DATA WAREHOUSE SCHEMA FOR MONITORING KEY PERFORMANCE INDICATORS (KPIS) FOR UNIVERSITY TEACHING AND LEARNING USING GOAL ORIENTED APPROACH

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Abstrak

Pertumbuhan dan pembangunan universiti sama seperti pertubuhan-pertubuhan lain, bergantung kepada kebolehan mereka untuk merancang dan melaksanakan pelan induk pembangunan secara strategik yang juga selaras dengan visi dan misi yang telah dinyatakan. Secara terasnya, kenyataan-kenyataan ini yang sering dirangkumi dalam matlamat dan sub-matlamat dan dikaitkan dengan pihak yang terlibat adalah lebih baik sekiranya diukur melalui Petunjuk Prestasi Utama (KPI). Di universiti-universiti yang mengendalikan data sederhana besar dan pelbagai, perkembangan dan penggunaan gudang data adalah sangat penting. Secara khususnya, Universiti Utara Malaysia (UUM) masih belum mempunyai gudang data untuk memantau Petunjuk Prestasi Utama (KPI) bagi organisasinya. Dengan ini, kajian ini mencadangkan skema gudang data digunakan untuk memastikan KPI universiti dari segi KPI pengajaran dan pembelajaran dengan menggunakan Analisis Keperluan Matlamat bagi Gudang Data KPI (ReGADaK) yang merupakan kesinambungan daripada analisis serta reka bentuk keperluan berorentasikan matlamat (GRAnd). Skema yang dicadangkan merangkumi fakta-fakta, dimensi, ciri-ciri dan langkah-langkah unit pengajaran dan pembelajaran UUM. Langkah-langkah daripada analisis matlamat unit ini berfungsi sebagai asas bagi membangunkan KPI universiti yang berkaitan. Skema gudang data yang telah dicadangkan dinilai melalui semakan dan kajian pakar, prototaip dan penilaian dari segi kebolehgunaan. Hasil daripada proses penilaian menunjukkan bahawa skema gudang data yang dicadangkan adalah sesuai untuk KPI universiti dari segipemantauan KPIpengajaran dan pembelajaran dan ia jugadianggap sebagai sesuatu yang boleh dilaksanakan.

Kata kunci: skema gudang data, berorientasikan matlamat, petunjuk prestasi utama, Universiti Utara Malaysia

Abstract

The growth and development of universities, just as other organisations, depend on their abilities to strategically plan and implement development blueprints which are in line with their vision and mission statements. The actualizations of these statements –which are often abstracted into goals and sub-goals and linked to their respective actors –are better measured by defined key performance indicators (KPIs). And in universities that handle modestly large and heterogeneous data, development of data warehouse is important. Specifically, Universiti Utara Malaysia (UUM) is yet to have a data warehouse for monitoring its organisational KPIs. This study therefore proposes a data warehouse schema for university's KPIs for teaching and learning KPIs using a Requirement Goal Analysis for Data Warehouse KPI(ReGADaK)approach which is an extension of goal-oriented requirement analysis and design (GRAnD). The proposed schema highlights the facts, dimensions, attributes and measures of UUM's teaching and learning unit. The measures from the goal analysis of this unit serve as basis of developing the related university's KPIs. The proposed data warehouse schema is evaluated through expert review, prototyping and usability evaluation. The findings from the evaluation processes suggest that the proposed data warehouse schema is suitable for university's KPIs for teaching and learning KPIs monitoring and practicable.

Keywords: data warehouse schema, goal-oriented, key performance indicators, Universiti Utara Malaysia

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Lastly, I dedicate this thesis to my lovely woman, my wife, my two daughters – Ruqayah and Rawan, and my sons in future.

Table of Contents

List of Tables

List of Figures

List of Appendices

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 Overview

This chapter serves as the introductory part of this study. It establishes the motives of the study, its underlying problem statement, its significance. The research questions and objectives to be attended to are also elicited. In summary, the background of this study is laid for further discussion on how the concept of business intelligence can be used to develop a data warehouse schema that is usable in monitoring the Universiti Utara Malaysia's key performance indicators (KPIs) by using Goal-oriented requirement analysis and design methodology (GRAnD).

1.2 Background of the Study

A university is a place that houses students from diverse backgrounds. These students come from every part of the globe for the purpose of knowledge acquisition and learning. Universities serve as places to cultivate thought process and where inquiries are provoked for discoveries to be made and verified (Altbach, Reisberg&Rumbley, 2009). Universities, as the topmost knowledge creation community, are always with their respective vision and mission statements. These vision statements are the university goals and they are periodically designed and revisited in line with the university future and the path to be taken for its actualization (The University of Edinburgh Strategic Plan: 2012- 2016). Universities, just as other organisations, are expectedly passionate about the actualizations of their goals and attainment of their visions. This has undoubtedly brought a fair apprehension to the decision making process of the organisation, and the need to

compete with other universities and achieve edge-cutting decision making abilities have necessitated heavy investment on human capital development and infrastructural building (Tilak, 2002; Ayodele&Sotola, 2014).

Universities, as bedrocks of economic and developmental prospects of their individual countries, have wide interests range which spans from consulting efficiency, research quality, teaching effectiveness, among others (Tassey, 2009). Each of these niches of the universities' interest is accompanied with the appropriate goal, befitting department, and the corresponding strategies for its execution. Universities are positioned to be the engine room for national development due to their capacity and capability in terms of being repositories of human and intellectual resources and data (Altbach et al., 2009). Certainly, as they have evolved and now capable of responding to both internal and external pressures, depending on their foundation of academic research, teaching and learning, human capacity building, and innovation are topmost of their focused service delivery. This is essentially done with high degree of programmatic self-direction, in a competitive environment that rewards success, and an entrepreneurial approach to attracting the resources necessary to be successful (Moyle, 2010; Altbach et al., 2009).

However, within the university organisational structure, the deluge of data and the choice of compatible ones with the university's need have been responsible for decision making constraint. This has called for an increasing need to solve the myriad of decision making bottlenecks which are caused by the volume of the organisation's data, the educational sector's ever-changing environment and increase in market need of the university products which are either tangible or intangible. This

experience, overtime, has been responsible for researches to generally improve the approaches of university's usage of its data. It has also helped in devising means on how to better make more sense from the data in order to support its decision making process (Semiu&Zulikha, 2014). This is essence of deploying business intelligence (BI) by organisations. According to Negash (2004) and Moyle (2010), BI is mainly employed to improve the quality of the inputs to decision process by combining operational data with the appropriate analytical technologies.

A tremendous usage of BI for decision-making and monitoring organisational performance using Key Performance Indicators (KPIs) among the university community was reported by Canada Health Infoway (2013) and Pant (2009). KPIs are metrics used in measuring organisational performance. On general note, an industry analyst firm, IDC, stated that the business analytics software implementing KPIs has grown by 10.3 percent annually throughout the year 2011. This is in line with the market survey conducted by Better Management[1]. It showed that 84 percent of various organizations are using BI systems to support their decision making process have been including performance measurement, especially the KPIs. KPIs are financial and non-financial metrics which are used by the organisations to estimate the success rate and trend of the organisation in relationship with its set goals (Velimirovića, Velimirović&Stanković́a, 2011).

Notably, data warehouse is a suitable type of BI that is needed as decision support system because of its capacity to leverage analytical technologies explore the

[1]http://www.bettermanagement.com/default.aspx

appropriate operational data within the pool of the organisational data. Past studies on monitoring organisational KPIs did not use data warehouse.

Therefore, in view of attending to these observed gaps, this study aims to develop a data warehouse schema for University KPIs for teaching and learning. The GRAnD approach is used as requirement design methodology to analyse the university goals. It is further used as the basis to extend to KPIs analysis as the operational activity of the proposed data warehouse schema. The deliverable of this study is capable of supporting monitoring activity for University KPIs for teaching and learning.

1.3 Motivation of the study

In this 21st century, universities globally, and in Malaysia specifically, are facing daunting task in strategic corporate decision making due to the plethora of goals set and needed to be met by the universities. The universities' goals range from attainment of a ranking position, locally or internationally, or particularly in a specific field, to attainment of international status, which is determined by the number of international faculty members and students, among other things (Mykkänen& Tampere, 2014). Achieving these goals has always been accompanied with KPI setting by the individual countries' ministries of education, and monitoring by the respective universities. The universities also use KPI to monitor their developmental growth as set by ministries of educations. KPIs are also used in measuring performance of the university's staffs. And this helps in ensuring that universities achieve their set goals and developmental blueprint by periodic readjustment of the KPIs to meet the current realities (AbdurRahman& Alan, 2013).

According to a 2012 report of Research Universities Consortium, published by Elsevier, the future of the American research university is more uncertain than it has been in the last 50 years. During this time, the public funding of academic research paused in its growth. Universities are then faced with the combined pressures of declining federal funding, record reductions in state funding, erosion of endowments, soaring tuition costs that is now reaching unaffordable limits. Also, with the intensification of global competition, increasing compliance and reporting requirements, as well as the loss of political and public confidence in the value of university-based research, the university demands more sophisticated decision making framework. At the same time, there have been expectations for university-based research to produce creative solutions for growing list of complex problems has never been higher (AbdurRahman& Alan, 2013). To surmount this myriad of challenges and achieve all the goals of the universities has necessitated the need to revamp the process of corporate decision making by deploying performance measurement and monitoring technology.

From the Malaysian government perspective, there are several issues facing the higher education institutions, and the lead of this is financing, including the ongoing 'corporatization.' The government wants public institutions to gain autonomy. This has propelled treating university system with business models, so as to attain full financial independence from the state (Zhang, 2008; Inayatullah, 2012). The universities are faced with the need to increase their internally generated revenue, which is essentially from international students' enrolment, commercialization of research products, and improving the consultancy services to be income-generating (Mykkänen& Tampere, 2014). Ruth (2013) also stated that the worrisome output of

the decision making process of the universities is linkable to the inability to be goal-specific and oriented in the decision making process. To actualize these revenue vehicles, staff capacity training must be overhauled, graduate research students' methods recruitment must be revisited, and all processes within the university's decision making must be strategically positioned (Kirkness & Barnhardt 1991). To attend to the mounting challenges facing universities globally and Malaysian universities specifically, decision making process must be improved, so as to ensure that the universities take decisions that are adaptable to the progress of the developmental plan and any unforeseen circumstance

This experience, as posited by Pourshahid, Richards, and Amyot (2011) is caused by lack of data relevance, comprehensive decision model, alignment with business strategy, amongst others, with the performance measurement strategy. The universities are equally not deploying sophisticated BI technology like data warehouse for KPI monitoring. And to achieve this, development of data warehouse with the inclusion of KPIs as operational information using the GRAnD method is suggested**.** It is on this basis that this study hopes to explore the university decision making process and its inherent constraint by developing data warehouse schemas with a GRAnD approach that will enhance monitoring of the KPIs in relationship with the goals for its decision making mechanism. In UUM case, no data warehouse approach has been previously used for managing the University's KPIs.

1.4 Problem Statement

The university goals are the actual projected plan of the educational organisation, often encapsulated in the vision and mission statements. The goal-oriented methodology is posed as a better design approach because it formally modelled the organisational goals. It also takes into consideration, the strength and weakness of its decision alternatives and the stakeholders involved (Giorgini, Rizzi, & Garzetti, 2008). The goal-oriented design methodology enables the data warehouse schema to attend to the high-level objectives of the organisation and decision makers rather than the specific functionalities of the system-to-be (Yu, Girogini, Maiden & Mylopoulos, 2011). However, from the researcher's preliminary investigation which was done through an interview with head of Strategic Corporate Information unit and its technical officer, the current-used university KPI monitoring system is not based on goal-oriented design methodology, and none specifically designed for its teaching and learning KPIs.

According to Pourshahid, Richards, and Amyot (2011), many studies that were conducted by researchers and practitioners on the effect of increasing use of the BI system by small, medium and larger organizations for improving decision making capabilities recorded little or no success, because of lack of KPI monitoring mechanism. Review of Giorginiet al. (2008) –a study on data warehouse design – also suggests there is lack of attention to goal-oriented requirement analysis and design methodology (GRAnD) in the design of the university data warehouse for monitoring its teaching and learning KPIs.

Also, Mazon et al. (2007) pointed out that most of these conceptual data warehouse models fail in addressing the required information as a result of a poor

communication between DW developers and decision makers. Actually, information needs cannot be understood by only analyzing the operational data sources, and a requirement analysis stage is needed in order to model the information requirements of decision makers and derive a suitable conceptual data warehouse schema. This shows that the decision makers in the organisation, as well as information pertaining to the organisational goals have not been sufficiently used in designing data warehouse schema, and specifically for monitoring KPIs.

In specific scope, information needed in designing, projecting and monitoring the universities' KPIs, which are the performance metrics towards the attainment of the university goal (vision and mission statement), needs a technology that could extract that from the pool of operational data of the university. In developing the data warehouse, the goal-oriented approach, i.e. GRAnD, is enjoined because of its ability to align the data warehouse functionalities with the university goals, especially as it relates with the University KPIs (Negash, 2004; Ta'a & Muhamad, 2008).

The constraint in the monitoring of universities' teaching and learning KPIs, generally, and that of Universiti Utara Malaysia, specifically, needs to be addressed by developing a data warehouse. The review of extant literature shows that past studies on university KPI monitoring did not much consider data warehouse technology (Balakrishman, Mei, Kia& Saw, 2011;Suryadi, 2007;Albert, 2014). Balakrishman, Mei, Kia and Saw (2011) on university KPI monitoring employed a simple data base technology like MySQL, Suryadi (2007) used a quantitative analytical method called Analytic Hierarchy Process (AHP), and Albert (2014) was on using Balance Score Card. Though not on university's KPI monitoring, Jian,

Xiangdong, Zhihui and Jin (2009) proposed a business performance management cycle for analysing KPI accomplishment in supply chain management. Notably, each of these studies acknowledged the progress made so far in KPI monitoring, but recommended the need for more sophisticated technologies or techniques to attend to the diverse and volume of organisational data.

Therefore, the universities need a goal-BI and a suitable data warehouse schema specifically for University's teaching and learning KPIs. Its influence on the KPIs attainment and the realization of the organisational goals can then be easily monitored. It is also suggested that such system will provide better KPI-monitoring ability than the currently used system. Thus, developing a data warehouse schema using goal-oriented requirement design approach for the monitoring of the university teaching and learning KPIs is necessary.

1.5 Research Questions

The research questions to be answered by this study are as follow:

a. How to design data warehouse schemas for monitoring university teaching and learning's KPIs?
b. Does the proposed data warehouse schema correct for monitoring university teaching and learning's KPIs?

1.6 Research Objectives

These are the objectives to be achieved by this study

a. To develop a data warehouse schema for monitoring university teaching and learning's KPIs using GRAnD approach.
b. To evaluate the correctness of the proposed data warehouse schemas for monitoring university teaching and learning's KPIs.

1.7 Scope of the Study

Considering the complexity of university goals, the volume of the related data and the varieties of the departments involved in the overall decision making, setting the scope for this study is essential. The UUM vision and mission statement of the University goals is the focus of this study. This is because the university is also in need of goal-oriented BI that will be in monitoring its KPIs, and evaluate the university's developmental progress.

This study concentrates on teaching and learning sub-goals from the university main goals. Therefore, this study focuses on teaching and learning related KPIs. It is noteworthy that teaching and learning are important drivers for university success. Moyle (2010) posited that teaching and learning are part of utmost priority of the education ministries. Also, the quality of the university graduates –which is a direct representation of its quality of teaching and learning- is mostly seen as the measure of the university's performance.

The concept of BI used in this study is data warehousing. This implied that data warehouse schema is proposed. The choice of data warehouse is because of its sophistication in exploring diverse operational data sources.

1.8 Significance of the Study

This study delivers data warehouse schemas usable as BI for monitoring university teaching and learning's KPIs. Its implementation will help in the decision making process of the universities. The theoretical contribution of this study is the data warehouse schema with as its requirements specification designed using an extend form of GRAnD i.e. ReGADaK which specifically illustrate and highlight how KPI analysis can be done from goal analysis. This aids the realisation of a usable, goal-focussed, functional and result-oriented strategic decision support system for KPI monitoring. It is part of the major contribution of this study.

This study would assist in understanding the university goal-focused strategic planning using the related performance monitoring indicators for the teaching and learning department. It will also serve as a timely research conducted for the purpose of strengthening and improving the university strategic decision making process.

1.9 Summary

This chapter serves as the introduction of the background of this study; the motivation and the problem to be attended to are also highlighted. The aim of this research is to present a goal-oriented data warehouse schema usable in the development of a university strategic decision support system for the monitoring of university teaching and learning's KPIs. The use of goal-oriented and BI is to ensure that the university goal, which is mainly incorporated in the vision statement, is accomplished through the deployment of the proposed data warehouse schema. Chapter 2 discusses the literature related to BI-based decision making, Goal-oriented requirement analysis, data warehouse model and KPIs for university.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents the University goals and its usage in strategic planning. Also discussed are BI-based decision making process generally and specifically to universities. The role of Key Performance Indicators (KPIs) and how these can be used in the design and development of a BI tool is also discussed. Goal-oriented requirement analysis, its modelling language, and advantages as method of achieving BI are also highlighted. The process of Goal Requirement analysis using KPIs for university decision making mechanism is also presented. Finally, the implication of these techniques and concepts to the actualization of this study's objectives are discussed.

2.2 University and its Goals

The university goals are the reflections of its mission statement and projected vision. They are periodically designed and revisited in line with the university future and the path to be taken for its actualization. Universities, as the topmost knowledge creation community, are always with their respective vision and mission statements. According to a University Foundation Centre, Non-Government Organization (NGO) that addresses the need for remarkable developmental growth among universities, the vision statement expresses the optimal goal of the university while the mission statement gives an overview of the plans and strategies that must be deployed to realise the set goals (vision). These statements are directly and indirectly pivotal to

the growth and development of the university because they consciously guide all activities of the university.

From example, the University of Edinburgh has its vision as “to recruit and develop the world’s most promising students and most outstanding staff and be truly global university benefitting society as a whole.” In consonance with the vision statement, the mission is “creation, dissemination and curation of knowledge,” and the proposed steps of actualizing are expectedly outlined. From this, it can be abstracted that University of Edinburgh’s goal is to become “world’s most promising students and most outstanding staff global university.”

In UUM’s case, the vision statement is “to become a leading management university”, and the mission statement states “To implement Universiti Utara Malaysia as a well-known centre of excellence in learning, teaching, research, publishing and consulting in the field of management on an ongoing basis in order to produce human capital who is capable and committed in developing the country and humanity”. The goal can also be succinctly stated as “becoming a leading management university”. To achieve this main goal, the university often designs periodic developmental blueprints that target specified sub-goals within the university overall interest.

2.3 Strategic Information Use in University and the Role of Key Performance Indicators (KPIs)

The central goal (vision statement) of universities is always simplified to narrow sub-goals that form the basis of periodic strategic plan (e.g. Vision 2020, Strategic plan 2012-2016, among others). These period-specific developmental goals are always designed in a way that when aggregated, they achieve the ultimate goal (vision statement) of the universities. Also, they are often employed in measuring and assessing the performance of each periodic target. It therefore serves as self-examination template for the developmental blueprint of the universities. At these instances, designing key performance indicators (KPIs) becomes important components of organisational performance projection and a monitoring technique.

KPIs are financial and non-financial indicators that organizations use in order to estimate and verify how successful they are, by aiming the previously specified goals. Appropriate selection of indicators that will be used for measuring these goals is of greatest importance (Velimirović&Stankovića, 2010). As Peter Elwin commented in the PriceWaterHouseCooper report, KPIs help companies on the information needed for the real understanding of corporate performance (TELUS, 2006). Therefore, organisations generally, and universities specifically, in the bid of achieving their goals and sub-goals, as the case might be, need to design revisable KPIs that will be used toward the projected target. In current terms, information needed in designing, projecting and monitoring the universities' teaching and learning KPIs, which is the needed tool towards the vision accomplishment, is becoming voluminous and diverse. Attending to this demands information system to support its understanding and subsequent decision support.

For example, if the university management is to decide whether recruiting graduate students from countries that have English language as their national language will be better than offering scholarship to all graduate students, irrespective of their country of origin, there must be understanding in the association of these decision data variables before a right decision can be made. This is a typical example of decision bottleneck when the university has a sub-goal of increasing its publication base which is indexed in reputable databases. According to Vessey (1991), the cause-effect analysis of each of these decision alternatives will improve the probability of goal accomplishment.

Sinclair and Zairi (1995) mentioned that KPIs, commonly referred to as KPIs, are used to measure the progress towards organization's goals or mission. After the organization identifies its goals, KPIs are derived to measure the business progress against these goals. In other words, KPIs reflect the organizational goals. However, each KPI should be based on a criterion, which will make it more suitable for analysis purpose. Shahin and Mahbod (2007); Doran (1981), inclined towards using the SMART criteria mainly for defining objectives. Because of KPI are derived from organizational goals and by the nature and definition of KPI, it should follow the S.M.A.R.T criteria:

i. Specific – it has to be specific to an area as it is linked to a process, functional area or preferably an objective.
ii. Measurable – it should be measurable, otherwise it won't indicate anything
iii. Assignable – it has to be assignable, otherwise it won't be measured
iv. Realistic – setting targets is inherent in the documentation and use of KPIs.
v. Time - it is involved in the measurement process.

Gorbach et al. (2006) mentioned that KPI consists of target value and actual value where by target value represents the success goal. To determine the progress of success, the actual values are compared to the target values. Because KPI can summarize large amount of data to a single value, the managers used it to monitor the business performance. Furthermore, KPIs provided a new advance functionality to help the decision-makers with their job, by integrating business metrics into DW solutions using BI applications.

Ranjan (2005) noted that the KPI is visualized in form of KPI dashboard as one of the important keys of BI, which represents performance management in a user friendly manner. KPI dashboard is contained some features: Interface, Role Based View, Reports, Charting and Graphing and Pre-defined Performance Metrics. Technically, it is reflected multi managerial reviews by giving the ability to drill-down details. BI Dashboard is similar in function to a car dashboard. It displays and provides access to the powerful analytical systems and key performance metrics in a form enabling business executives to analyze trends and more effectively manage their areas of responsibility. In another word, dashboard converts the complex data into a meaningful display such as charts, graphs, and gauges. Therefore, it eliminates the needs to several reports by giving a clear picture about the business performance in its critical area. Indeed, it allows the managers to drill-down data to give deeper analyzing.

On the other end, the essence of using goal-oriented methodology in the design of BI framework, especially, the data warehouse schema is that it allows due consideration of the organisation goal, simplified into manageable scopes, and in respect to the

stakeholders involved. Goal-oriented methodology of requirement analysis and design for BI supports analysis of worst case scenarios, what-if scenarios, cause-effect linkage of the organisational data with the KPIs as performance target and monitoring mechanism. This allows the decision makers to know success rate of the decision path to be taken, and a possibility for revision (Giorgini et al., 2008; Pourshahid, Richards, &Amyot, 2011). When this is connected with the KPIs, (for example, the graduate students has a number of publications that must be made before s/he can graduate), the setting, monitoring and aggregation are always instrumental to the goal accomplishment. This is one of the needs of BI framework that is designed through a goal-oriented methodology.

2.4 Business Intelligence and Goal-oriented Requirement Analysis and Design

Generally, BI-based strategic information system is used frequently in the organisations due to the competition in the business environment and the necessity for forecast, predictive analytics, and reporting (Schläfke, 2013; Viaene& Van den Bunder, 2011). This typical information system also has the capability of entailing comprehensive analysis that supports decision making or devoid of multifaceted statistical models. The system also identifies the actionable insights of organization through the processes of management; from planning, to operation and evaluation. In doing this, high cost would be reduced and the organisational resources would be well-utilised (Viaene& Van den Bunder, 2011).

