cycle is to develop design alternatives, evaluating the alternatives against requirements until a satisfactory design is achieved. Requirements are input from the relevance cycle and the design theories and methods are input from the rigour cycle into the design cycle where the evolving artefact is developed and evaluated. The refinements of the design evaluation are re-applied into the relevance and rigour cycles.

3.5.7 <u>Requirements gathering</u>

The section on requirements gathering is discussed because the dashboard study involves system design and development, where requirements gathering is an important element. Requirements gathering will be applied as one of the data collection methods to determine the specifications for the dashboards.

Kurbel (2008:239) brings the perspective of the application of interviews, questionnaires and focus groups in requirements engineering by listing the steps of requirements engineering in system development. It consists of a feasibility study, requirements elicitation (gathering of requirements), analysis (organisation of requirements), agreeing (finalising requirements by negotiation), validation (checking for correctness) and specifications (documentation of requirements).

Eliciting pertains to the gathering of requirements to identify the latent potential of a system or collecting feedback from stakeholders. It can be done with questionnaires, surveys, interviews, studying organisational documentation, and by system and other manuals. Group elicitation can be applied to clarify the requirements through techniques such as brainstorming, focus groups, as well as rapid application development (RAD) and joint application development (JAD) workshops, as well as prototyping. RAD was also called evolutionary system development and it is a method in systems engineering used in a project environment. It is based on prototyping that was iteratively refined.

Turban & Aronson (1998:295) provide the following steps for the evolutionary method: gathering user and system requirements, building a prototype of the most relevant function, testing and assessment by the users and then improving the system according to the assessment results. The last two steps are repeated until the users are satisfied. A JAD session is a session with all the stakeholders of the system, such as the developers, analysts and other users, to determine the system requirements (Kurbel, 2008:241). Another iterative design process is dynamic systems development method (DSDM), an iterative development approach with tight time frames. It uses iterative prototyping techniques.

Kurbel (2008:236) defines core activities that would be performed in software development regardless of the order or specific approach as requirements processing, design, implementation and testing (waterfall model). Whether performed in a "linear sequence (as in the waterfall model), in iterations as in the rational unified process (RUP) method or in an evolutionary manner, yet in any case they have to be done" (Kurbel (2008:236). In their proposal of the "living-systems approach", Plass & Salisbury (2002:35) see the waterfall method as being formally structured. They add that computer-based instruction (CBI) has the following directly corresponding phases:

- An analysis phase to compile specifications of the new system
- A design phase to compile a paper-based design of the system from specifications
- An implementation phase when a computer program is developed from the design
- A test phase for testing the system
- A delivery phase when the system is delivered to the customer

Requirements comprise the documentation of the purpose of the future system and its functioning. Kurbel (2008:236) provides the following requirement classifications:

- Functional requirements describe the functionality the system will provide to the user, such as the screens, forms, reports and data requirements.
- Non-functional requirements describe additional characteristics about the performance and quality, such as consistency, optimisation and reliability.

He also provides another classification of user and system requirements, where user requirements capture characteristics relevant to the user in ordinary language and intuitive diagrams, and system requirements capture the technical specifications that can serve as a blueprint to build the system.

3.5.8 Prototyping

Prototyping is discussed because of its relevance to the DSRM and its role in the design of dashboard systems. Nieveen (2009:90) defines prototyping as an introductory version of an artefact before the full version is implemented, and distinguishes between throw-away prototypes in educational design research, which are discarded after the evaluation of the prototype has been completed, and evolutionary prototyping when the refinement of the prototyping is repeated until a final product is produced.

Madsen & Aiken (1995:57) discuss cooperative interactive storyboarding prototyping (CISP), an approach where users validate requirements of the system by interacting with mock-ups of the system to fine-tune the requirements. “The concept of iteration as a discovery process is the key to prototyping. Each successive iteration brings the prototype one step closer to correctly representing the user needs” (Turban & Aronson, 1998:295). CISP involves tools to assist in minimising the number of iterations before final requirements were reached. It also served as a record of the approved requirements. The process was designed to provoke users to interact with the mock-up system and make suggestions towards improvements.

Prototyping is a method of involving the users to fine-tune the requirements of the system through iterative interaction with mock-ups of the system. Madsen & Aiken (1995:57) describe CISP as prototyping and storyboarding. In the discipline of human computer interaction (HCI), Truong et al. (2006:12) propose that storyboarding is often used to build replications of system interfaces and to simulate the same functional context. Experts find the storyboarding process natural, while newcomers find it more difficult.

Truong et al. (2006:12) tested storyboarding in system design and identified elements important for success, such as the use of people and text, minimising of detail and considering time as implicit. They found that understanding the audience, creativity, building examples and testing the storyboard with a sample audience are success factors in the development of storyboards.

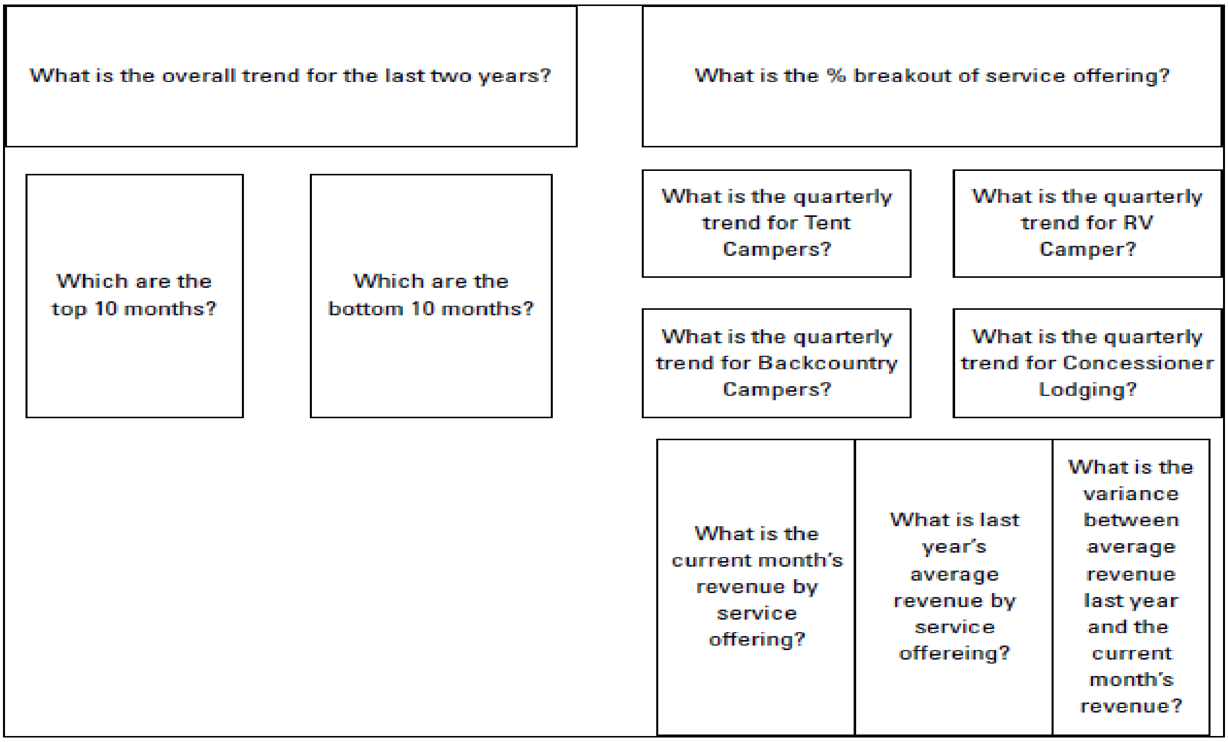
The purpose of storyboards, according to Truong et al. (2006:12), is to build replications of a system to test its functionality, similar to the mock-ups of Madsen & Aiken (1995:57) and Turban & Aronson (1998:295). The mechanism of storyboarding is used to brainstorm system requirements through the active participation of system user groups. Bowen & Reeves (2008:125) also recommend the involvement of users in the systems design process in an approach called user-centred design (UCD) that ensures that the intended functionality is met, but also that the experience of the user in using the system is acceptable and pleasant. UCD proposes the use of informal mock-ups of the system that consist of pencil drawings on paper, whiteboard results from brainstorming sessions or real-life prototypes. These mock-ups can serve as examples of the intended system to the non-technical users. Users are also involved in the design and development to ensure that the system is usable and that it produces the required results as requested. The real system is then built exactly according to the mock-ups that represent the "specifications" of the system to the developers. The mock-ups identify the integral assumptions, implications and characteristics of the system. Storyboarding can therefore be used to prototype the requirements of a system (Bowen & Reeves, 2008:125).

Storyboarding is often applied in the building of dashboards, according to Malik (2005:69), which signifies the role storyboarding plays in the development of dashboards. Storyboarding is a process developed by Walt Disney Studios to assist with designing motion pictures and animations, as well as organising the many different drawings and frames required for cartoon animation. Eckerson (2006a:257) elaborates by providing the following storyboarding steps for the building of dashboards:

- Identify the organisational dashboard segments
- Group metrics on dashboards
- Define the dashboard layout
- Map the navigation paths

Alexander & Walkenbach (2010:16) provide very useful and practical tips by creating mock-ups of the storyboards using "component questions" to build an example of the dashboard. A component question describes one component, such as a graph or table, that will represent the information described by the question.

Figure 3.4 shows an example of a mock-up layout and example component questions.



(Alexander & Walkenbach, 2010:16)

Figure 3.4: Mock-up with component questions

The authors generally ascribe the same characteristics to storyboarding and prototyping as methods to gather and verify user requirements, create mock-ups of the system in the relevant context, test usability and requirements, and test if the system functionality will deliver what it was intended for.

3.5.9 “Wicked problems” addressed by design science research

Designers have to design and envision elements that do not exist in an undefined environment full of “wicked problems” without knowing what the final outcome will be. “Finally, it points toward something that is often forgotten, that what many people call ‘impossible’ may actually only be a limitation of imagination that can be overcome by better design thinking” (Buchanan, 1992). Design science research addresses important unsolved problems in original and innovative ways or solves problems in more effective or efficient ways.

The identification of principles and methodologies to contribute to the theoretical knowledge base distinguishes the efforts as design science research (Hevner et al., 2004).

The following wicked problems are summarised by Hevner et al. (2004) and March & Smith (1995:256):

- The requirements and limitations are unclear in environments and contexts that are undefined.
- How components interact when their cause and effect in the problem environment and context are undefined.
- The design processes and artefact have to be resilient and flexible to adjust to the dynamics of the unknown environment.
- Human reasoning plays a major role in the design processes, and innovation and original thinking are important requirements to design effective solutions.
- The human interaction with the environment and relationships among participants, such as team dynamics, will impact on the delivery of effective solutions.

- Conceptualisations can blind researchers and practitioners to critical issues, such as the very widely used relational database design model that can have limited application in a data warehouse environment, where other database schemes are normally used.

3.6 RESEARCH APPROACH TO BE APPLIED IN THE DASHBOARD STUDY

For any research study, a specific design is required. The research design approach and triangulation criteria applied in the dashboard study will now be discussed.

The descriptors framework of research design defined by Cooper & Schindler (2001:135) will be followed for the research design of the dashboard study.
Table 1.2 in the research methodology section summarises the following eight research design descriptors as defined by Cooper & Schindler (2001:135):

- The degree to which the question has been crystallised
- Data collection methods
- The power of the researcher to have an effect on the variables under study
- The purpose of the study
- The time dimension
- The topical scope of the study
- The research environment
- The subjects' perceptions of the research activity

The next section will discuss how the research design descriptors and design science research will be applied in the current research study.

3.6.1 <u>The research question has been crystallised and the study can be viewed as a formal study</u>

There is a research question and purpose for the dashboard study, a specific qualitative methodology is followed, and the research question and subquestions are addressed with design science research.

Specific data sources and collection methods have been defined. Integral to the formal method of design science research is the characteristic to derive the framework and design of the dashboards, verifying practicality and utility that evolves as the study progresses.

The formal study elements were specified in the former statements and, although elements of exploration will be present, the identification of the formal elements disqualifies the study as a pure exploratory study. A pure exploratory study is normally characterised by a lack of formal study elements, the problem and objectives are unclear and the research elements are identified as the research process unfolds.

Sections 3.6.1.1 and 3.6.1.2 elaborate on the overarching design science research structure that will be applied, the design science steps to be followed and the outputs that will be produced.

3.6.1.1 Overarching design science research structure to be followed

An evolutionary prototyping approach will be followed to develop a storyboard version and exemplary dashboards in the actual environment. The results of the evaluation of each preceding version are used in the development of the next version.

Figure 3.5: Overarching structure
illustrates the overarching cycle phases and the development process of the prototypes in the dashboard study, adjusted from the design science cycles proposed by Hevner (2007:88) in (Hevner, 2007:88)
Figure 3.3.

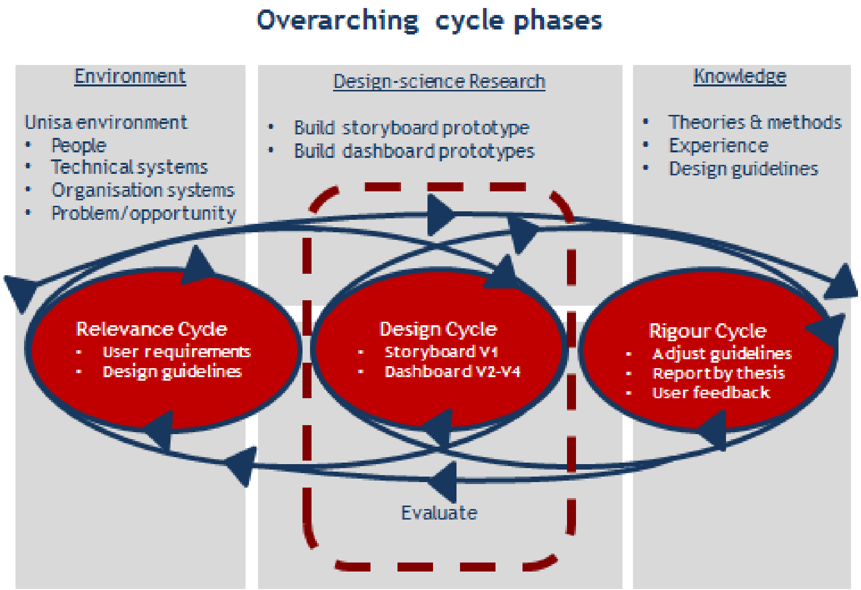


Figure 3.5: Overarching structure

The relevance cycle in Figure 3.5 is demonstrated in the research problem of the dashboard study as discussed in section 1.2 above. The "lack of accurate and timely management and planning information" of the research problem, demonstrates the relevance of the study to technical and organisational systems in the environment. Managers who need management information and the users involved in the requirement session relate the problems to people. The opportunity is addressed by the proposed system. The user requirements and design guidelines from the literature links the study to the environment and body of knowledge.

The design cycle is the primary component of the design science research project and iterates between the constructon of the artefact, evaluation and feedback, and refinement of the design.

The iterative process that will be followed and assessment interviews in the design cycle of the dashboard study indicated by the dashed line in Figure 3.5 is elaborated by Figure 3.6 below, demonstrating how the design alternatives will be developed and evaluated according to user feedback until a satisfactory design is achieved. Requirements and design guidelines are input from the relevance cycle. The design theories and methods are input from the rigour cycle into the design cycle where the evolving artefact is developed and evaluated, and the refinements of the design evaluation are re-applied into the relevance and rigour cycles.

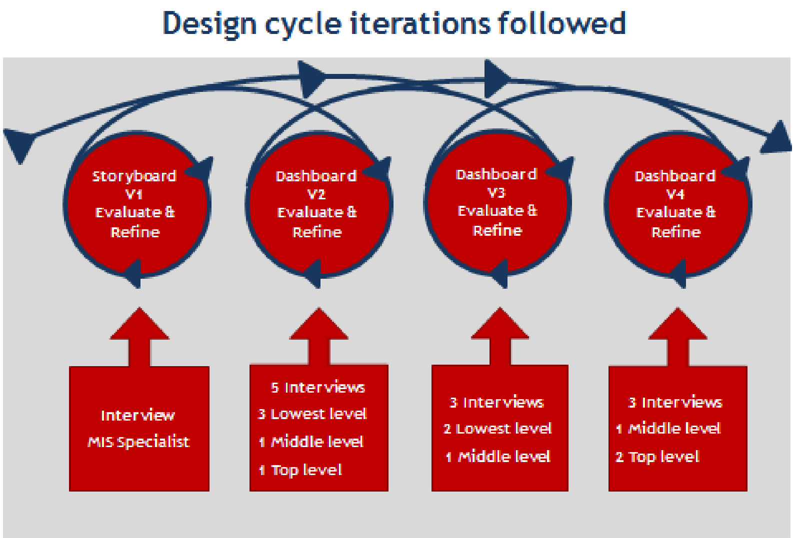


Figure 3.6: Design cycle iterations

The rigour cycle consists of the application of the theories, methods and design guidelines compiled in the literature review that are applied in the development of the exemplary dashboards in the actual environment. As indicated earlier, the design guidelines will be adjusted according to the feedback from the design cycle iterations. The knowledge and experience gathered in the design science process will be applied in formulating a framework for dashboard development in tertiary education institutions, thus contributing to the body of knowledge and communicating the findings of the research to the research community.

The rigour cycle satisfies the requirements of design science research and ensures that a rigorous research process is conducted.

The focus of the study is to find the characteristics of a framework to design and implement executive dashboards for portfolio managers of Unisa that will satisfy their decision-making information needs. The draft design guidelines are derived from the literature review discussed in section 2.3.8. An important question to ask in terms of the selection criteria for the design guidelines was: Can the guideline be applied to dashboards in a tertiary educational institution? User requirements will be gathered from potential users of the system. The design guidelines and user requirements will then be used to develop storyboard specifications of the dashboards. An exemplary version of the dashboards will be developed from the storyboard specifications and refined in an iterative process according to user feedback collected through a process of semi-structured interviews. Changes to the exemplary dashboards will be made according to the feedback from the interviews.

3.6.1.2 Design science processes, outputs and evaluation to be conducted

The process phases and outputs of Vaishnavi & Kuechler (2004) in Figure 3.1, combined with the anatomical framework for design theory of Gregor & Jones (2007), will be applied to address the research problem of this study.

Vaishnavi & Kuechler (2004) outline how the process phases and outputs of Vaishnavi & Kuechler (2004), demonstrated in Figure 3.1, were applied to address the problem of the dashboard study. In section 3.5.3, a parallel is drawn between the phases of design science research in IS and the research outputs of Vaishnavi & Kuechler (2004) and DSRM of Peffers et al. (2008). Because of the parallels, in applying the phases and outputs of Vaishnavi & Kuechler (2004), the research will correspond with the research methodology of Peffers et al. (2008) as well.

The process of Vaishnavi & Kuechler (2004) is chosen for the study because of the evident iterative character of its framework and correspondence with the requirements of the dashboard study to find the design guidelines for dashboard design and development in the case of Unisa.

As indicated in section 1.2, the purpose of the study is to develop a framework for dashboard design and development. This will be accomplished by the design, implementation and refinement of the dashboards to be effective and practical for tertiary education institutions.

The rigour of the design science process followed in the dashboard study will be validated against the anatomical framework for design theory of Gregor & Jones (2007) in Table 3.6 and in the example in Table 3.7 above.

The design theory anatomy framework is chosen to evaluate the dashboard study, because it acknowledges the role of the artefact instantiation as an exemplary or representational vehicle of the design theory. The artefact instantiation illustrates the design principles that are embodied in it and the anatomy framework recognises a degree of changing characteristics in the artefacts (Gregor & Jones, 2007:330). The specification provides a rigorous approach in specifying design science research and ensuring that the approach followed is sound.

The above design science evaluation combines a number of the design evaluation methods proposed by Hevner et al. (2004:84–85) and mentioned in 3.5.5 above. Observation, analytical, experimental, testing and descriptive evaluation will be applied to evaluate the design of the storyboards and dashboards. The testing of alternatives proposed by Pries-Heje & Baskerville (2008:736) will be very time-consuming and labour-intensive in the dashboard development, and are therefore not considered to be practical for the design science evaluation in the current study.

3.6.2 A process of interrogation and communication will be followed as data collection methods

Literature review and semi-structured interviews will be the data collection methods as defined in the research methodology and design of Chapter 3. The researcher questions the staff members who have a need for management information or who have experience in the field of providing management information to collect their responses and feedback during semi-structured interviews with interview schedules as guides and further probing by the researcher.

3.6.3 The researcher’s power to manipulate and control the variables in the study

The researcher’s power to manipulate and control the variables in the study is classified as *ex post facto* because the researcher cannot influence the variables and can only report what has happened or is happening.

The researcher directed the conversation to ensure that the interview schedule elements were addressed. The design guidelines and research subquestion elements had to be clarified where necessary. The researcher made notes and recorded the interviews, which limited the possibility of the researcher introducing bias when transcribing the interview results.

3.6.4 The purpose of the study

The research design descriptors framework of Cooper & Schindler (2001:135) classifies the purpose as descriptive or causal. The study is concerned with the design guidelines of the dashboards and processes to be followed, which are "who", "what", "where" and "how" elements, but it is also concerned with causal relationships and theory contributions during the design science research cycles. The study is therefore classified as both descriptive and causal.

3.6.5 The time dimension of dashboard study is longitudinal in nature

The prototyping is repeated over an extended period and, therefore, the time dimension of the study is longitudinal.

3.6.6 Topical scope

The topical scope of the dashboard study is a case study in the environment of Unisa. It will rely on qualitative data from more than one source and is verified through an iterative prototyping process.

3.6.7 Research environment

The study will be performed in field conditions in the actual environment. The storyboards will be a form of simulation and the dashboard development will be the real thing in the actual environment done in actual field conditions and not in a laboratory or as a counterfeit.

3.6.8 Subject perceptions of research activity

The perceptions of the researcher and participants are addressed by the selection criteria used to select the participants, which aims to select staff members who are responsible for performing an academic management function, to ensure that they will be able to bring insight into the study. Participants should be familiar with the kind of information requirements of the dashboards.

3.7 SUMMARY

The philosophical position of the study is rooted in an interpretive knowledge claim. The dashboard study uses a qualitative research methodology with a design science research approach. The artefacts designed and developed from draft design guidelines are dashboards for managers in Unisa. Literature review and semi-structured interviews were used as data collection methods. Exemplary dashboards will be developed for managers in tertiary education institutions, and design guidelines will be adjusted through an iterative process of assessment and refinement.

The empirical results and analysis of the findings of the empirical study will be addressed in the next chapter.

4. CHAPTER 4: EMPIRICAL RESULTS AND ANALYSIS

4.1 INTRODUCTION

This chapter covers the empirical work of the research study. It addresses the design and development of the dashboards and how design science research was applied in practice to find the design guidelines.

The outputs produced by the dashboard study were artefacts or instantiations consisting of a storyboard prototype Dashboard V1 and exemplary dashboard prototypes Dashboard V2 to Dashboard V4 in the real environment. Different evaluation criteria applied for the storyboard prototype and exemplary dashboard prototypes.

In the following section, the participant profiles and Storyboard V1 are discussed. Storyboard V1 was the first prototype of the design science process. It was developed by conducting a user requirements session and brainstorming paper-based storyboards, and translating them into Microsoft Visio. The feasibility to develop the user requirements in the dashboards was validated. The Microsoft Visio storyboards were validated by a management information specialist using an interview guide for conducting a semi-structured interview. The implications for the draft design guidelines were discussed.

Following that, exemplary dashboard prototypes Dashboard V2 to Dashboard V4 are discussed. The second prototype Dashboard V2 consisted of a teaching and learning module of dashboards in the real environment that were iteratively evaluated and refined into Dashboard V3 and Dashboard V4. This was developed to a fully functional stage using the storyboards as specifications. The full complement of the storyboard specifications could not be developed because the sourcing of data and development of the dashboards in the real environment required a considerable amount of time. The completion of the research study could not be prolonged for such a considerable period.

The results are analysed in the latter part of the chapter and the findings are summarised.

4.2 INTERVIEW PARTICIPANT PROFILE

The profile of participants required for the study was academic staff members who need management information and had enough experience to provide insight into the information requirements and dashboard design. Participants included members of staff who have experience in the preparation and provision of management information and BI in tertiary education institutions. Table 4.1 summarises the interview participant profiles and the versions of the prototypes assessed.

Table 4.1: Profile of participants

Prototype version	Discipline	Position	Number of participants
Storyboard V1	Management information	Management information specialist	1
Dashboard V2	Academic management	Lower academic management level Middle academic management level Top academic management level	3 1 1
Dashboard V3	Academic management	Lower academic management level Middle academic management level	2 1
Dashboard V4	Academic management	Middle academic management level Top academic management level	1 2

As indicated in Chapter 3, individuals were selected who were willing to participate, could relate to the information or had a need for the information presented in the dashboards and could yield the most information about the topic under investigation. The interview attendees completed attendance registers.

The management information specialist was considered a good candidate to evaluate the storyboards, because of his tenure in the delivery and preparation of management information and BI for use in the University and tertiary education institutions in general. The participant could contribute valuable insight in the context and content of the tertiary education environment.

The academic participants were considered good candidates for the current research study, because they had a general understanding of dashboards and had specific expectations and requirements to be satisfied by the dashboard delivery. They could relate to the suitability and usability of the information and could provide insight and understanding on how it could be applied in their field of work.

4.3 STORYBOARD V1

The documented requirements and design guidelines compiled in the literature review were applied in an interactive storyboard session with two information experts to brainstorm the first version of the exemplary prototypes on paper.

The user requirements, design guidelines relevant to the context and content validity were considered to brainstorm the metrics in the storyboards and to determine the logical grouping and hierarchy levels of the information.

The paper storyboards were converted to mock-ups in Microsoft Visio. Section 3.5.8 refers to the CISP approach, where users validate requirements of the system by interacting with mock-ups of the system to fine-tune the requirements (Madsen & Aiken, 1995:57). Photographs of the storyboards and examples of the Visio format can be viewed in Appendix 3 at the end of the thesis.

The storyboards, together with the design guidelines identified in the literature study, served as specifications for the exemplary dashboards in the actual environment.

The Visio storyboards were presented to a management information specialist working in the management information and institutional research department at the institution. The participant was asked to assess the completeness, relevance and content of the storyboard prototypes. The selection criteria considered the most relevant metrics in the storyboards and whether the presentation proposal and grouping made logical sense. The storyboards were adjusted, finalised and the development of the first “straw model” dashboard prototype commenced, using the storyboards as the specifications for development in the real environment.

Turban & Aronson (1998:295) postulate that prototyping revolves around the discovery achieved by the iteration process and that the successive iterations bring the prototype one step closer at a time to correctly representing the user needs. The development of exemplary dashboard prototypes involved a series of subsequent design and formative evaluation and revision steps of the prototypes. A process of develop, discuss and modify was conducted to create the prototypes. The suggestions emerging from the evaluations were implemented where applicable.

4.3.1 User requirements

A user requirements session was conducted with the 26 staff members and portfolio managers of one college. The requirements were discussed during the session and compiled by one of the college staff members after the session. The user requirements are provided in Appendix 4 at the end of the thesis.

The different areas that were covered in the requirements were research, master's and doctoral, teaching and learning, community participation and administrative information.

4.3.2 User requirements validation

College staff, as the possible end users of the envisaged dashboard system, documented the initial user requirements. The college staff consisted of academics who were not knowledgable about the availability of data from source systems. In order to convert the requirements into metrics in automated dashboards, electronic source data for the metrics had to be identified.

Before user requirements could be considered for presentation in the storyboards (discussed in the following section), it had to be considered whether electronic data to define the relevant metrics existed in the data repositories of the University. The data availability of the requirements was considered as part of the brainstorming for the storyboards.

Table 4.2 demonstrates how the user requirements could be addressed in the storyboards. Where “no system information” is shown in the second column, it indicates that the kind of information is not captured by an operational system and could not be used in the development of dashboards that are automatically updated on a regular basis. Out of the 51 requirements, the information for 16 metrics is not captured in a system, resulting in 69% of the metrics being covered in the storyboards.

Table 4.2: Summary of user requirements addressed in the storyboards

1. Research	**Covered in storyboard**
i. Current and proposed research projects	No system information
ii. Status of existing projects	No system information
iii. Access to research fund information	No system information
iv. Cumulative publication record per department and per individual	✓
2. Master’s and doctoral students	
i. List of master’s (M) and doctoral (D) students per department (names and research titles), including staff members	✓
ii. Progress report on students busy with research proposals	✓
iii. Progress report on M and D students (per supervisor and per student) – activity reports need to be available to director as soon as they are loaded	✓
iv. Summary of M and D application files need to be available to director, especially with regard to reasons for rejection of application by director or Chair of Department (CoD). Record creates precedent.	✓
v. List of examiners appointed for master’s and doctoral theses – internal and external	✓

3. Teaching and learning	
i. Early warning system regarding academic planners' due dates, with the ability for the CoD to add additional departmental due dates ii. Proposed "reminder" from 30 days prior to due date	No system information
iii. Information regarding study material (tutorial letters, exams and study guides)	✓
iv. Due dates at scheduling, production, etc.	✓
v. Staff member involved in each item and adherence to due dates	No system information
vi. Tracking progress through the system, percentage completed, at which stage, etc.	✓
vii. Stock levels at dispatch	✓
viii. Track receipt, marking and return of assignments by lecturers	✓
ix. Evaluation of lecturers in group discussions	No system information
x. Track submission of assignments by students and student performance	✓
xi. Attrition rates versus throughput rates (per module, per qualification and per primary lecturer)	✓
xii. Profile of success rate (normal curve and historic view)	✓
xiii. Tutors linked to each module code (number of tutors, region and demographic information)	✓
xiv. Students linked to a tutor in a region and students' performance	✓
xv. Profile of students per module (demographic, geographic, disabilities, etc)	✓
4. Community participation	
i. Current and proposed projects	No system information
ii. Registered versus non-registered projects	No system information
iii. Status of existing projects	No system information
iv. Names of staff involved in projects	No system information

5. Administrative		
i.	Early warning system regarding procurement closing dates, contract expiry, budget dates	✓
ii.	Tutor evaluation: Integrated Performance Management System (IPMS) for tutors	No system information
iii.	Contractor records	✓
iv.	Details of contract	✓
v.	Performance report (number of scripts marked, etc.).	✓
vi.	IPMS profile of individual staff member and IPMS review history (per staff member, per section and per department)	✓
vii.	Timesheet that dynamically records time spent at meetings, training, research	✓
viii.	Staff records	✓
ix.	Demographic information	✓
x.	Qualifications	✓
xi.	Status of current studies	No system information
xii.	Summary of leave per department (pending and current)	✓
xiii.	Electronic whiteboard – to be dynamically populated when people leave the office, attend meetings, etc.	No system information
xiv.	Equity reporting (departmental equity profiles)	✓
xv.	Budget information	✓
xvi.	Projected spend to actual spend (real-time)	✓
xvii.	Record of payments made to contractors	✓
xviii.	Contracts	✓
xix.	Status of applications	No system information
xx.	Tracking progress through system	No system information
xxi.	Training information	No system information
xxii.	Training budgets (utilised and available)	✓
xxiii.	Type of training being undergone	✓
xxiv.	Staff attending the training (by individual and department versus type of training)	✓

4.3.3 Storyboard creation and validation

4.3.3.1 Storyboarding

The documented requirements and design guidelines compiled in the literature review were applied in a storyboard session with two information experts to brainstorm the first prototype of storyboards on paper. The user requirements, design guidelines relevant to the context and content validity were considered to brainstorm the metrics in the storyboards and to determine the logical grouping and hierarchy levels of the information.

The selection criteria used to find relevant design guidelines for the storyboards were based on the question: “Is this guideline relevant in the context of portfolio management and is it relevant for storyboard prototyping?”

The paper-based storyboards were converted to mock-ups in Microsoft Visio. In section 3.5.8, reference is made of the CISP approach where users validate requirements of the system by interacting with mock-ups of the system to fine-tune the requirements (Madsen & Aiken, 1995:57).

Photographs of the storyboards and examples of the Visio format can be viewed in Appendix 3 at the end of the thesis.

Separate tabs of the Visio document were populated with indicators. Most of the tabs represented a unit of measure. The following tabs were populated: summary, ratios, applications, qualification enrolments, graduates, course enrolments, course success, degree credits, full-time equivalent (FTE) enrolments, non-formal enrolments, non-formal success, staff headcount, staff FTE, research and community participation and academic administration. The summary, ratio and academic administration tabs contained a combination of different units of measure (currencies), while the others contained different metrics of a currency, such as qualification enrolment, course enrolment, etc.

For example, “course enrolment per gender per year” and “course enrolment per course level per year” are metrics of the course enrolment unit of measure. An example of the course enrolment tab in the Visio document is provided in Figure 4.1.