The Business Intelligence (BI) importance towards the design of information system is not deniable. BI is a decision making technology formed in other to assist professional workers including executives, managers and business analysts to make a

better and faster decisions (Chaudhuri, Dayal, &Narasayya, 2011). Earlier studies have shown the BI capability in the transformation of data into information that could lead to making a better decision (Golfarelli, Rizzi, &Castenaso, 2004). BI entails several important components for supporting its operation. It extracts valuable data from sources of operational data with various platforms because of its inbuilt data processing technology. Also, these data can be extracted using various processes, transform, cleanse, and load into the data warehouse then integrate into subject oriented tables and chronological series. In information retrieval, this process is how BI supports analysis and mining of data and information.

For the decision support process, BI tools utilize dimensional model of the data, with data models that are designed in respect to the organisational goal specifications (Pourshahid, Richards, &Amyot, 2011). BI entails several important components for supporting its operation. It extracts valuable data from sources of operational data with various platforms because of its inbuilt data processing technology. Using Online Analytical Processing (OLAP) technology, these data can be extracted using various processes. They can therefore be transformed, cleansed, and loaded into the data warehouse. These can be integrated into subject oriented tables and chronological series. The sophistication of BI is determined by the correctness of the data, the appropriateness of the data warehouse schema and the precision in its OLAP technology (Connolly & Begg, 2010). It is therefore important to design the appropriate components for the goal-oriented data warehousing analysis and design, and identify sources and nature of the operational data.

This typical information system also has the capability of entailing comprehensive analysis that is supporting decision making amidst or devoid of multifaceted statistical models. The system also identifies the actionable insights of organization through the processes of management; from planning, operating, to evaluation. In doing this, high cost would be reduced and the organisational resources would be well-utilised (Viaene & Van den Bunder, 2011).

Achieving a BI-based strategic information system design, the process of requirements engineering through the three mainstream approaches -Goal-oriented, User-oriented and Data-oriented –must be used (Golfarelli, Rizzi, & Castenaso, 2004; Nur Hani, Jamaiah, & Aziz, 2013). The goal-oriented approach in the organisational goal analysis is always the basis for the data-driven decision support process. The determinant of the befitting data in the BI design and modelling is determined by the chosen and analysed organization goal. Also, data-oriented approach is referred to as supply-oriented approach. It begins with identifying the data available in the organisation and how they are applicable into the analysed process during the decision making. It can also be applied to resolve issues that are related to data redundancy, so as to ensure a valid and logical schema data. The approach of user-oriented approach is the potential users' involvement in the BI information system modelling, design and development.

The BI framework also known as BI architecture is the reference point of BI solutions development (Eckerson, 2003), The model points to: (1) the steps to be taken in BI solutions design. (2) The components summing to BI tool (John, 2007). BI architecture comprises of four different components known as: data warehouse

(DW) or its component like data mart, business performance management (BPM) which are the model that resonates with the organisational goal, business analytics (BA) and a user interface.

Notably, BI success is aided by data warehouse, particularly the medium-to-large types. It accommodates organized and summarized data with the aptitude of permitting users of data viewing and manipulation, and conforms to the information needed for supporting business decisions. The business analytics deals with all tools types that will be used to manipulate and analyse the data warehouse and mining of data. The sophistication of BI tool of decision support is based on the transformation of data to information by these tools (Connolly & Begg, 2010). Business performance management (BPM) is the corporate performance management, among all the composing applications and tools in BI. Finally, the analysed data (i.e., information) will be displayed using the visual and graphical representation through the user interface. This information is communicated to the users visually, subsequently presenting the interpreted information (Few, 2006). Figure 2.1 presents the BI architecture diagram.

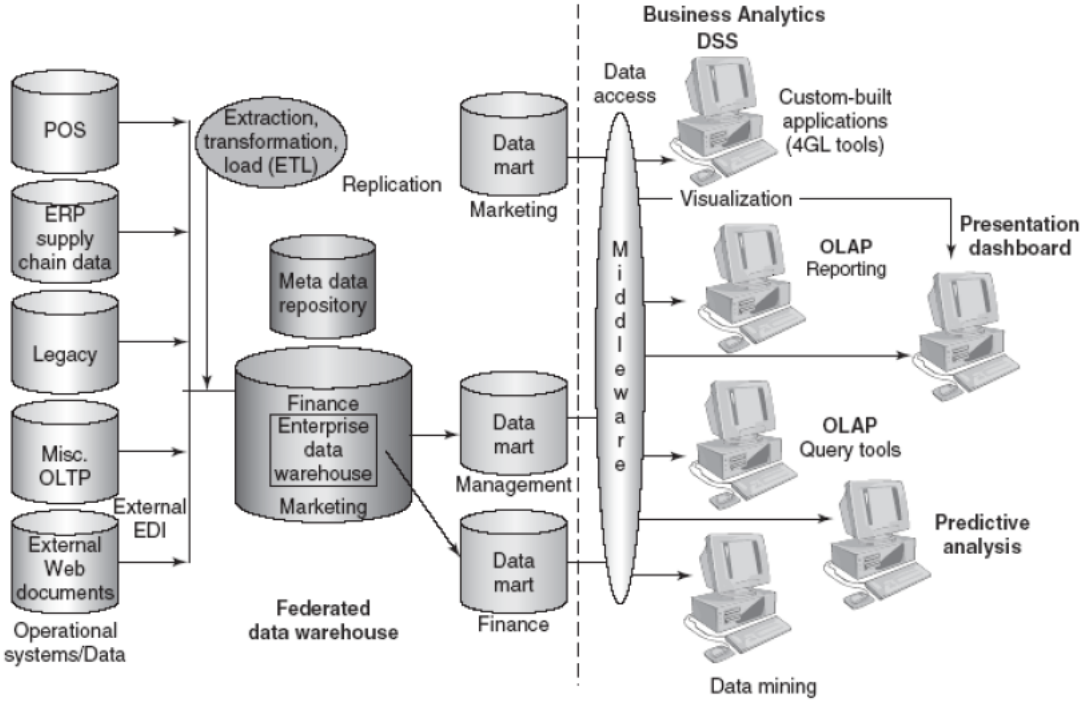


Figure 2.1. BI Architecture Diagram (Source: Turban et al., 2007)

In this study, an all-encompassing design methodology, involving data, users and goal oriented approached will be employed. The data will be the organisational monographs, documentations and publications that contain information regarding the specific goal that is attended to by this study. Also, the users, who are both the university decision makers, and the university strategic information department staffs will also be involved and engaged through interview sessions. First is in the design process at the pre-design through requirement elicitation and second is the post-design stage through the evaluation of the system designed. In the BI-based information system design, the modelling and development must be done with due attention to the overall compliance with the BI framework (Nur Hani, Jamaiah, & Aziz, 2013).

2.4.1 Requirement Analysis in BI Modelling

BI-based strategic information system, just as other software tools needs requirement analysis. IEEE (2004) defines software requirement as a property which developed or adapted software must exhibit to solve a particular problem. Thayer and Dorfman (1990) also defined software requirement as the capability of software needed by the user for solving a problem, or achieving an objective. The software capability must be possessed by a system or its component to satisfy a standard, contract, specification, or other formally imposed documentation. Therefore, requirement analysis is pertinent to achieve this set of software requirements.

Requirement analysis processes focus on the transformation of informal statements of user requirement, which are either user-driven or data-driven, into a formal expression or conceptual diagrams. This is to be done in a manner that the user requirements elicited and analyzed from the process are both in compliance with the organization and decision-makers perspectives (Prakash & Gosain, 2008; Giorgini et al., 2008). These requirements will be mapped with the available data sources, with due attention to the organisational goals, and used for the data integration and analytic stages.

Requirement engineering ensures that the system is designed with the required standard and alignment with the system's expected functions. Shams-Ul-Arif et al. (2010) and Tsumaki and Tamai (2005) reported that a sound process of requirement engineering is a requisite to having a functional and usable system. Requirements analysis has to do with identifying the stakeholders and their intentions on the needs

of information. Literatures on software engineering widely accept the fact that requirement analysis will considerably reduce the misunderstanding of user requirements (Mazon et al., 2005; Yu, Giorgini, Maiden, &Mylopoulos, 2011). BI modelling is built on two different requirement analysis perspectives: i) organizational modelling, concentrating on stakeholders; and ii) decisional modelling, focusing on the decision makers. The goal focus is the central point between these two perspectives, because the stakeholders are essentially working for the attainment of the organization's goals. The requirement model is always designed with the standard modelling language. The departments attached to the teaching and learning goal of the university are to be focussed for the organisational modelling of this study while their top officers are to be analysed for the decisional modelling.

2.4.1.1 Organisational Modelling

In its functional settings, the flow of information begins from the organizational perspective that was identified from the organization goals. Then, the information is determined by decision-maker in order to satisfy the organization goals. Finally, the information determined by the decision-maker derives the data integration and transformation process for providing the data.

Organizational modelling is employed for identifying organization goals, which must be satisfied by BI tool (i.e., facts). It made up of three different analyses produced in the iterative process. They include: i) goal analysis: the actor diagrams and rationale diagrams are produced; ii) fact analysis: the goal rationale diagrams are extended with facts; and iii) attributes analysis: the fact rationale diagrams are extended with

attributes. All goals, facts, and attributes are defined using individual context and organization views.

2.4.1.2 Dimensional Modelling

The conceptual data model in BI is a representative of the important entities and the association existing between the fact and dimension structure. It has been accepted widely in modelling and is refers to as dimensional modelling (DM) or multidimensional modelling (MDM) (Ponniah, 2007; Rizzi, 2007). The business dimension concept is a key definition in dimension modelling. In the real world, the business definition should be understood as the required information derived from the events sets (Rizzi, Abello, Lechtenborger, & Trujillo, 2006). In modelling, this concept is known as fact and contains the measures on specific users' requirements and dimensions which provide the description about the measurement. The dimensions can be determined in the hierarchy which has a connection among the attributes. The BI model is developed with the help of the database for supporting the conceptual and logical data model for implementation in the BI strategic information systems physical entities. The whole entries specification, based on the implementation platform (database, servers, etc.), is defined in the physical data model for the system implementation, and modelled by following the goal modelling activities.

2.4.2 The Goal Modelling Activities

The modelling activities are done to obtain as much information as possible about the system from an early requirement toward its refinement and with modelling

(diagrammatic representation) that unambiguously represents the system process evolution. The activities include actor modelling, goal modelling, dependency modelling, and plan modelling.

i. Actor modelling

This is done to identify and analyse the system actors and its environment. The modelling particularly concentrates on the application domain modelling and their intentions as social actors for achieving the goals. In each developmental phase, the modelling focus will change in accordance with the objective of the development phase. Stakeholders are modelled as business actors which are dependent on other actors for fulfilment of goals, plan under execution, and resources which are to be utilized (Bresciani et al., 2004).

ii. Dependency modelling

This involves dependencies identification between two actors, where by one actor is a dependent on another actor for goals achievement, plans to be executed, and resources to be furnished. The modelling work particularly concentrates on the goal dependencies between social actors within the settings of the environment. Similar to actor modelling, the modelling focus will undergo changes in accordance with the development phase objective.

iii. Goal modelling

This is to identify the goals for the actor, and conducts the goal analysis from views of the actors. Basically, the goal analysis is performed using reasoning techniques e.g. MEANS-END analysis, Contribution Analysis, and/or decomposition. The

application of goal modelling is in the early and late requirement model for refining and obtaining new actors and dependencies.

iv. Plan modelling

This isas an analysis task for supporting the goal modelling. All the reasoning techniques can be applied for analysing the plan and sub-plan to achieve the goals.

Modelling language is the graphical notation used in the analysis and modelling of goals, either for business or organisations, or both. Notably, goals are high-level objectives of any organisation, and goal-oriented approaches to system development have been acknowledged by the requirement engineering community (Yu &Mylopoulos, 1998). The goal modelling languages possess the ability to relate requirement, the processes and the suitable solutions that fit in into the business context. It can also analyse trade-off, thus supports development of software that are goal-driven (van Lamsweerde, 2009).

2.4.3 Data Warehouse Modelling Approach

The Data warehouse (DW) structure is normally defined during the database system design task. Practically, in order to satisfy the information need of the organization, the design approach is carried out by user application needs. The business process implemented by individuals in each department is used to derive the application needs. The database design concentrates on complying data for business processes transaction in the three modelling approaches, namely conceptual, physical and logical.

Chaudhuri and Dayal (1997) defined the Data warehouse (DW) as a place where the organization's data can be published so that the users can access it easily and quickly. DW is a collection of decision support technologies, aimed to make better and faster decisions. Data from all the source systems is transferred into DW through a process of ETL. During the ETL process, the information is cleaned and validated to be organized in a way that allow users to formulate their business questions and get their answers faster than using transaction systems. DW in design still uses relational databases, but uses a various approach to design a database schema that is called a dimensional model (DM).

2.4.3.1 Conceptual Modelling and the Star Schema Model

Conceptual modelling is a high level abstraction of defining solution for the problem by making use of terms, concepts and their relationships, as familiar to the users' application (Halpin, 2001; Olivé, 2007). Therefore, the earliest model for BI design is conceptual modelling. It captures the user requirements general specifications; data sources schemas, transformations of data, and data sources mapping. This helps in performing the data qualities integration and attributes towards the information system design. Hence, the modelling artefacts should be able to document and formalize the core engine of the BI system employing the star-schema model. Figure 2.2 depicts a star schema model.

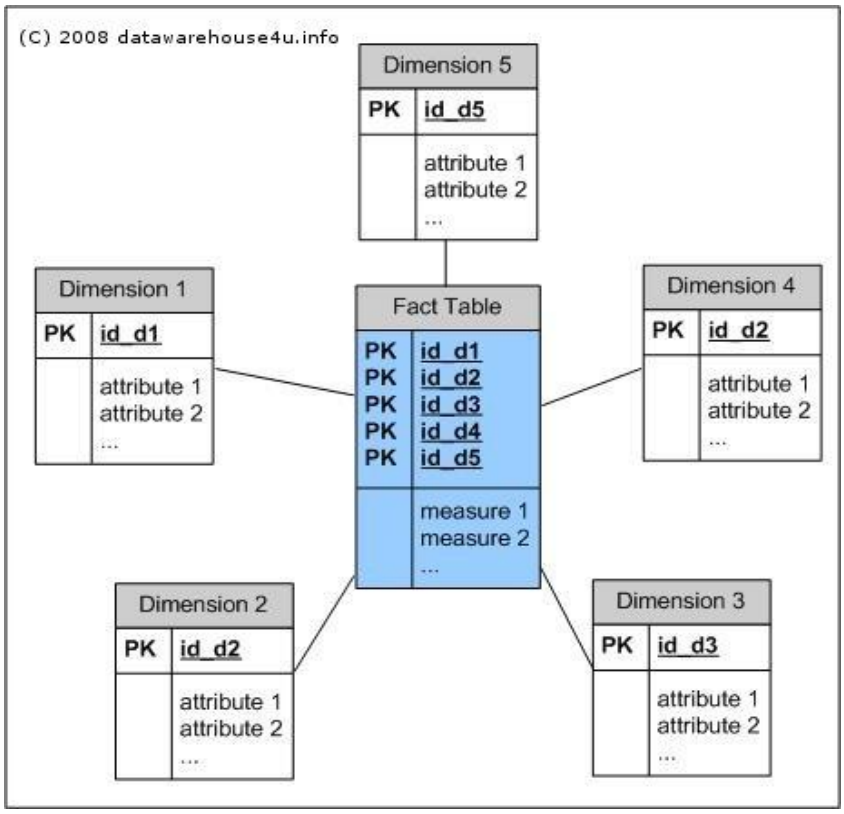


Figure 2.2. A Star Schema Model (Source: Data Warehouse Bulletin, 2008)

The star schema model represents the fact and dimensional modelling, with the entity-relationship (ER) linkage. In this study, for the BI-based strategic information system design, a star-schema is representing its data mart model by showing the fact and the dimensional tables needed for a comprehensive decision making activities that align with the analysed goal. For the process of the goal-oriented modelling, certain modelling activities are done, and these are discussed below.

2.5 Comparing GRAnD with other Requirement Analysis Approaches

Other requirement analysis techniques are Knowledge Acquisition in autOmated Specification (KAOS), Non-Functional Requirements (NFR), Goal-Based Requirements Analysis Method (GBRAM), and Tropos. Also are Unified Modelling Language (UML) as goal-driven approach, and SCenario based Requirements Analysis Method (SCRAM) as scenario-based approach. These other requirement analysis approaches are explained as follows:

KAOS: KAOS (Knowledge Acquisition in autOmated Specification) formal framework based on temporal logic and AI refinement techniques where all terms such as goal and state are consistently and rigorously defined(van Lamsweerde, 2009). The main emphasis of KAOS is on the formal proof that the requirements match the goals that were defined for the envisioned system.

NFR: Non-Functional Requirements (NFR) approach is based on the notion of soft goals rather than (hard) goals (Mylopoulos, Chung & Yu, 1999). A soft goal is satisfied rather than achieved. Goal satisfying is based on the notion that goals are never totally achieved or not achieved (Mylopoulos etal., 1999).

GBRAM: Goal-Based Requirements Analysis Method (GBRAM) defines a top-down analysis method refining goals and attributing them to agents starting from inputs such as corporate mission statements, policy statements, interview transcripts etc (Anton, 1996).

Tropos: Tropos is an agent-oriented software development methodology (Bresciani,Giorgini, Giunchiglia, Mylopoulos & Perini, 2004). This approach utilizes the concept of agent goal, and related notions are used to support all software development phases, from early requirement analysis to implementation (Giunchiglia, Mylopoulos & Perini, 2003). Tropos differs from other goal-oriented methodologies since it moves the notions of agent and goal to the early stages of software development (Giorgini et al., 2008).

Goal Driven Approach: UML Unified Modelling Language (UML) is a standardised general purpose modelling language (Tsui & Karam, 2007). It combines techniques from data modelling business modelling, object modelling, and component modelling (Windle & Abreo, 2003). It can be used with all processes, throughout the software development life cycle, and across different implementation technologies (Tsui & Karam, 2007).

Scenariobased Approach: SCRAMSCenario based Requirements Analysis Method (SCRAM) concern on scenario modelling. Scenarios are the representations of the real world(Sutcliffe, 2003). During requirements analysis the scenarios are generalized to models. Eventually these models and specifications get transformed into designs that are finally implemented (Misra, Kumar & Kumar, 2005). From DSS point of view, this method is suitable for simulation type of research where the elicitation approach were made through a series of iterative different scenarios (Uygun, Öztemel & Kubat, 2009).

GRAnD is chosen because it aligns with the objectives of this study. Its all-encompassing design methodology involves data, users and is goal-focused. The design process consists of requirement elicitation, followed by designing and modelling. The goal-oriented model will be applicable to BI-based information system design. This is done by ensuring that the strengths of goal-oriented modelling like explicit illustration of the association between the KPIs data variables, provision of alternative decision process, a cause-effect analysis of the decision options, and a formal specification that allows programmable conversion of the decision framework are incorporated with the BI framework.

In comparison with other modelling approaches in requirement analysis like Unified Modelling Language (UML), KAOS (Knowledge Acquisition in automated Specification) (van Lamsweerde, 2009), Non-Functional Requirements (NFR) (Mylopoulos et al., 1999), Goal-Based Requirements Analysis Method (GBRAM) (Anton, 1996), and Tropos (Bresciani et al., 2004; Giunchiglia et al., 2003), GRAnD remains the best because of the following:

a. Only Giorgini's et al (2008) GRAnD provides adequate formalisms and techniques to map high-level user's goals, design models and decision model.
b. Enhanced the current goal-driven approach by adding the decision modelling in DSS development.
c. GRAnD is purposely to design a data warehouse for DSS.
d. GRAnD integrates conceptual modelling and decision model in requirement analysis.

e. GRAnD takes the view that requirements should initially focus on the *why* and *how* questions rather than on the question of what needs to be implemented.
f. GRAnD is an extension of Tropos modelling technique which is a better framework compared to other RE techniques such as KAOS, i*, and Gaia.

On another end, other modelling techniques in requirement analysis phase (non-goal-oriented) are the scenario based approach and couple goals and scenario approaches which are concerned on simulation based system (Rolland et al., 1998). Based on the above explanation on requirement analysis, it is identified that goal driven approach is more suitable for modelling purposes due to scalability of features offered by the technique that ranges from early requirement to detailed design.

2.6 Data Warehouse Model and the University KPIs

Data warehousing evolved out of the necessity to access stored and structured organisational data that can be used for decision making. Achieving this is through the implementation of a defined process of accessing heterogeneous sources of data. The data is then subjected to cleansing, filtering, transformation, and then stored in a manner that can be easily accessed for usage and understanding (Ballard et al., 1998). The main import of BI concept in designing data warehousing is the need to ensure that users can make intelligence use of the stored data which is always dependent of the structure of the stored data. It is the storing of the data to meet the business rule of the organisation and its need that necessitate data modelling techniques.

The two data modelling techniques that are relevant in a data warehousing environment are ER modelling and dimensional modelling. ER modelling produces a data model of the specific area of interest, using two basic concepts: entities and the relationships between those entities. Detailed ER models also contain attributes, which can be properties of either the entities or the relationships. Dimensional modelling uses three basic concepts: measures, facts, and dimensions. Dimensional modelling is powerful in representing the requirements of the business user in the context of database tables (Ballard et al., 1998; Connolly & Begg, 2010). In GRAnD, measures, facts, dimensions, and attributes are parts of the data warehouse schema, a combination of what is obtainable in both ER and dimensional modelling (Giorgini, et al., 2008). This, with the organisational perspective that allows stakeholders modelling as actor in GRAnD, points to the additional strength in GRAnD, and its appropriateness for university data warehouse modelling.

Assessing some of the past related works on university's BI, amongst them are the design and development of a BI prototype usable by health practitioners in decision making carried out by Muraina (2011). Others are the requirement model for university library by Alwan (2012), and a general BI components for university's students data warehouse, but none on university teaching and learning KPIs, especially using GRAnD.

GRAnD demands the choice of the befitting data in the data warehouse schema, and this will be determined by the chosen and analysed organization goal. Hence, the first step will be the identification of the relevant data available in the organisation, their

sources and how they are applicable into the analysed process during the decision making. This will demand the usage of OLAP for aggregation from heterogeneous sources and filtering to meet the focus of the data warehouse schema which is teaching and learning-related KPIs. As earlier observed, facts are the integral part of BI models, and of data warehouse schema specifically. In this case of integrating data warehouse into KPIs management, the KPIs as organisation's operational information can adequately be served as the facts base for the data warehouse schema, and then, its attributes and measures are comprehensively analysed to achieve a functional schema. Also, to properly contextualize the state of university teaching and learning KPI monitoring system and strategies, a review of related previous studies is necessary. This is to properly highlight the gaps that this study intends to fill.

2.6.1 Previous Studies on University KPI Monitoring System and Strategies

Few of the studies that worked on different approaches of KPI monitoring by universities are Balakrishman, Mei, Kia and Saw (2011), Suryadi (2007), and Albert (2014). Each of these studies emphasised the need for KPI monitoring by the universities and devised methods or techniques that be taken for the exercise.

Balakrishman, Mei, Kia and Saw (2011) employed a simple database technology like MySQL for university KPI monitoring and PHP 5.2 as its scripting language. The online monitoring system which can be accessed remotely has a robust database for data storage. It is developed with intelligent algorithm that allows users to calculate raw data and produce charts and reports. The study posits that the system aids university performance improvement. The system allows the decision making body

to be acquainted with the progress made in the organisational goal set, and the system is a better tool compared to the previously known Excel spreadsheet-based system.

On another hand, Suryadi's (2007) work on KPI monitoring for university used a quantitative analytical method called Analytic Hierarchy Process (AHP). AHP was used weighing the KPIs which are derived based on the university key success factors that categorised into academic, research and consulting. The KPIs scores reflected the measurement results, and the system also provided a visualization presentation for easy users' understanding. Albert (2014) work using Balance Score Card for KPI monitoring also falls under the category of quantitative system.

As earlier highlighted, despite successes recorded by these previous studies on KPI monitoring systems and techniques for universities' performance improvement, employing more sophisticated technology like data warehouse is suggested. Data warehouse will allow extraction of data, and its processing from multiple data sources which are typical of university disparate data sources. Also, it can implement robust analytical algorithms which will be used in proper monitoring of the KPI and evaluation of the university performance measures. Also, designing such data warehouse technologies for KPI monitoring is more result-oriented through GRAnD. These are focuses and expected outcomes of this study.

The data warehouse schema can then support presentation of sound data models and variables that address the decision makers' goals (Nur Hani, Jamaiah, & Aziz, 2013). This is achievable through the integration of the goal oriented modelling and BI

concept to improving university decision making using its KPIs. This essentially is the focus of this study.

2.7 Summary of the Chapter

This chapter presents the literature review on university goals as often emboldened in its vision and mission statements. It further explains how these goals are connected with the periodic strategic plan of the universities and how they can be achieved through the usage of BI tools, using KPIs as fact components of the tool. The process of designing and developing these BI tools using the goal-oriented methodology is highlighted. Previous studies on KPI monitoring systems and strategies are also reviewed to underscore the focuses of this study and its expected outcomes. And in summary, the implication on the proposed data warehouse schema and the contribution to the literature gaps are presented for the monitoring of Universiti Utara Malaysia's KPIs. Chapter 3 discusses the research methodology. It highlights the processes and methods employed to achieve each of the study's objectives, and argue for the choice of GRAnD as a data warehouse design method. Necessary justifications in terms of instruments for data collection and choice of respondents are also discussed.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the process taken by this study to achieve its set objectives, and most importantly, the development of the data warehouse schema. The phases involved in the study and their respective methods are well-justified. Notably, the process and techniques involved in each of its phases are adapted towards the actualization of the research objectives. These are outlined and adequately justified.

3.2 Research Process

The purpose of this research is to improve the state of current practice as regards organisational usage of data for KPI monitoring. This study proposes a data warehouse schema which can be used in developing an information system for the purpose of monitoring university's teaching and learning KPIs. After this, the evaluation of the produced conceptual model is done through an expert review method. As earlier mentioned, the main objective of this study is to develop a data warehouse schema that could be used in developing a system that can monitor KPIs-related performance. The research process taken by this study is into five different phases. These are: Problem definition, Suggestion, Development, Evaluation and Conclusion. It is diagrammatically presented in Figure 3.1 below.

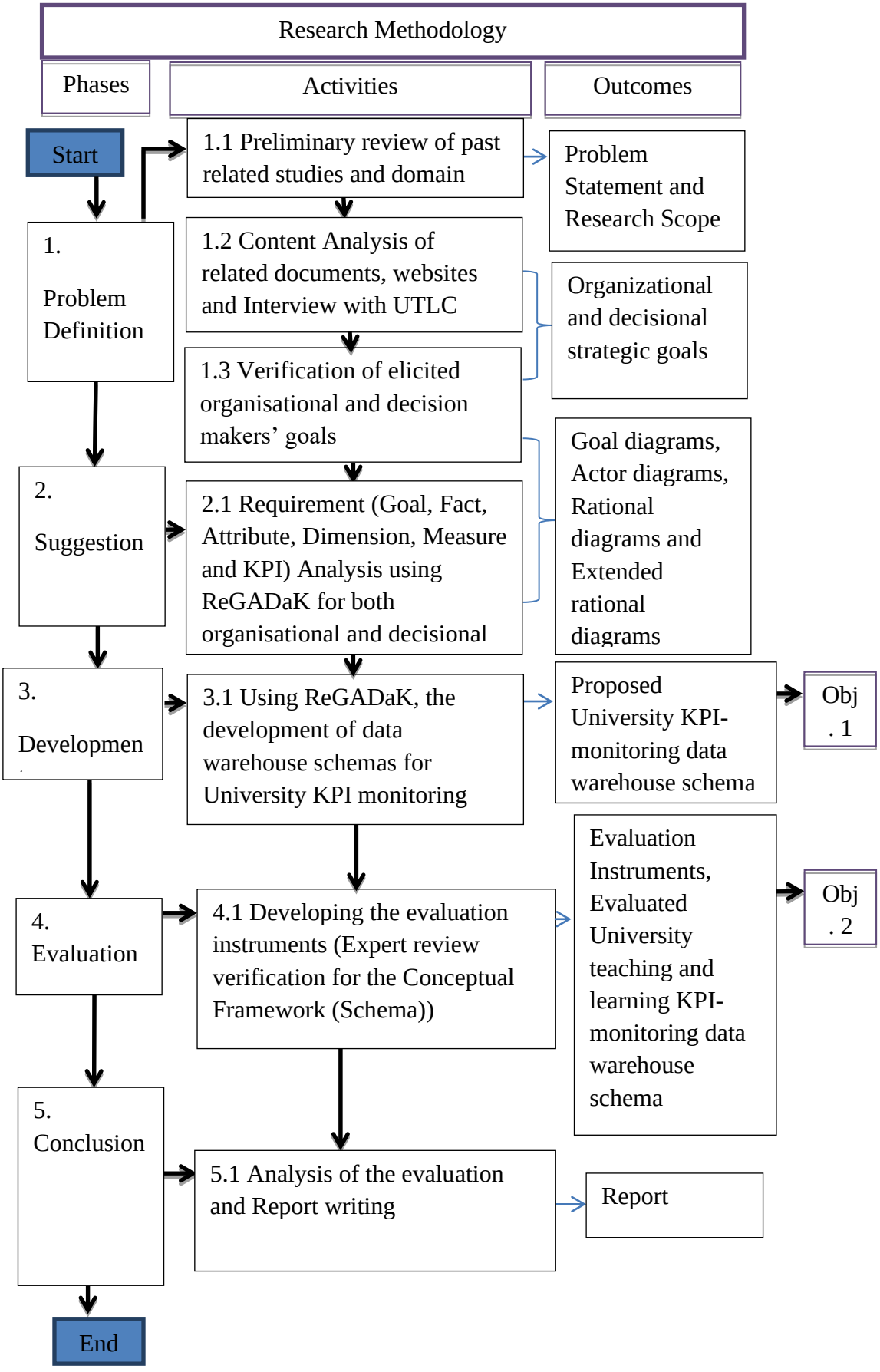


Figure 3.1. Research Phases

3.2.1 Explanation of the Research Phases

•Problem Definition: The research problems are investigated from the literature, as identified from industrial practitioners, and from the domain's body of knowledge in specifics. This justifies the purpose of the research.

• Suggestion: A suggestion of the technical know-how to be adopted or adapted to solve the earlier identified problem.

• Development: Implementation of the tentative design is done at this phase. This is basically dependent of the nature of the innovative product to be developed. This can be in terms of model, framework, algorithm and prototype.

• Evaluation*:* This is the evaluation of the innovative product or model that is developed. The evaluation is done on the basis of the criteria that are best suited for its purpose.

• Conclusions*:* This phase is the final stage of the research. Typically, the results are analysed and the findings are juxtaposed to check its linkage with the research objectives.

3.2.2 Justification of the Research Phases Explanation of the Research Phases

This study proposes a conceptual design framework which is an extension of Giorgini et al. (2008) GRAnD as one of its deliverables, and also a data warehouse schema for monitoring university teaching and learning KPIs. In view of this, the processes as illustrated in Figure 3.1 are justified according to similar works of Teegavarapuand Summers (2007) and Frankel and Racine (2010).The following subsections specifically state the methods involved in each of the research phase shown in Figure 3.1 above.

3.2.2.1 Phase I: Problem Definition

The objective of this phase is to justify the need for this study by highlighting the problem to be solved. Section1.4 in chapter 1 attends to this. Notably, the organisational goals of University Teaching and Learning Centre (UTLC), the associated stakeholders which are the decision makers and the decision makers' goals and respective sub-goals are identified ad this stage.

3.2.2.2 Phase II: Suggestion

The objective of this phase is to suggest the core components that will solve the earlier identified problem. Based on the identified organisational and decision makers' goals, requirement elicitation, requirement analysis and design are done to suggest the facts, attributes, dimensions, measures and KPIs of the organisation studied.

Requirement Elicitation

Notably, requirement elicitation process determines the users' need and goals for the system. Broadly, requirement elicitation can be defined as the goals' acquisition, constraints, and features for a proposed system by investigation and analysis (Coulin&Zowghi, 2005). Usually, before proceeding to the development of system, gathered information from the elicitation process has to be interpreted and elicited (Finkelstein, 1994).

This study employs the traditional technique for the requirement elicitation. According to Goguen and Linde (1993), traditional techniques are made of a broad

generic class of data gathering techniques including the questionnaires and surveys usage, interviews existing documentation analysis such as organizational charts, process model or standards and user or other existing systems manuals. This study employs content analysis of the UTLC website and related documents and technical papers on UUM's strategic goals to elicit the organisational and decisional strategic objectives.

The stakeholders (also known as actors), the organisational and decision makers goals are identified and verified by the Decision Maker and the Stakeholder in this unit.

Requirement Analysis and Design

As earlier hinted, Giorgini et al. (2008) GRAnD is specifically adapted for this phase. This step is essentially to produce the goal analysis, facts analysis, attribute analysis, dimension analysis, and measure analysis. From the measure analysis, this study extends to KPI analysis. Based on the sets of analyses done, goal diagram, actor diagram, rational diagram and extended rational diagrams are designed. These diagrams serve as the basis for the development of the data warehouse schema discussed in Section 3.2.2.3. The requirement analysis is done with both the organisational and decisional perspectives.

Requirements Analysis Based on Organization and Decisional Perspectives

Organizational modelling is made up of three different analyses which are interactively conducted. They include: i) goal analysis, this is where diagrams of actor and rationale diagrams are produced; ii) fact analysis, this is where the

diagrams of goal rationale are extended with facts. iii) Attributes analysis, this is where the fact rationale diagrams are extended with attributes. The definition of all goals, facts, and attributes are in the organization setting context. The goal analysis, fact, and attribute extraction approach is conducted sequentially and the goal, fact, and attribute information are captured accordingly.

The decisional modelling is however of four different analysis. These are: the goal analysis, the fact analysis, the dimension analysis, and the measure analysis. Based on argument and justification presented in Chapter 4 (section 4.2), the measure analysis serves as the basis for the introduction of the KPI analysis and the extension of Giorgini et al. (2008). The proposed GRAnD for KPI (ReGADaK) is discussed in section 4.2 and illustrated in Figures 4.1 and 4.2.

3.2.2.3 Phase III: Development

The objective of this phase is to develop the data warehouse schema that is usable for University's KPIs monitoring. The deliverables in the Requirement and Analysis Design stage are translated into the data warehouse schema with due attention to Giorgini et al.'s (2008) mixed design framework (See Section 4.5, chapter 4)

3.2.2.4 Phase IV: Evaluation

Requirement Evaluation

The requirement evaluation is into two folds –the verification and validation. The verification of the data warehouse star schema is to check the appropriateness of the schema components using the highlighted metrics. This is done through an Expert

Review method using a designed Expert verification instrument. The selected experts are in the field of data warehousing. Their profile is presented in Appendix D. Expert review is the evaluation method and this is justified by Rogers et al. (2011) and Shneiderman and Plaisant (2010).

Also, the design of instruments used for the expert review verification is further discussed in Section 3.4.

3.2.2.5 Phase V: Conclusion

This is the final phase. Its main objective is to write a report to highlight that the earlier identified problem has been solved by the study, stating the limitation and directions for future studies, where needed. This is essentially taken care of by this dissertation.

3.3 Respondents

3.3.1 Expert Review

The experts for the verification of the data warehouse conceptual model (schema) are from both the academics and professional practice. Their area of expertise is mainly data warehousing and business intelligence. This study uses three experts: two are practitioners and one is academic (See Appendix D). The sufficiency of three experts for verification is supported by Nielsen (1997). First, the verification instrument is designed based on chosen metrics. The details are presented in section 3.4.1. After the verification is conducted, the results are analysed. The details of the verification results are discussed in Chapter 5.

3.4 Instruments Used for Evaluation

Instrument used for evaluation is Expert Verification Instrument (See Appendix A).

3.4.1 Expert Verification Instrument

The expert review instrument is employed as a guide for the experts' verification and collection of feedback on the composition of the proposed data warehouse schema for monitoring university teaching and learning KPI. In this light, this study develops its evaluation metrics through the adaptation of Pedersen and Jesen's (1998) "Multidimensional Data Modelling of Complex Data." The metrics are: Explicit hierarchy, Symmetric treatment of dimensions, Multiple hierarchy in each dimension, Support for summary, Support for non-strict hierarchy, Supports for many-to-many relationship, Handling different levels of granularity and Handling uncertainty. According to Pedersen and Jesen (1998), proposed data warehouse schema must meet the listed criteria for validity.

The responses are collected through items with 5-point Likert scale of 1 (Not satisfactory), 2 (Fairly Satisfactory), 3 (Neutral), 4 (Satisfactory) and 5 (Very satisfactory).Table 3.1 presents the metrics, items and their respective explanations.

Table 3.1

Expert Verification metrics, items and their respective explanations

No.	Metrics	Items	Explanation
1	Explicit hierarchy	The model has explicit hierarchies in its dimensions	There is available relation between the different hierarchy levels of the model.

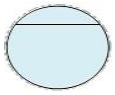
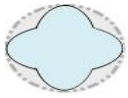
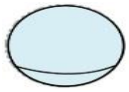
2	Symmetric treatment of dimensions	The model has symmetric treatment of its dimensions	The model allows summary attributes to be treated as dimensions
3	Multiple hierarchy in each dimension	The model contains multiple hierarchy in each dimension	A lower dimension can roll up to a higher one. Example: for time, days can roll up to months, to year.
4	Support for summary	The model supports correct summary	The model gives meaningful summaries to the user.
5	Support for non-strict hierarchy	The model supports non-strict hierarchy	The model has non-strict hierarchy because its members have cardinals
6	Supports for many-to-many relationship	The model supports many-to-many relationship between facts and dimensions	It supports many-to-many relationship between facts and dimensions
7	Handling different levels of granularity	The model handles different levels of granularity in summarizing properties	A dimension can be summarized by another item with granularity. Example: Grant accessed can be summarised by time, using date etc.
8	Handling uncertainty	The model handles uncertainty	The model identifies uncertainties in the fact set, entity set, attribute set etc.

3.5 Modelling Tools and Notations

OpenOME tool, DW-Tool 7-10, and Edraw are the software tools used in the designing of the diagrams presented as deliverables of the requirement analysis and design as illustrated in Chapter 4. The notations for these diagrams are presented in

Table 3.2

Notation for actor and rationale diagrams

No.	Symbol	Meaning
1		Actor (Agent type)
2		Actor (Position type)
3		Actor (Role type)
4		Goal
5		Dependency
6		AND decomposition

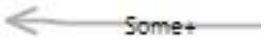
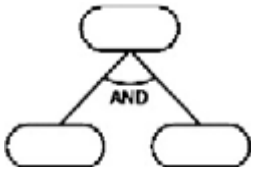
7		Some+ contribution

Table 3.3

Notation for Extend rationale and Further extend rationale diagrams

No.	Symbol	Meaning
1		Goal
2		Fact
3		AND decomposition
4		Attribute
5		Dimension
6		Measure
7		KPI (my proposed notation)

3.6 Summary of the Chapter

This chapter illustrates and describes, with due justifications, the research processes and phases taken in achieving this study's objectives. The methods and techniques involved in modelling and designing the goal-oriented data warehouse schema for monitoring the university teaching and learning KPIs are explained, and the evaluation process. With the process outlined in this chapter, the proposed data warehouse schema would conform to the standard and KPIs which are the operational information would be well-represented. The evaluation of the proposed data warehouse schema will be through verification using expert review. The adapted evaluation metrics are ensured to be in line with the objective of the study and justified with extant literatures.

CHAPTER FOUR

DATA WAREHOUSE SCHEMA FOR MONITORING UNIVERSITY TEACHING AND LEARNING's KPIs

4.1 Introduction

This chapter presents the proposed data warehouse schema for the monitoring of university teaching and learning's KPIs. It presents the goal analysis, fact analysis and attributes analysis as the prerequisite details of the proposed data warehouse schema, using GRAnD as requirement analysis and design approach. Importantly, the study extends GRAnD as a requirement analysis and design method to attend to KPI-focussed data warehouse schema. Notably, conceptual design of the data warehouse schema is developed from the requirement analysis of the university's teaching and learning department.

4.2 KPI-Focussed Data Warehouse Schema

Goal-oriented approach to requirement analysis in data warehouse (GRAnD) presented a generally-welcomed approach to analysing requirements and designing data warehouse using the goal-oriented method. These goals, as earlier explained, are the vision and mission statements of the organisations, which are often developed into strategic blueprint to implement for organisational growth and development. It is posited as a significant contribution to organisational decision support frameworks and one of the researches that suggested viable ways for meeting business objectives.

GRAnD, based on Tropos methodology, integrated two different perspectives for requirement analysis. These are organisational modelling, which centred on organisational stakeholders or organisation's representation, and decisional modelling that focused on decision maker perspectives. Tropos is an agent-oriented software development methodology, where agent, goal and other related notions are used to support software development. Thus, the GRAnD in the perspective of organisational and decisional goals are abstracted with appropriate notions and systematic analysis of the requirement to design the data warehouse.

The goal analysis in both organisational and decisional modelling produces respective rationale and actor diagrams, and followed by fact analysis where the facts are presented. However, in organisational modelling, fact analysis is followed by attribute analysis to produce the attributes, but followed by dimension analysis in decisional modelling to produce the dimensions. Organisational modelling's final product is extended rational diagrams after the attribute analysis. In decisional modelling, measure analysis follows dimension analysis, and there, measures are produced. Its extended rationale diagrams are them produced. The extended rationale diagrams from both the organisational and decisional modelling are integrated to design the conceptual model for the data warehouse, i.e. schema.

As remarkable as GRAnD's contribution is, this research opines that it must be extended for proper fitting into the objective of this study, which is KPI-monitoring for data warehouse schema. It is thus argued that KPI analysis to produce set of the organisational KPIs should only be extended from the measure analysis. KPI are practically definite measures, according to Iveta (2012). By being definite, it implies that it is given a particular, specific value, for deterministic performance measurement and evaluation (Teske, 2014).

For instance, a university can place number of publications as the performance measurement for its faculty members. In such case, number of publications is the measure of performance. However, when it is said that every faculty member must meet a yearly base of 2 publications, 2, for example, is a definite value to measure the performance set. Figure 4.1 presents the conceptualized KPI analysis model suggested and used by this study.

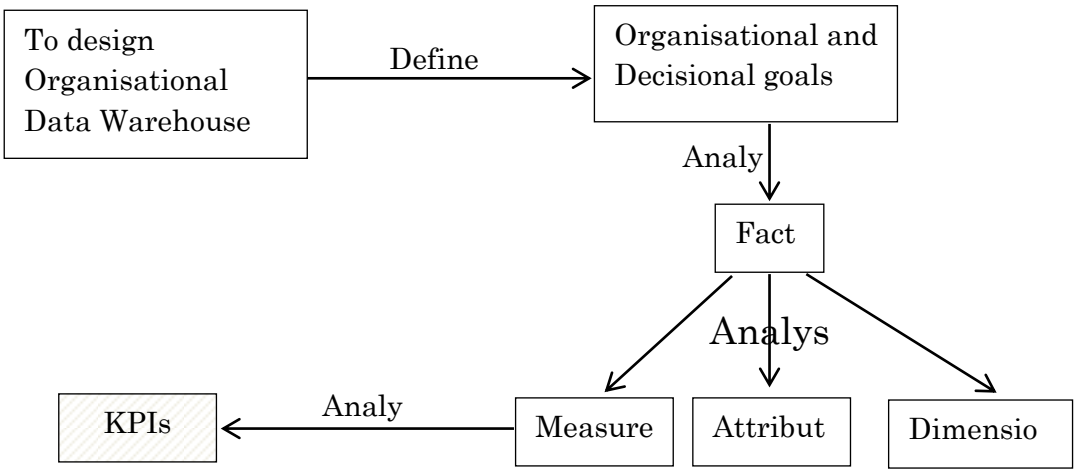


Figure 4.1. Conceptual Model for KPI Analysis

The KPI is analysed from the measure analysis, which serves as the extension of the GRAnD and the mixed design stage was undergone. According to Giorgini et al. (2008) in mixed design stage, the supply-driven and demand-driven facilities of the data warehouse schema are joined. The set of requirements analysed from both the decisional and organisational perspective are matched in respect to the source database. The phases involved are requirements mapping, hierarchy construction and refinement of the mapping. It is the extended GRAnD that is used by this study to develop a KPI-focussed data warehouse schema.

For the data collection form and the subsequent requirement analysis, the fact analysis is done through [Goal, Fact], attribute analysis is done by [Attribute, Goal, Fact], dimension analysis is done by [Goal, Fact, Dimensions], and measure analysis is done by the analyst associate a set of measures to each fact previously identified. Therefore, the KPI analysis is done in form of [Goal, Fact, Dimensions, Measures, KPI]. An extended version of GRAnD proposed by this study is thereby presented in Figure 4.2.

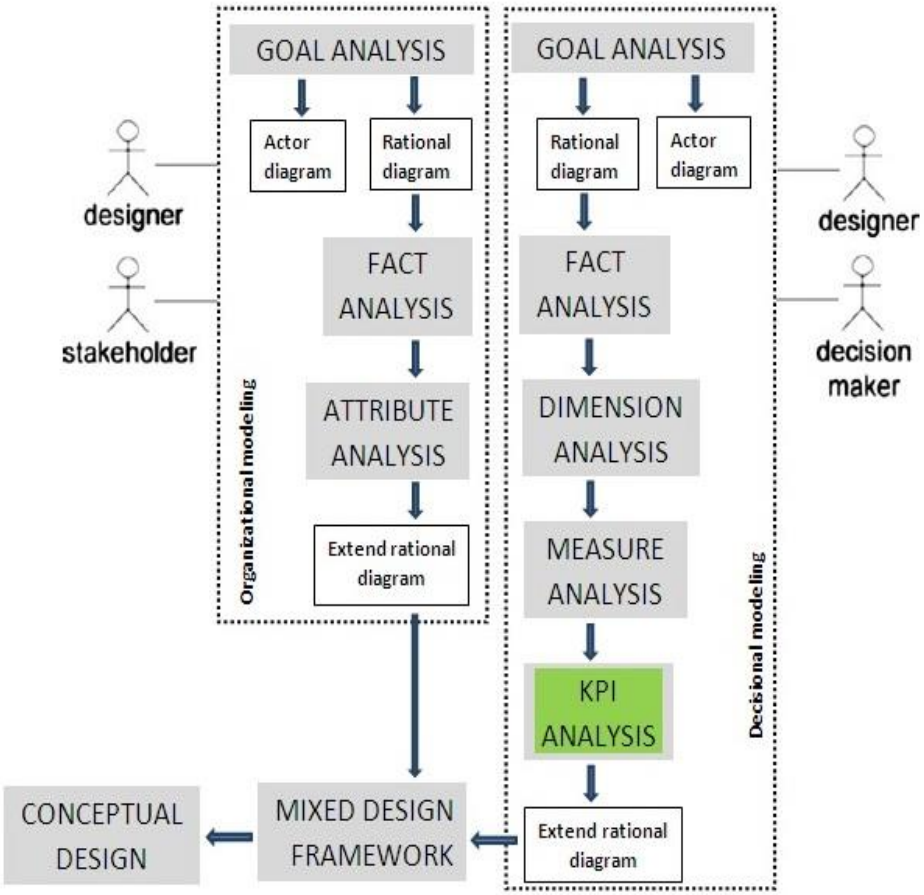


Figure 4.2. Requirement Goal Analysis for Data Warehouse KPI (ReGADaK) adapted from GRAnD (Giorgini et al., 2008)

4.3 UUM Data Warehouse Environment

UUM has a University Management Information System (UMIS), which provides the information as required by the students, operational staff, management staff, and Ministry of Higher Education (MoHE). UMIS houses other several applications which are also implemented in different databases. These applications are Graduate Academic Information System (GAIS), Integrated Financial and Accounting System (IFAS), Academic Student Information System (ASIS), and Personal Information System (PERSIS), Student Affair Information System (SAIS), and others.