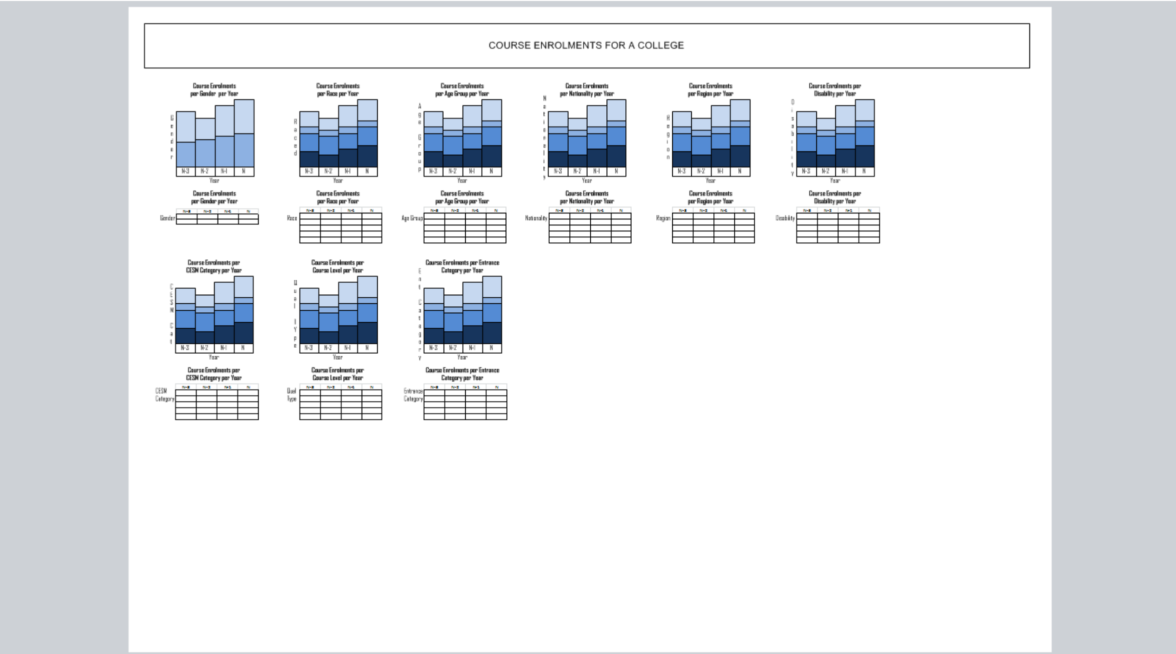


Figure 4.1: Example of Visio course enrolment storyboard

4.3.3.2 <u>Validation and guide</u>

The first interview covered the validation of the storyboard prototype version of the dashboards. The interview was conducted with a management information specialist at the University who has been working in the field for more than 20 years. The participant has a wide knowledge of tertiary education and management information provision, working in the institution’s management information and institutional research department. The management information specialist has extensive knowledge and experience of the business and information to perform the validation of the storyboard prototypes. The validation of the storyboards was done early in the development process before the dashboards were implemented as recommended by Nielsen (2009). The storyboards represented a form of paper prototyping as one of the methods recommended by Nielsen (1995), Nielsen (2009) and Hollingsed & Novick (2007:252). A combination of validation methods was used in the study. The storyboard version was the first prototype and was combined with user validation to strengthen the overall validation of the artefacts (Nielsen 1995; Holzinger 2005:72).

The Visio storyboards were presented to the management information specialist. The participant was asked to assess the completeness, relevance and content of the storyboard prototypes.

The selection criteria considered the most relevant metrics to include in the storyboards and whether the presentation proposal and grouping made logical sense. The storyboards were adjusted and finalised and the development of the first "straw model" dashboard prototype commenced, using the storyboards as the specifications for development in the real environment. Metrics related to applications, qualification enrolments, graduates, course enrolments, course success, degree credits, FTE enrolments, non-formal enrolments, non-formal success, staff headcount, staff FTE, research and community participation and academic administration were designed. Ratio and summary metrics to provide overview and performance monitoring views were also included.

The responses given are in the context of the discipline and view of the participant. A copy of the interview guide can be viewed in Appendix 4 at the end of the thesis.

The interview guide consists of an identification section, general discussion points and additional information per tab. In the identification section, details of the participant are captured and content validity, such as how many years' information should be displayed and whether a table and graph should be displayed per metric, is evaluated in section 2. Questions about the understandability, context validity and design logic are also included. In the third section, additional information per tab was elicited from the participant.

4.3.4 Storyboard V1: Validation

The storyboards were validated for simplicity, understandability, logical composition and representation of the content and context of the information. The validation had the format of a formative assessment, where the storyboards were presented and discussed for relevance, completeness, belonging in the context, various components logically linked together, and additional required information. The storyboards, being the first version of the prototypes, will also serve as the specifications for the dashboards in the real environment, as Gregor & Jones (2007:320) postulate that specifications can be represented by physical constructs, in narrative or as diagrams, and can be in generic terms without the finer detail. The responses captured during the interview of the Storyboard V1 of the prototypes are presented in Table 4.3.

Table 4.3: Interview responses for Storyboard V1

1. Identification	**Response**
Portfolio holder, initials and surname	Management information specialist: V1-1
Portfolio	Administrative
Portfolio name	Department of Statistical Information and Analysis
Portfolio position (management level)	Management information specialist: V1-1
2. General discussion points	**Response**
2.1 Information for the current year and three years' history will be used in all graphs and tables.	Between three and five years are required.
2.2 A table and a graph will be presented for each metric.	Participant considered it suitable.
2.3 The completeness of the information covered in the storyboards was considered.	The most important information is covered and additional information suggested per tab.
2.4 The relevance of the information to the context was considered.	The participant considered the information as relevant in the context.
2.5 The grouping of the information should be logical.	Information belonging together is logically grouped.
2.6 Drilldown cannot be displayed in the Visio format, but relevant drilldown paths were considered.	The view of the participant is that usually a lecturer needs to see module level information and HoDs need to see department level information, etc.
2.7 Additional information not covered in storyboards was elicited from the participant.	National Student Financial Aid Scheme (NSFAS) information is important on institution level (how funds are allocated per qualifications – no NSFAS for non-degree-purpose qualifications).

3.	Additional information per tab	Response
3.1	General	According to the participant, the range of information covered in all the tabs was relevant.
3.2	Qualification tab	Qualification specialisations are important at programme level.
3.3	Academic administration tab	Approved qualifications vs active qualifications Approved programmes vs active programmes
3.4	Course success tab	Year view for benchmarking and official and attrition reporting Exam sitting view for operational reporting
3.5	FTE tab	Funding group and level information
3.6	Non-formal tab	Number per course type, National Qualification Framework (NQF) level Varying assessment types per level
3.7	Graduates tab	Three views: Hemis, year view, ceremony view
3.8	Human resources (HR) information tab.	Approved positions vs filled positions according to C1 value (how many can be appointed).

March & Smith (1995) propose that construct evaluation involves completeness, simplicity, ease of use, elegance and understandability. From the user requirements in and the interview responses in Table 4.3 above, how the completeness, relevance and context, more information, logical grouping and understandability were satisfied by the storyboards are discussed. Simplicity, ease of use and elegance were not considered to be relevant to the storyboard prototype because the metrics were not designed as would be done for the dashboard presentation or ease of use, and elegance could not be tested on the paper prototype. About 69% of the metrics could be addressed in the storyboards and, according to the response of the information specialist in Question 2.4 of Table 4.3 above, the information in the storyboards were relevant in the context and belonged in the context as presented in the storyboards.

It can be concluded that most of the information could be addressed in the storyboards and that the information was as complete as possible.

Through the storyboard session, it was demonstrated that it would be possible to source the information of the user requirements for 69% of the metrics.

The information specialist suggested additional information in seven of the 16 tabs of the Visio document. It can therefore be concluded that more information is available than that which was included in the user requirements. The information is logically grouped together as mentioned in Question 2.5 above and, from the engagement by the information specialist and the fit with the user requirements, it is concluded that the information presented in the storyboards is understandable and the users will also be able to understand the information.

4.3.5 Storyboard V1: Implications for design guidelines

Guideline 5 of March & Smith (1995:255) in section 3.5.4 postulate that design guidelines of the artefact should be compiled and conceptualised in a logical and coherent way. These guidelines should also be documented and adjusted as the iterative refinement of the prototypes progress to contribute to research rigour in the process.

The initial design guidelines were compiled in broad terms from the literature study in section 2.3.8 where research Subquestion 8 was investigated. Five initial design guidelines and “wicked problems”, as discussed in section 3.5.9, that could be identified during the crafting and validation of the storyboards, were considered.

In Table 4.4, the guidelines and “wicked problems” are summarised as determined during the storyboard session and validated in the storyboard interview.

Table 4.4: Prototype 1: Adjusted design guidelines and "wicked problems" identified

Design guideline	Implication
1. Conduct thorough user requirements and liaise with users what the measures are.	User requirements were covered in section 4.3.2 above.
2. Dashboard presentation, design, layout and navigation	Graph and table per metric
	Current year plus a three-year history per metric
3. Users consulted about dashboard context drilldown	The user requirements ensured that the information is relevant in the context
4. Intuitive and economic dashboard navigation	Layout and navigation are not applicable in the storyboard prototypes.
5. Design best-suited metrics	Consultation with users is important to identify suitable metrics
6. "Wicked problems" identified	Data not captured by a system poses a major impediment to automated dashboards

Design guideline 1: A user requirements session was conducted and a wide range of metrics were specified and used in the storyboards. The validation in section 4.3.2 showed that additional metrics could be identified.

Design guideline 2: During the storyboard session, it was decided that the following display guidelines will be applied across all the metrics:

- Where it is possible and source data is electronically available, the current year and three years of historical data will be presented for every metric so that the performance of the metric can easily be determined.

- A graph display will be accompanied by the values in a table below the graph to support the visual display and make the presentation intuitive and easy to understand.

Design guideline 3: Because the metrics were developed from the user requirements, it ensured that the information was relevant in the context. Drilldown was not facilitated in the storyboards.

Design guideline 4: Intuitive and economic dashboard navigation was not applicable in the storyboard environment and became relevant in the next prototype versions.

Design guideline 5: The user requirements ensured that the metrics were in line with the requirements. The real value and usability metrics can only be verified when the users utilise the information on a day-to-day basis and have real-life decisions where the information should be applied. As indicated by the information specialist, depending on the type of decisions the users are confronted with, more metrics can be defined.

"Wicked problems": During the storyboarding of the user requirements and supported by the information in Table 4.2, information for 16 out of 51 metrics could not be sourced from a transactional system that is supported by existing business processes.

In order to develop these metrics in an automated dashboard, the required business process needs to be established and a facility to capture the information developed. This shortcoming poses a major impediment to automated dashboards because of the extra time needed for investigation and development, which is not in the scope of the dashboard development, but directly impacts on the efficiency of the dashboard delivery. The metrics are often available in Excel spreadsheets or manual files, which can be captured, but are normally a major maintenance burden. The shortcoming is seen as a "wicked problem" in the dashboard development process.

4.4 DASHBOARD V2, V3 AND V4

A module management dashboard component was developed for the prototype in the real environment. It contains elements of the teaching and learning section of the user requirements that are discussed under section 4.3.1.

This is based on the assumption that the logic that applies to the course enrolment currency can be applied to the other currencies, such as qualification enrolments, graduates, course success, degree credits, FTE enrolments, non-formal enrolments, non-formal success, staff headcount, staff FTE, research and community participation, as discussed in paragraph 4.3.

According to Vaishnavi & Kuechler (2004), the partial or completed artefact can be evaluated and iteratively refined. The development and sourcing of information is a time-consuming exercise and it was decided to proceed with the research evaluations of the sections mentioned earlier in the paragraph on the partial development, rather than waiting for the development of the full dashboard solution.

In order to distinguish whether the dashboards address the information needs for the different academic management portfolios, the interviews were conducted with managers on lower, medium and top academic levels at the University.

Figure 4.2, Figure 4.3 and Figure 4.4 provide screenshots of the module management dashboard component.

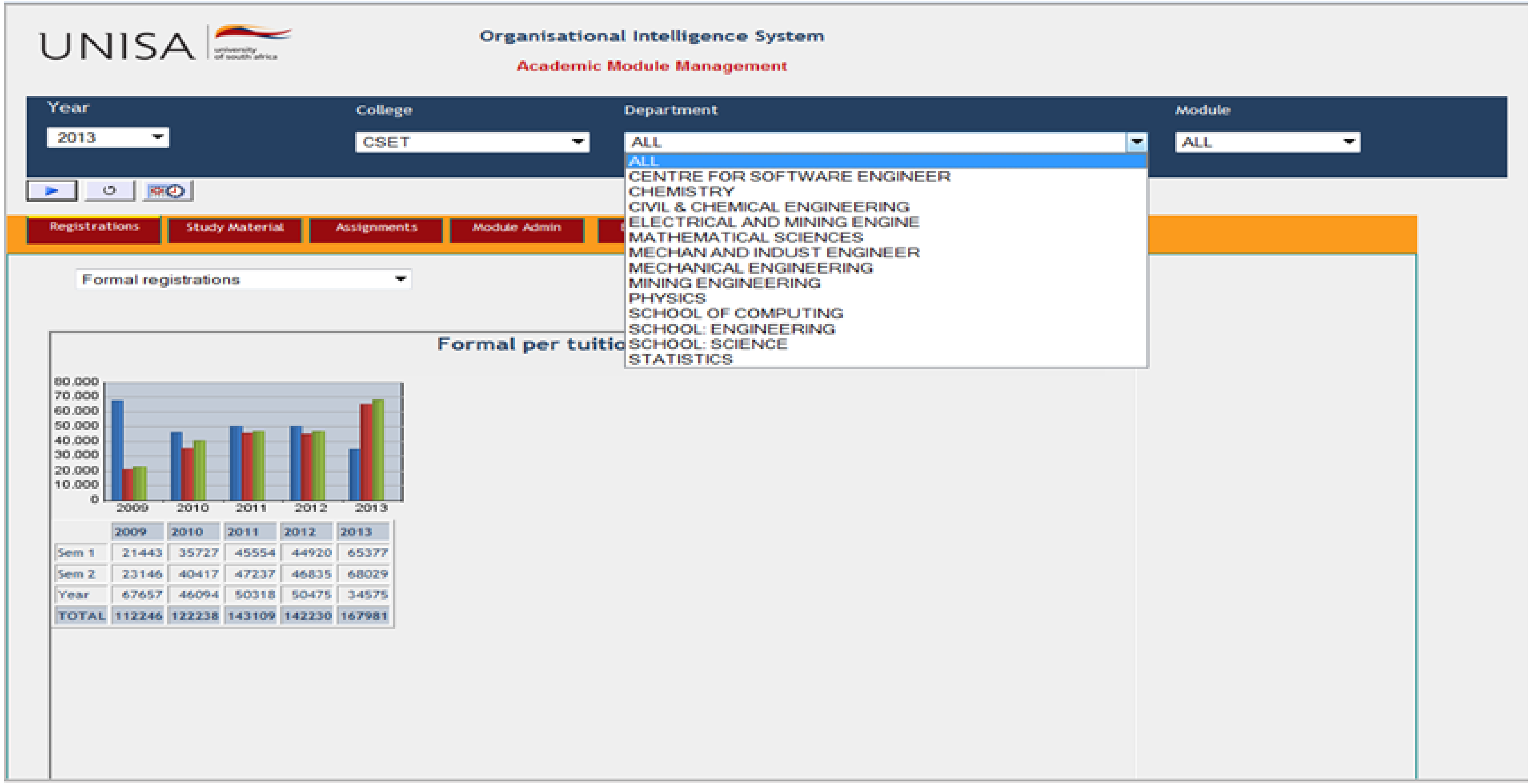


Figure 4.2: Navigation according to academic year, college department and module

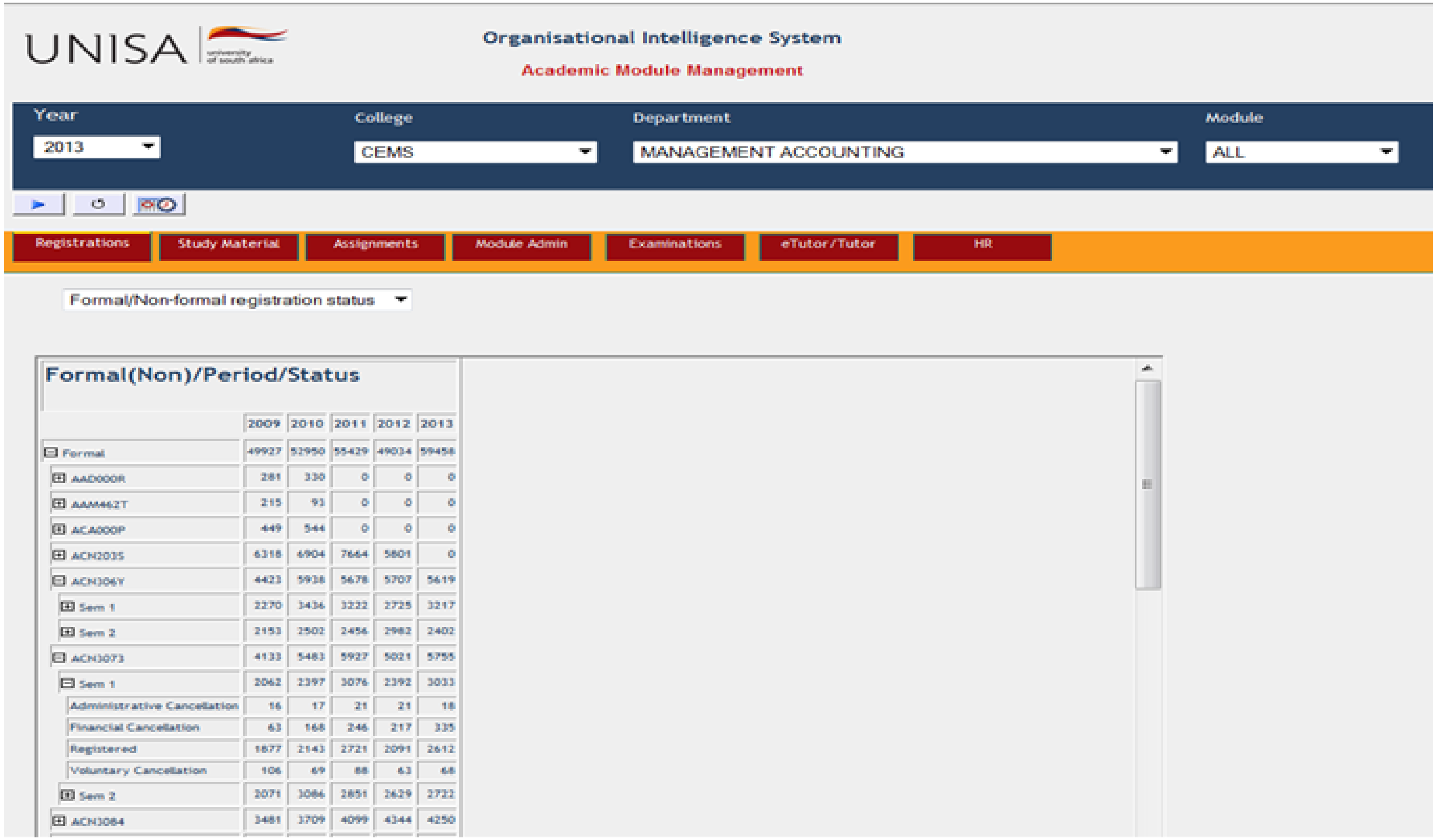
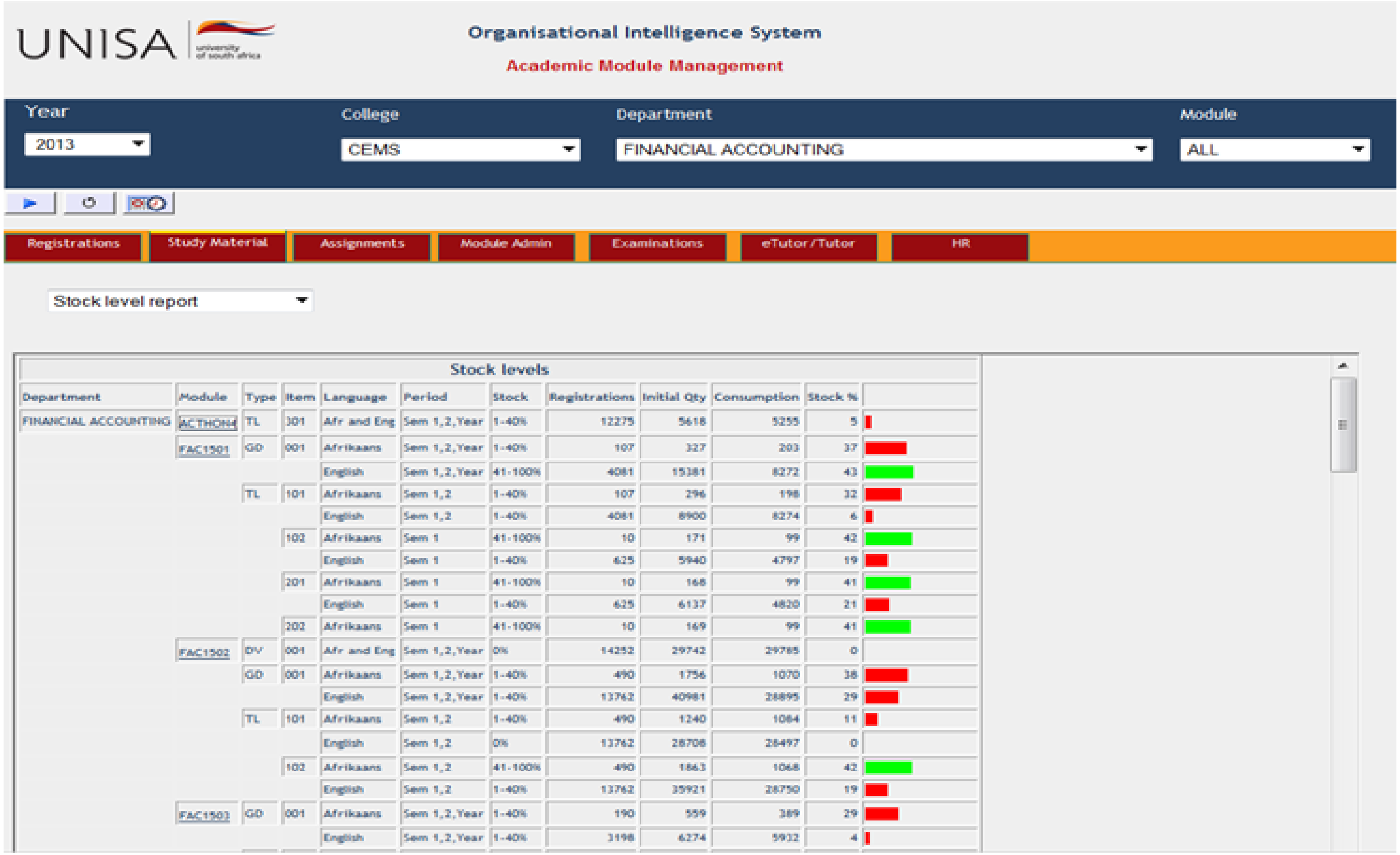


Figure 4.3: Accordion report with drilldown functionality



Stock levels

Department	Module	Type	Item	Language	Period	Stock	Registrations	Initial Qty	Consumption	Stock %	
FINANCIAL ACCOUNTING	ACTHON4	TL	301	Afr and Eng	Sem 1,2,Year	1-40%	12275	5618	5255	5	
	FAC1501	GD	001	Afrikaans	Sem 1,2,Year	1-40%	107	327	203	37	
				English	Sem 1,2,Year	41-100%	4081	15381	8272	43	
		TL	101	Afrikaans	Sem 1,2	1-40%	107	296	198	32	
				English	Sem 1,2	1-40%	4081	8900	8274	6	
			102	Afrikaans	Sem 1	41-100%	10	171	99	42	
				English	Sem 1	1-40%	625	5940	4797	19	
			201	Afrikaans	Sem 1	41-100%	10	168	99	41	
				English	Sem 1	1-40%	625	6137	4820	21	
			202	Afrikaans	Sem 1	41-100%	10	169	99	41	
	FAC1502	DV	001	Afr and Eng	Sem 1,2,Year	0%	14252	29742	29785	0	
		GD	001	Afrikaans	Sem 1,2,Year	1-40%	490	1756	1070	38	
				English	Sem 1,2,Year	1-40%	13762	40981	28895	29	
		TL	101	Afrikaans	Sem 1,2	1-40%	490	1240	1084	11	
				English	Sem 1,2	0%	13762	28708	28497	0	
			102	Afrikaans	Sem 1,2	41-100%	490	1863	1068	42	
				English	Sem 1,2	1-40%	13762	35921	28750	19	
	FAC1503	GD	001	Afrikaans	Sem 1,2,Year	1-40%	190	559	389	29	
				English	Sem 1,2,Year	1-40%	3198	6274	5932	4	

Figure 4.4: Study material exception report

4.4.1 Dashboard V2, V3 and V4: Interview process and guide

The study and its purpose were briefly explained to the participants and the prototype dashboards were demonstrated. During the interviews, the interviewer demonstrated the prototypes and went through the interview guide questions relating to the dashboard design and environment, and elicited feedback from the interviewees. There was opportunity to discuss the metrics and information required, as well as how it related to the way the participants managed their work. The interview detail was recorded because the researcher conducted the interviews with the participants and wanted the recordings to transcribe the information after the session without losing the valuable detail of the discussions and feedback.

The purpose of the interview guide was to serve as a basic guideline for the flow during the interview and to assist the interviewer to maintain a consistent structure and address all the required elements. A copy of the interview guide is included in Appendix 6 at the end of the thesis.

The interview guide is divided into three sections. Section 1 captured the identification profile detail of the participant. Section 2 elicited the general understanding of participants about dashboards and their awareness of the value of dashboards. Section 3 elicited information about indicators on dashboards, and the design, layout and navigation of the dashboards.

Section 1 captured the identification details about the participants. Dashboard V2 was evaluated by five participants, and Dashboard V3 and Dashboard V4 by three participants each. An attendance list was completed by the interviewees.

The elements of section 2 addressed issues of usability, suitability, content and the context relevance of the information provided on the dashboards.

Section 3 captured more detailed information about specific indicator requirements, the design of the dashboards in terms of the layout regarding the population of the dashboard real estate, the navigation, drill-paths and logical construction.

A meeting request was emailed to the participants, and candidates who responded to the request and attended the meeting were considered to be willing to participate. The Uniform Resource Locator (URL) of the dashboard system was included in the meeting request for candidates to try out and consider if they were willing to participate. The interviewer took the interview guide into the sessions when the interviews were conducted.

Eleven interviews were conducted on lower (L1), medium (L2) and top (L3) management level: five on L1, three on L2 and three on L3. Interview 1 had three participants. The dashboard versions were evaluated by different levels of academic managers.

Table 4.5 explains how the different dashboard versions were evaluated by the different management levels. For example, the identification of participant V2 (L1-2) represents the version of the Dashboard V2, the level of the participant L1 and the number of the persons on that management level (two). It is easy to see that L1 had five participants, L2 had three participants and L3 had three participants. The notification is also used in the interview responses of Table 4.8 and Table 4.9 below.

Table 4.5: How dashboard versions were evaluated per management level

	L1	L2	L3
V2	V2 (L1-1) V2 (L1-2) V2 (L1-3)	V2(L2-1)	V2 (L3-1)
V3	V3 (L1-4) V3 (L1-5)	V3 (L2-2)	
V4		V4 (L2-3)	V4 (L3-2) V4 (L3-3)

4.4.1.1 <u>Dashboard V2</u>

For the validation and formative assessment of Dashboard V2, one interview was conducted with a group of three participants on the L1 and two individual interviews were conducted with managers on L2 and L3. As indicated previously, individuals were selected who were willing to participate.

The interviewees of the group interview are from the University's College of Economic and Management Sciences and the individual interviewees are from the College of Law. The interviewees are responsible for the management of specific courses in the colleges. The two participants in the individual interviews occupy professoriate positions. The one participant in the group was the individual responsible for compiling the user requirements and was therefore well acquainted with the information under investigation. All the individuals have several years' experience as academics and could relate to the information in the demonstration of the dashboards and the questions of the interviews.

The design of the artefact is complete and effective when the constraints of the problems it was meant to solve and information that is required are addressed.

Table 4.6 presents the combined transcribed responses of three interviews for the evaluation of Dashboard V2 of the exemplary dashboards in the actual environment:

Table 4.6: Interview responses: Dashboard V2

1.	**Identification**	**Response**
1.1	Portfolio holder initials and surname	Academic manager V2 (L1-1) Academic manager V2 (L1-2) Manager electronic material V2 (L1-3) Tuition and learning manager V2 (L2-1) Executive Dean: College of Education V2 (L3-1)
1.2	Portfolio	Academic management
1.3	Portfolio name	College of Economic and Management Sciences College of Education
1.4	Portfolio position (management level)	Two academic managers, one manager of electronic material, one tuition and learning manager, one executive dean

2.	Value of the dashboards	
		i. V2 (L1-2): "I think what would be useful when we sit down to develop and implement modules, is if the classification of information is according to the guidelines of the profile in the team approach". ii. V2 (L2-1): "The information is consolidated and centrally available for the management of modules". iii. V2 (L2-1): "It is essential and we receive information such as this". iv. V2 (L3-1): "We need information such as this". v. V2 (L3-1): "The dashboard will address operational efficiencies".
2.1	How well are the indicators matched to the required decision-making information?	i. V2 (L1-1): "This is already much more than we currently have". ii. V2 (L3-1): "The context of the information is relevant to how we use the information".
2.2	How can dashboards help to monitor the efficiency of processes?	i. V2 (L1-2): Module administration information in Excel will help. "When we work with it, it will be very valuable if we can have this in Excel". ii. V2 (L1-2): "Prerequisites are also required". iii. V2 (L1-1): "The number of students registered for module phasing out is also required". iv. V2 (L2-1): "The information will definitely help to manage the efficiency of processes". v. V2 (L2-1), V3 (L1-4), V4 (L2-3): "It is easy to find our own information and no training is required". vi. V2 (L3-1): "I look at all the information".
2.3	How efficiently do the dashboards measure deliverables?	i. V2 (L3-1): "I look at all the levels of the information". ii. V2 (L2-1): "Students can pass the modules, but not the programmes; programme information is important for me". iii. V2 (L1-1), V2 (L1-2), V2 (L1-3): "Information is relevant".

2. Value of the dashboards (cont.)	
2.4 Do the indicators provide actionable, fact-based information?	i. V2 (L1-1): A participant responded that the “end date” used in the module detail should be the “assignment submission date”. ii. V2 (L1-2): “Information is relevant”. iii. V2 (L2-1): “As the system is used, the user will understand the possibilities of a system such as this”.
2.5 How well are the indicators updated and aligned according to the business cycles?	i. V2 (L2-1): Participants were satisfied with daily updated data. ii. V2 (L3-1): “If the information is updated daily, it is suitable to our needs”.
2.6 Do you have analytical requirements to perform your management duties?	This question was added in the evaluation of V3.
3. Dashboard characteristics	
3.1 Indicator/s	
3.1.1 Which indicators are understandable and which are difficult to understand?	i. V2 (L1-3): The “academic structure information” tab is not intuitive. A suggestion was made to use “module administration” instead. ii. V2 (L1-3): The “academic structure information” tab is not intuitive. A suggestion was made to use “module administration” instead. iii. V2 (L1-3): The “academic structure information” tab is not intuitive. A suggestion was made to use “module administration” instead.

3. Dashboard characteristics (cont.)	
3.1.2 Which indicators are understandable and which are difficult to understand?	i. V2 (L1-1), V2 (L1-2): The study material stage information needs study guide editor/graphic artist/typesetter stages. ii. V2 (L1-1), V2 (L1-2), V2 (L1-3): Exam markers: "Very few people can see HR data". Exam book and remark information, starting date of module and qualification information are also required. iii. V2 (L1-3): "Qualification information, such as final-year students and how many completed their course, will also be helpful". iv. V2 (L1-1), V2 (L1-2): Participants can relate to the information and could understand what is presented. v. V2 (L2-1): "The areas that were still under construction and not populated did not make sense".
3.1.3 Are there indicators that reinforce other indicators?	i. V2 (L1-1), V2 (L1-2), V2 (L1-3): Information per qualification is required "because other colleges also offer the same modules". ii. V2 (L1-2): "Assignment information cannot be used for supplementaries". iii. V2 (L2-1): "Module information reinforces programme information".
3.1.4 How well does the visualisation presentation suit the information it represents?	i. V2 (L1-1), V2 (L1-2), V2 (L1-3): "Graphic display is not particularly important, as long as we have the information". ii. V2 (L1-1), V2 (L1-2), V2 (L1-3): "Colours were bright enough".
3.1.5 Can you identify past, present and future indicators?	i. V3 (L1-4), V3 (L1-5): "Historical information is required". V2 (L2-1): "Registrations and pass rates had historical information and are always required to make decisions".