This study focuses on design of data warehouse schema for monitoring university teaching and learning KPIs. Indeed, it proposes a data warehouse schema that is suitable for monitoring University's teaching and learning KPIs.

4.3.1 UUM's Goal-oriented Requirement Analysis

This study focuses on teaching and learning role of UUM using the ReGADaK. Its process would centre on stakeholders/actors, goals, facts, attributes and measures associated with the teaching and learning role of the university. Since the primary purpose of the proposed data warehouse schema is to capture the university's teaching and learning KPIs, the related KPIs academic activities of teaching and learning are determined based on the measure analysis.

4.4 Requirement Analysis for Data Warehouse Schema

ReGADaK used to analyse requirement analysis for the data warehouse is based in two perspectives: organisational modelling and the decisional modelling

perspectives. The organisational modelling emphasises goals of the organisational entities and units, while the decisional modelling emphasises the goals of the decision makers in the organisation in the requirement analysis and design. The development of the data warehouse schema is therefore based on the outputs of the requirement analysis.

4.4.1 Organisational Modelling

Organisational modelling is of three different phases. These phases are goal analysis, fact analysis, and attributes analysis of the gathered requirements. These phases, from the organisational modelling perspective are presented below.

4.4.1.1 Goal Analysis

The goal analysis starts from the main goal of UUM which is "*to become a leading management university*". Based on the university mission and vision statements, this main goal can be further divided into four sub-goals which are "*to be the centre of excellence in research*", "*to be the centre of excellence in publishing"*, *"to be the centre of excellence in consulting",* and "*to be the centre of excellence in teaching and learning"*. Figure 4.3 presents the university goals diagram.

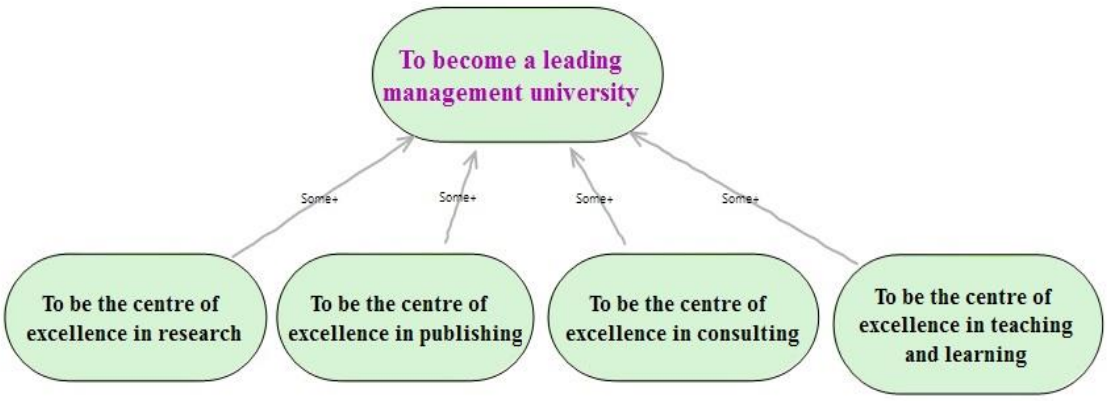


Figure 4.3. University Goals Diagram

The university goal diagram serves as the foundation for the building of this study's data warehouse schema. Based on the scope of this study which is data warehouse schema for monitoring university teaching and learning KPIs, the researcher's investigation identified that one of the departments given the responsibility of meeting the needs of technological innovation in teaching and learning is the University Teaching and Learning Centre (UTLC; with the motto: *"Transforming Teaching, Advancing Learning").*The main goal of UTLC is "*To transform teaching and advance learning."* Figure 4.4 presents the goal-oriented diagram for UUM goals, which contains the goal that related to teaching and learning managed by UTLC.

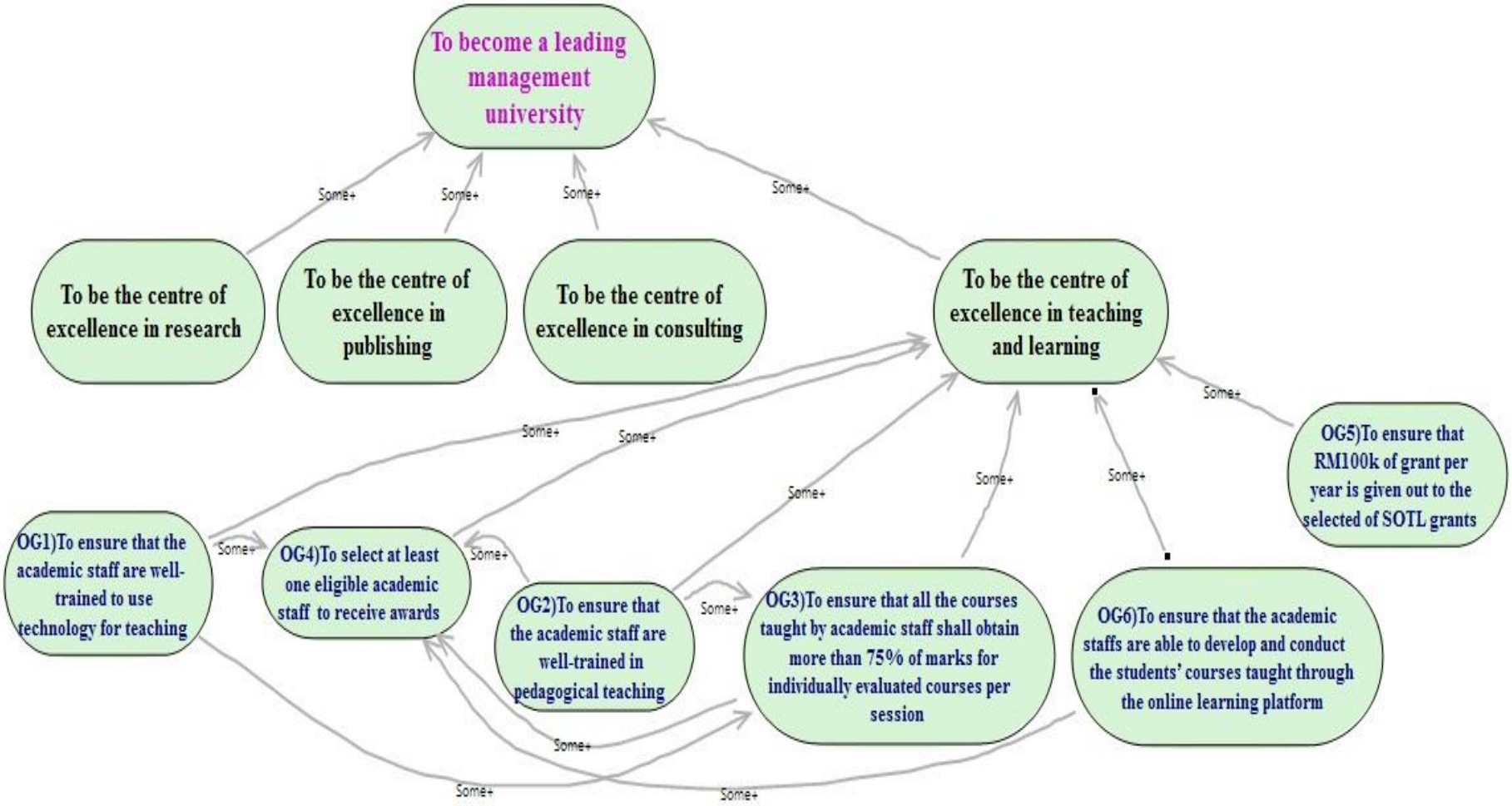


Figure 4.4. University's and UTLC goals

The main actor UTLC and the other main actors associated with the main strategic goals of UTLC are academic staffs and students. Table 4.1 presents the information about these main actors and their respective strategic objectives and goals.

Table 4.1

Main actors and their strategic objectives/goals

Main Actors	**Goal ID**	**Strategic objectives/goals**
UTLC	OG1	To ensure that the academic staff are well-trained to use technology for teaching
	OG2	To ensure that the academic staff are well-trained in pedagogical teaching
	OG3	To ensure that all the courses taught by academic staff shall obtain more than 75% of marks for individually evaluated courses per session
	OG5	To ensure that RM100k of grant per year is given out to the selected of SOTL grants
	OG6	To ensure that the academic staffs are able to develop and conduct the students' courses through the online learning platform
		To deliver excellent learning experience through innovative teaching
AcademicStaff		To receive excellent learning experience
	OG4	To select at least one eligible academic staff to receive awards

For the early requirement analysis of the proposed data warehouse, a content analysis of the department website (http://utlc.uum.edu.my) is done. To support this, an interview was conducted with assistant director and deputy head of the organisation. This is to identify the stakeholders/actors, goals, sub-goals, and dependency. The other needed information for the goal analysis of the proposed data warehouse schema, under the organisational modelling, is presented in Table 4.2 – 4.3, according to Giorgini et al. (2008). Table 4.2 presents the *Sub-Actor*, *Type* and *Goals* information, Table 4.3 presents the *Depender*, *Dependee*, and *Goals* information. The Tables 4.2 and 4.3 are to show the relationship between the actors with their goals and the relationship between the actors.

Table 4.2

Sub-Actor, Type and Goals information

Main Actor	**Sub-Actor**	**Type**	**Goals**
UTLC	Training and Research Unit	Role	To deliver excellent learning experience through innovative teaching
	UTLC committees	Role	OG1)To ensure that the academic staff are well-trained to use technology for teaching OG2)To ensure that the academic staff are well-trained in pedagogical teaching OG3)To ensure that all the courses taught by academic staff shall obtain more than 75%

		of marks for individually evaluated courses per session OG5) To ensure that RM100K amount of grant per year is given out to the selected of SOTL grants OG6)To ensure that the academic staffs are able to develop and conduct the students' courses through the online learning platform
Academic Staff	Agent	OG4)To select at least one eligible academic staff to receive awards To receive excellent learning experience

Table 4.3

Depender, Dependee, and Goals information

Depender	**Dependee**	**Goals**
UTLC committees	Training and Research Unit	OG1)To ensure that the academic staff are well-trained to use technology for teaching OG2)To ensure that the academic staff are well-trained in pedagogical teaching OG5) To ensure that RM100K amount of grant per year is given out to the selected of SOTL grants
UTLC committees	Training and Research Unit	OG3)To ensure that all the courses taught by academic staff shall obtain more than 75% of

	Academic Staff Student	marks for individually evaluated courses per session
UTLC committees	Training and Research Unit Academic Staff	OG6)To ensure that the academic staffs are able to develop and conduct the students' courses taught through the online learning platform
Training and Research Unit	Academic Staff	To deliver excellent learning experience through innovative teaching
Academic Staff	Training and Research Unit	OG4)To select at least one eligible academic staff to receive awards
Academic Staff	Student	To receive excellent learning experience

From Table 4.2, the types of the actors; Training and Research Unit and UTLC committees, and Academic Staff (an actor) are given as role and agent respectively. According to Yu et al. (2011), role characterises the behaviour of a social actor within as specialized context or domain of endeavour. Its characteristics are easily transferable to other social actors. On the other hand, an agent is an actor with concrete and physical manifestations. This can be human individual as we have in the Table 4.2 or software. The individuals mentioned in Table 4.2 act as depender and dependee as the circumstance demands. Based on the information provided in Tables 4.2 and 4.3, Figure 4.5 depicts the UTLC's actors' diagram from the organization perspective as a first result in goal analysis.

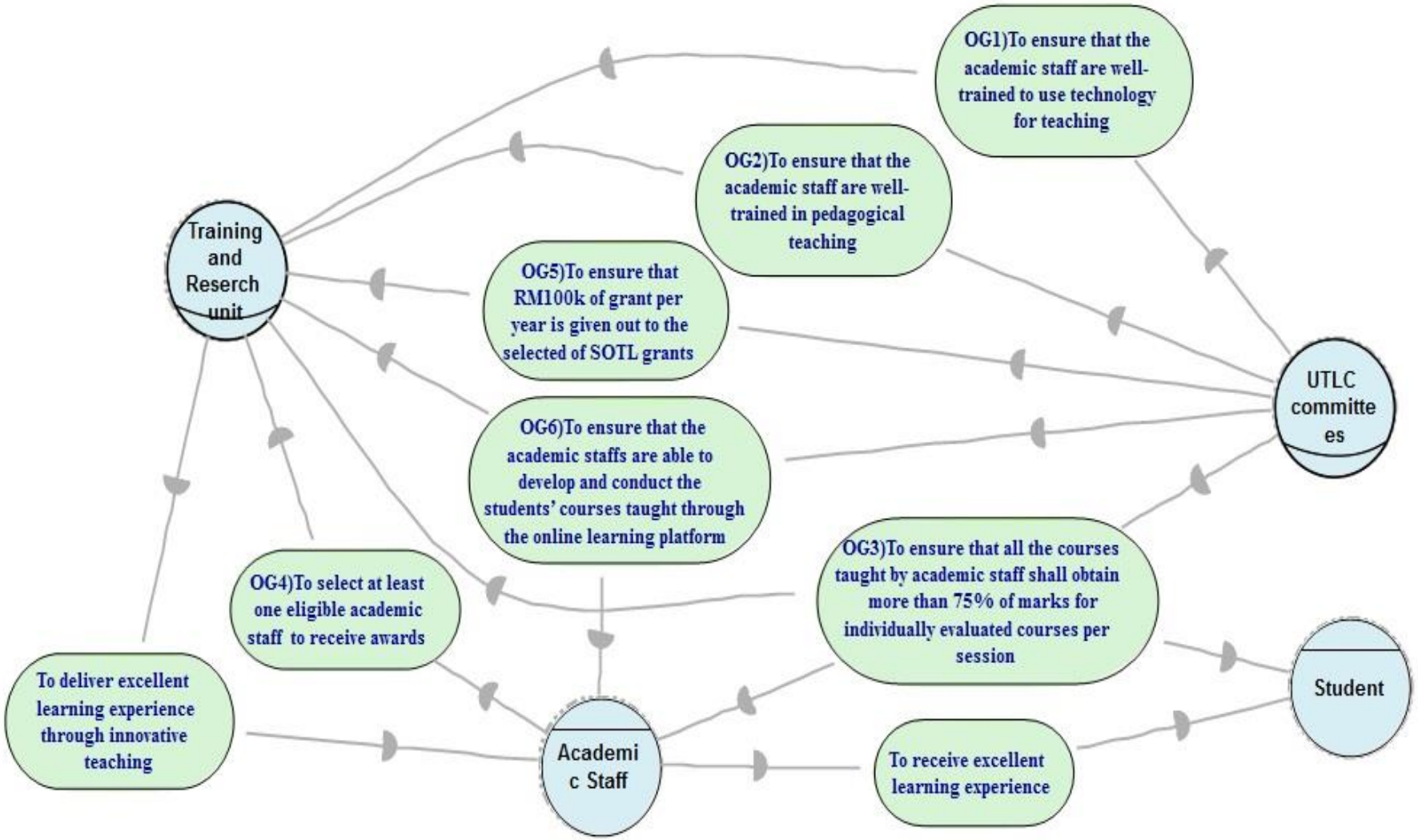


Figure 4.5. UTLC Actors' Diagram from the organizational perspective

Based on the information presented in Table 4.4, an extended goal diagram for the university goals –with the teaching and learning activities –is depicted by Figure 4.6

Table 4.4

Goal, Sub-goal, InContrib and OutContrib information

Goal	**Sub-goal**	**InContrib**	**OutContrib**
To be the centre of excellence in teaching and learning	OG1)To ensure that the academic staff are well-trained to use technology for teaching OG2)To ensure that the academic staff are well-trained in pedagogical teaching OG3)To ensure that all the courses taught by academic staff shall obtain more than 75% of		To become a leading management university

	marks for individually evaluated courses per session	
	OG4)To select at least one eligible academic staff to receive awards	
	OG5)To ensure that RM100k of grant per year is given out to the selected of SOTL grants	
	OG6)To ensure that the academic staffs are able to develop and conduct the students' courses through the online learning platform	

OG1)To ensure that the academic staff are well-trained to use technology for teaching	OG1-1)To ensure that all the academic staff acquire training through UUM online learning platform	To be the centre of excellence in teaching and learning
	OG1-2)To ensure availability of more than 25 training programs on technology usage every year	OG3)To ensure that all the courses taught by academic staff shall obtain more than 75% of marks for individually evaluated courses per session
	OG1-3)To ensure that all the academic staff acquires training using Web 2.0 tools	OG4)To select at least one eligible academic staff to receive awards

OG2)To ensure that the academic staff are well-trained in pedagogical teaching	OG2-1)To ensure availability of more than 25 training programs on pedagogy every year	To be the centre of excellence in teaching and learning
		OG3)To ensure that all the courses taught by academic staff shall obtain more than 75% of marks for individually evaluated courses per session
		OG4)To select at least one eligible academic staff to receive awards
OG3)To ensure that all the courses	OG1)To ensure that the academic	To be the centre of excellence in

taught by academic staff shall obtain more than 75% of marks for individually evaluated courses per session		staff are well-trained to use technology for teaching	teaching and learning
		OG2)To ensure that the academic staff are well-trained in pedagogical teaching	OG4)To select at least one eligible academic staff to receive awards
OG4)To select at least one eligible academic staff to receive awards	OG4-1)To ensure that at least one academic staff receives the DTA award	OG1)To ensure that the academic staff are well-trained to use technology for teaching	To be the centre of excellence in teaching and learning
	OG4-2)To ensure that there are academic staff who win the AAN	OG2)To ensure that the academic staff are well-trained in	

	award	pedagogical teaching OG3)To ensure that all the courses taught by academic staff shall obtain more than 75% of marks for individually evaluated courses per session OG6)To ensure that the academic staffs are able to develop and conduct the students' courses through the online learning platform	
OG5)To ensure that RM100k of grant per year is given out to the selected of SOTL			To be the centre of excellence in teaching and learning

grants			
OG6)To ensure that the academic staffs are able to develop and conduct the students' courses through the online learning platform	OG6-1)To ensure that the academic staffs are able to develop massive open online courses	OG1-1)To ensure that all the academic staff acquire training through UUM online learning platform	To be the centre of excellence in teaching and learning
	OG6-2) To ensure that the academic staffs are able to utilize the UUM online blended learning	OG1-3)To ensure that all the academic staff acquires training using Web 2.0 tools	
	OG6-3) To ensure that all the academic staffs are able to perform E-assessments on UUM online learning platform		

OG1-1)To ensure that all the academic staff acquire training through UUM online learning platform	OG1-2)To ensure availability of more than 25 training programs on technology usage every year	OG1)To ensure that the academic staff are well-trained to use technology for teaching
		OG6)To ensure that the academic staffs are able to develop and conduct the students' courses through the online learning platform
OG1-2)To ensure availability of more than 25 training programs on technology usage every year		OG1)To ensure that the academic staff are well-trained to use technology for teaching
		OG1-1)To ensure that all the academic staff acquire training

		through UUM online learning platform
		OG1-3)To ensure that all the academic staff acquires training using Web 2.0 tools
OG1-3)To ensure that all the academic staff acquires training using Web 2.0 tools	OG1-2)To ensure availability of more than 25 training programs on technology usage every year	OG1)To ensure that the academic staff are well-trained to use technology for teaching
		OG6)To ensure that the academic staffs are able to develop and conduct the students' courses through the online learning platform

OG4-1)To ensure that there are academic staff who receives the DTA award		OG4)To select at least one eligible academic staff to receive awards
		OG4-2)To ensure that there are academic staff who win the AAN award
OG4-2)To ensure that there are academic staff who win the AAN award	OG4-1)To ensure that at least one academic staff receives the DTA award	OG4)To select at least one eligible academic staff to receive awards

OG1-4 stands for Organisational goal 1-4, i.e. OG1=organisational goal 1, OG2 = organisational goal 2, etc. OG1-1 means Sub-goal 1 for Organisational goal 1, etc.

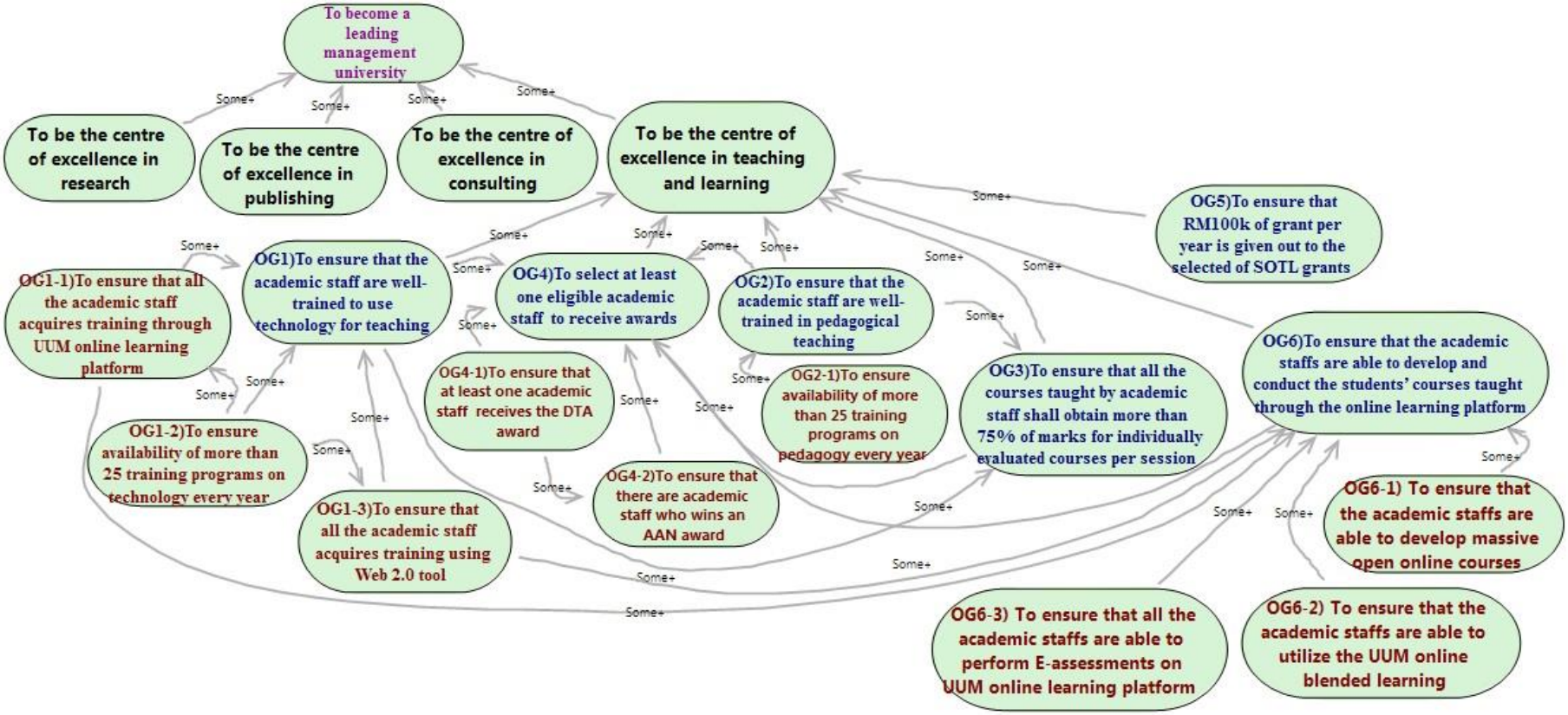


Figure 4.6. Extended Goal Diagram

For design the second result rationale diagrams in goal analysis, the goals are AND-decomposed and the contribution links (InContrib and OutContrib) between the goals are presented in figure 4.6. And the rationale diagrams are presented in Figure 4.7 – Figure 4.10

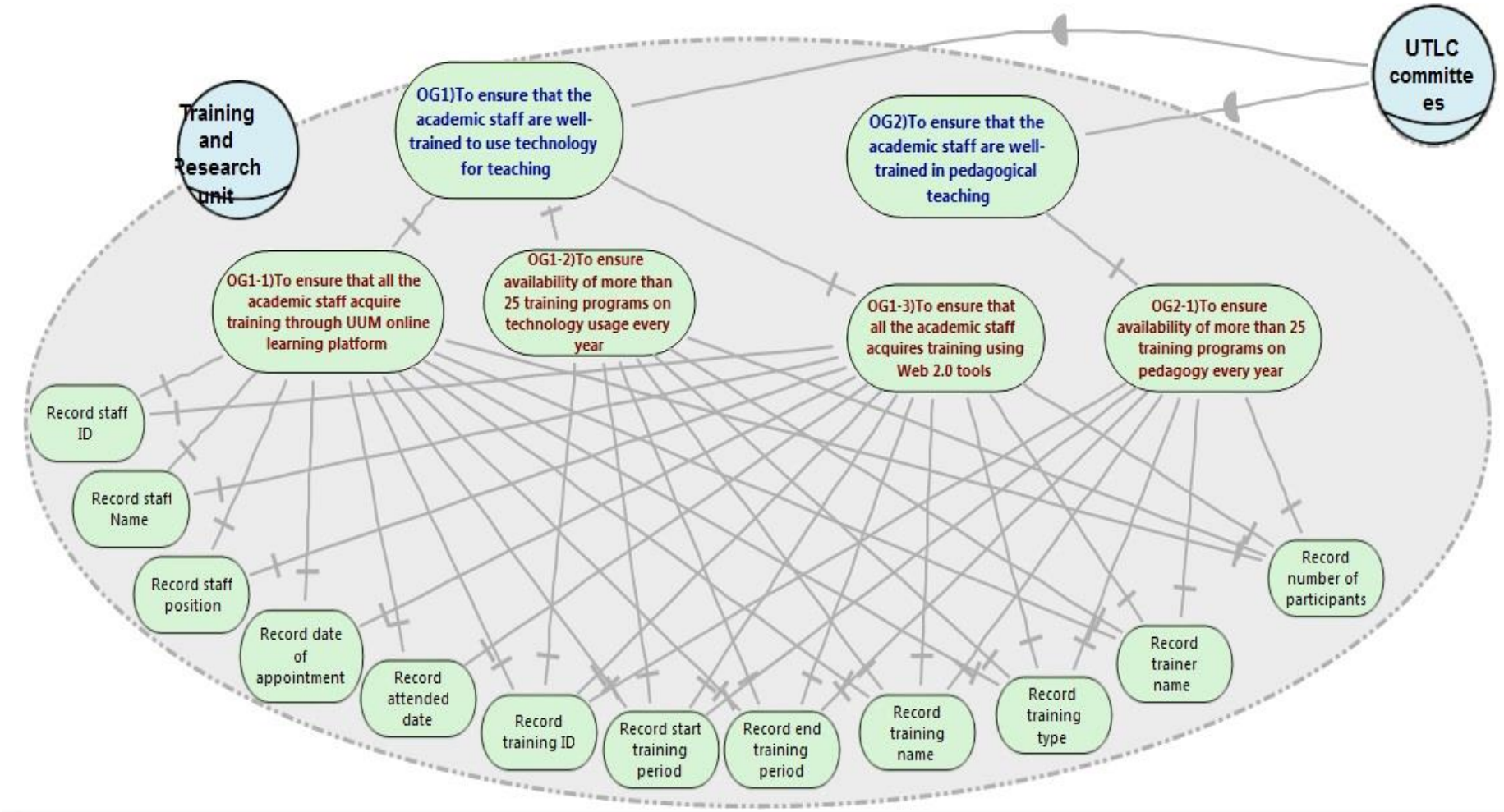


Figure 4.7. Rational diagram for Teaching and Research unit actor from organization perspective focusing on the Training goal

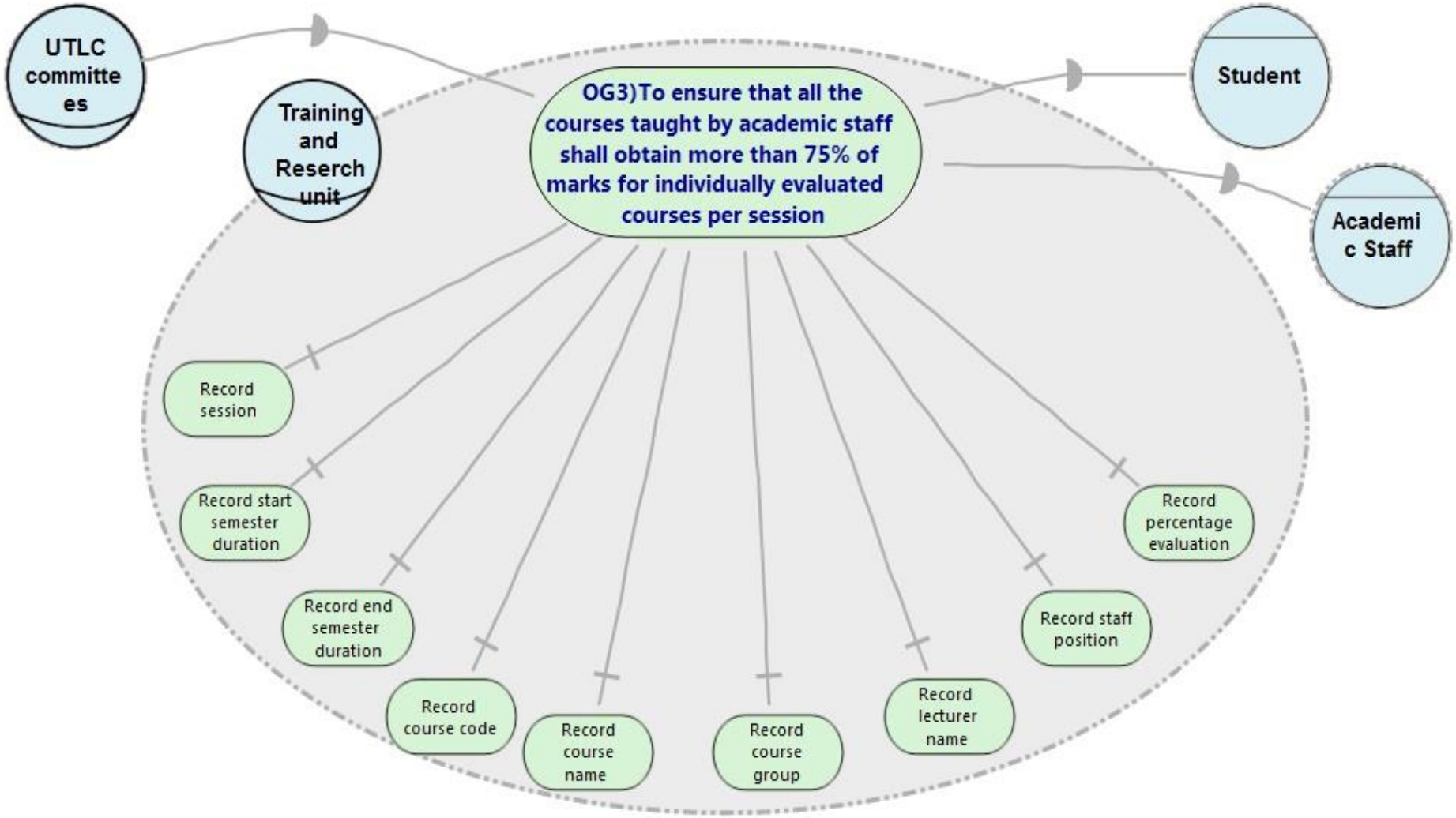


Figure 4.8. Rational diagram for Teaching and Research unit actor from organization perspective focusing on the Course Evaluation goal

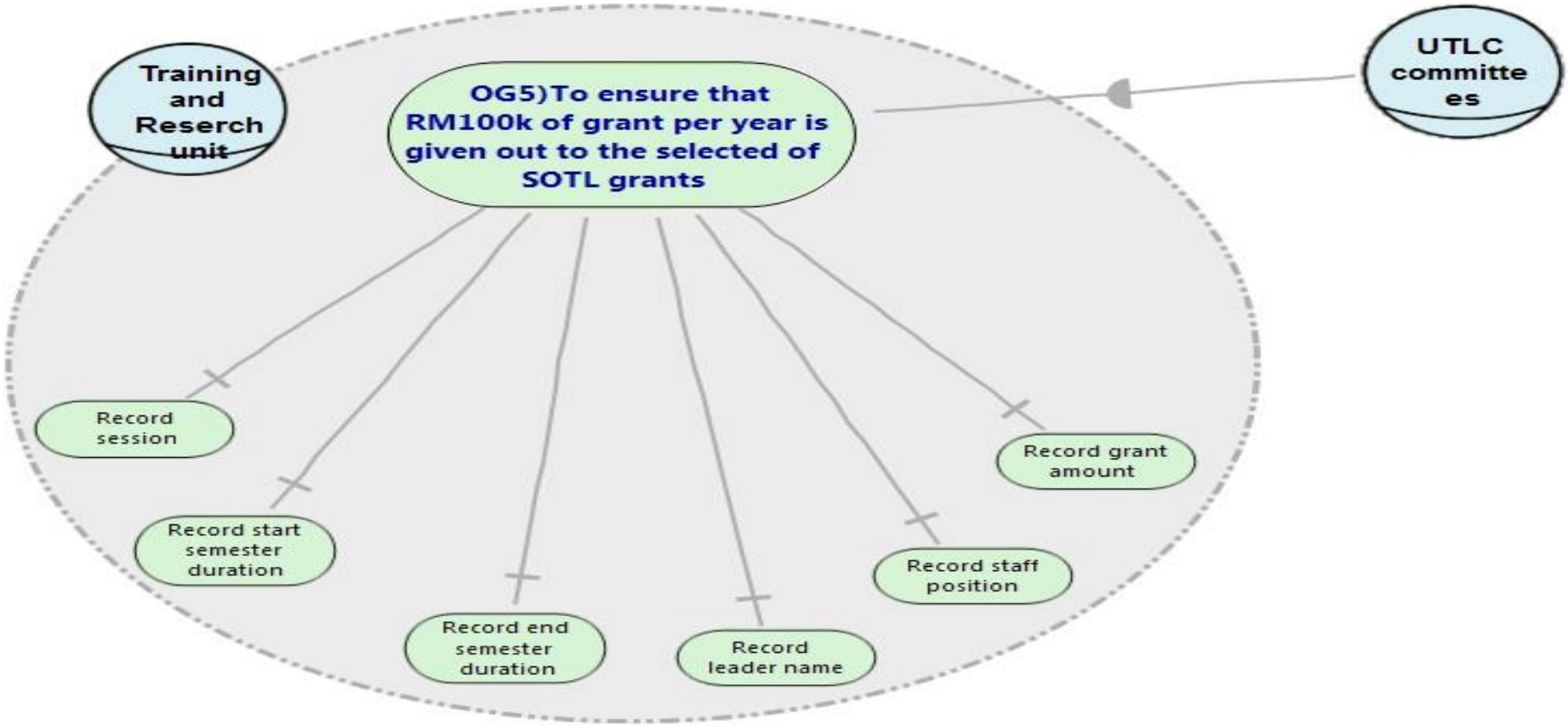


Figure 4.9. Rational diagram for Teaching and Research unit actor from organization perspective focusing on the Grant allocation goal

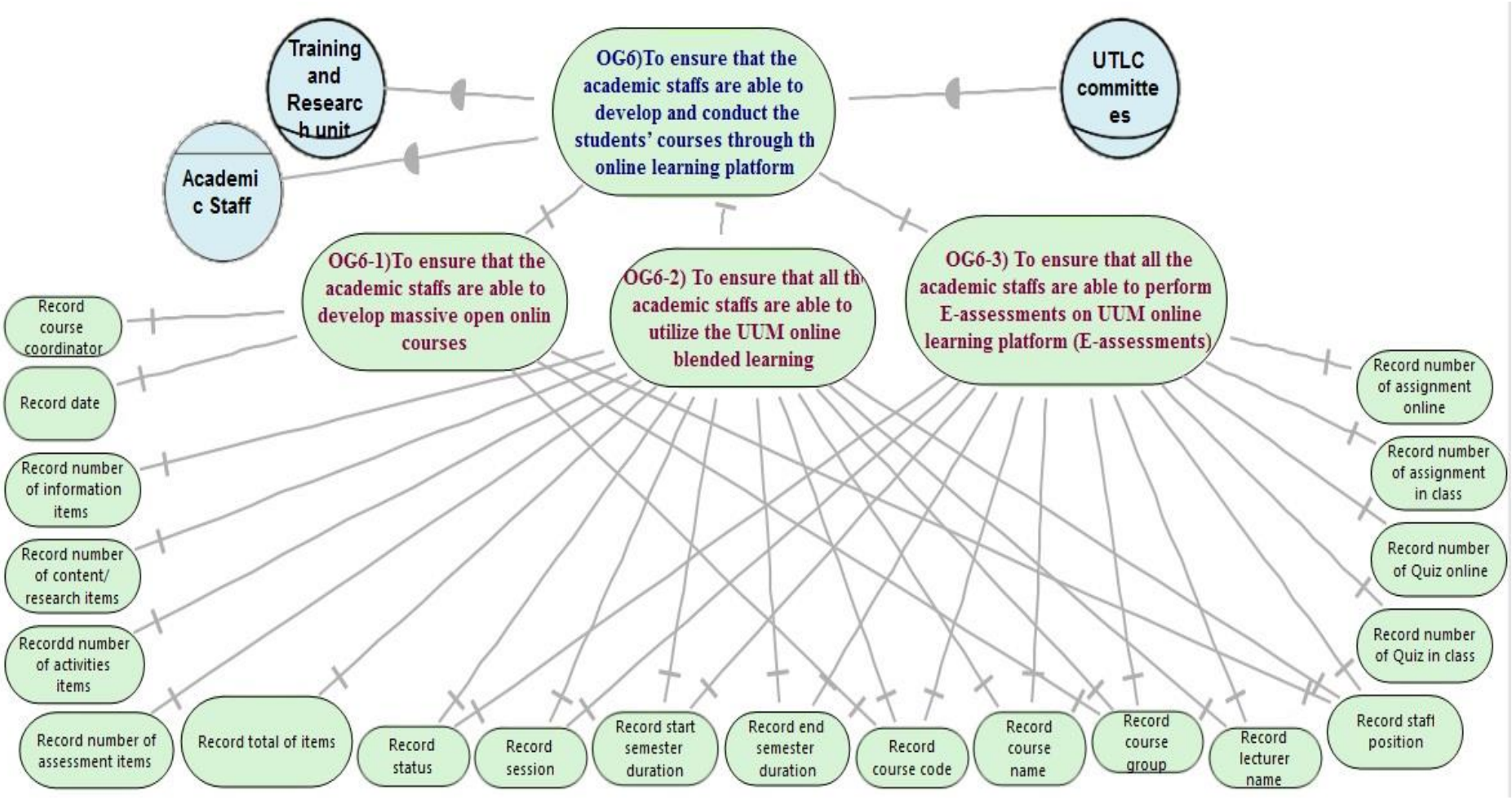


Figure 4.10. Rational diagram for Teaching and Research unit actor from organization perspective focusing on the Blended learning goal

4.4.1.2 Fact Analysis

The fact analysis describes the relationship between the facts and the goals. The facts abstracted in this study and their respective descriptions are presented in Table 4.5, the goals and facts are presented in Table 4.6.

Table 4.5

Fact and Description

Fact	**Description**
Technology Training	The training that focuses on the use of learning and teaching technologies like E-cEvas, Web 2.0 etc.
Pedagogy training	The training that focuses on the method of teaching and instructional deliveries.
Course Evaluation	The evaluation of courses taken by the organisations.
Awardees Selection	The selection of the eligible persons to be awarded.
Grant Allocation	The allocation of grants to selected faculty members.
Blended Learning	The use of both online and traditional face-to-face teaching as learning processes.

Table 4.6

Goal and Fact

Goal	Fact
OG1)To ensure that the academic staff are well-trained to use technology for teaching	Technology Training
OG2)To ensure that the academic staff are well-trained in pedagogical teaching	Pedagogy training
OG3)To ensure that all the courses taught by academic staff shall obtain more than 75% of marks for individually evaluated courses per session	Course Evaluation
OG4)To select at least one eligible academic staff to receive awards	Awardees Selection
OG5)To ensure that RM100k of grant per year is given out to the selected of SOTL grants	Grant Allocation
OG6)To ensure that the academic staffs are able to develop and conduct the students' courses through the online learning platform	Blended Learning

Based on the information provided in Tables 4.5 and 4.6, the extended rationale diagrams are presented in Figures 4.11 – 4.14.

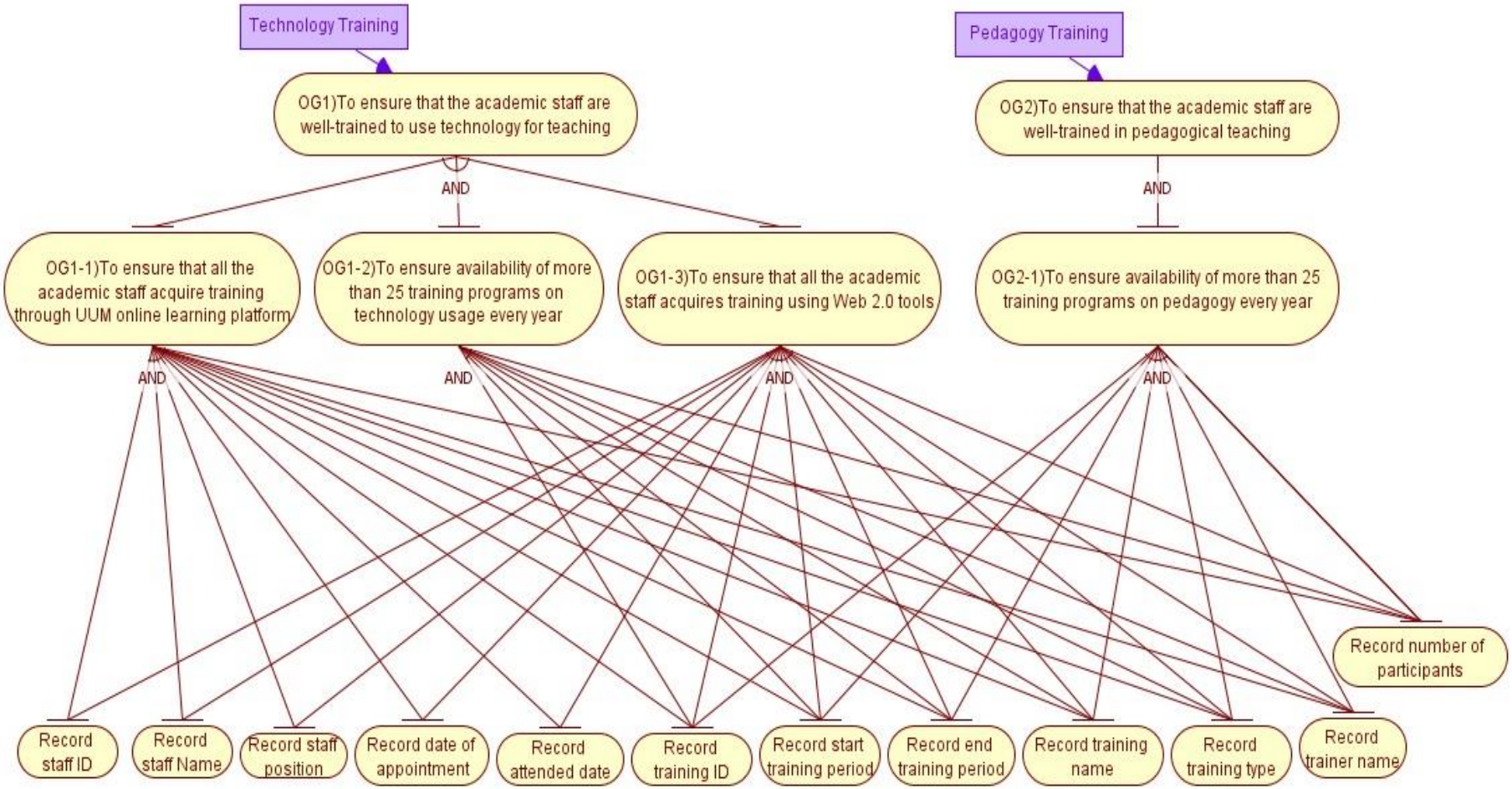


Figure 4.11. Extended rational diagram for Teaching and Research unit actor from organization perspective focusing on the Training goal

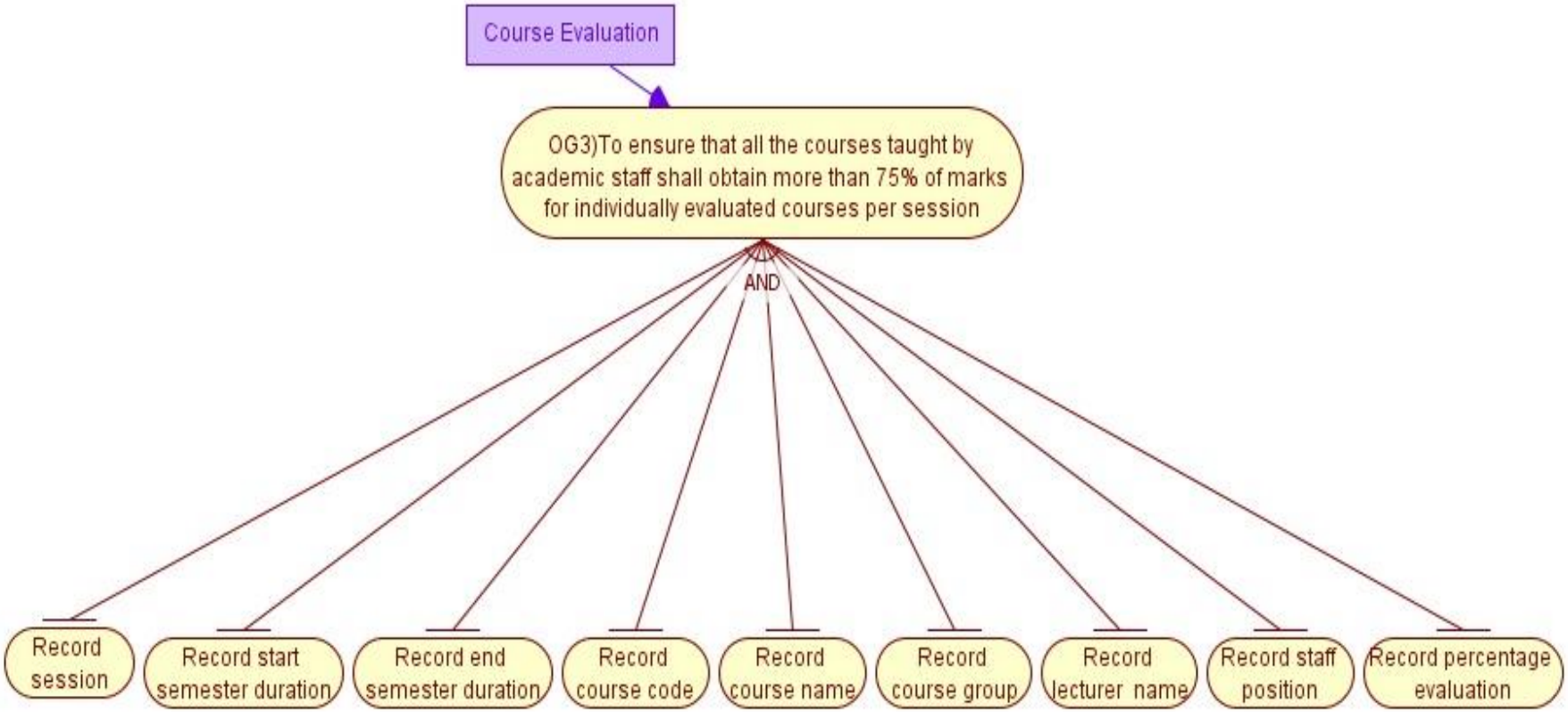


Figure 4.12. Extended rational diagram for Teaching and Research unit actor from organization perspective focusing on the Course Evaluation goal