3. Dashboard characteristics (cont.)	
3.2 Dashboard design	
3.2.1 Do you find the logos and brand elements distracting from critical information?	i. V2 (L1-1), V2 (L1-2), V2 (L1-3): No comments about the look-and-feel were given. ii. V2 (L2-1): "The branding represents corporate colours and relates to MyUnisa, which is attractively designed". iii. V2 (L3-1): "I wear glasses and do not see the information very well. I find the colours very dull". iv. V2 (L3-1): "The grey background is dull".
3.2.2 Is it accurate to conclude that the chart types present information correctly?	i. V2 (L1-3): "Graphs are nice to have". ii. V2 (L2-1): "The presentation of the dashboards is like the gadgets in a new car, where the gadgets will be discovered as the system is used". iii. V2 (L2-1): More exposure to the system is required to provide more detailed suggestions. iv. V2 (L3-1): "Yes".
3.2.3 Do you find the dashboard too cluttered?	i. V2 (L1-1), V2 (L1-2), V2 (L1-3): "Not too cluttered". ii. V2 (L2-1): "There is no overload of information and I like the presentation like this". iii. V2 (L3-1): "No, I like the information as it is here".
3.2.4 Do you find the number of indicators on the dashboard satisfactory?	i. V2 (L1-1), V2 (L1-2), V2 (L1-3): "Information with relevance is important, such as the drilldown facility". V2 (L1-1), V2 (L1-2), V2 (L1-3): Participants were satisfied because it was the right information to help them manage. ii. V2 (L2-1): "Profile information, such as the current drilldown facility, will be helpful". iii. V2 (L3-1): "I prefer the information as it is presented here".

3. Dashboard characteristics (cont.)	
3.2.5 Do you need the dashboard information in printable format?	This question was added from V3.
3.3 Dashboard layout	
3.3.1 Are you satisfied with the general appearance of the dashboard?	i. V2 (L1-1), V2 (L1-2): "This is better than that which is currently available". ii. V2 (L3-1); "The colours are dull". iii. V2 (L3-1): "The way the information is presented is suitable".
3.3.2 Do you find the number of frames or windows suitable?	i. V2 (L1-1), V2 (L1-2), V2 (L1-3): "Fewer frames are preferred and not information overload". ii. V2 (L2-1): "I like dashboards like this".
3.3.3 Are the symmetry and proportions of the dashboards distracting/not distracting?	No information.
3.3.4 Do the dashboards convey the correct context of the information?	i. V2 (L1-1), V2 (L1-2), V2 (L1-3): "The information is right for the context". ii. V2 (L2-1): The participants could see ways to use the information and could relate to the information in their management contexts. iii. V2 (L3-1): "Yes, I need all the information".
3.3.5 Do you think information grouping and hierarchies closely represent the business?	i. V2 (L1-2), V2 (L1-3): Participants understood the groupings and hierarchies and could suggest additional groupings. ii. V2 (L2-1): "I think we have to adapt to the data categories". iii. V2 (L2-1); "The categories should be organised according to the MyUnisa registration information". iv. V2 (L2-1): "I use programme categorisation rather than module level information". V2 (L3-1): "I need all the summaries that are there".

3. Dashboard characteristics (cont.)	
3.4 Dashboard navigation	
3.4.1 Do the support analytics provide relevant and explanatory information about the indicators?	i. V2 (L1-1): The College has an Excel planning document with everything related to a module, which could be displayed under "module administration"". ii. V2 (L1-2): "A "detail per qualification" description is necessary because other qualifications also take our modules". iii. V2 (L2-1): The registration information detail about cancelled students was received with interest by all participants. They could see the benefit of the lower level of detail in support of summary information.
3.4.2 Do the drilldowns represent the context correctly?	i. V2 (L1-1), V2 (L1-2), V2 (L1-3): "The drilldown to more detail is very helpful". ii. V2 (L2-1): "I work on programme information and not on module level information and I am interested in whether students pass the programme and not only the individual modules". iii. V2 (L3-1): "Yes, I need information like that – I use all the data, not only programme information".
3.4.3 What is your view about the security at all levels?	i. V2 (L1-1), V2 (L1-2), V2 (L1-3): All colleges can see module information across the institution. "We struggle to get our own information". ii. V2 (L2-1): "I do not think there is confidentiality and the information is there for everyone to see. It is also presented openly in meetings at the University". iii. V2 (L3-1): "I think it is problematic. It is sensitive data and cannot be in the public domain".

The participants were from two academic disciplines, namely Economic and Management Sciences, and Education. All the interviewees demonstrated a good understanding of the purpose of dashboards in general and they were aware of information that is required, but difficult to find.

In general, the interviewees on the lower level were very operationally focused and the participants responded that they experienced a general lack of information, which is usually difficult to obtain. They indicated that they work on individual student level and required information at a low level of detail such as individual student information. It was also clear that they have to respond to the monitoring of line management in terms of reports and information requested that they have to prepare and provide.

In response to Question 3.4.1 in Table 4.6, the drilldown report under the "registrations" tab of the dashboard was changed to display the qualifications to which the modules belong so that academic managers can see when modules are offered in other colleges. The tab description "academic structure" was changed to "module admin" in accordance with Question 3.1.1.

4.4.1.2 Dashboard V3

Changes made to Dashboard V3 and interview guide:

- The "assignment" and "examination" tabs were not populated with reports in Dashboard V2, but were changed between V2 and V3.
- Two questions were added in the evaluation of V3: "Do you have analytical requirements to perform your management duties?" and "Do you need the dashboard information in printable format?".
- The "academic structure information" tab is not intuitive. A suggestion was made to use "module administration" instead.

Dashboard V3 was validated during three interviews. The HoD of Criminal and Procedural Law in the College of Law and two professors who acted as HoDs in the College of Law participated in these interviews. The two professors were on level 1 because they were responsible for the management of modules in a department, like the other interviewees on level 1. All the interviewees are experienced academic managers and could relate to the information in the demonstration of the dashboards and the questions of the interview.

As indicated under the interviews relating to Dashboard V2 above, the dashboards were validated in the real environment to determine how well they are working and whether they are logically constructed.

Table 4.7 presents the combined transcribed responses of three interviews relating to Dashboard V3 of the exemplary dashboards in the actual environment.

Table 4.7: Interview responses: Dashboard V3

1.	**Identification**	**Responses**
1.1	Portfolio holder, initials and surname	Head of Department: V3 (L2-2) Professor: V3 (L1-4) Professor: V3 (L1-5)
1.2	Portfolio	Academic management
1.3	Portfolio name	College of Law
1.4	Portfolio position (management level):	HoD: College of Law Acting HoD: College of Law Acting HoD: College of Law
2.	**Value of the dashboards**	
2.1	Do the dashboards provide more readily available decision-making information?	i. V3 (L1-4): The participant could find the information independently. ii. V3 (L1-4): “Yes, the information will help us”. iii. V3 (L1-5): “The information will be helpful”.
2.2	How well are the indicators matched to the required decision-making information?	i. V3 (L1-4): “The information made sense”. ii. V3 (L1-5): “My module is part of the e-Transformation project run by the Department of Curriculum and Learning Development (DCLD) and we will need that kind of information”. iv. V3 (L1-4): “It showed how many students passed and that is what is needed”.

2. Value of the dashboards (continued)	
2.3 How can dashboards help to monitor the efficiency of processes?	i. V3 (L1-4): "Information can be accessed quick and easy". ii. V3 (L1-5): "The information will help us to improve the throughput of modules". iii. V3 (L1-4): "It will help to attach printed information to reports".
2.4 How can dashboards help to monitor the efficiency of processes?	iv. V3 (L2-2): "The information will definitely help to manage the efficiency of processes". V3 (L1-4), V3 (L2-2): "It is easy to find our own information and no training is required".
2.5 How efficient do the dashboards measure deliverables?	i. V3 (L1-4): "This information is very valuable to manage the department". ii. V3 (L1-4), V3 (L1-5): "Information is relevant". iii. V3 (L1-4): "It showed how many students passed and that is what is needed".
2.6 Do the indicators provide actionable, fact-based information?	i. V3 (L2-2): "Information centrally all in one place, such as this information, is very important". ii. V3 (L1-5): "e-Portfolio information will definitely be helpful". iii. V3 (L1-4): "Information is relevant". iv. V3 (L1-5): "Risk modules and results vary per semester or year and we have to manage how we can improve high-risk modules". v. V3 (L1-4): "The tuition language will help with tutorial letters". vi. V3 (L1-5): "e-Portfolio information will definitely be helpful". vii. V3 (L1-4); "Information is relevant". viii. V3 (L1-5): "Risk modules and results vary per semester or year and we have to manage how we can improve high-risk modules". iv. V3 (L1-4): "The tuition language will help with tutorial letters".

2. Value of the dashboards (continued)	
2.7 How well are the indicators updated and aligned according to the business cycles?	i. V3 (L1-4): Updating indicators daily and as cycles happen is correct. Participants understand how cycles work.
2.8 How well are the indicators updated and aligned according to the business cycles?	ii. V3 (L1-4), V3 (L1-5): The participants were satisfied with the update cycles, because it provided information that is better than that which they currently receive.
2.9 Do you have analytical requirements to perform your management duties?	i. V3 (L1-4): "Not used on departmental level". ii. V3 (L1-4): "Use personnel points. This could be more relevant for bigger departments". However, the participant intuitively knew where to appoint new staff. iii. "Forecasting will help with administration" V3 (L1-4). iv. V3 (L1-4): "Historical information is required more than analytical information, for example, five years' historical information is needed for risk modules". v. V3 (L1-5): "Forecasting and segmentation will be helpful". vi. V3 (L1-5): "Yes, according to discussion classes and exam papers, we would appreciate that kind of information where there is a greater need for video conferences, etc." Participants were more interested in current performance vii. V3 (L1-4); "More interested in current information". viii. V3 (L1-4): "If it is a poor student intake". Historical information is required to see if the same pattern occurred in the past.

3. Dashboard characteristics	
3.1 Indicator/s	
3.1.1 Which indicators are understandable and which are difficult to understand?	i. V3 (L1-4): "The information made sense and is readable". ii. V3 (L1-4): "The profile information as currently provided by some of the other disparate systems will make sense in the current context of modules". iii. V3 (L1-5): "If the information follows the student walk pattern, it makes sense". (Student progression, the cycle a student follows from registration, to assignment and discussion class assessment, to examination and other assessment, is called the "student walk" at the University.) iv. V3 (L1-4): The participant is satisfied with how the information is presented.
3.1.2 Are there indicators that reinforce other indicators?	i. V3 (L1-5): "I suspect discussion classes affect pass rates. We notify students about assessments, but students do not go into MyUnisa".
3.1.3 How well does the visualisation presentation suit the information it represents?	i. V3 (L1-4): "The presentation of information is logical and made sense". ii. V3 (L1-4): "Bar graphs make it easier to see what is happening". iii. V3 (L1-4), V3 (L1-5): "Colours were bright enough". iv. V3 (L1-4): The participant found information to be intuitive and could use the system.
3.1.4 Can you identify past, present and future indicators?	i. V3 (L1-4), V3 (L2-2): "Registrations and pass rates had historical information that is always required to make decisions". ii. V3 (L1-4), V3 (L1-5): "Historical information is required".

3. Dashboard characteristics (continued)	
3.2 Dashboard design	
3.2.1 Do you find the logos and brand elements distracting from critical information?	i. V3 (L1-4): The participant is not distracted by logos and branding. ii. V3 (L1-5): "One focuses on information and does not even notice branding and colours". V4 (L2-3): "No, I do not notice the logos and branding".
3.2.2 Is it accurate to conclude that the chart types present information correctly?	i. V3 (L1-4): "The presentation is easy to understand". ii. V3 (L1-4): "The figures, to a low level of detail, are more important than the graphs".
3.2.3 Do you find the dashboard too cluttered?	i. V3 (L1-4): "I prefer the simplicity". ii. V3 (L1-5): "Less information is preferred".
3.2.4 Do you find the number of indicators on the dashboard satisfactory?	i. V3 (L1-4), V3 (L1-5): Participants were satisfied, because it was the right information to help them manage.
3.2.5 Do you need the dashboard information in printable format?	i. V3 (L1-4): "Cut and paste is good enough". ii. V3 (L1-4): The participant is not in favour of printed reports". iii. V3 (L1-5): "We need both visual and printable formats". iv. V3 (L1-4): "I need printed information for reports".
3.3 Dashboard layout	
3.3.1 Are you satisfied with the dashboard's general appearance?	i. V3 (L1-4): The participant could intuitively use the dashboards.
3.3.2 Do you find the number of frames or windows suitable?	i. V3 (L2-2): The participant likes the simplicity of the system. ii. V3 (L2-2): The participant does not mind frames, as long as any indicator occurs only once. iii. V3 (L1-5): "Less is better".

3. Dashboard characteristics (continued)	
3.3.3 Are the symmetry and proportions of the dashboards distracting/not distracting?	i. V3 (L1-4): The participant likes the simplicity of the system. ii. V3 (L1-5): "I look at content and do not notice symmetry and proportions". iii. V3 (L1-4): "I did not find the presentation distracting". iv. V3 (L2-2): The participant suggested moving the "run" button to a more logical position.
3.3.4 Do the dashboards convey the correct context of the information?	i. V3 (L1-4): The participants could see ways to use the information and could relate to the information in their management contexts. ii. V3 (L1-4): "Registrations are required to manage assignments and are covered in the dashboard". iii. V3 (L1-4), V3 (L1-5): "Yes, the information is right for the context".
3.3.5 Do you think the information grouping and hierarchies closely represent the business?	i. V3 (L2-2), V3 (L1-5): Participants understood the groupings and hierarchies and could suggest additional groupings. ii. V3 (L1-4): If more than one qualification uses a module, then the participant can see that groupings and hierarchies are important and understandable. iii. V3 (L2-2): "School information is interesting, but I do not need information".
3.4 Dashboard navigation	
3.4.1 Do the support analytics provide relevant and explanatory information about the indicators?	i. V3 (L1-4): Registration information detail about cancelled students was received with interest by all participants and they could see the benefit of the lower level of detail ii. V3 (L1-5): The participant understood the information. iii. V3 (L2-2): The participant responded that analytical information is required on an ad hoc basis.

3. Dashboard characteristics (continued)	
3.4.2 Do the drilldowns represent the context correctly?	i. V3 (L2-2): “It would be great if a system can be a portal to all information, even to the student system”.
3.4.3 Do the drilldowns represent the context correctly?	ii. V3 (L1-4): “We work with individual students and would like information per student”. iii. V3 (L1-5): “We work with information holistically, but most of the time per individual student”. iv. V3 (L1-4), V3 (L1-5): “The drilldowns made sense. We could see how many students wrote exams and how many wrote supplementaries.
3.4.4 What is your view about the security at all levels?	i. V3 (L1-4): “Lecturers would always be able see detailed information of students”. ii. V3 (L1-4): “It does not seem to be a problem if other people can see your information”. iii. V3 (L1-4): “Any information can be found if you need it”. iv. V3 (L1-5): “The information is not confidential, we help and critique each other”. v. V3 (L2-2): “Confidential information is openly distributed in the College, therefore this is not confidential”.

It was evident from the interviews that the participants are at a more senior level of management and that the various disciplines have slightly different information requirements. All the participants demonstrated a good understanding of the purpose of dashboards in general and were very aware of the information that they require on a regular basis.

During the interviews with the lower management level, it became clear that some managers required reports in printable format and not only on the screens in the dashboards. The question: “Do you need the dashboard information in printable format?” was added from Dashboard V3.

During the discussions of Dashboard V2, it became clear that some managers referred to statistical and analytical reports. A question: “Do you have analytical requirements to perform your management duties?” was added to elicit the need for analytics in the dashboards.

The “assignment” and “examination” tabs were populated with reports in Dashboard V3. The “pass rate” and “assignment” information was received with interest, as can be seen from the responses to questions such as questions 3.3.4 and 3.1.2 regarding dashboards V3 and V4.

4.4.1.3 Dashboard V4

Changes made to Dashboard V4 and interview guide:

- In response to Question 3.3.3 (Are the symmetry and proportions of the dashboards distracting/not distracting?), Participant V3 (L2-2) responded that the “run” button is not in an intuitive position. The button was moved to the end of the navigation filters in Dashboard V4.
- The “assignment” and “examination” tabs were populated with reports in Dashboard V3 and V4.
- Additional information was suggested in V4 interviews.

The HoD: College of Human Sciences, Executive Dean: College of Agriculture and Environmental Sciences, and the Deputy Executive Dean: College of Law at the University validated Dashboard V4. One participant is the HoD responsible for the management of the Department of African Languages. The other two participants are responsible for the overall management of colleges consisting of departments that are divided into schools. They are responsible for the overall management of courses and programmes in the different colleges. They are experienced academic managers and could relate to the information in the dashboard demonstration and interview questions.

The responses are given in the discipline's context, as well as in the context of participants' views. The dashboards were validated in the real environment to determine how well they are working and whether they are logically constructed. When the user requirements are met and the artefact solves the problems that were identified, the artefact's design is considered to be complete and effective.

Table 4.8 presents the combined transcribed responses of the three interviews relating to Dashboard V4 of the exemplary dashboards in the actual environment.

Table 4.8: Interview responses: Dashboard V4

1. Identification	**Responses**
1.1 Portfolio holder, initials and surname	Head of Department: College of Human Sciences: V4 (L2-3) Executive Dean: College of Agriculture and Environmental Sciences: V4 (L3-2) Deputy Executive Dean: College of Law: V4 (L3-3)
Identification	**Responses**
1.2 Portfolio	Academic management
1.3 Portfolio name	One HoD, one Executive Dean One Deputy Executive Dean
1.4 Portfolio position (management level)	HoD, Executive Dean Deputy Executive Dean
2. Value of the dashboards	
2.1 Do the dashboards provide more readily available decision-making information?	i. V4 (L3-2): "This will facilitate easy access to pass rates without going through a long process to get to the information". ii. V4 (L3-3): "This will absolutely help with decision-making".
2.2 How well are the indicators matched to the required decision-making information?	i. V4 (L3-2): " One cannot get pass rates anywhere – this is very valuable.". ii. V4 (L3-3): "Everything that is provided in the dashboard is what we need". iii. V4 (L2-3): "The information is very needed and knowledge of home language vs beginners in African language will enhance the value".

2. Value of the dashboards (continued)	
2.3 How can dashboards help monitor the efficiency of processes?	i. V4 (L3-2): "The other information is available with a little bit of difficulty, but pass rates are not available anywhere". ii. V4 (L3-3): "We use the "admitted", "wrote" and "pass" information to manage the assessments with interventions, take-home exams, e-portfolios, etc.".
2.4 How can dashboards help monitor the efficiency of processes?	iii. V4 (L3-3): "We have to manage coursework master's degree students with low pass rates, historical information helps to determine admission and selection criteria". iv. V4 (L2-3): "Exam information of previous sittings is removed and we need that. The dashboard will help with that".
2.5 How efficiently do the dashboards measure deliverables?	i. V4 (L3-2): "The qualification information is important not just per programme, I look at it holistically. Lecturers want to convince me that students are performing badly in a specific module and I am not convinced that they cannot improve their pass rates". ii. V4 (L3-3): "At least I can take action immediately and not six months down the line. We have to manage the students in the system and have too many LLB students". iii. V4 (L3-3): "Cap students that are in the system: The number of repeaters is important to see how many students remain in the system". iv. V4 (L3-3): "Half modules are outstanding, so are F1-concessions" v. V4 (L3-3): "It helps indicate how much the College would like to grow with regard to the qualification.

2. Value of the dashboards (continued)	
2.6 Do the indicators provide actionable, fact-based information?	i. V4 (L3-2): "I can make decisions on information that I have, such as for Vice Chancellor sign-off meetings". ii. V4 (L3-3): "We have to implement interventions and can only do that if we have the relevant information, such as the pass rates".
2.7 How well are the indicators updated and aligned according to the business cycles?	i. V4 (L3-2): "Data is updated daily and data will only be available as cycles revolve". ii. V4 (L3-3): It will be an advantage if the information is up to date because participants struggle to get this kind of information. i. V4 (L3-3): "College management and chairs of departments need the information in the dashboards on a daily basis". ii. V4 (L2-3): Updating indicators daily and as cycles happen is correct. Participants understand how cycles work.
2.8 Do you have analytical requirements to perform your management duties?	i. V4 (L3-2): "Probably, but what you give is at least a start. I can give you lots of ideas for BI". ii. V4 (L3-3): "We are interested in managing the throughput". iii. V4 (L2-3): "To manage cost units to appoint new staff members and study material forecasting per language can be useful if scientifically calculated".
3. Dashboard characteristics	
3.1 Indicator/s	
3.1.1 Which indicators are understandable and which are difficult to understand?	i. V4 (L3-2): The participant interpreted the information on the dashboard very well and responded" "There is a glitch in 2011 and what is the 13 in the setting?".

3. Dashboard characteristics (continued)	
	ii. V4 (L3-3): "All the information provided in the dashboards is needed". iii. V4 (L2-3): "The main focus of the department is their own discipline and dashboards find it easily". iv. V4 (L2-3): "We do not want death by statistics".
3.1.2 Are there indicators that reinforce other indicators?	i. V4 (L3-2): "The participant related very well to the information and understood how it interrelates".
3.1.3 How well does the visualisation presentation suit the information it represents?	i. V4 (L3-2): "Information is useful for managing the exam process with the due date three weeks after the exam is written and submitted. An assignments and assessments plan is required". ii. V4 (L2-3): The participant found information intuitive and could use the system. iii. V4 (L2-3): "The information should not be repeated in different graphs".
3.1.4 Can you identify past, present and future indicators?	i. V4 (L3-2), V4 (L3-3): The participant understood historical and current information as represented in the registration and pass rates.
3.2 Dashboard design	
3.2.1 Do you find the logos and brand elements distracting from critical information?	i. V4 (L3-2): The participant responded that she did not notice logos and branding, but is very interested in information and how to manage it. ii. V4 (L3-3): The participant responded that she did not particularly notice it.
3.2.2 Is it accurate to conclude that the chart types present information correctly?	i. V4 (L3-2): "The graph per exam sitting is very valuable". ii. V4 (L3-3): The participant found the information easy to understand. iii. (L2-3): The participant understood the charts easily V4.

3. Dashboard characteristics (continued)	
3.2.3 Do you find the dashboard too cluttered?	i. V4 (L3-3): The participant liked the fact that the screens were not cluttered. ii. V4 (L2-3): The participant prefers fewer graphs and tables to be able to focus on one area.
3.2.4 Do you find the number of indicators on the dashboard satisfactory?	iii. V4 (L3-3): There should not be more information on the screen, because it helps the participant to understand what she is busy with. iv. V4 (L2-3) the participant prefers fewer graphs and tables to be able to focus on one area. v. V4 (L2-3): The participant could find usable indicators on the dashboard.
3.2.5 Do you need the dashboard information in a printable format?	i. V4 (L3-3): The participant indicated that they would like to print and really need to be able to print. ii. V4 (L2-3): Printable information is important. iii. V4 (L2-3); "To be able to email will be helpful".
3.3 Dashboard layout	
3.3.1 Are you satisfied with the general appearance of the dashboard?	i. V4 (L2-3): "The information is suitable and groups information logically together".
3.3.2 Do you find the number of frames or windows suitable?	i. V4 (L3-3): "I like only one graph, because it is focused on one area".
3.3.3 Are the symmetry and proportions of the dashboards distracting/not distracting?	i. V4 (L2-3): The participant likes the simplicity of the system.
3.3.4 Do the dashboards convey the correct context of the information?	i. V4 (L3-2): "Yes, I need all the information". (V4 (L3-3) had the same view.) ii. V4 (L2-3): The participants could see ways to use the information and could relate to the information in their management context.

3. Dashboard characteristics (continued)	
	iii. V4 (L2-3): "It is important to manage exams and how many students are going to write. These areas are covered in the dashboard".
3.3.5 Do you think information grouping and hierarchies closely represent the business?	i. V4 (L3-2): "I look at college, school, department and module level".
3.4 Dashboard navigation	
3.4.1 Do the support analytics provide relevant and explanatory information about the indicators?	i. V4 (L3-2): "I like to know what I am driving and this is nice". ii. V4 (L3-3): "The kind of information will be used daily". iii. V4 (L2-3): All participants received registration information details about cancelled students with interest and they could see the benefit of the lower level of • detail in support of summary information.
3.4.2 Do the drilldowns represent the context correctly?	i. V4 (L3-2): Additional information required by the participant is to be able to click on pass rate, percentage, group. ii. V4 (L3-2): "What happened over the last years and the current sitting year < 50%, < 60%, etc.". iii. V4 (L3-3): The information is very relevant to the participant. iv. V4 (L3-3): The drilldowns are logical and understandable.
3.4.3 What is your view about the security at all levels?	i. V4 (L3-3): The participant responded that if they collaborate to improve the institution, it is good to have access to each other's information. ii. V4 (L2-3): "Lecturers could always see detailed information of students".

The participants are from three academic disciplines: Human Sciences, Law, and Agriculture and Environmental Sciences. It was evident from the interviews that the participants' views are more strategic and that they are more holistically focused. All the participants demonstrated a good understanding of the purpose of dashboards in general. They were also very aware of the information they require on a regular basis and have difficulty finding.

Changes to Dashboard V4 would be to populate the unpopulated tabs with reports and to collaborate with the users to develop more reports with diagnostic drill-paths, as Participant V4 (L3-2) indicated, in response to Question 2.7 relating to Dashboard V4 that: “I can give you lots of ideas for BI”.

4.4.2 Interview validation: Dashboards in real environment on different academic management levels

Table 4.9 below provides a summary of the interview responses to the assessments of dashboards V2, V3 and V4 per management level.

Table 4.9: Summary of interview responses per management level

Lower academic management level	Middle academic management level	Top academic management level
1. Value of the dashboards		
1.1 Please discuss how the dashboards provide more readily available decision-making information.		
The participants who tried the dashboards indicated that they could quickly navigate to their own information. A general observation on the lower management level was that the dashboards provide information that the managers find difficult to obtain and they responded several times with: "This is already much more than we currently have". When the one participant saw the detail of her own information in the dashboards, she realised the potential of checking the correctness of her module data in the system databases and that it would be easy to find. She said: "I like this because we can see whether there are errors in the data."	The participants were pleased with the way their own information could be accessed and is logically organised for the management of modules. They indicated that it is essential information and all the participants voluntarily performed hands-on trials before the interviews and could intuitively and independently work with the dashboards.	All the participants were convinced that the dashboards will help with decision-making information and provide easy access to pass rates without going through a long process to get the information.

Lower academic management level	**Middle academic management level**	**Top academic management level**
1.2 How well are the indicators matched to the required decision-making information?		
Participant V3 (L1-5) is involved in an e-Transformation project at the University and, when she saw her own module data, responded that it could help with the information required for the project, which signifies that the information is useful and relevant for initiatives at the University. Participants responded that the examination information and pass rates are needed.	Participant V2 (L2-1) responded that even if the dashboard is still incomplete and a work in progress,“[it] is already much more than we currently have”. The information is matched to the required decision-making because participants found the information understandable and “very needed”. The participant from the Human Sciences discipline requested home language student profile information, which is essential for management in a language discipline, to distinguish beginners from more advanced students and for managing discussion classes and study material. This request demonstrates an awareness of the dashboards’ potential.	The context of the dashboard information matches the way all the participants need the information and the examination information is very valuable because it cannot be accessed anywhere else. Participant V4 (L3-3) responded that “everything that is provided in the dashboard is what we need”, which confirms that the information matches the management context.

Lower academic management level	**Middle academic management level**	**Top academic management level**
1.3 Discuss how the dashboards help monitor the efficiency of processes.		
Participants related that module administration information will be helpful for planning purposes and when the information is exported to Excel, it will make them more efficient.	The access to the information will be improved, which will improve the efficiency of the processes because the “information can be accessed quickly and easily”. Participant V3 (L2-3) felt that the fact that she does not have to be trained to use the system improves its efficiency.	Some of the information can be found in other sources with more difficulty, but the dashboard will make the information provision more efficient. All the participants responded that the information will help to manage process efficiency with examples of “admitted”, “wrote“ and “pass” information helping to manage assessment methods such as take-home exams or e-portfolios. In managing coursework master’s degree students with low pass rates, the historical information helps to determine admission and selection criteria.

Lower academic management level	**Middle academic management level**	**Top academic management level**
1.4 Discuss how efficiently the dashboards measure deliverables.		
The academic managers recognised that examination information measures how many students wrote, passed and failed examinations and it represents a measurement of a deliverable, measuring how many students were successful in their module studies.	Examination information from another source is removed after the examination periods and the information available on the dashboard will help with that.	The top-level participants look at the information more holistically and need all the levels of information. Participant V4 (L3-2) responded that lecturers are convinced that students perform badly in a specific module, but she is not convinced that the pass rates cannot be improved. She wants to use the information to determine other interventions by looking at the figures from different angles. Participant V4 (L3-2) mentioned a very important aspect. She mentioned that she can take action immediately and does not have to wait six months before information becomes available, which confirms that the information is actionable. The participant also needed the information for enrolment planning, to reduce the number of LLB students in the system who take too long to graduate, to grow certain qualifications, etc.

Lower academic management level	**Middle academic management level**	**Top academic management level**
1.5 Do the indicators provide actionable, fact-based information?		
The participants were aware that the number of registrations and type of cancellations, assignment progress and examination information is required to design management interventions to improve the pass rate of high-risk and e-portfolio modules.	Participant V3 (L2-1) wanted information per programme to be able to determine if the information indicators measure deliverables, but V3 (L2-2) considered the information valuable to manage his department. The interviewees indicated that they have to use the system more to be able to know if the information is fact-based and actionable.	The indicators provide actionable, fact-based information as can be gathered from the response of participant V4 (L3-2): "I can make decisions based on information that I have for the Vice-Chancellor's sign-off meetings". According to participant V4 (L3-3), relevant information, such as pass rates, will assist with implementing interventions.
1.6 How well are the indicators updated and aligned according to the business cycles?		
The participants were satisfied with the update cycles, because they do not get up-to-date information automatically and they consider the dashboard information better than that which they currently have.	All the participants are familiar with the student walk cycles and were satisfied if the information is refreshed daily, but that the information changes according to the academic cycles.	It will be an advantage if the information is up to date because participants struggle to get this kind of information and, if it updated daily according to the academic cycles, it will be suitable to their information needs.

Lower academic management level	Middle academic management level	Top academic management level
1.7 Do you have analytical requirements to perform your management duties? Please discuss.		
Participant V3 (L1-5) responded that five years' historical information for risk modules is important to assess how the module has improved or if interventions made a difference, etc. One participant deemed forecasting and segmentation to be helpful. Another participant indicated that he/she is more interested in current information, but would like to identify "if it is a poor student intake" by comparing current information to historical information to see if the same pattern occurred in the past. Current information is important to manage video conferences for discussion classes.	One participant felt that analytical information is mostly required on an ad hoc basis, while another participant did not need it on departmental level. Bigger departments might have a requirement for it. One participant thought scientifically calculated analytical information, such as forecasting, can be helpful for administration on department level.	Participants V4 (L3-2) responded that the current dashboard information is a start and that more analytical information would probably be required. V4 (L3-3) was interested in throughput information.
2. Dashboard characteristics		
2.1 Indicator/s		
2.1.1 Which indicators are understandable and which are difficult to understand? Please discuss.		

Lower academic management level	Middle academic management level	Top academic management level
When complete, the dashboards will provide information for student progression, the cycle a student follows from registration, to assignment and discussion class assessment, to examination and other assessment, which is called the "student walk" at the University. The participants find the presentation to be intuitive as the response indicates: "If the information follows the student walk pattern, it makes sense". Participants responded with relevant comments and suggestions to all the information. They could also relate to the information and understand what was presented.	Some of the areas on the dashboards are not yet populated and participant V3 (L2-1) indicated that it was confusing. Participant V3 (L2-2) thought the information made sense and was readable and that the profile information that could be accessed in disparate systems would assist with understanding the module-related figures. Participant V3 (L2-3) indicated that her focus is her department and the dashboards make information easy to find and are not too overwhelming to cause "death by statistics".	The participants needed all the indicators provided, and understood the information very well. Participant V4 (L3-2) was able to discern questionable categories in the data.
2.1.2 Please discuss which indicators reinforce other indicators.		

Lower academic management level	Middle academic management level	Top academic management level
Information per qualification is required "because other colleges also offer the same modules". The comment of participant V3 (L1-4) that assignment information cannot be used for supplementaries showed that she understood that assignment information might give an indication of how well students will perform in the examination assessment and the comment: "I suspect that discussion classes affect pass rates" also illustrates this understanding. We notify students about assessment, but students do not go into MyUnisa".	The participants are aware of how one measure influences another. They understood that module information affected programme information. V3 (L2-3) understood that home and tuition language can give an indication of discussion class attendance.	Participants V4 (L3-2) and V4 (L3-3) understood the interrelation of the information in the dashboards. Because they spontaneously discussed interventions, they could contribute to the indicators provided in their data.
2.1.3 How well does the visualisation presentation suit the information it represents?		
The participants seemed to agree that graphic display is not particularly important, as long as they had the right information. One participant expressed a preference for bar graphs, because it is easier to see what is happening.	Participants considered the visual presentation of the information to be intuitive and logical. It is easy to use the system themselves. Participant V3 (L2-3) observed that, although the visualisation is easy to understand, the same information should not be repeated in different graphs.	The information's visual presentation was easy to understand because they liked the way the information was presented and they easily understood the graphic representation. Participant V4 (L3-2) suggested additional graphic representation of exception reporting requirements.