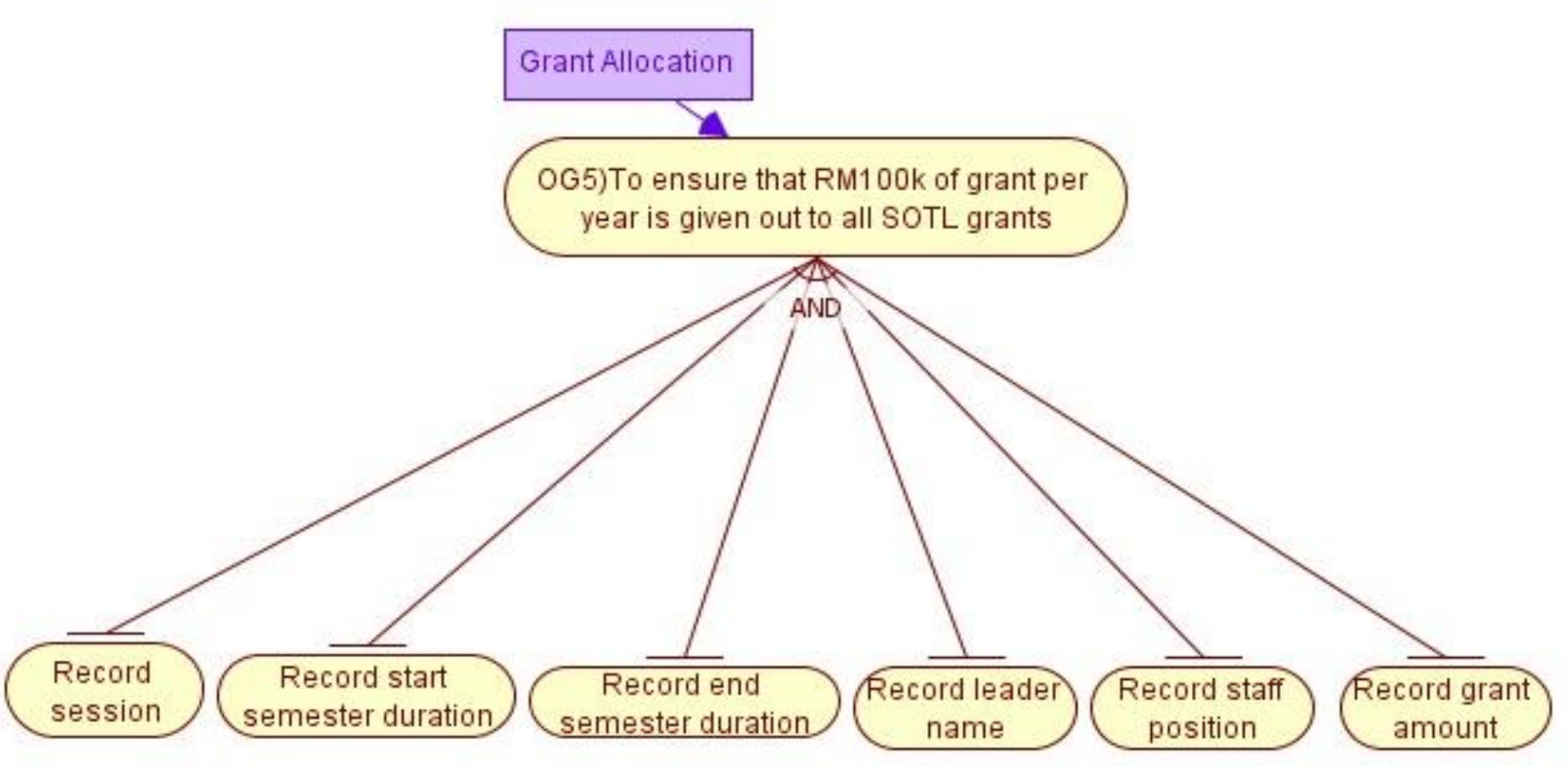


Figure 4.13. Extended rational diagram for Teaching and Research unit actor from organization perspective focusing on the Grant allocation goal

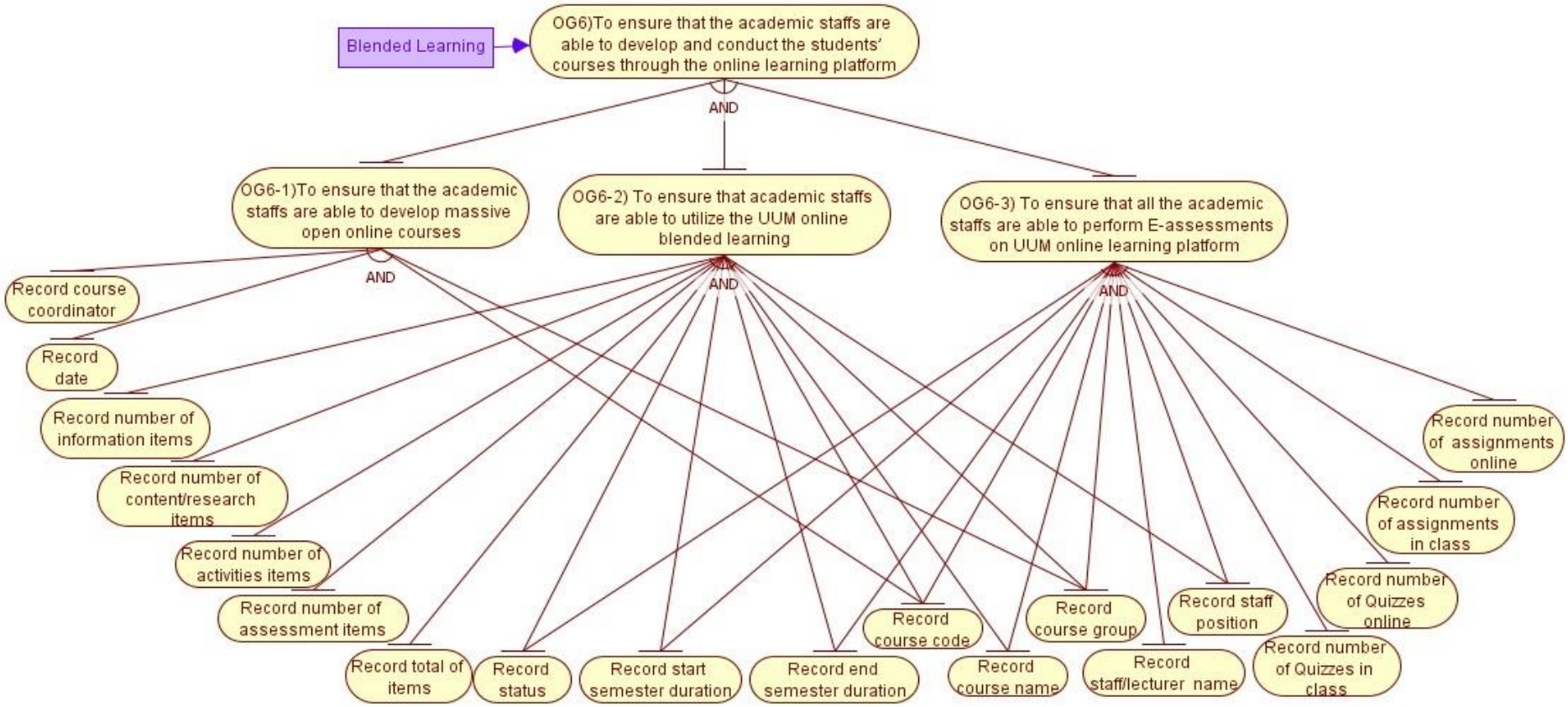


Figure 4.14. Extended rational diagram for Teaching and Research unit actor from organization perspective focusing on the Blended learning goal

4.4.1.3 Attribute Analysis

The attribute analysis presents attributes as data that are associated with the goals without specifying their roles as dimensions or measures. The goal, fact and attribute information is presented in Table 4.7. The further extended rational diagrams, based on the information presented in Table 4.7, are presented in Figure 4.15 to Figure 4.18

Table 4.7

Attribute, Goal and Fact

Attribute	**Goal**	**Fact**
training ID training type training name start training period end training period number of participants staff ID staff/trainer name staff position date of appointment attended date	OG1-1)To ensure that all the academic staff acquires training through UUM online learning platform	Technology Training
training ID start training period	OG1-2)To ensure availability of more than 25	Technology Training

end training period training name training type trainer name number of participants	training programs on technology every year	
training ID training type training name start training period end training period number of participants staff ID staff/trainer name staff position date of appointment attended date	OG1-3)To ensure that all the academic staff acquires training using Web 2.0 tools	Technology Training
training ID start training period end training period training name training type trainer name number of participants	OG2-1)To ensure availability of more than 25 training programs on pedagogy every year	Pedagogy training

session start semester duration end semester duration course code course name course group staff/lecturer name staff position percentage evaluation	OG3)To ensure that all the courses taught by academic staff shall obtain more than 75% of marks for individually evaluated courses per session	Course Evaluation
session start semester duration end semester duration staff/leader name staff position grant amount	OG5)To ensure that RM100k of grant per year is given out to the selected of SOTL grants	Grant Allocation
course code course name course group course coordinator date	OG6-1)To ensure that the academic staffs are able to develop massive open online courses	Blended Learning

session start semester duration end semester duration course code course name course group staff/lecturer name staff position number of information items number of content/research items number of activities items number of assessment items total of items status	OG6-2) To ensure that academic staffs are able to utilize the UUM online blended learning	Blended Learning
session start semester duration end semester duration course code course name course group staff/lecturer name staff position number of Quizzes in class number of Quizzes online	OG6-3)To ensure that all the academic staffs are able to perform E-assessments on UUM online learning platform	Blended Learning

number of assignments in class
number of assignments online
Status

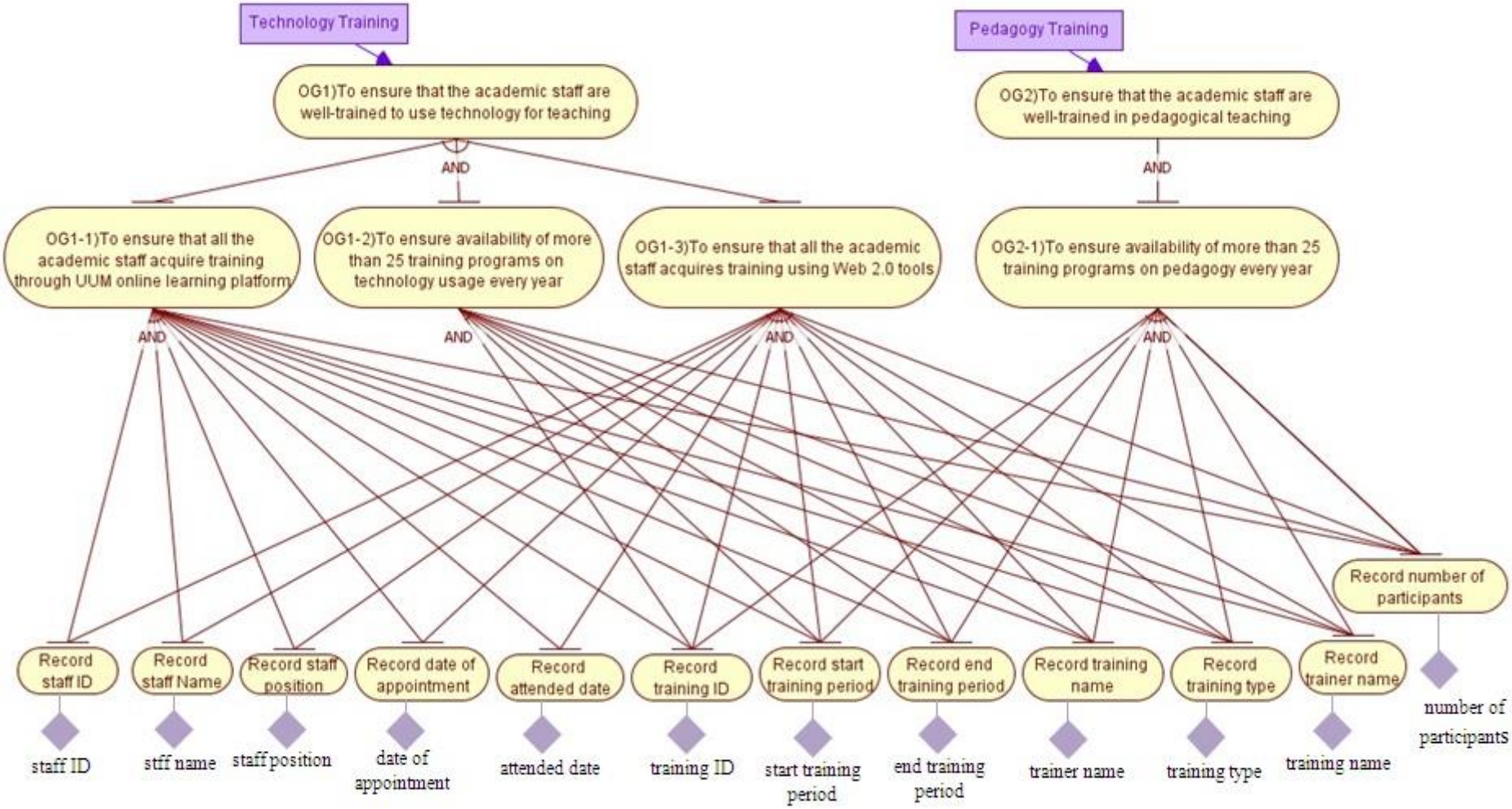


Figure 4.15. Further extended rational diagram for Teaching and Research unit actor from organization perspective focusing on the Training goal

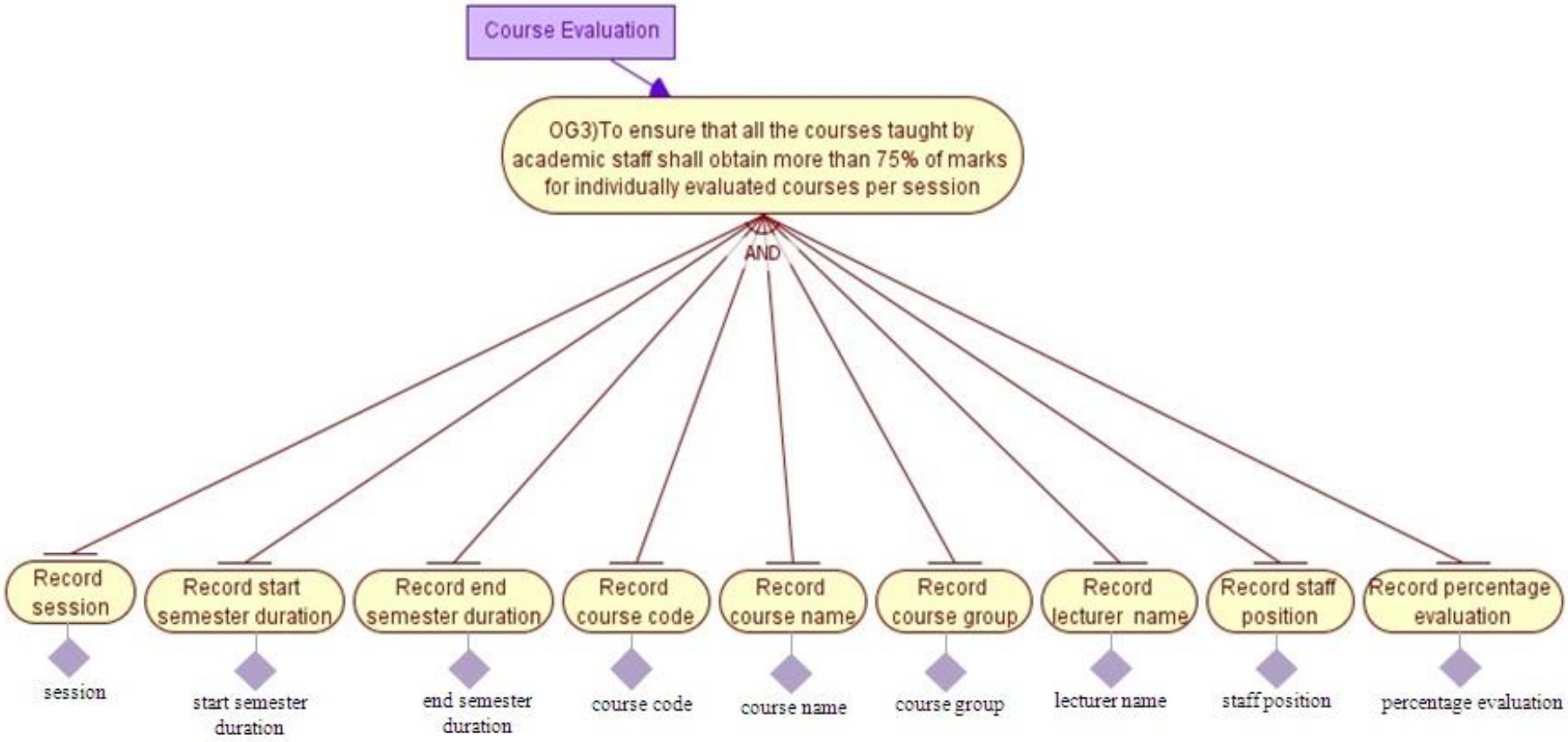


Figure 4.16. Further extended rational diagram for Teaching and Research unit actor from organization perspective focusing on the Course Evaluation goal

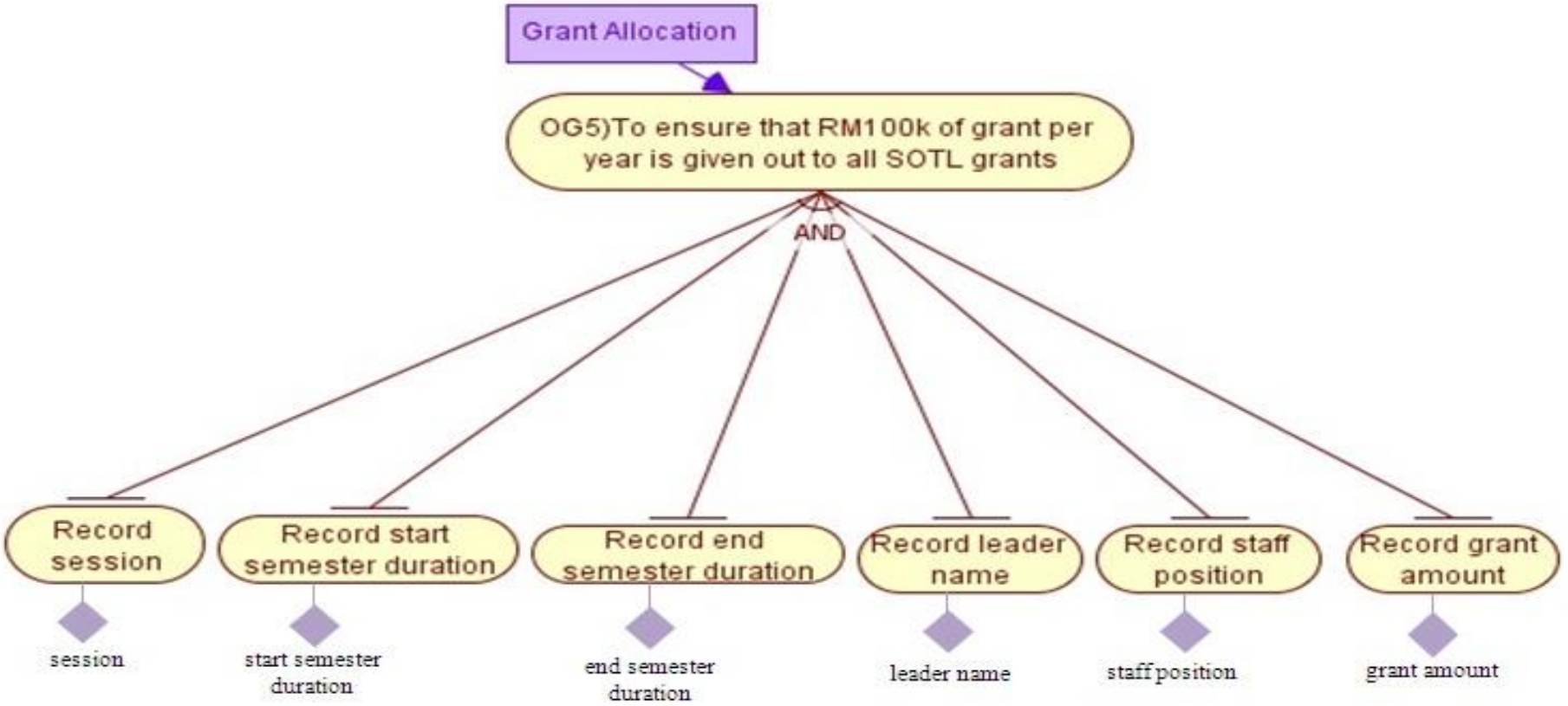


Figure 4.17. Further extended rational diagram for Teaching and Research unit actor from organization perspective focusing on the Grant allocation goal

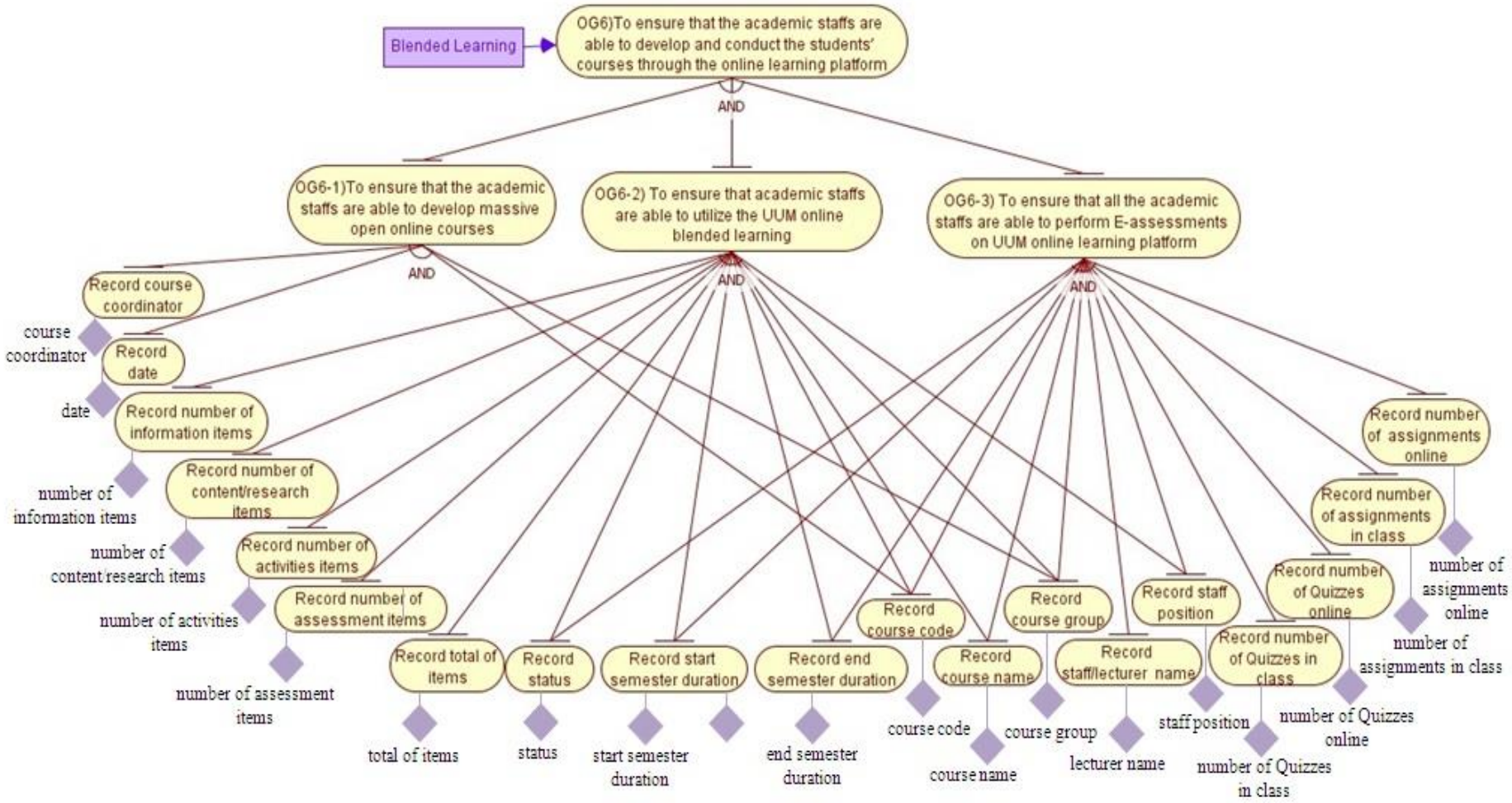


Figure 4.18. Further extended rational diagram for Teaching and Research unit actor from organization perspective focusing on the Blended learning goal

4.4.2 Decisional Modelling

The decisional modelling analyses the data warehouse requirements from the decision makers' perspectives. It is of five different phases. There are four phases, and one additional phase as proposed by this study. These phases are: the goal analysis, fact analysis, dimension analysis, measure analysis, and KPI analysis. These analyses are provided in ReGADaK.