Lower academic management level	Middle academic management level	Top academic management level
2.1.4 Can you identify past, present and future indicators?		
	All the participants agreed that historical information in registrations and examinations is useful and is always required to make decisions.	Participants V4 (L3-2) and V4 (L3-3) could see how the current and historical information in the registration and examination figures could assist with identifying patterns to determine actions.
2.2 Dashboard design		
2.2.1 Do you find the logos and brand elements distracting from critical information?		
The participants did not find logos and brand elements distracting, because they felt that “one focuses on information and does not even notice branding and colours”.	Participant V3 (L2-1) thought the branding and colours are similar to another system that is nicely designed. The other participants were not distracted by the branding and logos and did not notice it.	When questioned about the general appearance, Participant V1 (L3-1) responded that the colours are dull. Participant V4 (L3-3) would like fewer frames per tab to help her focus on one area at a time.
2.2.2 Is it accurate to conclude that the chart types present information correctly? Please discuss.		
Participants considered graphs to be “nice-to-haves” and that figures at a low level of detail were more important to participants than a graphic information.	One participant said: “The presentation in the dashboards is like the gadgets in a new car, where the gadgets will be discovered as the system is used” and needed more exposure to the information to be able to respond with better suggestions. The other participants found the chart types intuitive and easy to understand.	The participants responded that they need all the information to confirm that the context is correct and that all the groupings and hierarchies are true reflections of the data they need. At the top management level, they all indicated that they need all the levels of data. Participant V4 (L3-2) said: “I look at college, school and department information.

Lower academic management level	Middle academic management level	Top academic management level
2.2.3 Do you find the dashboard too cluttered?		
More than one participant indicated that they prefer less information on a screen and did not find the presentation too cluttered. The participants were in favour of relevant information, such as the drilldown information in the “registration” tab.	All the participants considered the dashboards to be not too cluttered and preferred fewer graphs and tables on a screen because there is no overflow of information. The simplicity helped them to focus on what is presented. They thought the dashboards are intuitive, grouped information logically and are better than they currently have. One participant did not mind if there are many frames, as long as the same information is not repeated in different frames and presentations.	All the participants experienced the dashboards as not being too cluttered and preferred fewer items on a screen. They all indicated that they liked the screens as they are.
2.2.4 Do you find the number of indicators on the dashboard satisfactory?		
Participants responded that they were satisfied with the kind of information because it was the right information to help them manage.	Participants could find usable indicators on the dashboard and preferred fewer items, because it made it less distracting.	Participants were satisfied with the indicators because they could understand and relate to the information as it is arranged.
2.2.5 Do you need the dashboard information in printable format?		
One participant responded with: “I need printed information for reports”, and another with: “We need both visual and printable information”.	Participants did not have the same requirements for printed reports. One did not want any printable reports and opted for cut-and-paste, while two participants wanted a printable and a visual display.	Participant V4 (L3-3) responded that printable information is much needed.

Lower academic management level	**Middle academic management level**	**Top academic management level**
2.3 Dashboard layout		
2.3.1 Are you satisfied with the general appearance of the dashboard?		
Participants were satisfied with the general appearance because they felt that it gives the information they need.	Participants considered the appearance better than the one they had. They liked the fact that information was logically grouped and all participants could intuitively use the dashboards and find their own information.	All the participants liked the appearance, but one participant experienced the colours as being dull.
2.3.2 Do you find the number of frames or windows suitable?		
They were satisfied with the number of frames because it did not create information overload and they could focus on one area.	All participants were satisfied with the number of frames and liked the simplicity. Participant V3 (L2-3) did not want repetition of the same information in different visual forms.	All the participants preferred fewer frames because it improved their ability to focus.
2.3.3 Symmetry and proportions of the dashboards are distracting/not distracting?		
The symmetry and proportions were not distracting.	The symmetry and proportions were not distracting and participants liked the system's simplicity.	The symmetry and proportions were not distracting.
2.3.4 Do the dashboards convey the correct context of the information?		

Lower academic management level	Middle academic management level	Top academic management level
The information was considered to be in the right context because participants could recognise their modules right away and confirm when the numbers were in the right ballpark or modules were being phased out.	All the participants could see ways to use the information and relate to it in their management contexts. Participant V3 (L2-2) noted that the registration figures are required to manage assignments, and knowing how many students are going to write examinations will help manage examinations.	Participants confirmed that the context is correct, because they need all the information.
2.3.5 Do you think information grouping and hierarchies closely represent the business?		
In all instances, the participants understood the groupings and hierarchies and could suggest additional groupings.	Participant V3 (L2-1) felt that they have to get used to the data groupings and hierarchies and that categories should be aligned among the different systems. All participants felt that groupings like modules per qualification provide important information. Categories that are not necessary, such as school categories, are not necessary for HoDs because they do not need it.	The participants responded that they need all the information to confirm that the context is correct and that all the groupings and hierarchies are true reflections of the data they need. At the top management level, they all indicated that they need all the levels of data. Participant V4 (L3-2) said: “I look at college, school, department and module level”.
2.4 Dashboard navigation		
2.4.1 Support analytics are relevant and provide explanatory information about the indicators. Please provide reasons for positive and/or negative answers.		

Lower academic management level	Middle academic management level	Top academic management level
Support analytics are relevant and provide explanatory information about the indicators. In the registration drilldown, participants particularly liked the drilldown, which gave extra information about summarised numbers. The participants requested detail per qualification description because other qualifications also offer their modules and impacted on the performance of the modules.	All participants received the example of support analytics (registration information and detail about cancelled students) with interest. Participants thought the example provided explanatory information about the indicators and they could see the benefit of the lower level of detail in support of summary information.	The support analytics are relevant and provide explanatory information about the indicators. Participant V4 (L3-3) indicated that she needs this kind of information daily, while V4 (L3-3) responded: “I like to know what I am driving and this is nice because it helps to investigate the patterns and performance of indicators.”
2.4.2 The drilldowns represent the context correctly. Please provide reasons for positive and/or negative answers.		
The drilldowns made sense and explanatory information, such as how many students wrote exams, how many passed and how many wrote supplementaries, was received positively.	Participant V3 (L2-1) needed drilldown information per programme to determine whether students pass programmes and not only individual modules. Drilldown per qualification was added to Dashboard V3. Participants were very interested and found it valuable.	The drilldowns helped participants to understand their own module information and participant V4 (L3-2) identified additional drilldown paths that would help her in managing pass rates in the College.
2.4.3 Security is appropriate at all levels. Please provide reasons for positive and/or negative answers.		
Participants did not consider the information as confidential and indicated that College staff can currently see “all levels” of information across the institution and “we struggle to get our own information” and cannot see that it can be confidential.	All the participants considered the information as non-confidential because module information is openly presented in meetings and distributed across colleges. All lecturers can see detailed information of students and any information can be found if people needed it.	Participant V1 (L3-1) thought it was problematic that the information is open to the University community and considered the information to be sensitive, while participant V4 (L3-3) considered it positive that everyone can work together to improve academic performance of modules across the University.

4.4.2.1 Value of the dashboards

All the interview participants indicated that the information is logically organised and essential. They also indicated that the information was much more than they had. Participants were pleased that they could find their own information so easily and that information in the presented format allowed them to identify errors in the data, which confirms that the dashboards address information needs and that they have diagnostic value to identify data errors. Participants in middle and top management voluntarily performed hands-on trials before the interviews and could work with the dashboards intuitively and independently. All the participants were convinced that the dashboards would help with decision-making and provide easy access to pass rates without going through a long process to get the information.

The metrics are matched to the management context and the way all the participants need the information for decision-making purposes because participants indicated that the information was understandable, “very needed”, useful and relevant for initiatives at the University. The dashboard information could improve operational efficiency because it could assist with planning processes, access to the information itself improved efficiency and many participants could spontaneously access their own information without training. That fact that participants did not need training also helped with efficiency because the participants felt that they could not allocate time for training in their management schedules. The daily refreshment cycles would improve the efficiency as participants indicated that they struggle to get the right information. The participants indicated that the information is fact-based and actionable.

On all the levels, the participants could suggest additional information. At the middle management level, there were differences in the way the various disciplines required the information and the focus of the top management level was more strategic and holistic.

4.4.2.2 Indicators on the dashboards

The dashboards provide the information according to the student walk and participants found the layout intuitive. Participants found the areas still under construction confusing. Lower and middle management participants were only interested in information relating to their own management focus, while the top-level management was interested in all the levels of aggregation.

According to participant V3 (L2-2), information is required per qualification “because other Colleges also offer the same modules”. The participants were aware of how one measure influences another. They understood that module information affects programme information and that interventions can be implemented to stimulate improvement in the performance of indicators.

Graphic display is not particularly important, as long as participants had the right information, found the visual presentation of the information intuitive and logical, and experienced the system as being easy to use. The same information should not be repeated in different graphs. Current and historical information of the registration and examination figures can assist with identifying patterns to determine actions and manage risk modules. Historical and current information was required to identify poor student intakes by comparing current to historical information.

4.4.2.3 Dashboard design, layout and navigation

Participants focused on information and did not notice branding and colours. One participant responded that the colours were dull and all participants liked fewer frames, graphs and tables per tab to be able to focus on one area at a time.

Participants considered graphs to be “nice-to-haves” and preferred the figures to be at a low level of detail. In general, participants found the chart types intuitive and easy to understand. The participants responded that they needed all the information, that the context was correct and that all the groupings and hierarchies were true reflections of the data they need. Members of top management indicated that they need all the levels of data.

All the participants considered the dashboards to be not too cluttered and preferred fewer graphs and tables on the screen because there was no overload of information and the simplicity helped them to focus on what was presented. More than one participant indicated that they preferred less information on the screen and did not find the presentation too cluttered. The symmetry and proportions were not distracting and participants liked the simplicity of the system. Participants favoured relevant information, such as the drilldown information in the "registration" tab. They considered the dashboards intuitive, logically organised and better than the one they had.

The information was considered to be in the right context because participants could recognise their modules right away and confirm whether the numbers were in the right ballpark and could see ways to use the information and relate to it in their management context.

In all instances, the participants understood the groupings and hierarchies and could suggest additional groupings. Participant V3 (L2-1) felt that they have to get used to the groupings and hierarchies in the data, and categories should be aligned among the different systems. All participants felt that groupings like modules per qualification provide important information. Participants on the middle management level felt they did not need a higher level of information. Top management needs all the levels of data.

Support analytics are relevant and provide explanatory information about the indicators, such as the registration drilldown. Detail per qualification description was requested because other qualifications might also offer the same modules, which influenced the performance of the modules. The support analytics are relevant and provide explanatory information about the indicators. A participant indicated that she needs this kind of information daily to investigate patterns and the performance of indicators.

The drilldowns made sense and provided explanatory information to determine the reasons for patterns in the information. A drilldown per qualification was added.

All the participants considered the information to be non-confidential because information was openly presented in meetings and distributed across colleges, and everyone could work together to improve the academic performance of modules across the University. Lecturers could see detailed information of students and any information could be found if people needed it. One participant considered the information to be sensitive.

4.4.2.4 Analytical requirements

The question about need for analytical information was met with a mixed response, because three participants felt that they can use scientifically calculated forecasting and segmentation, one participant was interested in analytical information on an ad hoc basis and another participant viewed it necessary for bigger departments.

4.4.2.5 Printable format

Participants did not have the same requirements for printed reports. One did not want any printable reports and most were satisfied with the cut-and-paste facility, while two participants wanted a printable as well as a visual display. Participant V4 (L3-3) responded that printable information is necessary.

4.5 ANALYSIS OF THE INTERVIEW FINDINGS

Considering the responses of the interviews at the three levels of academic management, the following interpretations can be drawn according to the subsections of the interview guide:

4.5.1.1 Value of the dashboards

Judging from the results of the interviews, the value of dashboards for the academic managers can be summarised as follows:

1. Dashboards are useful, relevant, inform initiatives at the University and would address an essential need for information.

2. The information is intuitive to managers and they could independently find their own information and work with the dashboards.
3. The information was very well suited to the context and all the participants found it easy to understand and could interpret how the information could be used to make fact-based and actionable decisions.
4. The dashboards can improve operational efficiency by assisting with planning, facilitating self-help, access rights, as well as regularly updated and current information to address decision-making. Information is logically grouped, more than currently available information, has diagnostic value to identify data errors, simplifies access and reduces access time.
5. The interpretation can be made that analytical information will not address the general decision-making information needs. Although it is also required, the analytical information has a secondary priority to the general information. Scientifically calculated forecasting and segmentation of analytical information will be useful to the academic managers.

Because the dashboard prototypes were a work-in-progress and not all the modules were completed, many additional information requirements could be identified.

4.5.1.2 Indicators on the dashboards

The participants were well informed about information they needed, especially if it was difficult to find. Indicators that demonstrate the exemplary dashboards' mechanism and characteristics were developed. Therefore, the dashboards did not address the need for all the required indicators. The findings from the interviews that related to indicators were the following:

1. Participants were aware how one measure influenced another and how to develop interventions that could stimulate improvement in the performance of indicators.
2. Indicator information should not be repeated in different formats, which was facilitated by the simpler design.
3. Current and historical information in the indicators are important for identifying patterns and changes in student intakes.

4. The right information is more important than graphic display, as long as it is intuitive and logical to the users.

4.5.1.3 Dashboard design, layout and navigation

In the exemplary dashboard in the real environment, the presentation, design, layout and navigation have significant roles. The exemplary dashboard module was developed for the currency of a course (module).

The participants in all the interviews related well to the navigation in the top of the dashboard that was organised according to the organisational structure where the year, college, department and courses could be selected to find the information relevant to the individual. A participant said that the information could be accessed "quick-quick".

The next level of navigation using tabs represented the student walk, which is familiar to users. In the demonstrations, the modules relevant to participants were easily selected and the participants related positively to the functionality. Where participants performed hands-on trials, they were able to find their own information intuitively because the student walk is a well-known business cycle at the University. Participants found the layout and navigation intuitive and easy to use.

The results of general design and layout factors are interpreted below:

1. Colours and branding seemed unimportant to the participants. This can be because they find it difficult to get the right information.
2. When the information is prepared for a wide audience, it can be important to ensure that it is suitable for colour-blind and visually impaired people.
3. The participants preferred a simpler design, such as fewer frames, graphs and tables per view, because they felt the information was easier to find and they were not distracted by unrelated items. When fewer items are displayed per view, the symmetry and proportions are simpler.
4. Information that is logically grouped is preferred.

5. Information with relevant drilldown functionality was received with more interest than just a table and a graph.
6. The context of the information can be considered suitable because participants could recognise their modules right away and confirm when the numbers were in the right ballpark, and could see ways to use the information and relate to it in their management context.
7. All participants were familiar with the groupings and hierarchies and could see additional groupings. This indicates that they regularly work with information and have a need for the right information that suits their requirements.
8. When support analytics, such as the drilldown, provide explanatory information about the indicators, participants find it useful and they investigate patterns and the performance of indicators daily.
9. In general, the information is considered non-confidential and that could assist with collaboration towards improvement at the University.
10. In order to address a variety of information formats, it would be useful to make on-screen and printable information available.

4.5.1.4 Effect of interview results on design guidelines and wicked problems

As mentioned in section 4.3.4 regarding the validation of the first prototype, the design guidelines have to be adjusted for the following iterations as well. Table 4.10 summarises how the design guidelines were affected by the interview results of the assessment of Dashboard versions 2 to 4 and the “wicked problems” that were identified.

Table 4.10: Design guideline adjustment and "wicked problems" identified versions 2 to 4

Design guideline	Lower academic management level	Middle academic management level	Top academic management level
Conduct thorough user requirements and liaise with users what the measures are.	User requirements were covered in section 4.3.1 above.	User requirements were covered in section 4.3.1 above.	User requirements were covered in section 4.3.1 above.
Decide on dashboard design and layout.	In general, the layout of information and design were secondary to information content.	A participant suggested moving the "run" button to a more logical position.	Participants felt that information can be accessed quickly because it was organised according to the organisational structure and student walk, which is familiar to users. The colours were dull to one participant.
	In general, the navigation in the top section and tabs were well received.		
	Additional groupings and hierarchies were suggested.		
Users were consulted about dashboard context drilldown.	Users find the context drilldown very useful if there is a diagnostic route integral to the drill-path.	Users require more engagement to consider the functionality better.	Customised investigative drill-paths according to user rationales will be helpful.

Design guideline	**Lower academic management level**	**Middle academic management level**	**Top academic management level**
Intuitive and economic dashboard navigation	The users engaged spontaneously and were able to find their own information intuitively. Navigation did not present an obstacle.	The users were able to intuitively find their own information and were familiar with the logic of the student walk.	Organisation structure navigation for filtering made information easy to understand.
Design best-suited metrics.	Users indicated that they need all the information in the dashboards. Users identified additional information.	Best-suited indicators can only be designed with engagement from the end users. Care should be taken not to provide redundant information such as duplicating the same information in different guises.	Exception reporting based on user-defined rationales will help with management.
“Wicked problems” identified	Diagnostic drill-paths could not be defined without user line-of-thought patterns.		It is time-consuming to develop dashboards intelligently.

4.5.1.5 Information on different management levels

The interviews were structured according to three academic management levels and therefore warrant a discussion of the findings according to the levels. The interpretation of the academic management level results is discussed below:

1. Lower and middle management participants were only interested in information of their own management focus.
2. The top management level required strategic and holistic information with all the levels of aggregation. Strategic requirements were wider and more holistic and can be generically developed.
3. The middle and lower management level require discipline-specific information customisation per department and lower management levels wanted diagnostic drilldown into operational transaction-level detail.
4. The middle management level felt they did not need a higher level of information.

As can be seen in points 1 to 4 above and in the interpretation of the interview results, the information requirements are different on the various levels of academic management. The general response was that the managers did not have access to enough information. The information on the different aggregation levels in the exemplary dashboard does not need to be changed and the managers can use the information from the level that suits their needs, but they will have access to higher and lower levels for better understanding if required.

4.6 SUMMARY

The empirical results and analysis chapter covered the process that was followed in the dashboard study. The user requirements session, participant selection, interview guide design and different interview sessions were discussed. The findings of the user requirements, storyboard interview and exemplary dashboard interviews on different management levels were documented. In section 4.5, the findings of the user requirements, storyboards and interviews were interpreted and analysed.

The results of the iterative design science process are used to adjust the draft design guidelines in the next chapter and the theoretical grounding of the design research process is justified.

5. CHAPTER 5: DESIGN GUIDELINE REFINEMENT AND RESEARCH METHODS FOLLOWED

5.1 INTRODUCTION

Frameworks for executive dashboards in tertiary education institutions were investigated in section 2.3.10.5. During the empirical work of the current study, conclusions regarding dashboard design were crystallised and are discussed in section 5.2. The design guidelines are adjusted in line with the findings of the research in section 4.5 and the research approach, the triangulation applied and theory building during the process in the study are discussed.

5.2 DASHBOARD DESIGN

During the empirical iterations of the dashboard study, the following dashboard design elements were identified for the tertiary education environment.

5.2.1 <u>Lens</u>

The dashboard design used a lens of module management to organise the information related to the management of modules logically.

The term “lens” is a conceptual term chosen to represent a business area. The business area chosen for the prototype development is that of module management. It is an academic management area identified during the user requirement sessions and the interaction with the academic managers during the study. Dashboard elements related to the business area can be grouped according to the lens, and the users are familiar with the business area.

5.2.2 <u>Currency</u>

The currency of the information in the exemplary dashboards was a module. The term “currency” is also a conceptual term chosen to represent the unit of the business transactions for the selected lens. It is similar to a monetary currency that is the unit of business in sales transactions. The rationale of the design is that the currency can be course enrolments (modules), qualification enrolments, graduates, course success, degree credits, FTE enrolments, non-formal enrolments, non-formal success, staff headcount, staff FTE, research and community participation.

5.2.3 Student walk

The dashboard tabs are logically arranged according to the student walk (student progression). It is called the student walk because it represents the route of students' activities from registration to assessment on module level. The tabs represent the operational processes of registration, assignments, examinations and module administration. The student walk represents the business life cycle of a tertiary education institution. The qualification enrolment process has similar stages from registration to graduation when multiple modules are completed to satisfy the qualification requirements.

Operational support related to the operational processes mentioned above are also provided in the tabs and provide centralised access for the academic managers to monitor the administrative processes performed by administrative departments in the University. The operational support would entail study material information, assignment, discussion class, examination administration information and the contract appointments of tutors and markers. The managers are familiar with and dependent on administrative support in their day-to-day work and need to be informed about the marking progress of assignments, examination papers, etc.

5.2.4 Navigation and aggregation

The navigation route for managers to find their own information is according to the academic organisational structure hierarchy. The navigation is performed by selecting the academic year, college, department or module code according to the academic organisational structure of the University. The levels of academic management correspond with the levels of college, school and department. Depending on the selection, aggregated information for the level of college, department or module code is provided. An example of the academic organisational structure of Unisa is provided in Figure 5.1 below. There are eight colleges: Human

Sciences (CHS), Agriculture and Environmental Sciences (CAES), Economic and Management Sciences (CEMS), Education (CEDU), Law (CLAW), Science and Engineering (CSET), Graduate Studies (CGS) and Accounting Sciences (CAS). The relevant departments are displayed below each college. For the dashboard navigation, a list of modules belong to each department.

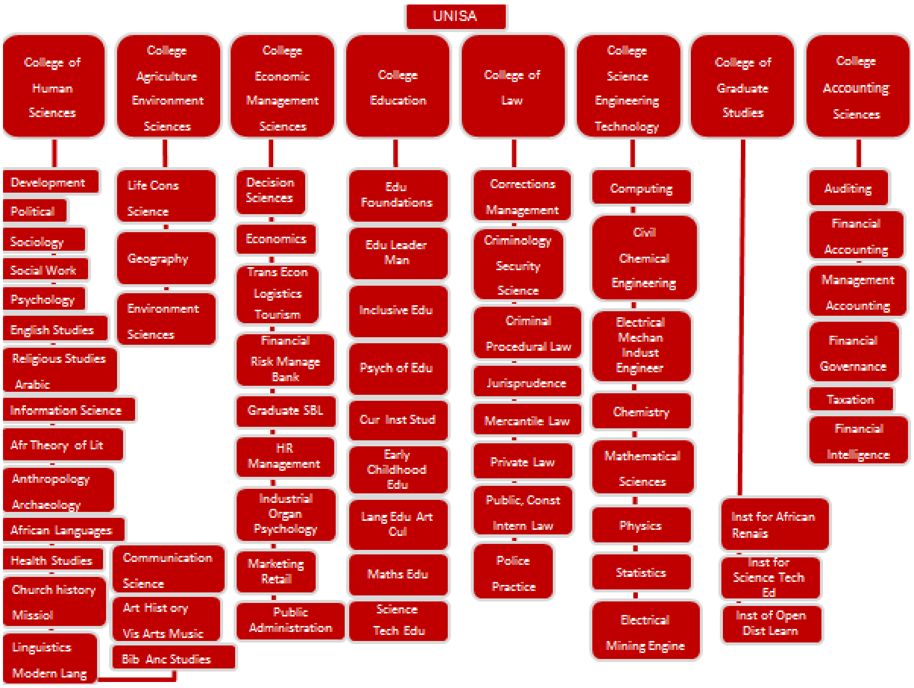


Figure 5.1: Unisa academic organisational structure

5.2.5 Context drilldown

Context drilldown was provided by accordion reports with levels that cascade down and hyperlinks with more detailed information on lower levels of the drilldown. The participants could identify the modules they were managing and, from the responses, the drilldown information helped to diagnose problems visible on aggregated levels.

5.2.6 Analytics

The current year information and four years' history were provided as far as possible. Analytical information was not provided in the dashboards, but the responses of the managers were in favour of more specialised analytical information designed in collaboration with statistical experts who could assist managers to investigate their own areas of responsibility.

5.2.7 Refreshment cycle

The refreshment cycles occurred daily, but information changed as the life cycle of the academic year progressed through the different stages of student progression. Participants were able to relate information to current stages of the life cycle, such as examination pass rates for the modules.

5.2.8 Utility, practicality and suitability

The results confirmed that the information is usable. Participants found it practical and intuitive to access and find their information. It was suitable according to the results of the interviews and intuitive, since they were able to perform hands-on trials.

5.3 ADJUSTMENT OF DESIGN GUIDELINES

After the iterations and evaluations of the dashboard prototypes in the real environment detailed in section 4.4, the design guidelines have to be adjusted according to the findings compiled during the iterations.

5.3.1 Design guidelines

5.3.1.1 Design Guideline 1

Conduct thorough user requirements and liaise with users with regard to the measures.

A user requirements session was conducted and a wide range of metrics was specified and used in the storyboards. As indicated in section 4.3.1, system information exists for 69% of the requirements. The development of the dashboards in the real environment focused on developing a component of the dashboards to a fully functional stage. The full dashboard system could not be developed because of the time involved in system development and thesis writing, but the logic used to develop the functional component can be replicated for the different currencies covered in the storyboards.

The responses in the validations of the dashboards recognised a need for the information required. In general, the information was more than managers had access to at the time. The user requirements session contributed to the suitability of the information.

The guideline is therefore valid for the development of dashboards in tertiary education institutions.

5.3.1.2 Design Guideline 2

Decide on the dashboard design and layout.

The design and layout elements discussed under the findings in section 4.5.1.3 confirm that the design and layout evaluated in the interviews should be consistently applied in the development. The guideline is confirmed. From the results of the interviews, a guideline can be added to develop dashboards that provide accessibility for colour-blind or visually impaired users.

5.3.1.3 Additional Design Guideline 2a

Ensure accessibility for colour-blind or visually impaired users in the design and development.

5.3.1.4 Design Guideline 3

Consult users about the dashboard context drilldown.

As mentioned in section 4.5.1.3, participants responded that indicators with support analytics in the form of drilldown functionality had more value than a static graph and table presentation. It was found that users have information needs according to management decisions, which customised investigative and diagnostic drill-paths can address. Lower level managers wanted to drill into the transactional level of information for diagnostic purposes, which can be considered where applicable. The results of the interviews confirmed that the design guideline is valid.

5.3.1.5 Design Guideline 4

Design intuitive and economic dashboard navigation.

As indicated in section 4.5.1.3, the currency of the dashboard development module was a course (module). A significant factor in the dashboard development is the navigation structure used in the exemplary dashboards. The navigation design according to the organisational structure and student walk played a significant role in dashboards' usefulness and the participants' experience of dashboards. The student walk represents the student progression during their study period. The participants could intuitively use the dashboards and find their own information. They also responded with understanding and insight about the navigation design and it can be concluded that the navigation was intuitive and economic, therefore confirming that the design guideline is valid.

5.3.1.6 Design Guideline 5

Design best-suited metrics.

The reaction of the participants in the interviews demonstrated that they need all the information provided in the dashboards and that it is more than the information to which they currently have access. The additional information suggested in most of the interviews confirms that the users have to be consulted to develop best-suited metrics and exception reporting. The design guideline could be reformulated to state: "Design best-suited metrics in consultation with users."

5.3.1.7 Additional Design Guideline 6

Design and develop scientifically calculated analytical information according to business requirements.

The responses to Question 2.7 in the interview guide confirmed that analytical information does not replace the general decision-making information needs, but is also required. Therefore, an additional design guideline can be added as mentioned above.

5.3.1.8 Additional Design Guideline 7

Design information in formats for on-screen and printing in the dashboards.

The results of the additional question confirmed that on-screen and printable information are necessary to address the needs of the participants. Therefore, an additional design guideline can be added as mentioned above.

5.3.2 "Wicked problems" identified

The interaction with participants and the development of the dashboard system confirmed that a system could not be designed without the involvement of the users to identify diagnostic and investigative line-of-thought patterns to apply as drill-paths. Line-of-thought patterns refer to the specific patterns managers wanted demonstrated to drill down to lower levels of data. Relevant and usable exception reporting also required user input, relying on individuals who are often very busy and have an interest in decision-making information. It became apparent during the development of the exemplary dashboards that designing a dashboard with built-in reasoning, such as diagnostic drill-paths and analytical capability that will dovetail with the academic managers' approach, is time consuming.

5.3.3 Information on different management levels

With regard to section 4.5.1.5, the interviews were conducted on three academic management levels. The responses are given below:

1. Lower and middle management participants were only interested in information about their own management focus.
2. The top management level required strategic and holistic information with all the levels of aggregation. Strategic requirements are wider and more holistic and can be developed generically.
3. The middle and lower management levels require discipline-specific information customisation per department and lower management levels wanted drilldown into operational transaction-level detail.
4. The middle management level felt they did not need higher-level information.

From the responses in points 1 to 4 above, it can be observed that the information needs are different for the various levels of management and the managers responded that they do not have access to information in general. The dashboard aggregation levels provide information on different levels, which the managers can use according to their requirements and the higher or lower levels can be used to interrogate the information for diagnostic or investigative understanding. Lower-level managers required information at a transactional level of detail, which is discussed in section 5.3.1.4 of Design Guideline 3. Another guideline is not necessary to address the information requirements on the different management levels.

Table 5.1 is a summary of the revised design guidelines updated in the second, third and fourth iterations of the design science research process.

Table 5.1: Design guidelines from the V2 to V4 dashboard iterations

Design guidelines		Update
1.	Conduct thorough user requirements and liaise with users with regard to the measures.	User requirements were covered in section 4.3.1.
2.	Decide on dashboard design and layout.	In general, the layout of information and design were secondary to information content.
		In general, the navigation in the top section and tabs were well received.
		New groupings and hierarchies were suggested.
2a.	Ensure accessibility for colour-blind or visually impaired users in the design and development.	The dashboards should be accessible for users with visual impairments.
3.	Consult users about the dashboard context drilldown.	Users find the context drilldown very useful if there is a diagnostic route integral to the drill-path.
4.	Intuitive and economic dashboard navigation.	The users engaged spontaneously. Navigation did not present an obstacle.

	Design guidelines	Update
5.	Design best-suited metrics in consultation with users.	Users expressed a need for more information.
6.	Design and develop scientifically calculated analytical information according to business requirements.	Analytical requirements in specific cases will be useful.
7.	Design information in formats for on-screen and printing in the dashboards.	Different information formats such as printable and on-screen formats are required.
8.	“Wicked problems” identified.	Diagnostic drill-paths could not be defined without user line-of-thought patterns. Intuitive dashboards are time consuming to develop.

5.4 RESEARCH APPROACH FOLLOWED

The research study started with the identification of a problem and the approach to address the problem. A research method was sought, and the data required and data collection methods were identified in order to verify the findings.

The descriptors' framework of research design defined by Cooper & Schindler (2001:135) was used for the research design of the dashboard study as discussed in section 3.6. The following eight research design descriptors were defined:

1. A research question and subquestions were identified in section 1.2 and a specific qualitative methodology of design science research was followed. The validation and evaluation of the design science methodology are discussed at the end of the eight descriptors.
2. Data sources and collection methods have been identified. Literature review and semi-structured interviews were applied as data collection methods. Semi-structured interviews were used with an interview guide and further probing.
3. Three levels of academic managers who have a need for management information or staff members who have experience in the field of providing

management information were interviewed to collect their responses and feedback.

4. The researcher did not have power to manipulate and control the variables in the study and could only report participants' responses. The researcher directed the conversation to ensure that the interview guide elements were addressed, and design guidelines, as well as research subquestion elements, were clarified where necessary. The researcher made notes and recorded the interviews, which limited the possibility of the researcher introducing bias when transcribing of the interview results.
5. The purpose of the study was to design guidelines for the dashboards and processes. To determine why the dashboards had the effect that they had in the theory deductions, the causal nature of the dashboard design constructs was considered.
6. The time dimension of the study was longitudinal because the iterative prototyping was repeated over an extended period. The study was conducted over a period of 28 months from 2010 to 2013.
7. The topical scope of the study is a case study in the Unisa environment. The study relied on qualitative data from more than one source and was verified through an iterative prototyping process.
8. The research was performed in field conditions in the actual environment. The storyboards were a simulation of real data and the dashboards were developed in the actual environment. It was developed in actual field conditions and not in a laboratory or as a counterfeit.
9. The perceptions of the researcher and participants are addressed by the selection criteria used to select the participants. The aim was to select staff members who are responsible for performing academic management functions and would be able to bring insight into the study. They were selected because they were familiar with the kind of information required in the dashboards.

Deriving the dashboards' design guidelines, as well as verifying practicality and utility, is integral in the formal method of design science research. The design science process phases and outputs of Vaishnavi & Kuechler (2004) and Vaishnavi & Kuechler (2012), as set out in Table 5.2, were validated in the following way:

Table 5.2: Summary of the design science research process

Design theory process	Validated by current study
Awareness of the problem	There is a need to understand how to design and implement executive dashboards for Unisa's portfolio managers that will satisfy their decision-making information needs.
Suggestions	Storyboards and prototype dashboards can be designed, developed and refined to develop design guidelines for dashboards for managers.
Development	The development of exemplary dashboard prototypes will involve a series of subsequent design, formative evaluation and revision steps of the prototypes. Starting from original design guidelines and user requirements, the exemplary prototypes were iteratively refined and design guidelines adapted.
Evaluation	The dashboard development is verified to be understandable, easy to use, address information needs and be workable to users.
Conclusion	The prototype in the real environment was refined after an evaluation phase. Reportback will be to managers and the dashboard study to other researchers.

Vaishnavi & Kuechler (2004)

The rigour of the design science process was validated against the anatomical framework for design theory of Gregor & Jones (2007), as summarised in Table 3.6.

Table 5.3: Summary of the dashboard study as per the design theory anatomy

Design theory anatomy	Components of the dashboard study
The purpose and scope	There is a need to understand how to design and implement executive dashboards for Unisa's portfolio managers that will satisfy their decision-making information needs.
Constructs	The specifications are presented by storyboard examples and by physical dashboard system development.

Design theory anatomy	Components of the dashboard study
Form and function guidelines	The storyboard prototypes explain the original design and serve as design guidelines for the components and their functionality. The dashboards in the real environment are documented to explain how they are organised and components relate to each other.
Artefact mutability	During the refinement of the dashboard prototypes, the dashboards were adjusted according to changing requirements and environments. The dynamic nature was evaluated and explained.
Testable propositions	The interview questions included testable propositions for the usability, utility and practicality of the dahboards in the real environment.
Justificatory knowledge	The justificatory requirements were gathered during the iterative cycles of the design process to explain how the dashboards function and why they are developed the way they are. In section 5.6, the jusitification for why the constructs have the effects they have is done.
Implementation guidelines	Guidelines are compiled and refined for the implementation of models and system components in the real environment.
Example of instantiation	The dashboard development provides a practical demonstration of the design in the real environment. Problems encountered during the iterative process were identified by the evaluation of the instantiations.

Gregor & Jones (2007:323)

A summary of the design evaluation methods applied in the dashboard study is provided in Table 5.4.

Table 5.4: Summary of the design evaluation methods in the dashboard study

Design evaluation methods	
1. Observational	Case study performed in the Unisa environment
2. Analytical	Static analysis by examining the structure of the artefact for logical design
	Dynamic analysis by examining the changing nature of the artefact

Design evaluation methods	
3. Experimental	Experimental evaluation by investigating whether dashboards are intuitive and usable
4. Testing	Functional evaluation by trial to test if the dashboards work
5. Descriptive	Informed argument about the value of the utility of the dashboard prototypes

From the above, it was demonstrated that justificatory requirements were gathered during the iterative cycles of the design process to explain how the dashboards function and why they were developed the way they were. The dashboards were empirically tested and the implementation in the real environment confirmed the theory. The initial design guidelines for the dashboard development were compiled from general literature and refined during the empirical testing in the tertiary education environment. The logical and contextual constructs proposed are generic to tertiary education institutions, as well as to other educational institutions, such as teacher colleges and private colleges. Therefore, the refined guidelines can be generalised for tertiary education institutions in general and could be applied to other educational institutions, as mentioned earlier. In section 5.6, the causality of the constructs and concepts are translated to explain why they behave as they do.

5.5 TRIANGULATION APPLIED IN THE DASHBOARD STUDY

1. From the above approach, triangulation criteria are satisfied in the dashboard study through the use of different data collection methods, measuring at different times or over a period, the use of different theoretical viewpoints and the combined levels of participants as individual or groups. In 1959, Campbell & Fiske, in Cohen et al. (2007:141), defined triangulation as “a powerful way of demonstrating concurrent validity, particularly in qualitative research”. The technique of applying two or more data collection methods in the research of human behavioural sciences is defined as triangulation. According to Herrington et al. (2007:7), the methods are determined by the necessity of meeting triangulation criteria, such as various data collection sources, times, places and participants, research methods, and researchers and helpers. Participants in design science research are clients, end users and researchers

who partner as co-researchers or teachers, lecturers or other educational staff who perform research of their own work (De Villiers, 2005:11). Carlsson et al. (2011:11) postulate that the effects of heuristic design propositions can be tested in context and lead to sufficient evidence. They recommend alpha, beta and gamma testing. In the current study, alpha testing was applied by the further development of the original design development. It also involved gamma testing to test whether practitioners can use the design theory in practice and produce the desired outcomes.

Table 5.5 is adjusted from (Cohen et al., 2007:142) to indicate which methods were applied in the dashboard study.

Table 5.5: Triangulation methods applied in the dashboard study

Type	Explanation	Applied in dashboard study
Time	Testing validity over time and when data is similar when gathered at the same time	The development of the exemplary prototypes of the dashboards was conducted over a period of 28 months.
Space	Applying cross-cultural techniques	Not applicable to the dashboard study.
Combined levels.	Testing on more than one level, of individual, interactive group or collectives, such as the organisation, culture or society	Evaluation by individuals and groups was applied in the current study.
Theoretical	Using more than one theoretical viewpoint	The theoretical viewpoint of more than one author was considered throughout the study.
Investigator	Using the observations of more than one investigator	The researcher conducted the study, but consulted with experts and colleagues for insight.

Type	Explanation	Applied in dashboard study
Methodological	Using the same method on different occasions, applying different methods to the same object of research	Different methods were applied: - The research design descriptors defined by Cooper & Schindler (2001:135). - Triangulation (Cohen et al., 2007:142); Krathwohl (in Herrington et al., 2007:7). - Design science research (Vaishnavi & Kuechler, 2004; Gregor & Jones, 2007).

(Cohen et al., 2007:142)

Plomp (2009:30) advised to take several measures to address conflict of interest of the researcher as designer, implementer and evaluator.

1. Each part of the research design is considered to be equally important: The user requirements, storyboards and dashboard prototypes constituted different parts of the research design. Different practitioners were involved in the design of the user requirements, storyboards and dashboards. The different parts were separately evaluated by different evaluators.
2. The different data sources, data collection, empirical testing of the usability and effectiveness of the artefact are triangulated: Different evaluation sessions with different evaluators were applied; users performed hands-on testing, and semi-structured interviews were performed with predetermined interview guides.
3. Systematic documentation, analysis and reflection of design and development was applied: During the design science cycles, the design guidelines were updated after each evaluation session.

5.6 THEORY BUILDING DURING DESIGN SCIENCE RESEARCH PROCESS

The design science process was performed according to the steps discussed in Table 5.2 and illustrated by Figure 3.1, as well as by the updated version in Figure 3.2. In the dashboard design in section 5.2, design elements of the lens, currency, student walk, navigation and summary levels drilldown were applied. The elements were used for the dashboard development and are constructs contributing to the ISDT (Vaishnavi & Kuechler, 2012:398). The constructs contribute to making the dashboards intuitive and practical. The utility theory of Venable (2006:14) proposes that a particular type or class of technology (meta design), including software and system development, is useful in solving or improving a problematic situation. The author is of the view that the theory is relevant for the class of artefacts to which the dashboards belong. The utility theory is concerned with a technological solution that addresses undesirable implications and causes of a problem. The ISDT specifies meta requirements that describe how the class of artefacts should behave (Vaishnavi & Kuechler, 2012:396). In this case, it is applicable to the class of artefacts of which dashboards in tertiary education institutions are an instantiation belonging to the discipline of business process monitoring (Wise, 2006) or business intelligence (Eckerson, 2006), as discussed in sections 2.2.1 and 2.2.2 above. For the study, it was assumed that the problem for which the artefact was designed is not unique and that technical rationality can produce relevant solutions in a rigorous way for practical business problems (Wieringa & Morali, 2012:234).

Theory proposition for design output products from empirical observations during artefact construction is as follows.

- From a social, design science and organisational perspective, some participants intuitively engaged with the system and experienced the student walk and module management lens as intuitive in the hands-on evaluation. In doing so, the participants demonstrated familiarity with the content of the dashboards. The interaction and intuitive engagement with the dashboards can be interpreted as one of the confidence biases identified by Arnott (2006:9). The reaction of the participants to the components can be interpreted as the explanation and causality of Gregor (2006: 634). The current author interprets the correspondence of the design with tertiary educational elements to justification of the design as generalisable to other tertiary educational institutions.

  The utility theory of Venable (2006:14) of the system design discussed above is considered to be a mid-range theory, compared with the five theories defined by Gregor (2006: 628). The translation of relevant information that is familiar to the user into a technological perspective improves the utility, addressing the problem of unavailable data.

- The drilldown functionality in the dashboards received specific recognition from participants when they could drill into and "diagnose" the cause of specific performance in their own information. The view of the author is that the complexity bias of Arnott (2006:10) can be applied, and the requirements translate into meta-requirements, applying the mid-range utility theory of Venable (2006:14) to the class of artefacts.

The theory propositions above can be related to Theory Type V (design and action) of Gregor (2006: 628), which is about principles of form and function, methods and justificatory knowledge used in the development of artefacts. The propositions satisfy the requirements of the DREPT and an optional output of design science research (Vaishnavi & Kuechler, 2012:396). It is concerned with the justificatory knowledge of the artefact, and explains why the artefact has the effect that it does. It also satisfies the grounding of the design theory in "extant" theories (Carlsson et al. 2011:8). Carlsson et al. (2011) view extant theories as those theories that interact with the current design knowledge and research, and that are useful in the context.

- The DREPT theory proposition for the design research process can be made to reframing, based on Tversky & Kahneman (1986:S257). The design science process iterations can be linked to the reframing of user perspective by interaction with the system artefact. The artefact is shaped by the interaction and feedback of the users. The justificatory explanation can be related to Theory Type V (design and action) of Gregor (2006: 629), which satisfies the criteria by claims of effectiveness, ease of use and utility to a community of users.

5.7 SUMMARY

In Chapter 5, the inference drawn from the design science process for dashboard design in tertiary education institutions was documented. The design guidelines were adjusted according to the refinements of dashboards V2, V3 and V4 during the design science process. Three additional design guidelines were added and the other guidelines were confirmed by the empirical work. The interpretation was made that dashboard information will be addressed on different academic management levels through aggregation per organisational structure level. Additional guidelines were not required to address the alignment of information according to the different management levels.

Sections 5.4, 5.5 and 5.6 showed how the research conditions specified in section 03.6 were satisfied, and how triangulation and design science theory interpretation related to the research.

The recommendations from the study for tertiary education institutions are documented and the framework for dashboard design and development is presented in Chapter 6. It is demonstrated how the research questions are addressed by the research, and further research areas that are unveiled during the study are discussed. The thesis is concluded in Chapter 6.

6. CHAPTER 6: FRAMEWORK DEVELOPMENT AND CONCLUSION

6.1 INTRODUCTION

The study commenced because a general lack of timely and suitable decision-making information at the University has been apparent for a long time. This problem had prevailed for more than 10 years. The background of the problem was investigated through a literature study. The study proposed a dashboard system to alleviate the shortage of decision-making information and adopted a qualitative approach using design science research to investigate the viability and suitability of such a system. According to the design science guidelines, an instantiation of the dashboards was designed and developed from draft design guidelines that were drawn from the literature. User requirements were elicited from academic managers who are the potential users of a dashboard system. The utility, practicality and effectiveness of the dashboard prototypes compiled from the user requirements were verified and semi-structured interviews were conducted on three management levels. The interview results were used to refine the prototypes and design guidelines during an iterative design science process.

Dashboards are widely used in different industries, and the demonstrations and examples provided by BI vendors are often focused on sales or profit-driven environments. In order to develop dashboards for tertiary education, and even educational institutions in general, a mindset change is required to apply the software for the different business environments.

A theoretical or conceptual research framework can be seen as the derived theoretical knowledge consisting of constructs, variations and combinations of constructs, properties, relationships and the application in practice with the effects it produces (Sinclair, 2007:39).

Classification theories are frequently referred to as typologies, taxonomies or frameworks (Gregor, 2002).

For the framework proposition that follows, a conceptual framework is considered to be a diagram or written explanation of the main elements, logical conceptual constructs of the phenomena and the presumed relationships among them (Miles & Huberman, 1994:18). It captures the ideas and understanding about the phenomena of the study, whether these are written or not.

A framework is developed in the next sections. The framework proposition is a "how-to" approach that is simple to follow and easily understood by any staff member involved in tertiary education activities. The framework development will cover the general purpose and process followed to develop the framework. Next, the dashboard design and development framework is explained on the basis of its position in the technological architecture. The findings of the research are applied to propose and discuss the components of the framework. The framework is completed by using the foregoing to infer the final framework in diagrammatical format. Further research opportunities are highlighted and conclusions are made.

6.2 LOCATION IN SYSTEM ARCHITECTURE

An overview of the dashboard system architecture is presented in Figure 6.1. The diagram serves to demarcate where the dashboard design and development framework fits into the bigger system architecture. The data flow is illustrated from the source databases of the operational systems on the left-hand side of the diagram to the final outputs of dashboards and reports on the right-hand side.

The raw data is extracted from the operational databases indicated by the block labelled "computer centre" with databases for HR, students, finances, research and building information (estates). ETL processes extract and translate the data from the source databases and load it into the data warehouse and data marts. The data warehouse and marts are hosted in the BI environment identified by the Business Intelligence Competency Centre (BICC) in the diagram. The dashboards and reporting source aggregated data are prepared for reporting from the data warehouse and data marts. The dashboards and reporting consist of dashboards, analyses, research, briefing and statutory reports. Ad hoc queries are used to extract custom information according to user specifications on an ad hoc basis.

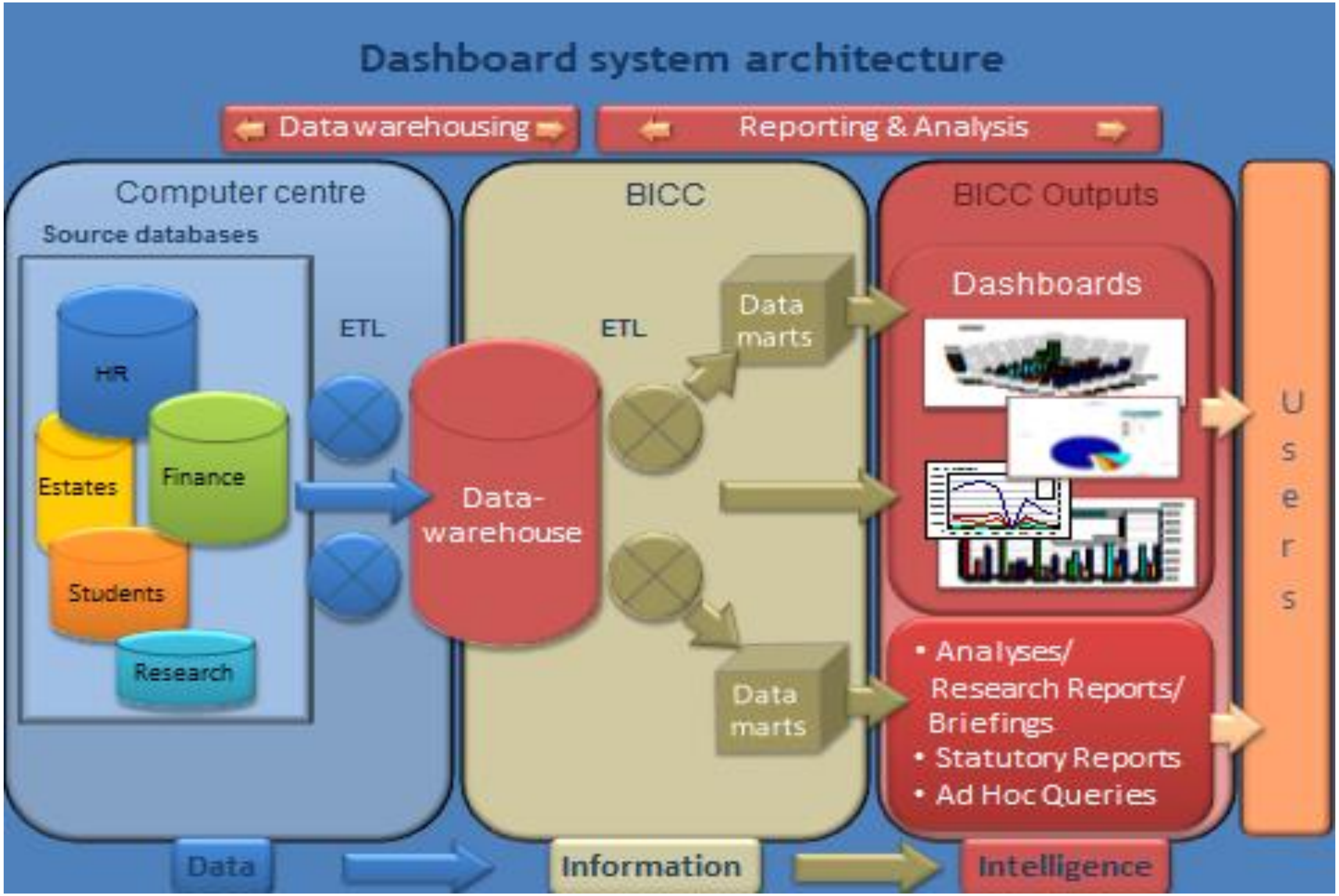


Figure 6.1: Dashboard system architecture

Based on Figure 6.1, the focus of the current study is on the design and development of the dashboards as illustrated in Figure 6.2.

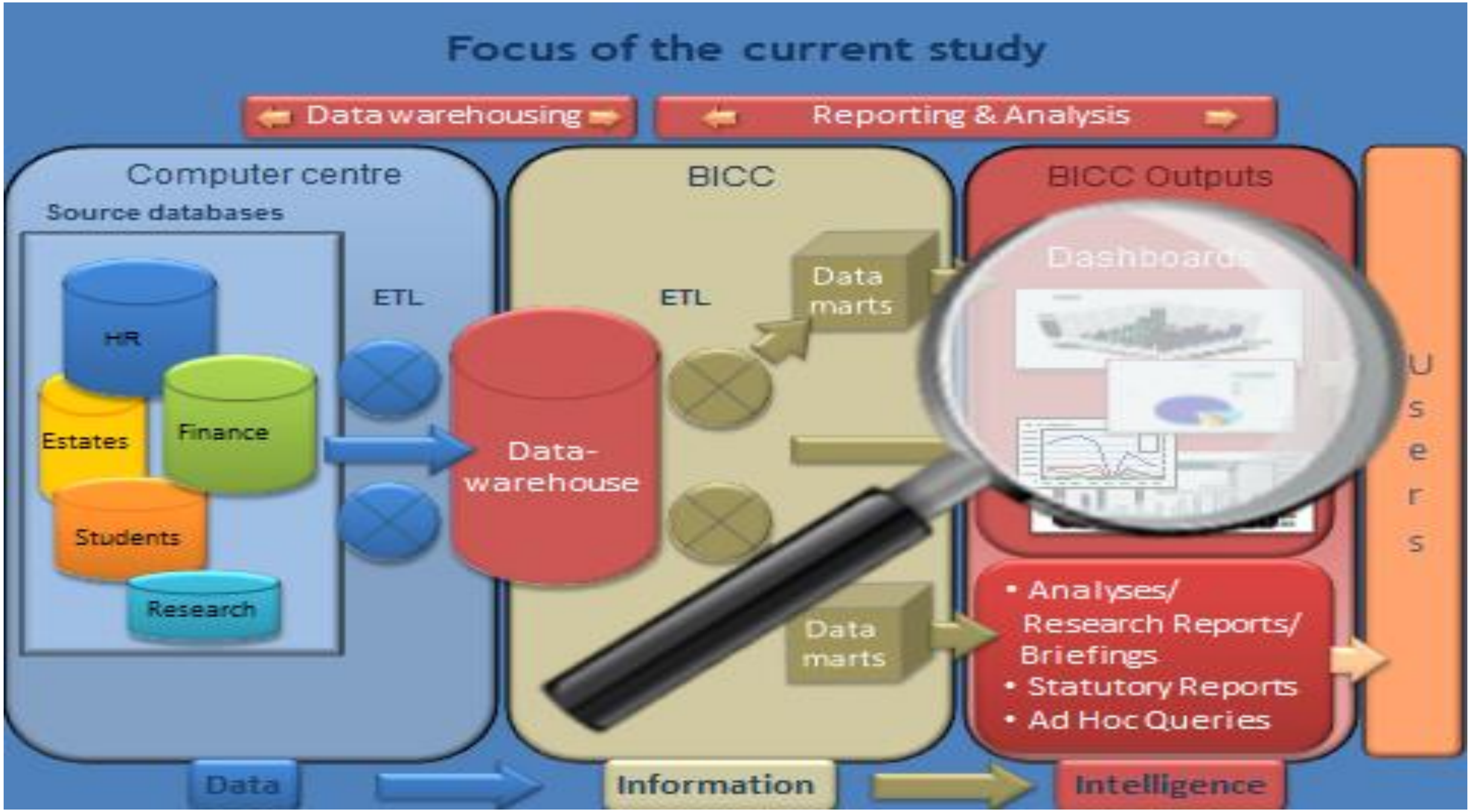


Figure 6.2: Focus of the current study

6.3 DESIGN AND DEVELOPMENT FRAMEWORK

The aim of the proposed framework is to offer one way to conceptualise the development of operational dashboards in the academic management environment. The proposed framework has the following characteristics:

- Intuitive and user-friendly access to their own information for academic managers on all levels
- Up-to-date information in an automated solution
- Investigative and diagnostic capabilities to drill down into more detail
- Exception reporting
- Information in different formats
- Analytical information that can assist academic managers to understand their area of responsibility

The dashboard design and development framework consists of the following components:

1. Design and development cycle
2. Functionality
3. Technology specifications
4. Design and conceptual elements/constructs
5. Design guidelines
6. Design and development process

Following the dashboard design and development, a framework proposition is made and presented in Figure 6.3 below.

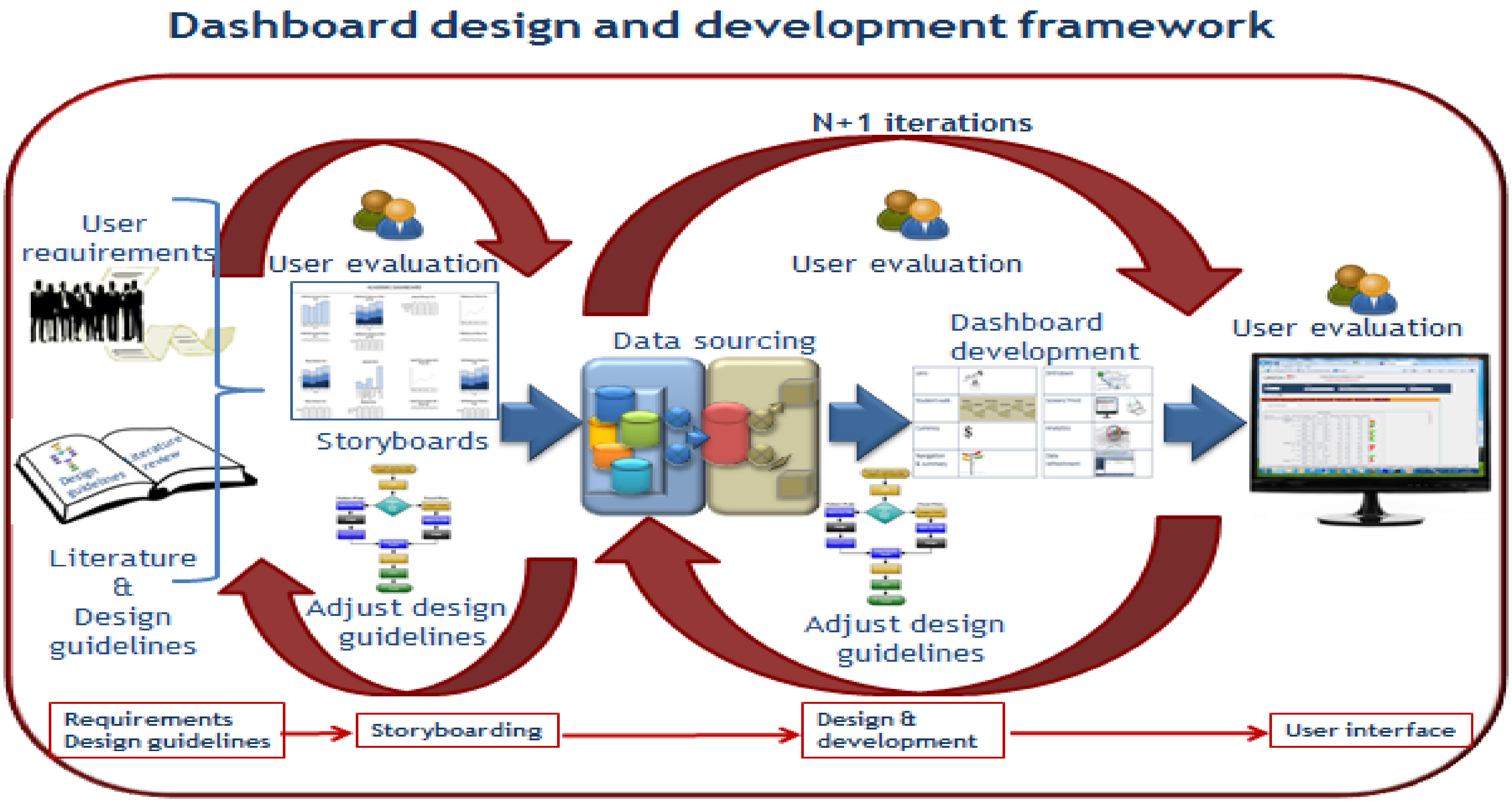


Figure 6.3: Dashboard design and development framework

6.3.1 Functionality

In order to include comprehensive functionality the following are required: a raw data warehouse; ad hoc query and transactional reporting; analytical multidimensional; data mining; predictive modelling reporting; monitoring layer with personalised dashboards; institutional performance scorecards with performance indicators; university level web portal and overview areas; diagnostic drilldown; complete data warehousing functionality with automated sourcing and ETL processes; multidimensional OLAP and historical trend analysis. Although the features are mentioned in the frameworks for tertiary education institutions the list is not comprehensive. Technology changes almost continuously and the features will change accordingly.

6.3.2 Technology specifications

Level 3 in the Goldstein (2005:4) study of institutions' use of technology in management information systems, represents an enterprise-wide data warehouse or multiple data marts used in conjunction with ETL reporting tools and triggers and alerts to support an automated system for workflow and business process management.

6.3.3 Design and conceptual constructs

An iterative approach is followed in the design and development of the dashboards. When the refreshment cycles of the data have been automated, the reporting components, consisting of dashboards and reports, can be developed. The dashboard design consists of the elements distilled during the design science process and discussed in section 5.2. The elements are the lens, currency, student walk, navigation and summary levels, context drilldown, analytics, different information formats and refreshment cycles.

The dashboard elements determined during the study are discussed in more detail in the following sections, and Figure 6.4 provides the proposed elements.

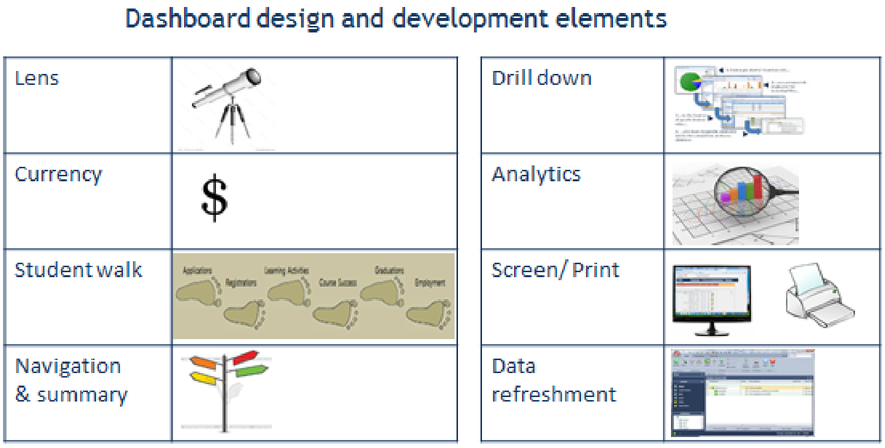


Figure 6.4: Dashboard design and development elements

6.3.3.1 Lens

As indicated in section 5.2.1, module management has been chosen as the "lens" of the development. It provides a feeling that the information is logically grouped, as the responses from the interviews showed. The academic managers are familiar with the concept of module management, and therefore it contributed to an intuitive understanding for the managers.

6.3.3.2 Currency

The currency in the module management lens is a module. As discussed earlier in section 5.2.2, the currency for the framework can be course enrolments (modules), qualification enrolments, graduates, course success, degree credits, FTE enrolments, non-formal enrolments, non-formal success, staff headcount, staff FTE, research and community participation. The currency elements correspond with the metrics identified during the storyboards sessions in section 4.3.3.2.

6.3.3.3 Student walk

The lens of module management is concerned with the business process of a tertiary education institution. Figure 6.5 provides a graphic representation of the student walk and the related supporting information, and Figure 6.6 demonstrates the application in the dashboards. The supporting information is also necessary to provide decision-making information in a module management context, because there are administrative processes related to the registration, assignment-marking and examination-marking processes. Similar support functions exist for the other stages in the business processes for other currencies.

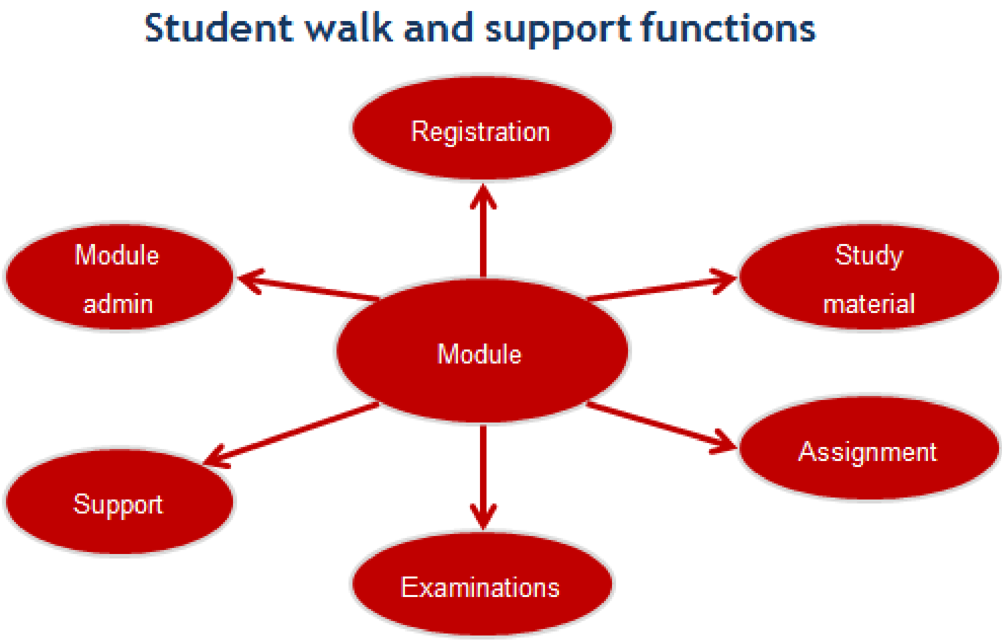


Figure 6.5: Student walk and support functions

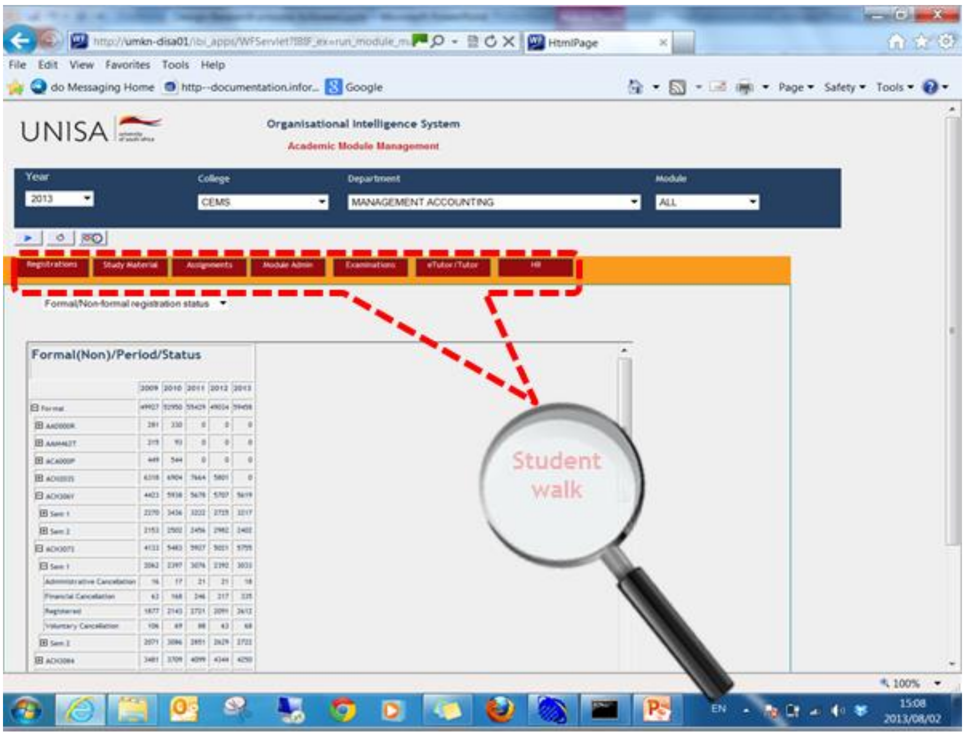


Figure 6.6: Example of student walk

6.3.3.4 Navigation and summary levels

The student walk, navigation and summary levels were applied to address Design Guideline 4 (designing intuitive and economic dashboard navigation) of section 5.3.1.5.

Drawing from the graphic representations of Framework 2 discussed in section 2.3.10.5.1, the navigation and summary levels of the dashboard development are illustrated in Figure 6.7.