4.4.2.1 Goal Analysis

The goal analysis is to represent the decision makers as actors and their respective goals. The (*actor* and *goal* information), (*Sub-Actors***,** *Type*and *Goals), (depender*, *dependee*and goals information) are presented in Table 4.8 to Table 4.10. These represent the goal analysis information from the decisional modelling perspective.

Table 4.8

Main Actors and Goals information

Main Actors	**Strategic objectives/goals**
Director	DG1)To support innovative learning process through training in technology for teaching purposes DG2)To support teaching process through pedagogicaltraining DG3)To support academic staff to achieve more than 75% of marks for individually evaluated courses per session DG4)To select suitable and competent academic staff to receive the

			DTA and AAN awards DG5)To support SOTL grants allocation by RM100k per year DG6)To support academic staff to be able to develop and conduct the students' courses through the online learning platform

Table 4.9

Main Actors, Sub-Actors, Type and Goals

Main Actor	**Sub-Actor**	**Type**	**Goals**
Director	Deputy Director (Technical)	Position	DG1)To support innovative learning process through training in technology for teaching purposes DG3)To support academic staff to achieve more than 75% of marks for individually evaluated courses per session DG6)To support academic staff to be able to develop and conduct the students' courses through the online learning platform
	Deputy Director (Training)	Position	DG2)To support teaching process through pedagogical training

		DG4)To select suitable and competent academic staff to receive the DTA and AAN awards
		DG5)To support SOTL grants allocation by RM100k per year

Table 4.10

Depender and Dependee and Goals information

Depender	**Dependee**	**Goals**
Director	Deputy Director (Technical)	DG1)To support innovative learning process through training in technology for teaching purposes
		DG3)To support academic staff to achieve more than 75% of marks for individually evaluated courses per session
		DG6)To support academic staff to be able to develop and conduct the students' courses through the online learning platform

Director	Deputy Director (Training)	DG2)To support teaching process through pedagogical training DG4)To select suitable and competent academic staff to receive the DTA and AAN awards DG5)To support SOTL grants allocation by RM100k per year

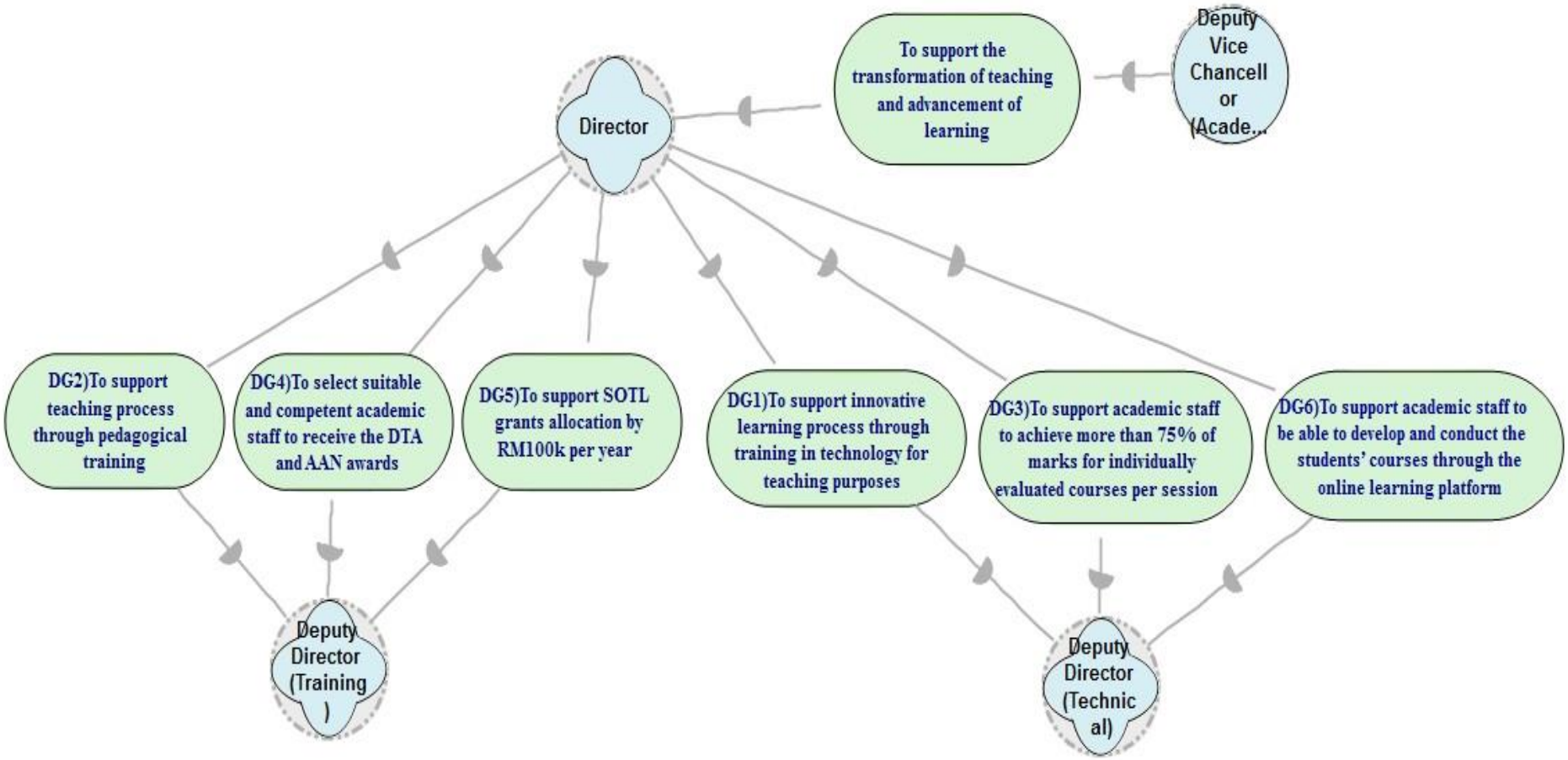


Figure 4.19. UTLC Actors' Diagram from the decisional perspective

The rational diagrams from the decision makers' perspective are presented in Figures 4.20 to 4.23

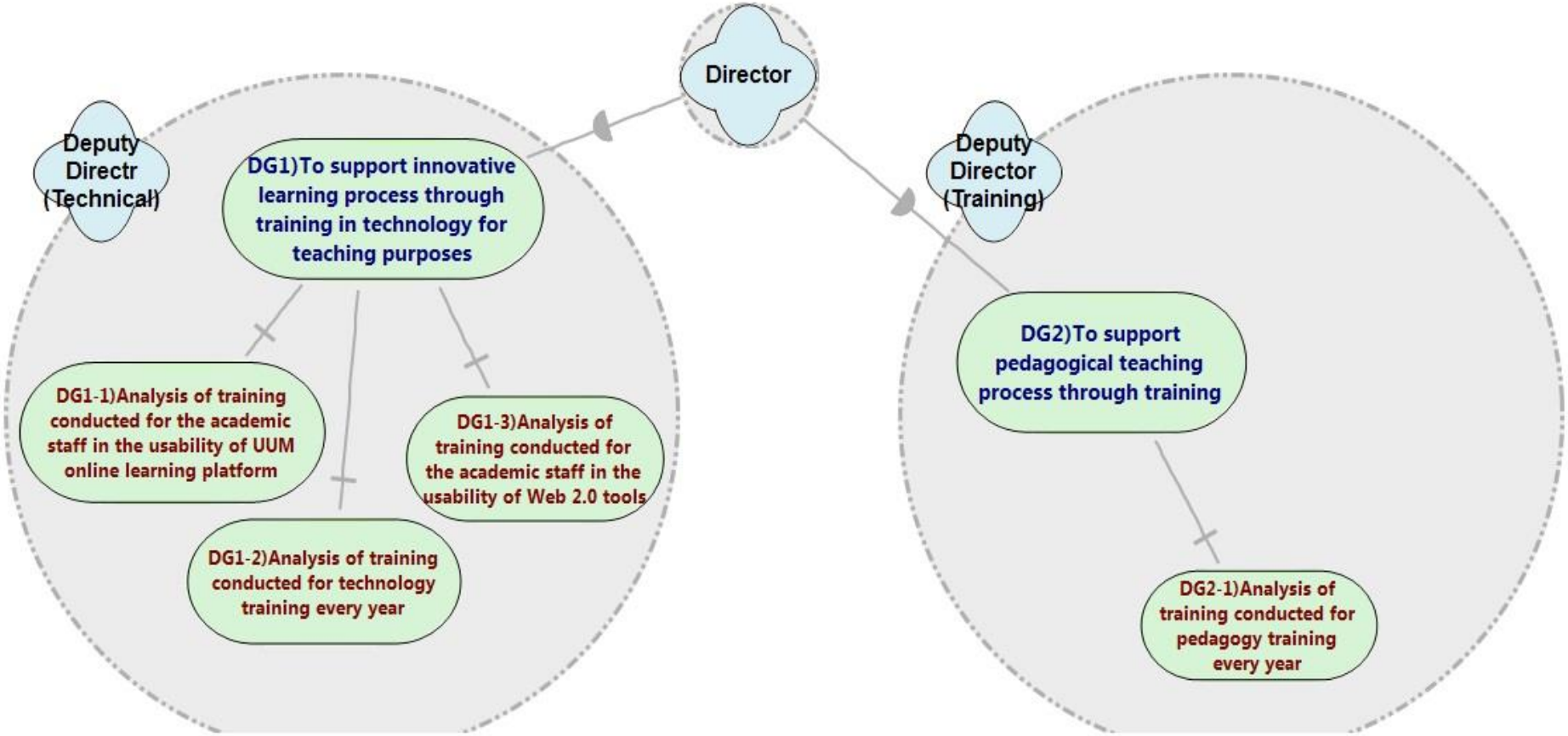


Figure 4.20. Rational diagram for Deputy Director (Training) and Deputy Director (Technical) actors from decisional perspective focusing on Training goal

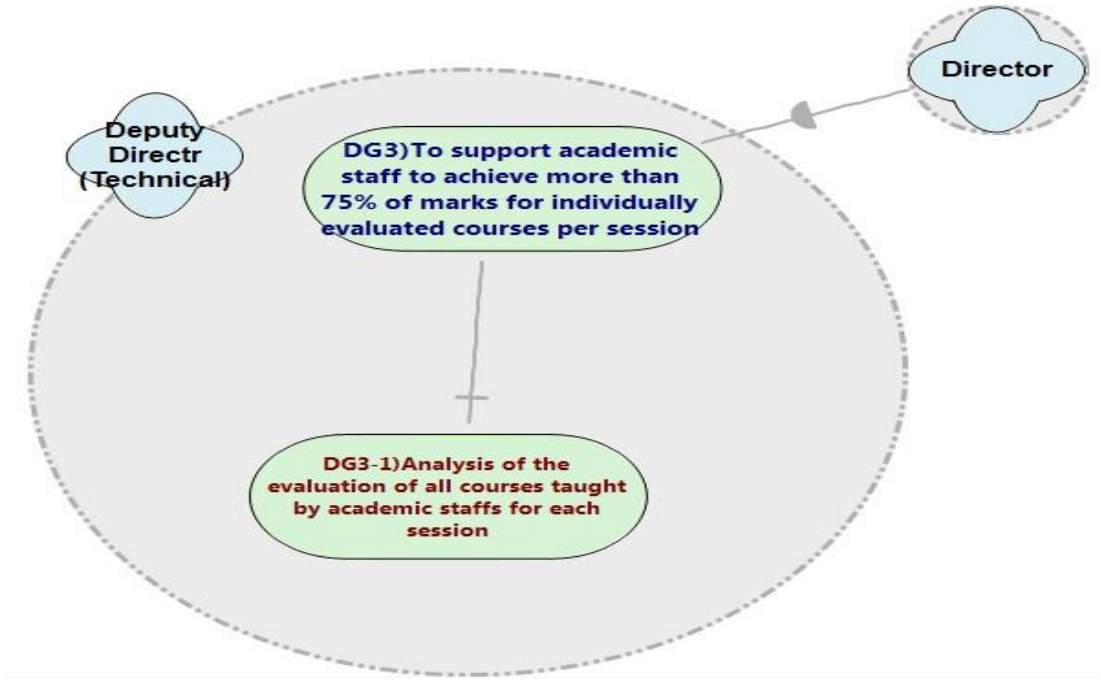


Figure 4.21. Rational diagram for Deputy Director (Technical) actor from decision perspective focusing on Course Evaluation goal

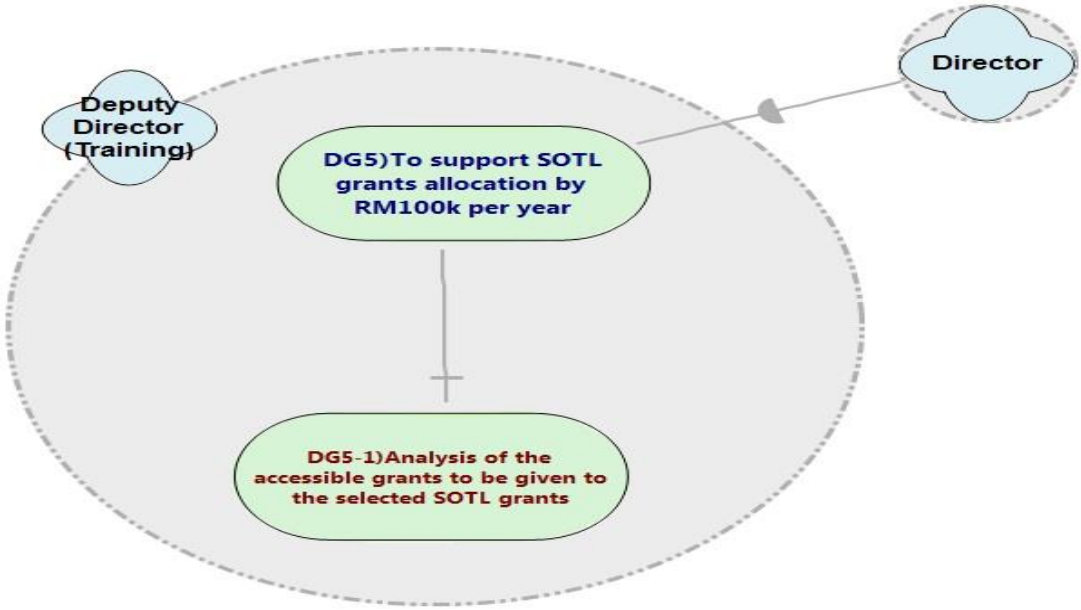


Figure 4.22. Rational diagram for Deputy Director (Technical) actor from decision perspective focusing on Grant allocation goal

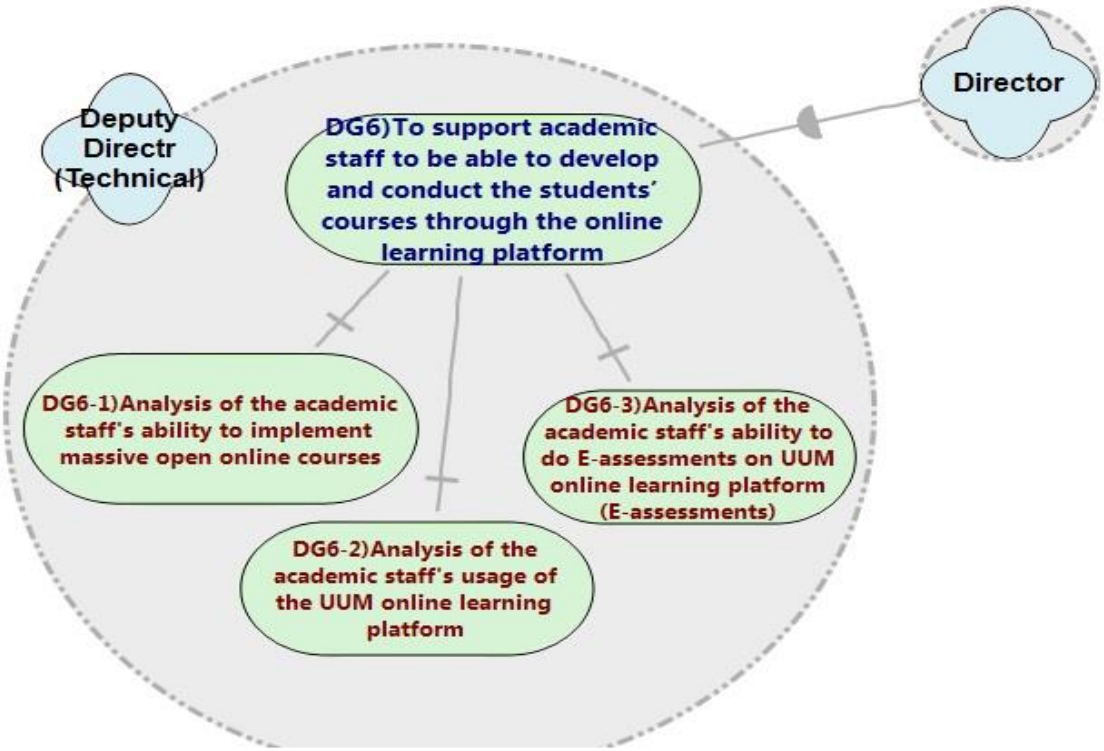


Figure 4.23. Rational diagram for Deputy Director (Technical) actor from decision perspective focusing on the Blended learning goal

4.4.2.2 Fact Analysis

Based on the goals defined from the decisional modelling, the goals and facts information, are analysed and presented in Table 4.11 and Table 4.12.

Table 4.11

Fact and Description

Fact	Description
Technology Training	The training that focuses on the use of learning and teaching technologies like E-cEvas, Web 2.0 etc.
Pedagogy training	The training that focuses on the method of teaching and instructional deliveries.
Course Evaluation	The evaluation of courses taken by the organisations.
Awardees Selection	The selection of the eligible persons to be awarded.
Grant Allocation	The allocation of grants to selected faculty members.
Blended Learning	The use of both online and traditional face-to-face teaching as learning processes.