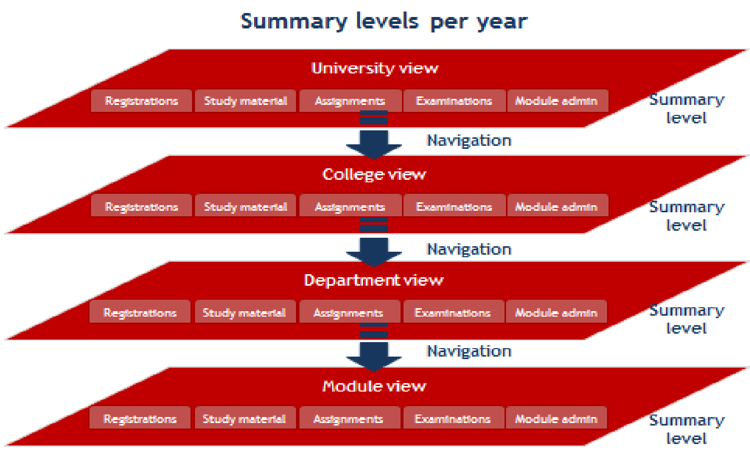


Figure 6.7: Navigation and summary levels

The levels correspond with the navigation area in the dashboard as indicated in Figure 6.8.

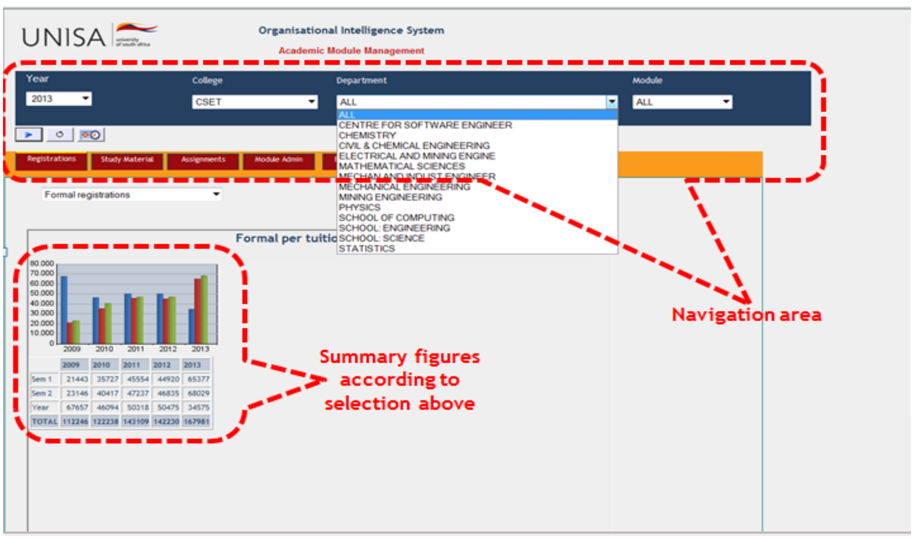


Figure 6.8: Dashboard navigation and summary

To find their own areas of responsibility academic managers selected the relevant academic year, the college they belong to, the department in the relevant college and then the modules related to their departments as illustrated by Figure 6.7. The navigation design displays only the relevant options available to choose from once a previous selection is made. When the academic year and college is chosen only the relevant departments and modules for the department are available in the drop down list boxes to choose from.

The organisational structure is defined as a dimensional hierarchy in the data warehouse and it facilitates the selection functionality and summary of the data per level as mentioned above as indicated in Figure 6.7.

6.3.3.5 Context drilldown

The drilldown was provided by accordion reports with levels that cascade down and hyperlinks that link to more detail on lower levels of drilldown. Figure 6.9 shows an example of the drilldown functionality from the dashboards. The example illustrates the summary of the enrolments for all the modules of the Management Accounting department over five academic years. The number of enrolments per module with drilldown into the registration statuses of registered, academic cancellation, financial cancellation and voluntary cancellation is provided.

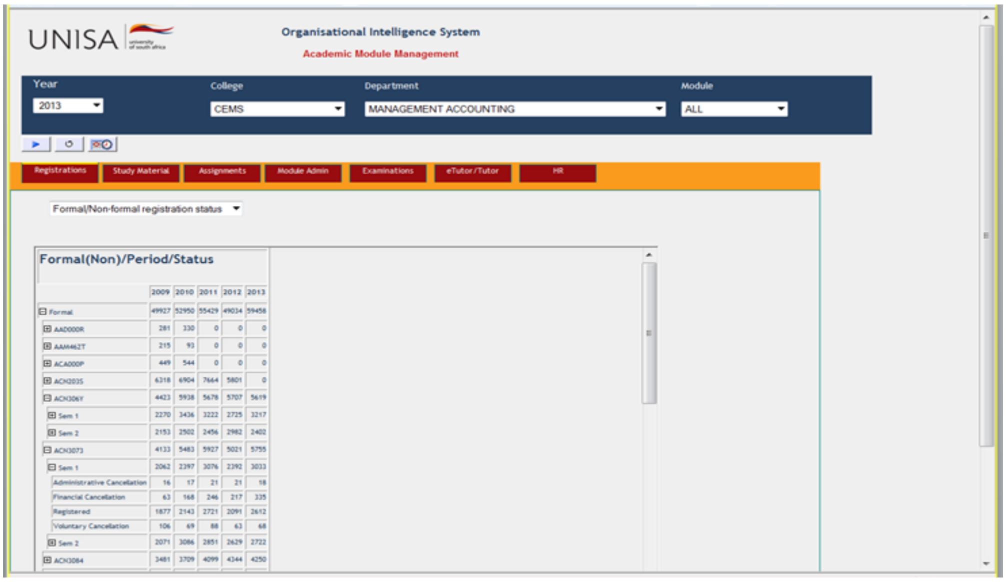


Figure 6.9: Example of drilldown functionality

The interest of academic managers in modules mainly revolves around the students who enrol for the modules.

Figure 6.10 provides dimensions that describe the module context. Several of the dimensions are related to the subset of students enrolled for the specific module, and the dimensions represent potential drilldown routes.

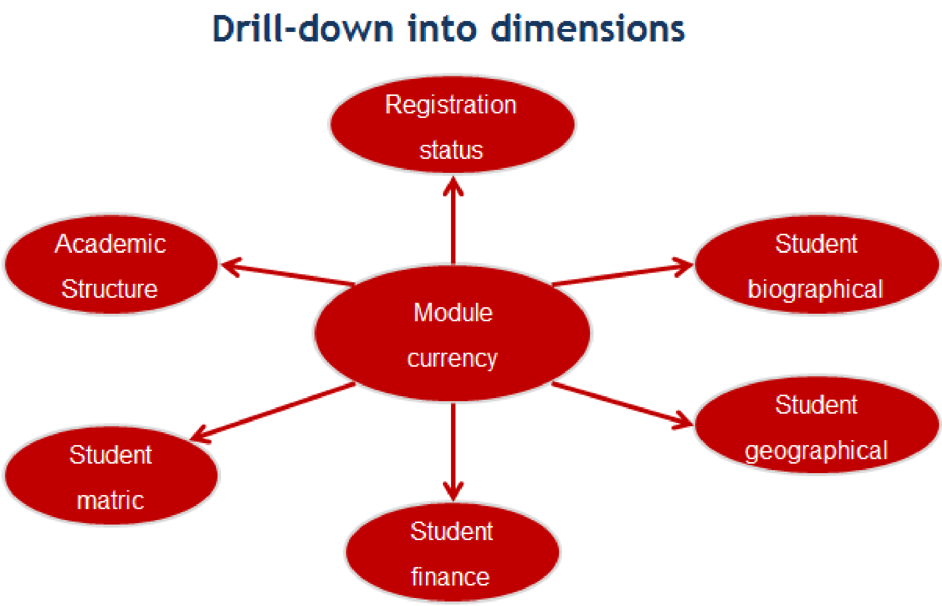


Figure 6.10: Drilldown dimensions

6.3.3.6 Analytics and different information formats

The prototypes of the dashboard study did not include scientific analytics in the form of segmentation or forecasting, but the empirical evaluation showed that it is required and academic managers envisage that it could enhance insight into their domains. The participants were wary of "death by statistics". It is proposed to investigate how to make analytical information available that is statistically valid, but can be interpreted by non-statisticians. The analytics have to be designed in collaboration with statistical experts to provide scientifically designed, but easy to use analytics for academic managers. Possible types are trend forecasting, clustering and data mining to make the information more meaningful for the managers. In the current form, the historical information helps with looking backwards in performing root cause investigations. Forecasting will help with looking forward at future outcomes.

The empirical evaluation also showed that on-screen and printable information is required. Developers should ensure that versatile formats of information are developed since the on-screen information is not formatted to fit onto pages. One of the minimum requirements is that information should be developed in printable format, as well as being available on-screen.

6.3.3.7 Refreshment cycles

The dashboard functionality proposed above requires automated ETL data management processes to support the refreshment cycles of the information. The raw data is housed by the University's central computer centre. It is extracted into the data warehouse, which is under the control of the institution's BICC.

The extraction process is automated to update at regular cycles according to the relevant business processes. In many cases, it is done on a daily basis. In the data warehouse, the data is prepared for multidimensional data warehouse database design, and data marts are developed. It is grouped and aggregated according to the lowest levels of data, such as the module or qualification levels. The information is prepared into a web-based interface by the dashboard development software. The architecture of the system is illustrated in Figure 6.1, where the sourcing of data is graphically presented.

6.3.4 Design guidelines

Draft design guidelines were compiled from literature sources and refined during the design science process.

6.3.4.1 Design Guideline 1

Conduct thorough user requirements and liaise with users with regard to the measures.

This is a well-known guideline, but cannot be excluded for the sake of completeness. In the empirical work, the user requirements assisted in designing suitable information.

6.3.4.2 Design Guideline 2

Decide on the dashboard design and layout.

- Simpler design and layout were preferred, such as fewer frames, graphs and tables per view. When fewer items are displayed per view, the symmetry and proportions are simpler.
- It is important to ensure that information is suitable for colour-blind and visually impaired people.
- Drilldown functionality received more interest than just a table or a graph.
- Ensure that groupings and hierarchies are relevant in the context through user involvement and requirements.
- Support analytics, such as drilldown to investigate patterns in the performance, can be included.
- In general, information was considered non-confidential and could assist with collaboration towards improvement at the University.
- In order to address a variety of information formats, it would be useful to make on-screen and printable information available as a minimum.

6.3.4.3 Design Guideline 3

Ensure accessibility for colour-blind or visually impaired users in the design and development.

Develop dashboards that provide accessibility for colour-blind or visually impaired users.

6.3.4.4 Design Guideline 4

Consult users about the dashboard context drilldown.

It was found that users have information needs according to management decisions, which can be addressed by customised investigative and diagnostic drill-paths. User involvement is important to develop customised drill-paths. Lower-level managers required drilldown into the transactional level of information for diagnostic purposes.

6.3.4.5 Design Guideline 5

Design intuitive and economic dashboard navigation.

Navigation design according to the organisational structure and student walk (student progression) provides a logical route to make information easy to understand and easy to find managers' own information.

6.3.4.6 Design Guideline 6

Design best-suited metrics in consultation with users.

Users have to be consulted to develop best-suited metrics. The way users work with information is imperative in designing exception reporting.

6.3.4.7 Design Guideline 7

Design and develop scientifically calculated analytical information according to business requirements.

Level 4, with predictive modelling, and simulation with logistic regression, neural networks, decision trees and survival analysis (Goldstein, 2005:5), as well as Level 5, with automatic triggers of business processes (such as alerts) in an automated system to manage workflow, and business processes and data management will automate the dashboards and make them applicable.

6.3.4.8 Design Guideline 8

Design information in formats for on-screen and printing in the dashboards.

Information in different formats is required and at least on-screen and printable information is necessary to address information needs.

6.3.5 Design and development process

The following design and development process consists of the preparation and paper prototyping, data sourcing and iterative design-evaluate-refinement processes.

The dashboards are developed in the real environment by applying the components until a fully functional stage is reached where users can evaluate them. In order to evaluate the practicality and workable condition of the dashboards, a hands-on trial of the dashboards' functionality, practicality and suitability is facilitated. Changes are made to the dashboards and the design guidelines are adjusted. N + 1 iterations can be repeated for the evaluation and refinement cycles to fine-tune the development according to user feedback.

6.3.5.1 Preparation and paper prototyping

In the design and development of the dashboards, an iterative process of refinement and assessment was followed. The process commenced by collecting user requirements, and initial design guidelines were compiled from the literature. The documented requirements and design guidelines were applied in a storyboard session to brainstorm the first prototype of storyboards on paper. An exemplary version of the dashboards in the real environment were developed from the storyboard specifications and refined in an iterative process according to user feedback. The user requirements, design guidelines and storyboarding processes are diagrammatically presented in Figure 6.11:

Figure 6.11: User requirements, design guidelines and storyboarding

The process illustrated in Figure 6.11 can be considered as the preparation phase for the development phase. The user requirements were elicited from potential users of an academic dashboard system. The requirements were analysed for suitability and feasibility in dashboards. In order to develop a dashboard system that is automatically updated, the data to satisfy the user requirements in the dashboards had to be electronically available in an operational system and automatically updated on a regular basis. The study focused on data that are electronically available, and these requirements were brainstormed and incorporated in storyboards. User requirements and validation are discussed in sections 4.3.1 and 4.3.2. Initial design guidelines were compiled from literature and discussed in section 2.3.9. Design guidelines were updated according to the refinements in all the stages during the process.

The dashboard design was brainstormed through a storyboarding process, where the user requirements and initial design guidelines were applied in creating paper-based storyboards as the first prototypes. The results of the brainstorming, organisation and arrangement of the requirements and measures were captured in sketches and models. The storyboarding is discussed in section 4.3.3. The storyboards were evaluated for context and the content validity of the information. Relevant changes were affected to the storyboards and design guidelines. The storyboards and design guidelines served as specifications to develop the dashboards in the real environment. The dashboard development and evaluation in the real environment are discussed in section 4.4.

6.3.5.2 Data sourcing

To move from the storyboards to dashboards in the real environment and develop the identified measures on the dashboards, the data for the measures have to be identified and sourced. The data is sourced and prepared in the data warehouse and data marts for reporting purposes. The data sourcing process for the dashboard development is explained below and presented diagrammatically in Figure 6.12:

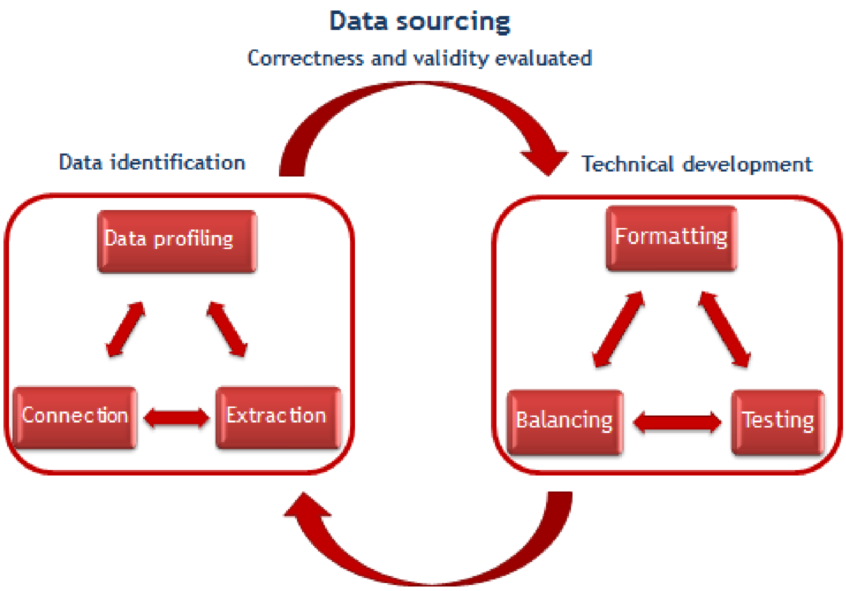


Figure 6.12: Data sourcing

The data sourcing consists of the identification of suitable data in source databases for the measures in the storyboards. The data is profiled to determine where data exists for categories and where data is missing.

Connection to the relevant data sources is established. ETL processes have to be developed where data is extracted and prepared for the data warehouse and data marts. The extraction process also involves the scheduling of data updates on a regular basis. The data is formatted, balanced and tested for accuracy. The data sourcing forms part of the system architecture discussed and presented in section 6.2.

Cognisance should be taken of data available in electronic format. Unavailable electronic data can pose a major obstacle if data has to be captured manually or if business processes have to be put in place to support the data capturing. Where data does not exist in transactional system databases, it creates a diversion in the dashboard development process. It requires the dashboard developers to capture data manually or put a process in place to capture the data electronically. This might be out of the developer's jurisdiction and may not be possible within the required time frames.

6.3.5.3 Iterative design-evaluate-refine process

When the data has been identified, the dashboard prototypes are designed by conceptualising metrics, layout and navigation with drawings and presentations. After the elements on the dashboards have been conceptualised, the prototypes are developed in the real environment using relevant dashboard software linked to the real data in the data warehouse. The prototype development consists of the development of dashboard reports and visual components. The components are logically organised for ease of use, practical in their design and address information needs. The detail of the prototype design is discussed in section 5.2.

Although the data sourcing, and dashboard design and development are explained by two separate diagrams, the process can move back and forth through all the actions in the two processes. The design and development processes are represented in Figure 6.13. The process flow is not in one direction as the arrows indicate. When a new metric is added to a dashboard, the setup processes have to be performed to source data for the metric or, if sourced data needs to be corrected, several steps have to be corrected to address the issues.

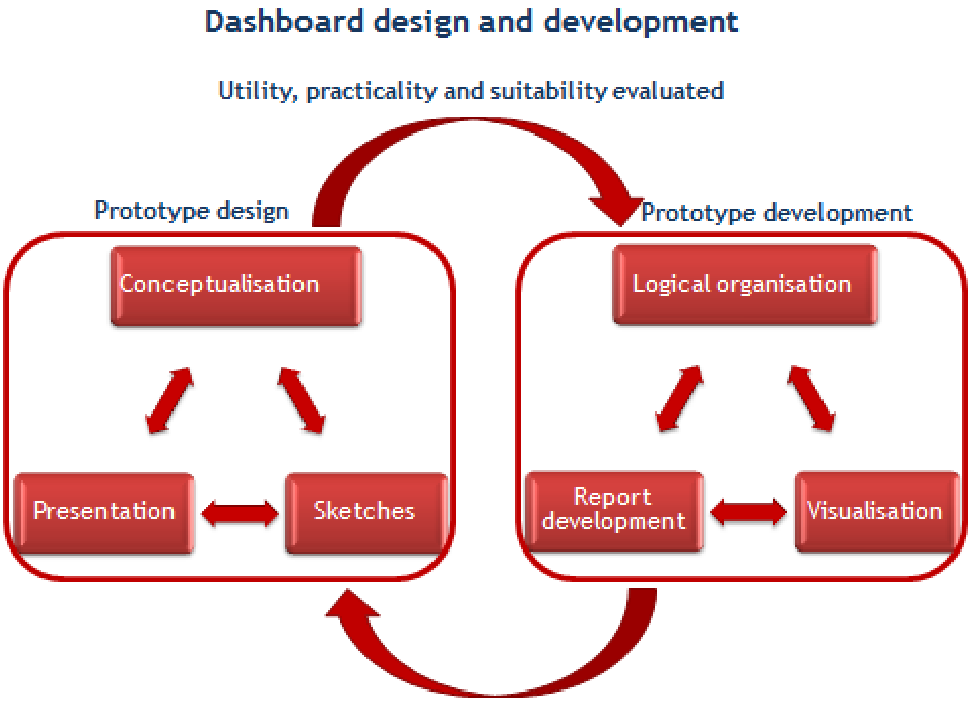


Figure 6.13: Dashboard design and development

Figure 6.13 provides a high-level overview of the prototype design and development refinement iterations. Prototype design is performed by conceptualisation of the prototype, and the presentation of the design in the form of sketches. The prototype development consisted of report or visualisation development and the logical organisation of the components.

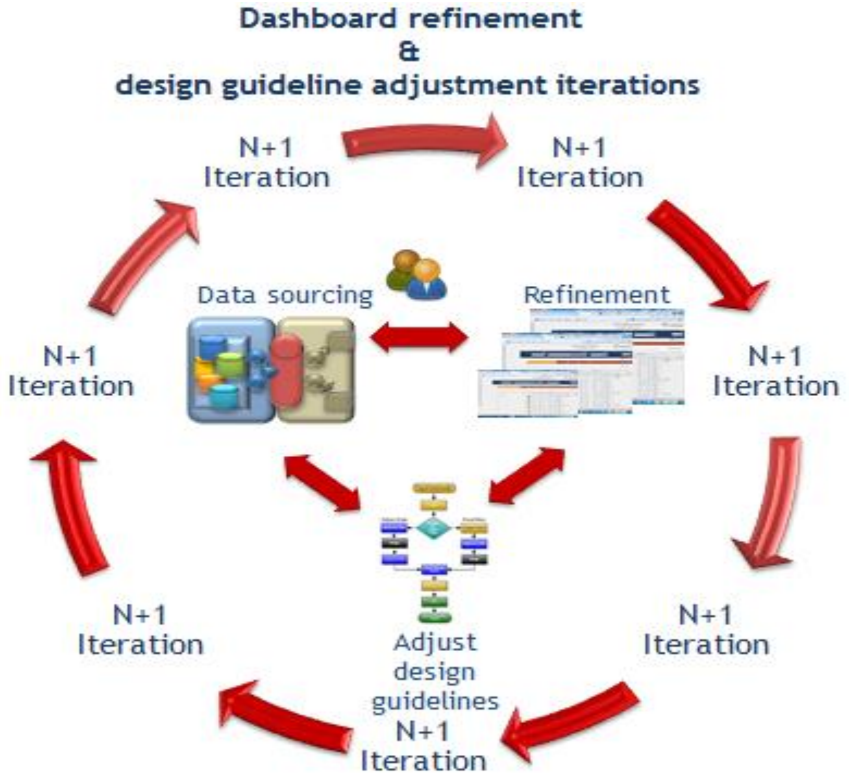


Figure 6.14: Dashboard refinement and design guideline adjustment

The refinement iterations involved the end users to evaluate the dashboard prototypes. The dashboards were evaluated by the users and the changes were made to the dashboard development. If necessary, data sourcing and design guidelines were adjusted according to the changes. The process was repeated, as illustrated diagrammatically in Figure 6.14. The prototype development can be iteratively refined by changing data sourcing, refining the prototype and changing the documented design guidelines.

When combining the components discussed above, the design and development process can broadly be presented as a preparation phase and a development phase as demonstrated in Figure 6.15.

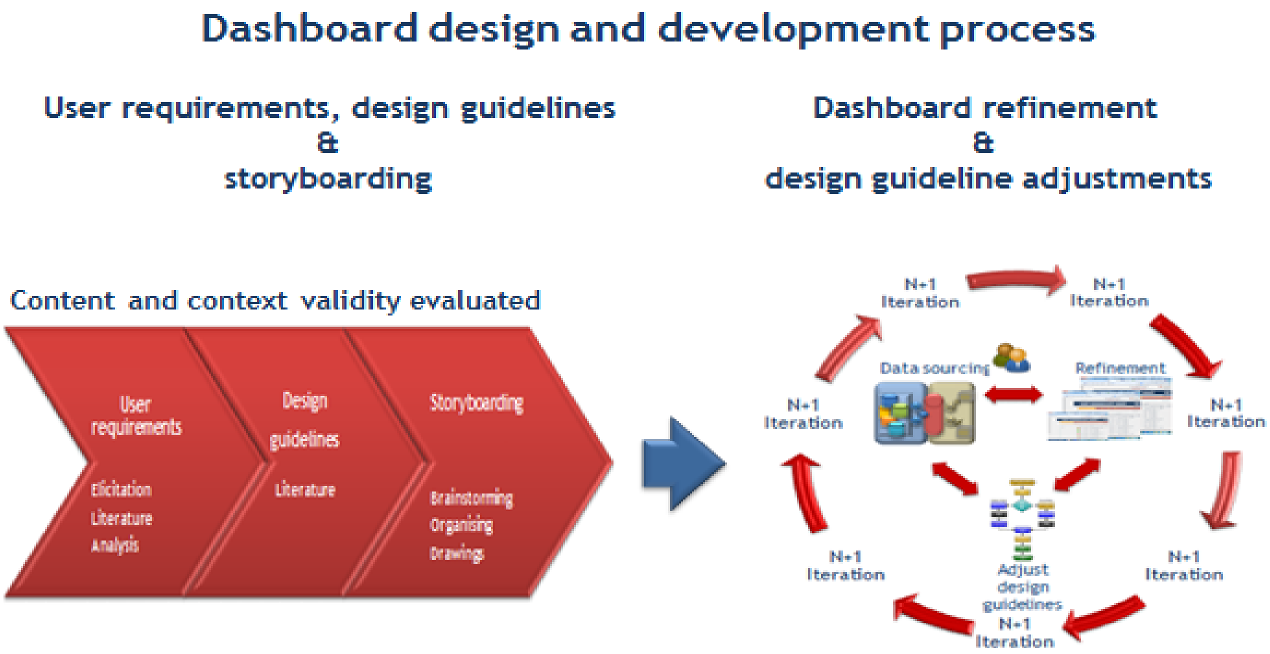


Figure 6.15: Dashboard design and development process

6.4 RESEARCH QUESTIONS ANSWERED

The main research question of the study is:

> *What are the characteristics of a framework to design and implement executive dashboards for portfolio managers at Unisa that will satisfy their decision-making information needs?*

Below, the study addresses the subquestions formulated in section 1.2.2 of Chapter 1.

6.4.1 <u>Subquestion 1: What is the general background of executive dashboards?</u>

The subquestion was addressed in section 2.3.1 of Chapter 2 in the literature analysis. Definitions of dashboards by various authors were considered and it was concluded that there is no hard-and-fast definition. However, the following general elements can be observed in the definitions:

- A dashboard is a graphic representation of KPIs.
- It provides customised decision-making information.

- Most of the definitions require KPIs to measure critical strategic information for the organisation.

The difference between dashboards and scorecards was investigated. Dashboards monitor the performance of operational processes, while scorecards monitor the progress against strategic and tactical targets.

Dashboards were found to provide users with relevant and actionable information that empowers them to monitor the efficiency of processes, bring alignment between strategic matters and accountable persons, improve decision-making and analysis, data integrity, timeliness and operational efficiency. It presents complex relationships and metrics in understandable formats that managers can intuitively understand, and it improves the use of information in decision-making.

6.4.2 Subquestion 2: How should dashboards be designed and implemented?

The subquestion was addressed in sections 2.3.1 and 2.3.2 of Chapter 2 in the literature analysis. The subquestion was subdivided into two areas: "Approach to follow in the planning and design of dashboards" and "The implementation processes". In investigating the approach to follow, it became clear that the design of the metrics or KPIs forms a crucial part in the bigger dashboard design, including operational and performance dashboards. In the design of performance dashboards, it is important to follow a scorecard methodology, such as the Kaplan & Norton model (Kaplan & Norton, 1996) or the Baldrige Award Model (Brown, 2000:31), to facilitate the systematic strategic alignment of the design.

6.4.3 Subquestion 3: What are the characteristics of metrics on dashboards?

The subquestion was addressed in sections 2.3.1 and 2.3.3 of Chapter 2 in the literature analysis. The subquestion was divided into the following five subelements:

- How metrics are determined
- How institutional performance indicators are strategically aligned
- Leading and lagging indicators

- How the combined effect can be portrayed and transformed into metrics easily interpreted for decision-making
- The design characteristics to consider

It can be concluded from the literature analysis that the key to determining suitable indicators on dashboards lies in wide consultation with all stakeholders involved in the dashboard design and utilisation. The analysis of the interview findings during the evaluation of the dashboard prototypes in section 4.5 confirmed that users were well informed about the information that is required and how indicators are influenced by other indicators and how to develop improvement interventions for the indicators. Historical information is important to determine trends, and interviewees considered the right information to be more important than the way it is displayed.

The strategic alignment of institutional performance indicators is important in performance dashboards. The strategic alignment can be performed through strategy mapping or relationship mapping of critical success factors. Some of the authors referenced in the literature analysis considered the strategy mapping guidelines difficult to understand.

The purpose of considering leading, lagging and diagnostic or supporting indicators in the literature analysis was to create an understanding of indicators or metrics that are crucial components on the dashboards as discussed under Subquestion 2.

It is evident from the literature sources that an enterprise-wide view of summarised information that portrays the “health of the organisation” is required. The aim of a dashboard system should be to provide information that is a rich, complete, and as appropriate as possible for the level of focus under consideration.

In section 2.3.3.5, the design characteristics of indicators were investigated. An understanding of the audience and purpose of the dashboard, the measures, their data sources and the refreshment cycles, data dimensions, filters and drilldowns is required.

The business processes and related information requirements should be collected in collaboration with all the relevant stakeholders. The design characteristics can be determined by understanding the physical elements, thresholds, alerts and hierarchies of dimension granularities.

6.4.4 Subquestion 4: How are metrics presented on dashboards?

The subquestion was addressed in section 2.3.4 of Chapter 2 in the literature analysis. The subquestion was addressed by the following subelements:

- Visualisation requirements of dashboards
- Dashboard design
- Dashboard layout
- Dashboard navigation
- Different dashboards for different levels of management and how it relates to the different metrics

As indicated under the previous subquestion, the aim of dashboards is to provide an enterprise-wide overview of summarised information and to present an "at-a-glance" view, as described by Pappas & Whitman (2011:253), with relevant information grouped together to convey a summary view.

General visualisation requirements of homepage usability, as provided by the guidelines of Nielsen & Tahir (2002:33), have to be considered, as well as guidelines specific to the purpose of dashboards focusedon presenting an overview. Authors such as Gonzalez (2005:Part 2), Few (2006:124) and Malik (2005:45) provide guidelines and objects, such as icons, gauges and chart types, specifically for dashboards.

In the literature analysis of the subelement of dashboard design, the dashboard elements are investigated in more detail. These elements include screen graphics, logos and brand elements, and details of presentation characteristics, such as colour, chart types, text, KPI representation and animation with relevance.

The dashboard design elements in the subquestion were considered in compiling the preliminary design guidelines for the empirical work of the study.

The dashboard layout literature review considered the number of frames or windows, symmetry and proportions of objects, computer resolutions and context of information on the dashboards. The dashboard design elements in the subquestion were considered in compiling the preliminary design guidelines for the empirical work of the study.

Under the dashboard navigation subelement, context grouping, tabs, pivots and context drilldowns were considered. The involvement of users to determine the context, grouping and hierarchies of information are highlighted as important. The components of the subelement were included in compiling the preliminary design guidelines for the empirical work of the study.

The different levels of management are categorised as follows:

- The operational level, emphasising monitoring processes
- The tactical level to analyse the performance of processes on departmental and project level
- The strategic level to monitor business performance against strategic objectives, often presented in performance dashboards or scorecards.
- The components of the subelement were included in compiling the preliminary design guidelines for the empirical work of the study.

6.4.5 Subquestion 5: How is data sourced for dashboard metrics?

The subquestion was addressed in section 2.3.5 of Chapter 2 in the literature analysis. The subquestion is divided into two subelements: complexities to overcome when data from different data marts are united into a single dashboard; and which security measures should govern.

Loopholes in data delivery, such as lack of data integrity, redundancy and the integration of different sources and gaps in business rules, are exposed when data from different sources are integrated to perform data delivery to dashboards.

In order to effectively source data for KPIs on dashboards, information pertaining to data sources, granularity, calculation and variance has to be gathered and compiled. Data sources, such as relational databases, multidimensional databases and OLAP cubes, vendor-specific reporting and vendor-specific ERP systems and more, may form part of the data sources of dashboards.

The security measures that have to be considered in dashboard personalisation have to be considered on different levels, namely user groups and hierarchies, privilege domain and content domain.

6.4.6 <u>Subquestion 6: How should executive dashboards be managed and maintained?</u>

The subquestion was addressed in section 2.3.6 of Chapter 2 in the literature analysis. The subquestion is divided into two sub-elements: where the management of executive dashboards fit into the reporting structure; and which skill sets are required to develop and maintain dashboards for executives.

The views of Dresner et al. (2002) and Eckerson (2006) are that the management of executive dashboards should not be located in line function departments, the BI and data warehouse services can be centrally located to provide services to other departments, and units or BI and data warehousing services can be performed in decentralised locations in organisations.

The typical mix of resource skills and expertise required in a dashboard development team are a dashboard software expert, BI expert, business analyst, business subject matter expert, database administrator, IT manager and project manager (Malik, 2005:87). One person can perform more than one role.

Hammond (2006) considers the co-opting of end users during the early deployment phase as a critical requirement to assess the full scope of users' information requirements and to elicit their input during the storyboarding process. This requirement has been confirmed in the study's empirical work.

At Unisa, the management information and BI functions are currently performed in a department located in the Research portfolio. It provides services to other departments, but some of the administrators of transactional systems also supply management information. As a result, the information is not integrated or centrally available. The mix of skill sets of the staff performing the BI functions are not as comprehensive as mentioned earlier in the section.

6.4.7 Subquestion 7: How can the ROI of executive dashboards be determined?

This subquestion was addressed in section 2.3.7 of Chapter 2 in the literature analysis. The challenge is to quantify benefits and costs in monetary terms. Cost savings and additional business opportunities can determine the ROI. Cost-savings factors are related to efficiencies and increased business opportunity, which should be supported by the strategy and vision of the organisation.

Malik (2005:168) postulates that the TCO for an extended period should be considered according to the following main cost factors: software cost, annual support cost, hardware cost, initial deployment costs, user training costs and ongoing support personnel costs to determine the success of a dashboard implementation.

Although this subquestion was not empirically investigated, the investment for Unisa to deploy dashboards to the entire university can be significant. Unisa management will have to weigh the cost benefits of such a system carefully before embarking on a large-scale implementation of dashboards throughout the University.

6.4.8 Subquestion 8: What are the design guidelines and typical problems found in executive dashboard implementations?

The draft design guidelines of Subquestion 8 were compiled from the information in subquestions 1 to 7. Design science research addresses important unsolved problems in original and innovative ways or solved problems in more effective or efficient ways. The problems of Subquestion 8 were discussed in section 3.5.9.

The problems were identified during the empirical process of the study, although some examples are mentioned in the discussion. During the storyboard process, a problem was identified as explained in the discussion that followed. The information for 16 out of 51 metrics could not be sourced from a transactional system, which is supported by existing business processes. In order to develop these metrics in an automated dashboard, the required business process needs to be established and a facility to capture the information needs to be developed. Data that is not captured and available in electronic format provides a major obstacle for automated executive dashboards with regular refreshment cycles.

More problems were identified during the refinement iterations of the dashboards in the real environment. The outcomes were discussed in section 5.3.2 and it is a problem that the system cannot be designed without the involvement of users to identify diagnostic and investigative drill-paths.

The users are very busy and the development of the exemplary dashboards is therefore time consuming if built-in reasoning, such as diagnostic drill-paths and analytical capability, is included in the dashboards.

6.4.9 Subquestion 9: How should the preliminary design guidelines for executive dashboards be adapted for the case study of Unisa?

In conjunction with user requirements, the design guidelines of Subquestion 8 were used to compile the draft design guidelines for the first storyboard prototype instantiation in the Visio storyboards as described in Chapter 4. The design guidelines for the storyboards were focused on the context and content of the information in the storyboards. The design guidelines were adjusted and applied in conjunction with the storyboards to develop the dashboards in the real environment. The design science iterations with the exemplary dashboards in the real environment evaluated the utility, intuitiveness and practicality to determine whether the dashboards are effective. Problems were identified during the iteration processes. The design guidelines were refined in the tertiary education environment through the design science iterations with the academic managers on three levels. These design guidelines were documented in Chapter 5.

6.4.10 Subquestion 10: What are the characteristics and dashboard frameworks for tertiary education institutions?

This subquestion was addressed in section 2.3.10 of Chapter 2 in the literature analysis. In general, literature sources about dashboards in tertiary education institutions focused on the following five main areas:

- Scorecards with performance indicators
- Operational dashboards monitoring operational processes
- The kind of analytics involved in the processing of information for dashboards
- Technology levels
- Frameworks for dashboard development in tertiary education institutions

References to scorecards that were focused on internal improvement and external accountability were found at international universities. References were found to scorecards at South African universities, but no live link could be found to dashboard systems.

Regarding the monitoring of operational processes in tertiary education institutions, sources were found that are internally focused, and the focus revolved around the analytical components and framework development discussed in the following two areas.

Academic analytics in institutional effectiveness and in the academic domain play an important role in core functional areas of tertiary education institutions. Segmentation and cluster analysis are used to determine the probability that a subset of the population will perform in a specific way. Logistic regression, neural networks, decision trees, support vector machines and survival analysis form part of forecast analysis.

Five sophistication levels were identified in the use of technology in education institutions' MISs. The lowest level was on the transaction level, and the highest level employed multiple technologies, such as enterprise-wide data warehouse, ETL and reporting tools.

Three frameworks for dashboards in higher education institutions were found in the literature that were focused on the internal monitoring of operational processes. A summary of the frameworks is compiled in Table 2.9 according to functionality, analytical capabilities and technical classification.

Framework 1 provides comprehensive guidelines of the elements of a dashboard framework in universities and the level of sophistication is high compared to other institutions, as demonstrated in the previous paragraph. However, the study did not document the empirical process followed to develop the components in sufficient detail to enable other institutions to follow the guidelines to develop dashboards for academic managers.

Framework 2, with a university summary level of information and the user input into the system, is very sophisticated and advanced, but not easily generalised and implemented without specific assistance from the designers. The principle of using a course as the currency in the system has the potential to serve as a guideline for dashboard development and, therefore, it was exploited in the current study.

In Framework 3, good academic management components, such as programme review, peer reviews and ranking, and institutional performance indicators were addressed by the decision support system. The data warehousing environment that is mentioned with role-based customisation and drilldown functionality provides proof of a good level of sophistication. Not enough detail or guidelines about the decision support component were documented to evaluate them against the other two frameworks and, therefore, this does not offer a good framework to replicate in another environment.

6.4.11 Subquestion 11: How can a framework be defined to guide the development of dashboards in tertiary education institutions?

In Subquestion 11, a framework for dashboard development for tertiary education institutions is distilled from the design science process and the literature information of Subquestion 10. The main research question was addressed by the dashboard design and development framework in section 6.3 of Chapter 6.

The system architecture is used to identify where the current framework fits into the bigger picture. A process for dashboard design and development involving user requirements elicitation, storyboard prototyping, dashboard development in the real environment, and regular evaluation and refinement is proposed. The components included in the dashboard design and development are a lens, a currency, the student walk business process, navigation and summary levels, a context drilldown, analytics and various reporting formats, and automated refreshment cycles.

6.5 CONTRIBUTION OF THE STUDY

The current study contributes to the area of dashboard frameworks for tertiary education institutions and to the design science research of dashboards in the class of dashboard artefacts belonging to the discipline of business process monitoring (Wise, 2006) or business intelligence (Eckerson, 2006). The dashboards in tertiary education institutions represent an instantiation in the class of artefacts (Vaishnavi & Kuechler, 2012:397).

6.5.1 Synthesis of proposed dashboard framework in tertiary education institutions with existing frameworks

The current framework proposes conceptual and design elements, as well as a design and development process, and was proven with theory-linked research. It provides an easy-to-follow approach that can be applied in tertiary education institutions. The proposed framework has a focus for a specific purpose, and the dashboard design and development framework find application on an operational academic level that can be replicated in different areas of tertiary education institutions. As a result, it is more generalisable than the other three frameworks.

The dashboard design and development framework for tertiary education institutions is based on generic characteristics of the environment, such as the student walk, academic business currencies and lens views discussed in the framework design. It provides an easy-to-follow approach that can be applied in any tertiary education institution. The current framework is generalisable specifically in tertiary education institutions because it is based on educational processes, and participants in the study intuitively related to the conceptual design as argued in section 5.6 above.

It provides easy-to-follow guidelines for dashboard developers. It is easier to understand, since concepts do not have to be converted from a sales environment into an education environment as is generally required for BI reporting development in educational institutions.

In Table 6.1, the proposed framework features were added to the area, functional, analytical and technological features of the three frameworks as earlier summarised in Table 2.9 and compared in the row below the features. As a result of the empirical work in the current study, three additional features were added: documented design, documented development and empirically researched.

Table 6.1: Existing frameworks features vs proposed framework features

Feature	Framework 1: Romanian universities (Muntean et al., 2010:208)	Framework 2: University of Malaysia (Mohd et al., 2010:55)	Framework 3: Santa Barbara City College (Pickett & Hamre, 2002)	Framework for dashboard design and development in tertiary educational institutions
Areas	Performance dashboard areas: 1) Student, teaching and learning 2) Faculty dashboards 3) Finance dashboards 4) Research dashboards 5) Staff and workplace satisfaction 6) Business process and operations	The dashboard system comprises the following three layers: 1) An institutional overview dashboard that visually presents the performance of the main subjects to the management of an institution. 2) A clustering engine that clusters different objects, such as students, lecturers or courses according to behavioural attributes in the data and allows experts to interact with the system to fine-tune the clustering process.	Decision support and data warehousing is part of portal technology. The decision support system comprises the following: 1) Academic programme review 2) Planning 3) Ranking college staff 4) Institutional performance 5) Accreditation	Student – module management

Feature	Framework 1: Romanian universities (Muntean et al., 2010:208)	Framework 2: University of Malaysia (Mohd et al., 2010:55)	Framework 3: Santa Barbara City College (Pickett & Hamre, 2002)	Framework for dashboard design and development in tertiary educational institutions
	Comprehensive	3) The characteristics of the clusters in "feature vector" views, which can be used to design interventions to improve object performance. **Narrow focus**	**Moderate scope**	**Comprehensive potential**
Comparison The areas of Framework 1 is considered to be comprehensive because a wide range of educational areas are covered in the framework. Framework 2 has a narrower view, judged by the information available in the literature. The areas of Framework 3 are considered to cover the business areas in a tertiary educational institution moderately. One module was developed for the study, but it has the potential to be replicated in most of the business areas of a tertiary educational institution, teaching and learning, academic planning, finance, research, staff and community participation.				

Feature	**Framework 1: Romanian universities (Muntean et al., 2010:208)**	**Framework 2: University of Malaysia (Mohd et al., 2010:55)**	**Framework 3: Santa Barbara City College (Pickett & Hamre, 2002)**	**Framework for dashboard design and development in tertiary educational institutions**
Functionality	• Raw data warehouse • Ad-hoc query and transactional reporting • Analytical multidimensional, data mining, predictive modelling reporting • Monitoring layer with personalised dashboards • Scorecards with performance indicators • University-level web portal **Comprehensive**	1) Performance indicator selection and fine-tuning clustering 2) Drill down into trend causes **Specialised and complex**	Role-based customisation with drilldown **Unknown scope**	1) Web access dashboards with monitoring layer of personalised dashboards. 2) Diagnostic drilldown and cascading features. 3) Complete data warehousing functionality with automated sourcing, ETL multidimensional OLAP. 4) Historical trend analysis **Comprehensive potential**
Comparison The functionality of the proposed framework, when full developed, can can be compared to Framework 1. The functionality of Framework 2 is considered to be advanced and complex. The functionality of Framework 3 was not documented in detail.				

Feature	Framework 1: Romanian universities (Muntean et al., 2010:208)	Framework 2: University of Malaysia (Mohd et al., 2010:55)	Framework 3: Santa Barbara City College (Pickett & Hamre, 2002)	Framework for dashboard design and development in tertiary educational institutions
Analytical	1) Ad-hoc query and transactional reporting 2) Analytical multidimensional, data mining, predictive modelling reporting 3) Monitoring layer with personalised dashboards and scorecards with performance indicators **Goldstein Level 4**	1) Data mining “MaxD K-means” clustering technique without any input parameters 2) Clustering and forecasting 3) Web development for the visualisation and trend analyses features **Goldstein Level 5**	**Goldstein Level 2**	Potential personalised trend, forecasting and clustering analysis. **Goldstein Level 2**

Comparison

The analytical components of Framework 1 are considered to be on Goldstein Level 4. The clustering, forecasting and data mining is considered to be on the same level as logistic regression, neural networks, decision trees and support vectors as measured by the Goldstein study. Framework 2 is considered to be on Goldstein Level 5 because of the automated decision system features. Framework 3 and the proposed framework is considered to be on Goldstein Level 2 because of the analysis and monitoring of operational performance.

Feature	Framework 1: Romanian universities (Muntean et al., 2010:208)	Framework 2: University of Malaysia (Mohd et al., 2010:55)	Framework 3: Santa Barbara City College (Pickett & Hamre, 2002)	Framework for dashboard design and development in tertiary educational institutions
Technical	Data warehouse populated from various internal transactional systems with current and historical information with several data marts and ETL **Goldstein Level 3**	Technical environment of custom-developed programmes and database functionality. **Goldstein Level 1, 2 or 2a**	Data warehouse and web portal **Goldstein Level 3**	Comprehensive data warehousing functionality with automated sourcing, ETL, multidimensional and OLAP. **Goldstein Level 3**
Comparison The proposed framework and frameworks 1 and 3 are considered to be on Goldstein Level 3 with data warehouse, data marts, ETL, reporting tools, executive dashboards or alerts. Framework 2 is considered to be on Goldstein Level 2 because data base technology is considered equivalent to transaction system data bases.				
Documented design	None	Scientific formulas	None	Design guidelines in terms of dashboard elements and design features
Comparison Frameworks 1, 2 and 3 did not document the design and conceptual elements of the dashboards. Design guidelines were documented and refined during the design science research of the current study. Conceptual design logic elements were documented.				
Documented development	None	Complex	None	Iterative development process design guidelines with prototyping and refinement
Comparison				

Development process of the proposed framework is documented and refined during the design science research. The design of Framework 2 is documented and statistical knowledge is required to replicate it. The design of frameworks 2 and 3 are not documented.				
Feature	**Framework 1: Romanian universities (Muntean et al., 2010:208)**	**Framework 2: University of Malaysia (Mohd et al., 2010:55)**	**Framework 3: Santa Barbara City College (Pickett & Hamre, 2002)**	**Framework for dashboard design and development in tertiary educational institutions**
Empirically researched	Research method and process not fully documented	Documentation of data mining “MaxD K-means” clustering technique	Research method and process not fully documented	Empirical research method and process fully documented
Comparison The research method and process of frameworks 1 and 3 were not documented. Some documentation was provided in Framework 2 and the proposed framework was empirically developed using a design science methodology, iteratively refined and adjusted in the real environment.				

As illustrated in Table 6.1, in terms of the documentation, Framework 2 included scientific formulas to explain the design logic. However, the other frameworks did not have design guidance. The proposed framework documented conceptual logic to create a feeling of familiarity with the user by incorporating the lens, currency and student walk logical components. The design and conceptual elements are constructs contributing to the ISDT (Vaishnavi & Kuechler, 2012:398) and specifying meta requirements for the class of artefacts. It describes how the artefact should behave to make the dashboards intuitive and practical. The constructs form part of the meta design as defined in the utility theory of Venable (2006:14).

The navigation features provided ease of use because the participants were able to spontaneously find their own departments and modules.

During the empirical development prototyping, iterative development and user involvement in the real environment were empirically tested and the responses of participants were documented and design guidelines adjusted. Prototyping and iterative design are well-known principles, as demonstrated in works by Madsen & Aiken (1995:57) and Nieveen (2009:90). User involvement and storyboard prototyping were discussed by Bowen & Reeves (2008:125), Truong et al. (2006:12) and Malik (2005:69).

The other three frameworks did not document and include the research methodology applied in the development of the dashboards. In the proposed framework, dashboard design and development were applied through the principles of design science. The design science knowledge is discussed in the next section.

6.5.2 Synthesis of knowledge on dashboard design applied in tertiary education institutions through the principles of design science research

The dashboard design and development framework for tertiary education institutions contribute to the management information and BI system design knowledge areas that have scientifically been investigated and confirmed in the real-life environment of a tertiary education institution. The actual dashboards were developed and evaluated in the real environment and did not rely on assumptions and simulations.

Design science research was applied by performing the following methodologies:

- The design science process phases and outputs of Vaishnavi & Kuechler (2004), Kuechler & Vaishnavi (2011) and Vaishnavi & Kuechler (2012) with phases of awareness of the problem, suggestions, development, evaluation and conclusion.
- The design theory anatomy of Gregor & Jones (2007) was performed considering elements of purpose and scope, constructs, form and function guidelines, artefact mutability, testable propositions, justificatory knowledge, implementation guidelines and example of instantiation.
  - Evaluation methods were observational, analytical, experimental, testing and descriptive.
  - The following triangulation methods, adjusted from Cohen et al. (2007:142), were applied: time, space, combined levels, theoretical, investigator and methodological.

In the interpretation of the design science research, the design elements of the lens, currency, student walk, navigation and summary levels, and drilldown were applied in the dashboard design. The elements were constructs contributing to the ISDT. The ISDT applied the utility theory of Venable (2006:14) when a technological solution addressed undesirable implications and causes of a problem. The ISDT specifies meta requirements that describe how the class of artefacts should behave (Vaishnavi & Kuechler, 2012:396). It is applicable to the class of artefacts in the business process monitoring and intelligence domains as mentioned in section 5.6 above.

In the drilldown functionality of the dashboards, the complexity bias of Arnott (2006:10) and the utility theory of Venable (2006:14) were applied. The requirements translate into meta requirements and apply the mid-range theory to the class of artefacts. The confidence bias identified by Arnott (2006:9) was demonstrated by the student walk and module management lens of the proposed framework. The confidence bias is one of the confirmation biases from a social, design and organisational perspective.

The requirements of the DREPT of Vaishnavi & Kuechler (2012:396) are concerned with the justificatory knowledge to explain why the artefact has the effect it does. The design research process followed is interpreted to apply reframing based on Tversky & Kahneman (1986:S257). The user perspective is reframed by interaction with the system artefact during the iterations of the design science process. The artefact is shaped by the interaction and feedback of the users. Criteria of effectiveness, ease of use and utility to a community of users provide the justificatory explanation for Theory Type V (design and action) of Gregor (2006: 629). The contribution of the theory is the utility to a community of dashboard users in the business intelligence discipline of which the tertiary education application is an instantiation. The generalisability is therefore for the dashboard users in business intelligence and it was empirically tested for the tertiary education environment.

6.6 FURTHER RESEARCH

Based on the results of the empirical work and analysis in Chapter 4 and the framework development in Chapter 6, future research possibilities were identified.

Benchmarking studies that are available in the literature can be conducted to evaluate the BI maturity of tertiary education institutions in South Africa. During the dashboard study, it became apparent that tertiary education institutions in South Africa are obligated by regulatory prescriptions to provide management information for national management information requirements. The conceptual frameworks for management information are largely dominated by the prescribed frameworks, and institutions remain very pedestrian in the development of sophisticated BI solutions. It is not clear whether the inhibiting factors are management-related or financial.

An investigation can be conducted to define a generic data model for tertiary education institutions with the generic architecture(s) based on the possible information areas on which the dashboards can focus.

The assimilation of analytics into BI solutions has a lot of potential for investigation. During the interviews of academic managers, it became apparent that there are many opportunities for the different academic disciplines to work in cross-functional ways to contribute to richer solutions by complementing them with other disciplines' perspectives and expertise.

In the development of statistical procedures to augment the intelligence of decision-making information, insight can be drawn from mathematical and statistical skills for the design of valuable solutions that can improve the quality of informed and actionable decision-making.

The current study focused on a simple practical solution for building intuitive and easy-to-use dashboards in tertiary education institutions. These dashboards are mainly developed for an academic target audience. An immediate potential study is to develop dashboards for the other currencies mentioned in the framework and other possible lenses, such as the graduation or tutoring processes. Many potential approaches to build dashboards for specific purposes in tertiary education can be explored. To track student progress during the study process, the throughput and attrition of students or other functional areas, such as student finances, are possible areas of study.

Wicked problems identified during the research were the following:

1. Data not captured by a system poses a major impediment to automated dashboards.
2. Diagnostic drill-paths could not be defined without user line-of-thought patterns.
3. It is time-consuming to develop dashboards intelligently.

Further research can be conducted to find solutions for the wicked problems and how to design and develop dashboards without the problems impacting on the development.

6.7 CONCLUSION

Chapter 6 is the culmination of the dashboard study undertakings. The framework for dashboard design and development in tertiary education institutions is introduced through a diagrammatical presentation of the dashboard system architecture. The system architecture serves to demarcate the design and development process that follows. The dashboard design and development framework proposition is made in terms of its functionality, technology specifications, design and conceptual constructs, design guidelines, and design and development process.

Following this, it is explained how the main research question and subquestions were answered in the thesis. The contribution of the study is discussed by the synthesis of proposed dashboard framework in tertiary education institutions with existing frameworks and knowledge on dashboard design applied in tertiary education institutions through the principles of design science research. Further research is suggested into BI maturity benchmarking, the assimilation of analytics and statistical analysis, and other approaches to academic dashboards, like tracking and throughput, and investigating solutions for the wicked problems identified during the research process. The study is concluded in the next paragraph.

In conclusion, the shortage of decision-making information remains a challenge in tertiary education institutions. The dashboard study provides guidelines to develop dashboards around different currencies with the organisational structure as a navigation mechanism and the student walk as a logical progression to facilitate easy access and a sense of customisation without specifically customising information according to the needs of individuals. The guidelines should be easy to replicate in other educational institutions and ought to save time when analysing the logic required to provide intuitive information in the academic environment.

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8. APPENDICES

8.1 APPENDIX 1

APPENDIX 1

MIS, EIS, ESS and DSS

8.1.1 MIS, EIS, ESS and DSS

8.1.1.1 Management Information Systems (MIS)

MIS provide managers with detailed and summarised information from operational databases created by the transaction processes (TPs) and activities in various functional business areas (for example, accounting, finance, and marketing). MIS is usually geared for internal data in one functional area (accounting IS or marketing IS). As a result, an MIS usually lack data integration across functional areas and they do not combine data from different sources. Presenting information in a specifically designed format to fit the decision-making styles of specific users is simply too expensive to provide in an MIS, since an MIS is designed to serve hundreds or thousands of users. These users change continuously. Furthermore, executive decision-making, especially strategic decision-making, is complex and multidimensional. A conventional MIS is usually designed to deal with structured and much simpler configurations and does not include customised, executive information system capabilities (Millet, 1991).

8.1.1.2 Executive Support Systems

Lee & Chen (1997) describe an ESS as an interactive computer system that provides business executives with the capacity to obtain easy access to relevant internal and external information. McAuly (2000) describes an ESS as a comprehensive support system that goes beyond EIS to include communication, office automation, analysis support and intelligence.

8.1.1.3 Executive Information systems

Bird (1991) defined an EIS as a Computer-Based Information System (CBIS), front-ended by a user-friendly interface that electronically provides executives with rapid and reliable access to relevant business information. Information flows from functional units in the internal environment (finance, marketing, production, accounting, personnel, and so on) and the external environment (for example, the internet and other online databases, newspapers, video news services.

Clearly, the combined information from all these sources is extremely valuable – indeed, this information is an important organisational resource if the organisation is to survive. Access to internal and external information is critical and relevant to the organisation's critical success factors.

McAuly (2000) sees an EIS as more than just a tool providing us with summarised data. One of the vital attributes of an EIS is that it can interrogate external information sources, such as demographic databases, international news and stock exchange information, and use them in association with internal information. The latter are often seen as "soft data". Soft information is "fuzzy", unofficial, intuitive, subjective, nebulous, implied and vague. The high use of soft information in the form of predictions, speculations, forecasts, and estimates is important for planning purposes. McAuly (2000) considers soft data to have a greater psychological impact on a organisation than hard facts.

The following are characteristics of an EIS based on Currie & Galliers' (1999) list. From my viewpoint, ESS is almost equivalent to EIS and should be included to cover the spectrum in the list.

Information warehousing	Pellisier (2000:76) explains that "information warehousing is designed and developed corresponding with important organisational strategies, such as EIS, MIS, DSS and marketing and financial strategies". The information warehouse forms an integral part of the technological framework for information delivery. An information warehouse is more than a store of data. It consists of an entire process of: - Extracting data from operational systems - Reconciling and organising it in ways that make business sense - Exploiting it with knowledge discovery and analytical software
Drilldown	One of the most useful capabilities of an EIS is to provide details of any summarised information. For example, suppose an executive notices a decline in corporate sales in a daily (or weekly) report. To find the reason, the executive may want to see sales in each region. If he/she then identifies a problem region, he/she may want to see further details (by product or by salesperson).
Data mining	- Databases have become large and multidimensional, making access and analysis virtually impossible - Standard statistical methods may be impractical because of missing values for some of the data items - The large databases make it impossible for system administrators to know what information is contained in the data or even what search questions they should ask.

Status access	The latest data or reports on the status of key indicators can be accessed at any time, and the latest relevant information and data should be available. Although status access allows executives to pursue the information requested (for example, by conducting a drilldown), it is basically geared for data manipulation.
Analysis:	Analytical capabilities are available in ESS. Instead of merely having access to the data, executives can use the ESS to do their own analysis. Such analyses can be carried out by using built-in functions and converting information to tables or graphs. Multidimensional analyses are also possible. Simple comparisons, trends or ratios can be calculated automatically and an alert is issued if there are significant deviations from standards.
Use of colour	Typically, critical items are reported not only numerically, but also in colour: green for OK, yellow for a warning, and red for performance that is outside the preset boundaries (danger). The colour (or shading, for the colour-blind) alerts the executive user to potential problems that require his or her immediate attention.
Exception reporting	Exception reporting is based on the concept of management by exception. In other words, exception reporting means that the executive's attention focuses only on cases of very bad (or very good) performance. For example, the EIS can compute variances and variences that exceed a certain limit are then highlighted. This approach eliminates the need to sift through huge amounts of data and saves the organisation a considerable amount of time.
Navigation of Information	Navigation of information is a capability that allows large amounts of data to be explored easily and quickly. Hypermedia tools can be used to improve this capability.
Communication	Executives obviously need to communicate with others. Communication can be by email, a transfer of a report to the attention of someone, a call for a meeting, or a comment made to a newsgroup on the internet.

8.1.1.4 DSS

According to Currie & Galliers (1999), a DSS is an interactive, flexible, and adaptable CBIS specifically developed for helping to solve non-structured management problems. DSS is one of the fundamental areas within information systems. It uses data, provides easy user interface, and can incorporate the decision-maker's own insights. DSS can also use models, and is built by an interactive process (often with a great deal of input from end users). It provides support during all the phases of decision-making, and may include a knowledge component. In short, DSS enables decision-makers to make better, more consistent decisions.

8.2 APPENDIX 2

APPENDIX 2

Interview questions taken from Bak, 2004:136:

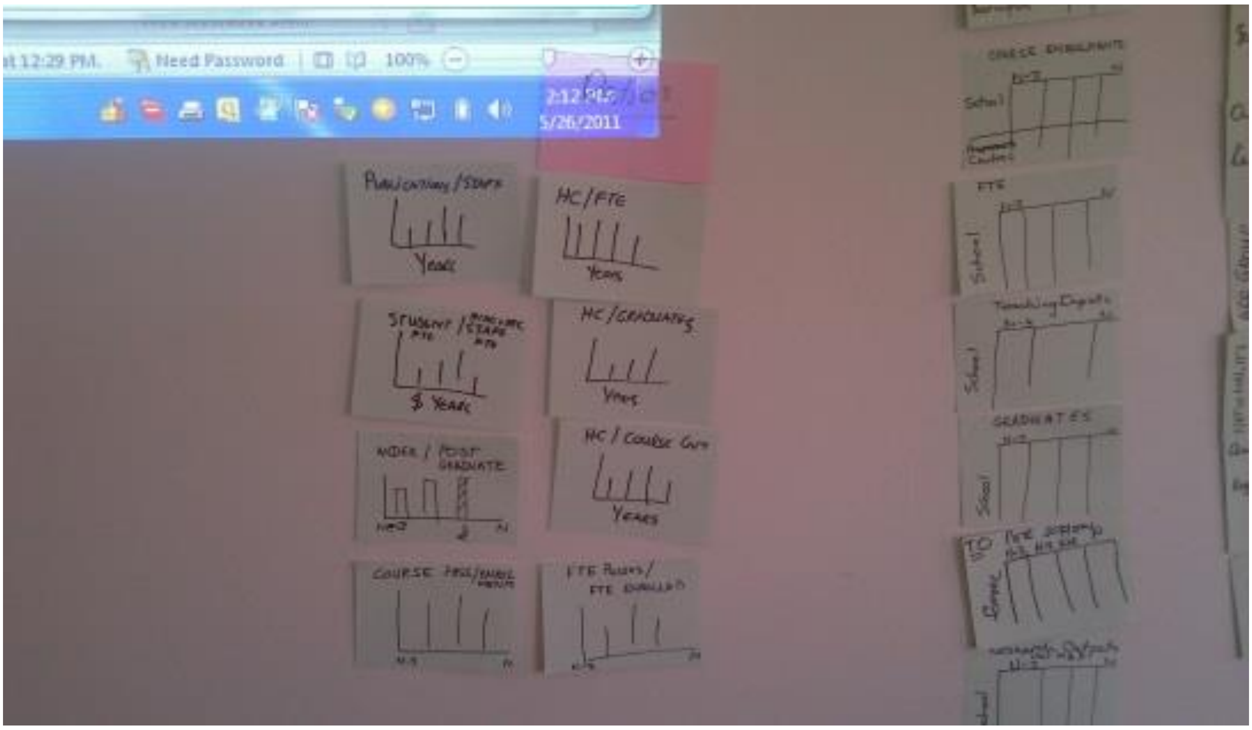
Questions to address in interview, questionnaires and focus groups or case studies
What do you want to find out? What is the purpose of the interviews?
Who are you going to interview? Why?
How many are you going to interview? Why this number?
When/ how often are you going to interview? Why?
What are the criteria for your interview sample? (Age, gender, socio-economic levels, status, job position, geographical distribution institutional affiliations) Why?
What will be the structure of the interview? Why?
In what language will you be interviewing? What language will the interviews respond in? What might be some of the implications?
How will you ensure confidentiality of information and adherence to ethical principles of research?
Perceptions of interviewees vs facts. How will you substantiate the responses and test validity?
How are you going to analyse your data?
What are the practical arrangements you will need to make? Access? Time? Equipment? Transcriptions? Costs?
For case studies: What will be the limits of your case study?

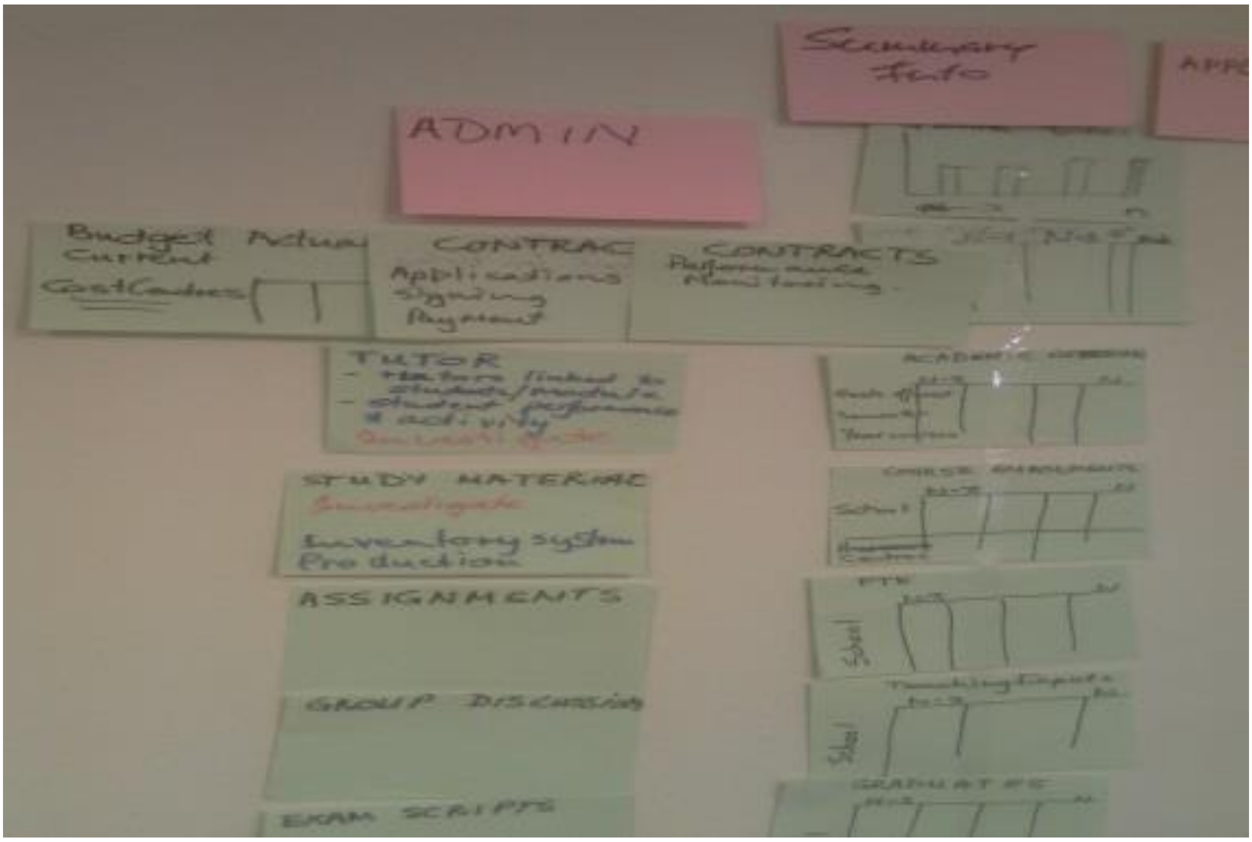
8.3 APPENDIX 3

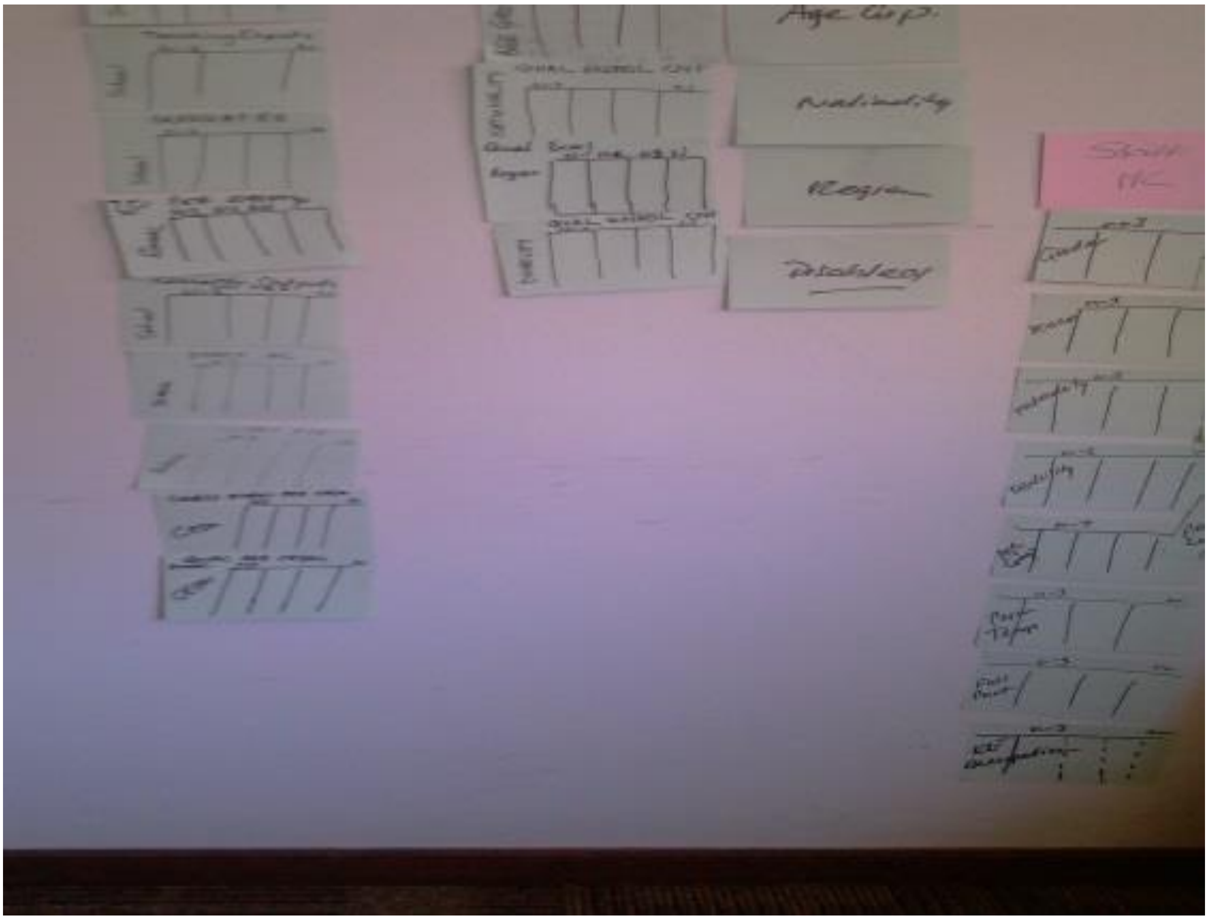
APPENDIX 3

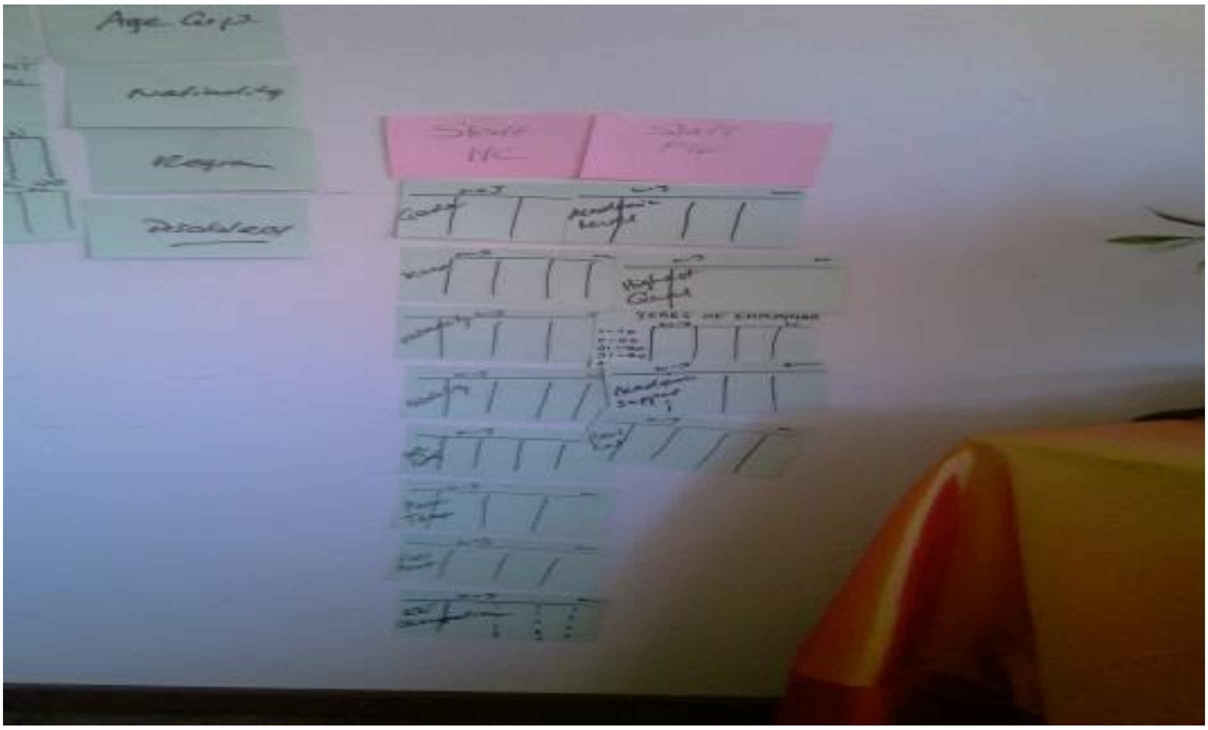
Photographs of storyboards
and
Visio screen prints

8.3.1 <u>Photographs of storyboards</u>



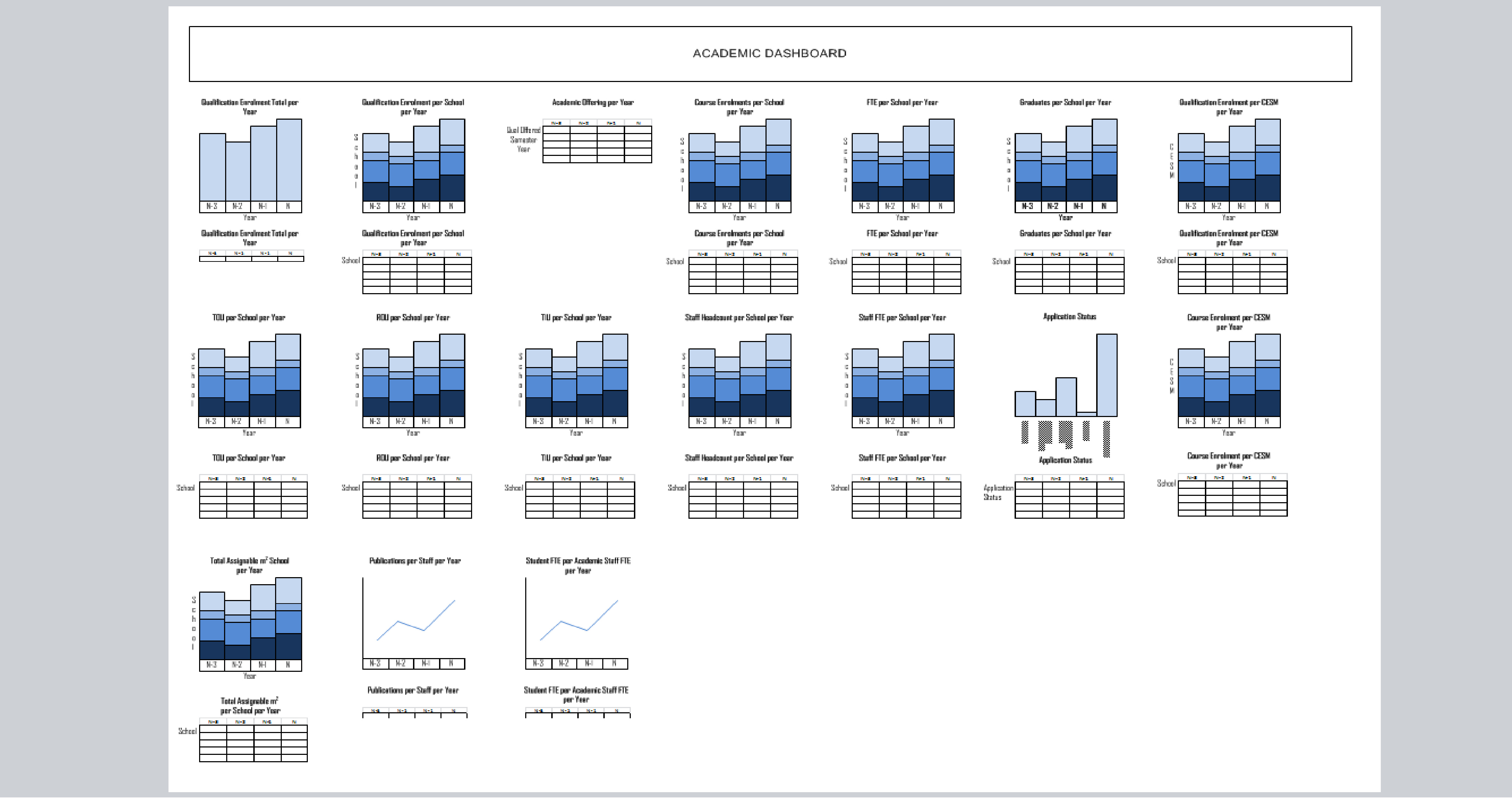




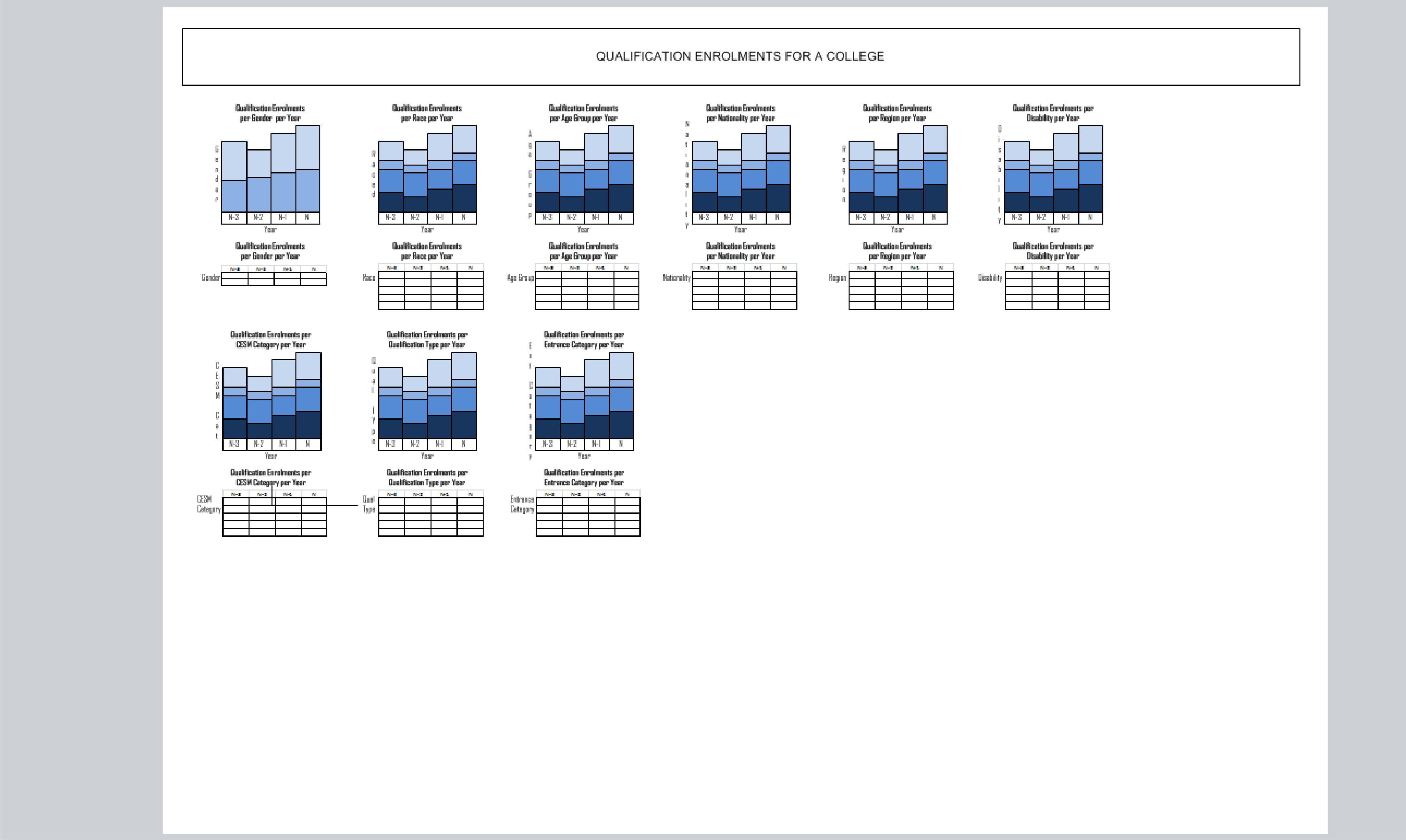


8.3.2 Screen prints of Visio tabs

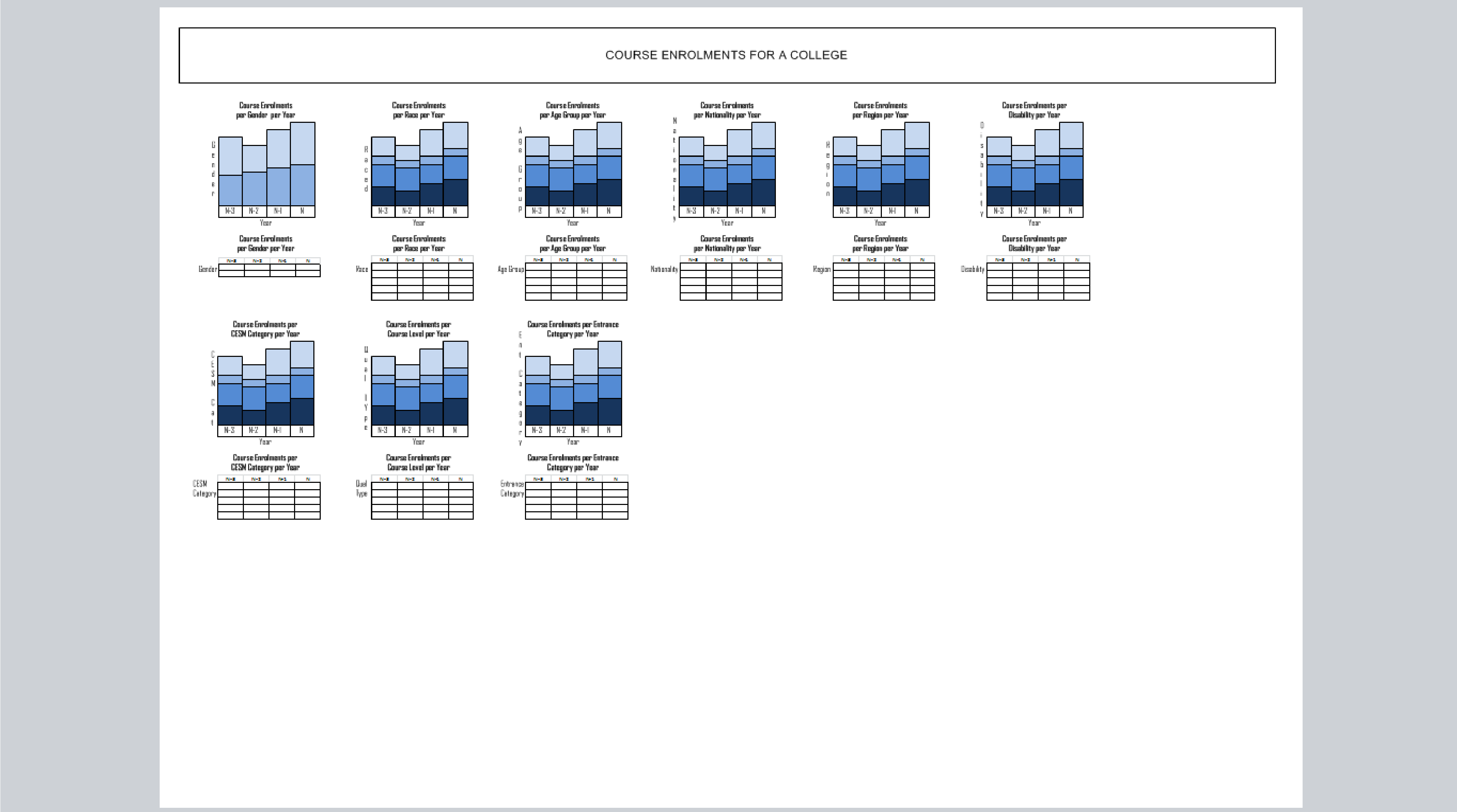
8.3.2.1 Summary view



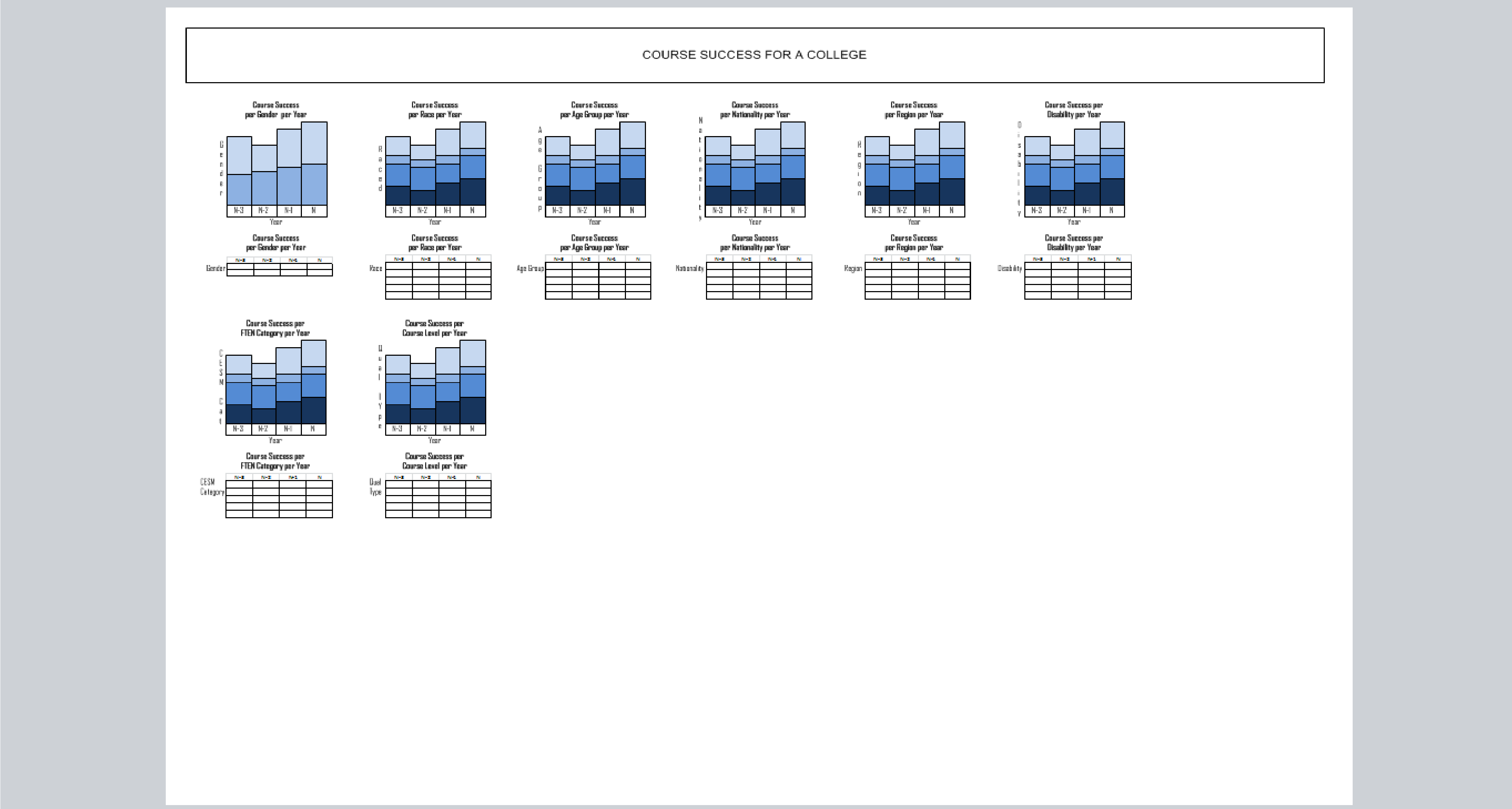
8.3.2.2 Qualification enrolments per College



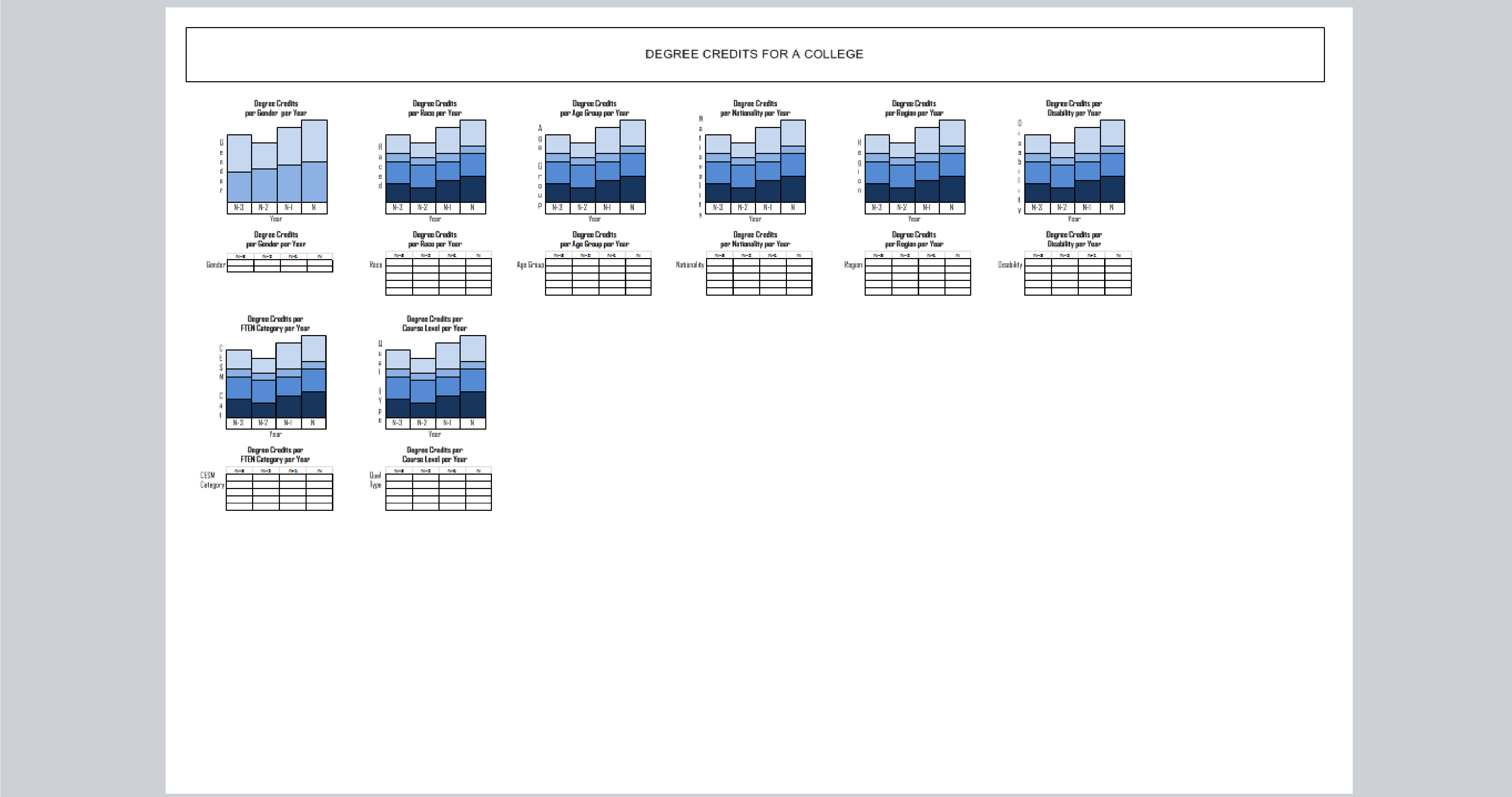
8.3.2.3 Course enrolments per College



8.3.2.4 Course success per College



8.3.2.5 Degree credits per College



8.4 APPENDIX 4

APPENDIX 4

User requirements

8.4.1 User requirements

Preliminary report on data requirements from the School of Management Sciences for the College of Economic and Management Sciences (CEMS) Dashboard project

The data needs, as derived from the Director of the School of Management Sciences at Unisa and the CoDs within the school outlined below, are grouped into the four key operational areas as guided by the IPMS, namely research, teaching and learning, community participation and administration. Masters and Doctoral information was mentioned so frequently as critical need-to-know information, that a separate category was included. In summary, the requirement is that the data be available in a **graphic** format in **real-time**.

Data requirements are similar for CoDs across the school and for the director; the scope of the information differs slightly with the director wanting to see data summarised for each department, rather than for each individual. CoDs need the information summarised for their department with the ability to easily drill down to an individual level.

1. Research

i. Current and proposed research projects
ii. Status of existing projects
iii. Access to research fund information
iv. Cumulative publication record per department and per individual

2. Masters and doctoral students

i. List of master's and doctoral students per department (names and research titles) including staff members
ii. Progress report on students busy with research proposal
iii. Progress report on master's and doctoral students (per supervisor and per student) – activity reports need to be available to the Director as soon as they are loaded
iv. Summary of master's and doctoral application files need to be available to the Director, especially with regards to reasons for rejection of application by the Director or CoD. Record creates precedent
v. List of examiners appointed for master's and doctoral thesis – internal and external

3. Teaching and learning

i. Early warning system regarding Academic planners' due dates, with the ability for CoD to add additional departmental due dates. Proposed "reminder" from 30 days prior to due date

ii. Information regarding study material (tutorial letters, exams and study guides)
   - Due dates at scheduling, production etc
   - Staff member involved in each item and adherence to due dates
   - Tracking progress through the system, % completed, at which stage etc
   - Stock levels at dispatch

iii. Track receipt, marking and return of assignments by lecturers

iv. Evaluation of lecturers in group discussions

v. Track submission of assignments by students and student performance

vi. Attrition rates versus throughput rates (per module, per qualification, per primary lecturer)

vii. Profile of success rate (normal curve and historic view)

viii. Tutors linked to each module code (number of tutors, region and demographic information)

ix. Students linked to a tutor in a region and students performance

x. Profile of students per module (demographic, geographic, disabilities etc)

4. Community participation

i. Current and proposed projects

ii. Registered versus non-registered projects

iii. Status of existing projects

iv. Names of staff involved in projects

5. Administrative

i. Early warning system regarding procurement closing dates, contract expiry, budget dates

ii. Tutor evaluation (IPMS for tutors)

iii. Contractor records
   - Details of contract
   - Performance report (number of scripts marked, etc.)

iv. IPMS profile of individual staff member and IPMS review history (per staff member, per section and per department)

v. Timesheet that dynamically records time spent at meetings, training, research

vi. Staff records
   - Demographic information
   - Qualifications
   - Status of current studies
   - Summary of leave per department (pending and current)

vii. Electronic whiteboard – to be dynamically populated when people leave the office, attend meetings etc.

viii. Equity reporting (departmental equity profiles)

ix. Budget information
   - Projected spend to actual spend (real-time)
   - Record of payments made to contractors

x. Contracts
   - Status of applications
   - Tracking progress through system

xi. Training information
   - Training budgets (utilised and available)
   - Type of training being undergone
   - Staff attending the training (by individual and department versus type of training)

Most preferred **front-end is graphical interface (such as pie charts)** with the option to drill down to individuals. Example on next page:


Yellow Boxy Dashboard
Another HTML Template from The Dashboard Spy
Dashboard
Page 2
Page 3
Page 4
Page 5
Portlet Title 1
Key Performance Indicator Name
Place description or commentary here. This is some placeholder text.
Portlet Title
Here is some placeholder text
Portlet Title 2
Here is some placeholder text
Column 1
Column 2
Column 3
1234
234234
87435
84352
43525
43524
4523523
345266
432664
Another Portlet Title
Here is some placeholder text
This portlet can contain text, a table, a chart or anything else you might think of. Think of a portlet as a logical unit of business intelligence. It is a way to put focus on data that otherwise may be several levels deeper than the homepage of an application.
Another Portlet Title
Your portlet can contain a form. Or have a submit button that does something.
Panic!
Portlet Title 3
KPI Alert 1 1
Dashboard alert information goes here.
Read more...
KPI Alert 2
Place your KPI notifications here.
Read more...
Portlet Title Here
Dashboards
The Dashboard Spy has the world's largest collection of dashboard screenshots. By studying thousands of business dashboard examples and sifting through the good, the bad, and the ugly, we've learned what to do and, more importantly, what not to do!
View the Dashboard Examples
Digital Dashboards
Why struggle through years of trial and error with your business intelligence dashboards when you have the best practices of the dashboard design community at your disposal? Take a look at the Dashboard Spy's List of Dashboard Experts to see what the top BI experts are doing with dashboards.
Dashboard Experts
Dashboard | Business Intelligence White Papers | Excel Dashboard | Dashboard Templates
Copyright © 2009 ---. All Rights Reserved.
Web Template created with Artisteer.

8.5 APPENDIX 5

APPENDIX 5

Storyboard interview guide

Interview guide to evaluate storyboards

8.5.1 Storyboard interview guide

1. Identification	Response
Portfolio holder initials and surname:	
Portfolio	
Portfolio name	
Portfolio position (management level)	
2. General discussion points	**Response**
2.1 Information for the current year and three years' history will be used in all graphs and tables.	
2.2 A table and a graph will be presented for each metric.	
2.3 The completeness of the information covered in the storyboards was considered.	
2.4 The relevance of the information to the context was considered.	
2.5 The grouping of the information should be logical.	
2.6 Drilldown cannot be displayed in the Visio format, but relevant drilldown paths were considered.	
2.7 Additional information not covered in storyboards was elicited from the participant.	
3. Additional information per tab	
3.1 General	
3.2 Qualification tab	
3.3 Academic administration tab	
3.4 Course success tab	
3.5 FTE tab	
3.6 Non-formal tab	
3.7 Graduates tab	
3.8 HR Information tab	

8.6 APPENDIX 6

APPENDIX 6

Dashboard V2, V3, V4
interview guide

Dashboard interview guide

8.6.1 Dashboard V2, V3, V4 interview guide

1.	**Identification**	**Responses**
1.1	Portfolio holder initials and surname	
1.2	Portfolio	
1.3	Portfolio name	
1.4	Portfolio position (management level)	
2.	**Value of the dashboards**	
2.1	Do the dashboards provide more readily available decision-making information?	
2.2	How well are the indicators matched to the required decision-making information?	
2.3	How can dashboards help to monitor the efficiency of processes?	
2.4	How efficiently do the dashboards measure deliverables?	
2.5	Do the indicators provide actionable, fact-based information?	
2.6	How well are the indicators updated aligned according to the business cycles?	
2.7	Do you have analytical requirements to perform your management duties?	
3.	**Dashboard characteristics**	
3.1	Indicator/s	
3.1.1	Which indicators are understandable and which are difficult to understand?	
3.1.2	Are there indicators that reinforce other indicators?	
3.1.3	How well does the visualisation presentation suit the information it represents?	
3.1.4	Can you identify past, present and future indicators?	
3.2	Dashboard design	
3.2.1	Do you find the logos and brand elements distracting from critical information?	
3.2.2	Is it accurate to conclude that the chart types present information correctly?	
3.2.3	Do you find the dashboard too cluttered?	
3.2.4	Do you find the number of indicators on the dashboard satisfactory?	
3.2.5	Do you need the dashboard information in printable format?	
3.3	Dashboard layout	
3.3.1	Are you satisfied with the general appearance of the dashboard?	
3.3.2	Do you find the number of frames or windows suitable?	
3.3.3	Are the symmetry and proportions of the dashboards distracting/ not distracting?	

Dashboard interview guide

Dashboard characteristics (continued)	
3.3.4 Do the dashboards convey the correct context of the information?	
3.3.5 Do you think information grouping and hierarchies closely represent the business?	
3.4 Dashboard navigation	
3.4.1 Do the support analytics provide relevant and explanatory information about the indicators?	
3.4.2 Do the drilldowns represent the context correctly?	
3.4.3 What is your view about the security at all levels?	