Table 4.12

Goal and Fact

Goal	Fact
DG1)To support innovative learning process through training in technology for teaching purposes	Technology Training
DG2)To support teaching process through pedagogical training	Pedagogy training
DG3)To support academic staff to achieve more than 75% of marks for individually evaluated courses per session	Course Evaluation

DG4)To select suitable and competent academic staff to receive the DTA and AAN awards	Awardees Selection
DG5)To support SOTL grants allocation by RM100k per year	Grant Allocation
DG6)To support academic staff to be able to develop and conduct the students' courses through the online learning platform	Blended Learning

The extended rational diagrams for the decisional perspective, based on the information given in Tables 4.11 and 4.12 are presented in Figures 4.24 to 4.27

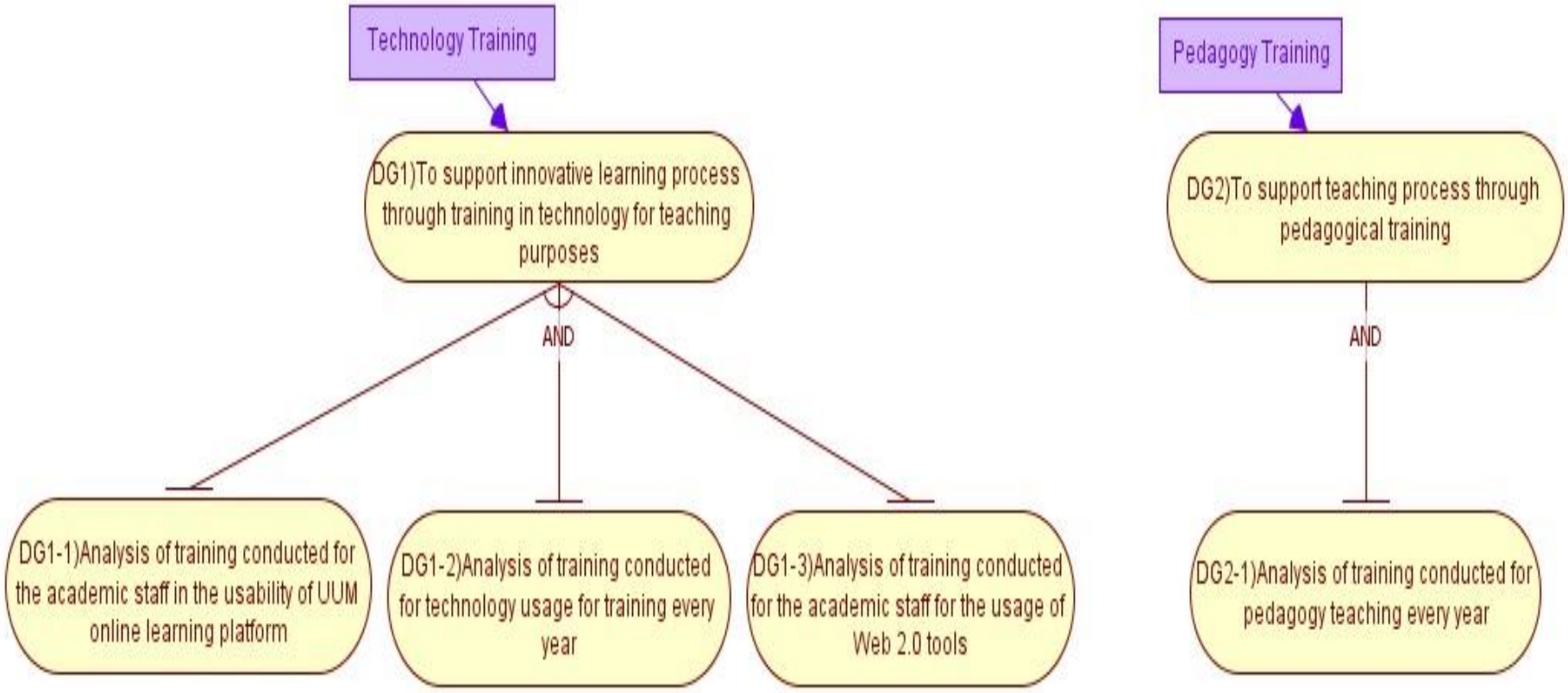


Figure 4.24. Extended rational diagram for Deputy Director (Training) and Deputy Director (Technical) actors from decisional perspective focusing on the Training goal

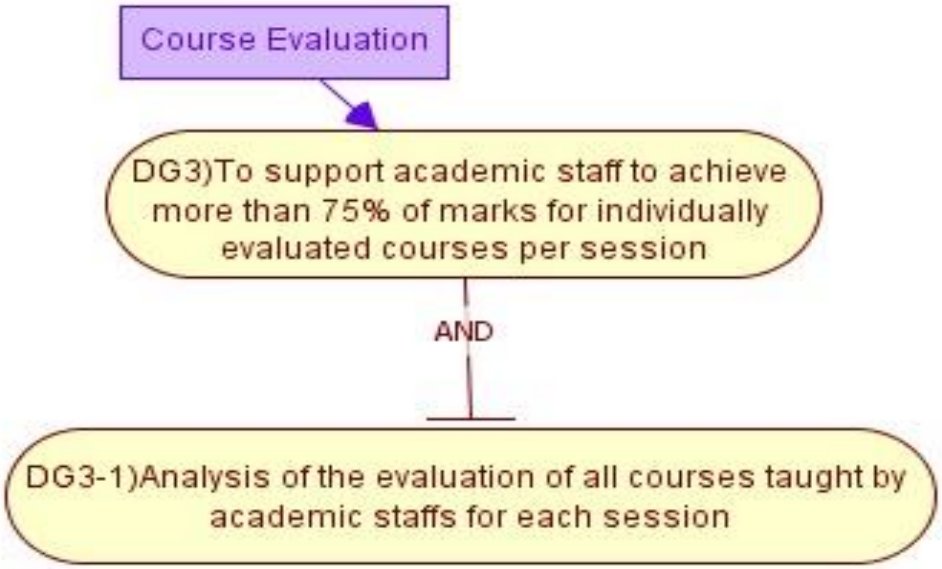


Figure 4.25. Extended rational diagram for Deputy Director (Technical) actor from decision perspective focusing on the Course Evaluation goal

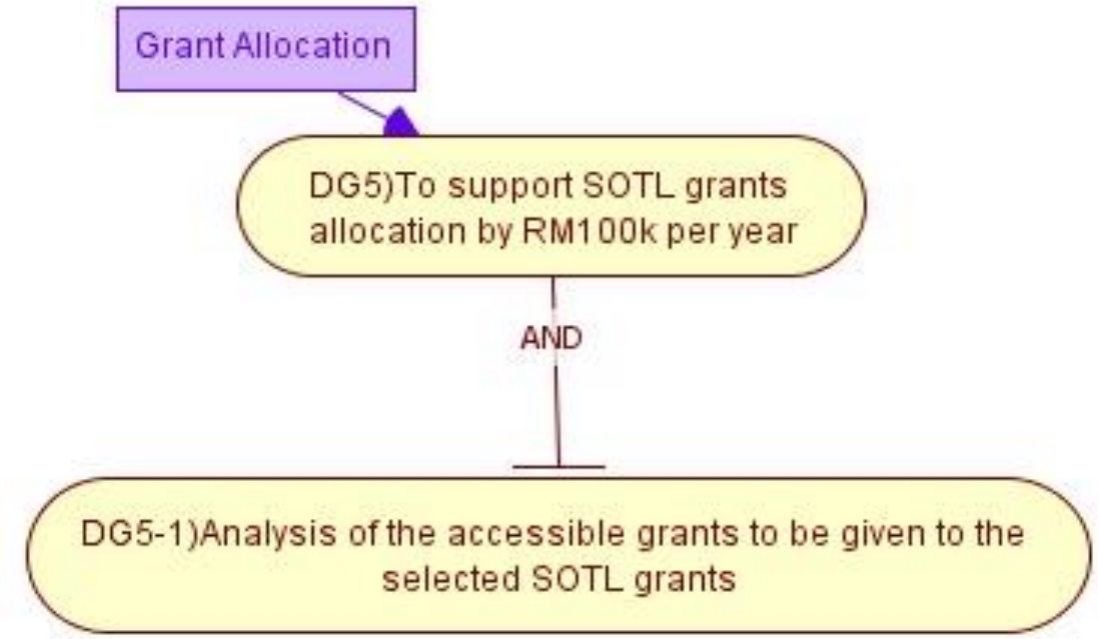


Figure 4.26. Extended rational diagram for Deputy Director (Technical) actor from decision perspective focusing on the Grant allocation goal

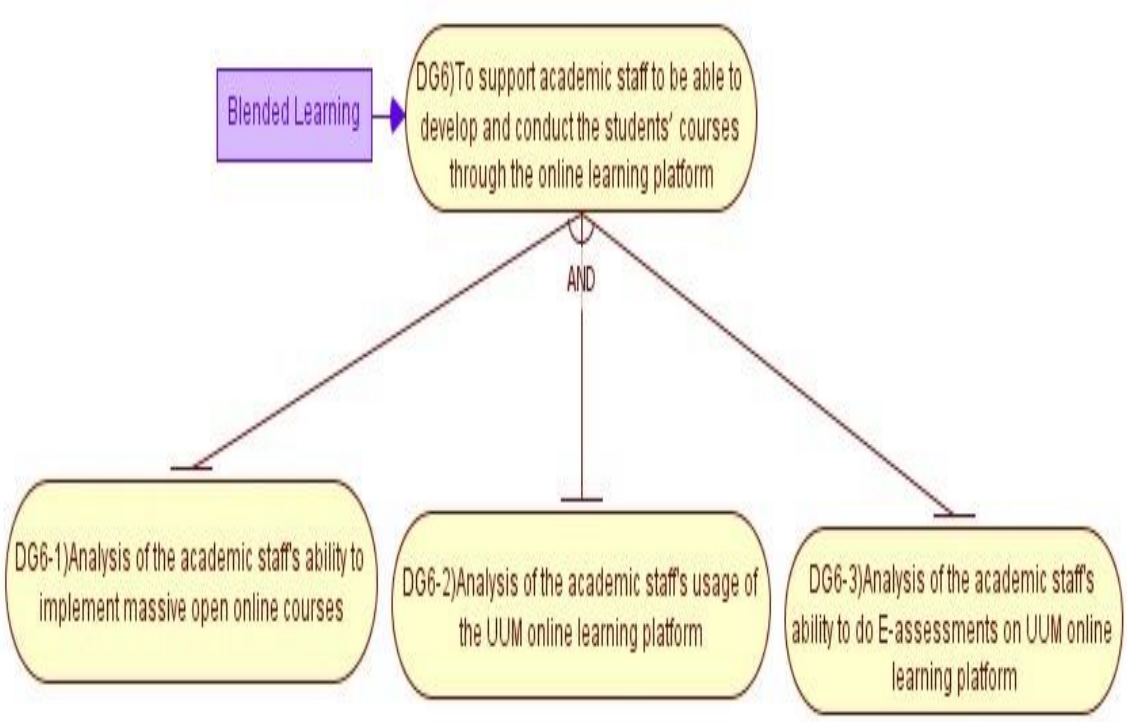


Figure 4.27. Extended rational diagram for Deputy Director (Technical) actor from decision perspective focusing on the Blended learning goal

4.4.2.3 Dimension Analysis

The dimensions analyses are extension task of the fact analysis. The information regarding the dimension is presented in Table 4.13

Table 4.13

Goal, Fact and Dimensions

Goal	**Fact**	**Dimensions**
DG1-1)Analysis of training conducted for the academic staff in the usability of UUM online	Technology Training	Training Data Attended Training Data

learning platform		Academic Staff Data Date
DG1-2)Analysis of training conducted for technology training every year	Technology Training	Training Data Date
DG1-3)Analysis of training conducted for the academic staff in the usability of Web 2.0 tools	Technology Training	Training Data Attended Training Data Academic Staff Data Date
DG2-1)Analysis of training conducted for pedagogy training every year	Pedagogy training	Training Data Date
DG3-1)Analysis of the evaluation of all courses taught by academic staffs for each session	Course Evaluation	Course data Courses evaluation data Date
DG4-1)Analysis of the selected award receivers of the DTA award	Awardees Selection	Award receivers data Date
DG5-1)Analysis of the accessible grants to be given to the selected SOTL grants	Grant Allocation	SOTL data Date
DG6-1)Analysis of the academic staff's ability to implement	Blended Learning	MOOCs Data Date

massive open online courses		
DG6-2)Analysis of the academic staff's usage of the UUM online learning platform	Blended Learning	Blended Learning Data Course Data Date
DG6-3)Analysis of the academic staff's ability to do E-assessments on UUM online learning platform	Blended Learning	E-assessment courses data Course Data Date

The dimensions were defined based on the comprehensive (organisational and decisional modelling) requirement analysis. The descriptions of these dimensions are presented in Table 4.14.

Table 4.14

Dimension and Description

Dimension	**Description**
Training Data	All the information pertaining to the training course
Attended Training Data	All the information pertaining to the training course attended
Academic Staff Data	All the information about the academic staff members.
Date	Date of the event

Course data	All the information about the courses taken.
Courses evaluation data	Information about courses evaluated.
Award receivers data	Information about the persons that received the award.
SOTL data	Information about SOTL
MOOCs Data	Information about MOOC.
Blended Learning Data	Information about blended learning
E-assessment courses data	Information about courses assignment and quiz through the online platform.

4.4.2.4 Measure and KPI Analysis

The measures and KPIs are extension of the fact and dimension analysis tasks. The information regarding are the measure and KPI are presented in Table 4.15 and the KPIs' descriptions are presented in Table 4.16.

Table 4.15

Goal, Fact, Dimensions, Measure and KPI

Goal	**Fact**	**Dimensions**	**Measure**	**KPI**
DG1-1)Analysis of training conducted for the academic staff in the usability of UUM online learning platform	Technology Training	Training Data Attended Training Data Academic Staff Data Date	Total number of academic staffs that use UUM online learning training Total number of lecturers/academic staff	100% fulfilment for the acquired academic staffs training through the UUM online learning platform
DG1-2)Analysis of training conducted for technology training every year	Technology Training	Training Data Date	Total number of training programs on technology conducted every year	A minimum of 25 training programs on technology every year
DG1-3)Analysis of training conducted for	Technology Training	Training Data Attended Training Data	Total number of academic staff that use the Web 2.0 tools	100% fulfilment for the acquired academic staffs

the academic staff in the usability of Web 2.0 tools		Academic Staff Data Date	Total number of lecturers/academic staff	training using Web 2.0 tools
DG2-1)Analysis of training conducted for pedagogy training every year	Pedagogy training	Training Data Date	Total number of training programs on pedagogy conducted every year	A minimum of 25 training programs on pedagogy every year
DG3-1)Analysis of the evaluation of all courses taught by academic staffs for each session	Course Evaluation	Course data Courses evaluation data Date	Total number of courses for each session Total number of courses that achieved more than75% of marks for individually evaluated courses per session	100% of the courses that taught by the academic staff in each session must achieved at least 75% of marks in individually evaluated course

DG4-1)Analysis of the selected award receivers of the DTA award	Awardees Selection	Award receivers data Date	Total number of academic staffs that received the DTA award	At least one academic staff per year must qualify to receive the DTA award
DG5-1)Analysis of the accessible grants to be given to the selected SOTL grants	Grant Allocation	SOTL data Date	Total number of SOTL grants given out to the researchers by the UTLC unit per year Total amount of SOTL grants given out by UTLC unit per year	100% of the RM100k amount that is allocated per year for UTLC must be given out as SOTL grants
DG6-1)Analysis of the academic staff's ability to implement massive open online courses	Blended Learning	MOOCs Data Date	Total number of MOOC courses conducted every year	A minimum of 10 massive open online courses develop every year
DG6-2)Analysis of the academic staff's usage	Blended Learning	Blended Learning Data	Total number of courses that achieved 50% of blended	50% of courses offered in each session must be in blended

of the UUM online learning platform		Courses Data Date	learning method in each session Total number of courses for each session	learning
DG6-3)Analysis of the academic staff's ability to do E-assessments on UUM online learning platform	Blended Learning	E-assessment courses data Courses Data Date	Total number of the courses that achieved 15% of E-assessment in each session Total number of courses for each session	100% of courses offered in each session must achieved 15% of E-assessments

Table 4.16

KPI and Description

KPI	**Description**
100% fulfilment for the acquired academic staffs training through the UUM online learning platform	This states that all the academic staff must acquire formal training or self training on UUM online learning platform.
A minimum of 25 training programs on technology every year	There must be at least 25 training programs on technology in a year.
100% fulfilment for the acquired academic staffs training using Web 2.0 tools	This states that all the academic staff must acquire formal training or self training on usage of Web 2.0
A minimum of 25 training programs on pedagogy training every year	There must be at least 25 training programs on pedagogy in a year.
100% of the courses that taught by the academic staff in each session must achieved at least 75% of marks in individually evaluated course	This states that all courses taught by the academic staff must attack at least 75%satisfaction when evaluated

At least one academic staff per year must qualify to receive the DTA award	At least, one of the academic staff must receive the DTA award per year
100% of the RM100k amount that is allocated per year for UTLC unit must be given out as SOTL grants	All elected SOTL grants must get grants
A minimum of 10 massive open online courses develop every year	There must be at least 10 massive open online courses every year
50% of courses offered in each session must be in blended learning	Half of the courses taught through the blended learning mode must achieve 50% satisfaction
100% of courses offered in each session must achieved 15% of E-assessments	All of the courses taught must achieve 15% of E-assessment in each session

The further extended rational diagrams are presented in Figure 4.28 to Figure 4.31.

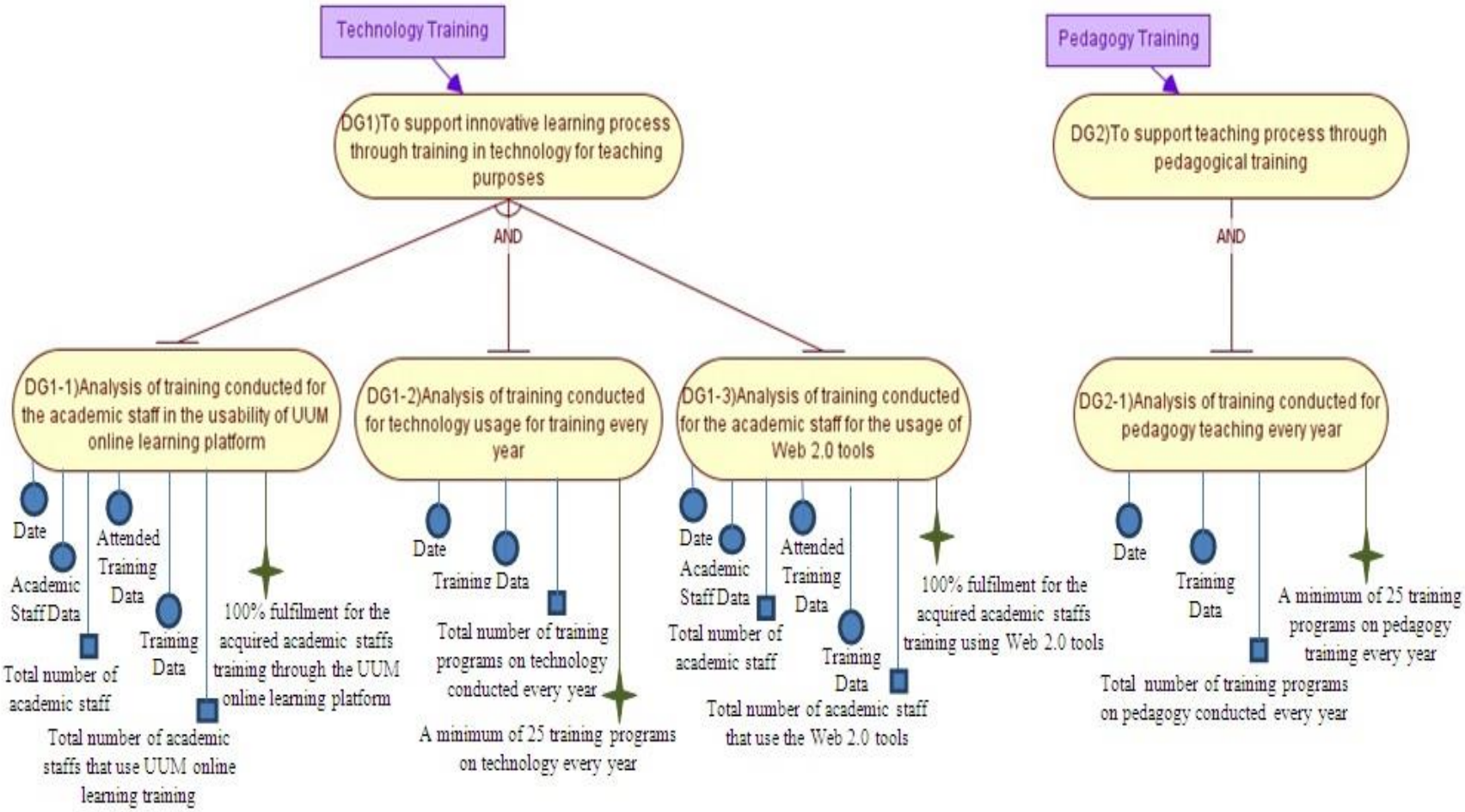


Figure 4.28: Further extended rational diagram for Deputy Director (Training) and Deputy Director (Technical) actors from decision perspective focusing on the Training goal

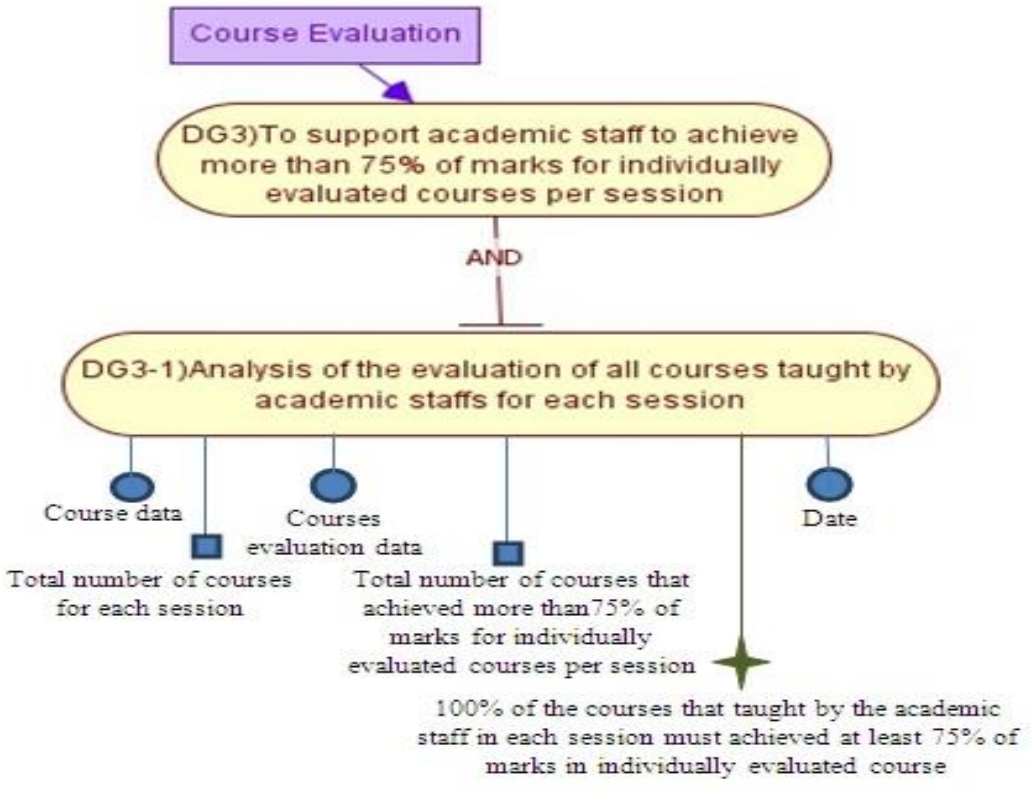


Figure 4.29. Further extended rational diagram for Deputy Director (Technical) actor from decision perspective focusing on the Course Evaluation goal

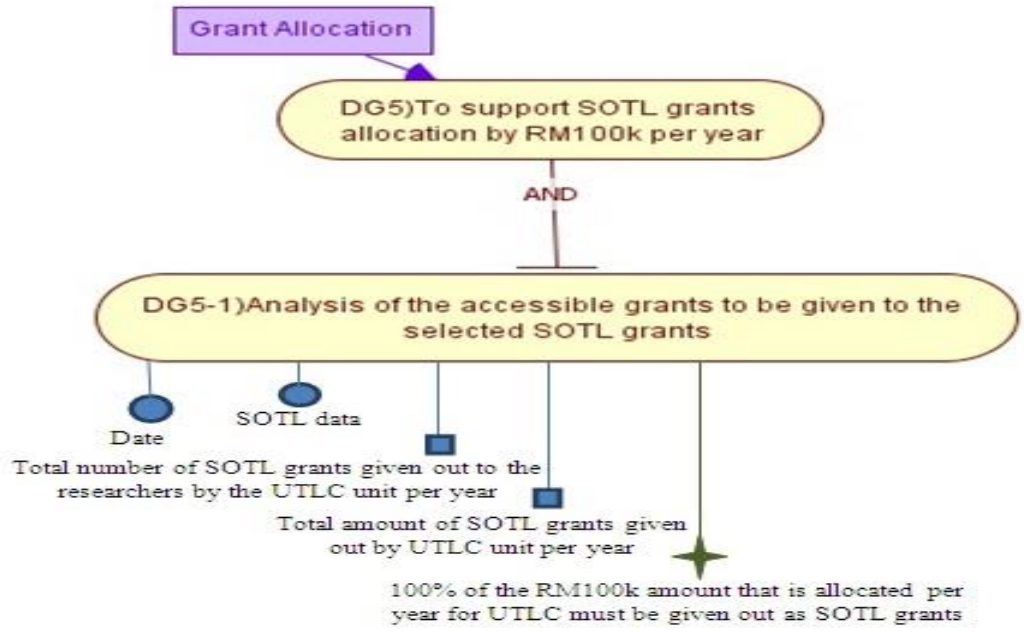


Figure 4.30. Further extended rational diagram for Deputy Director (Technical) actor from decision perspective focusing on the Grant allocation goal

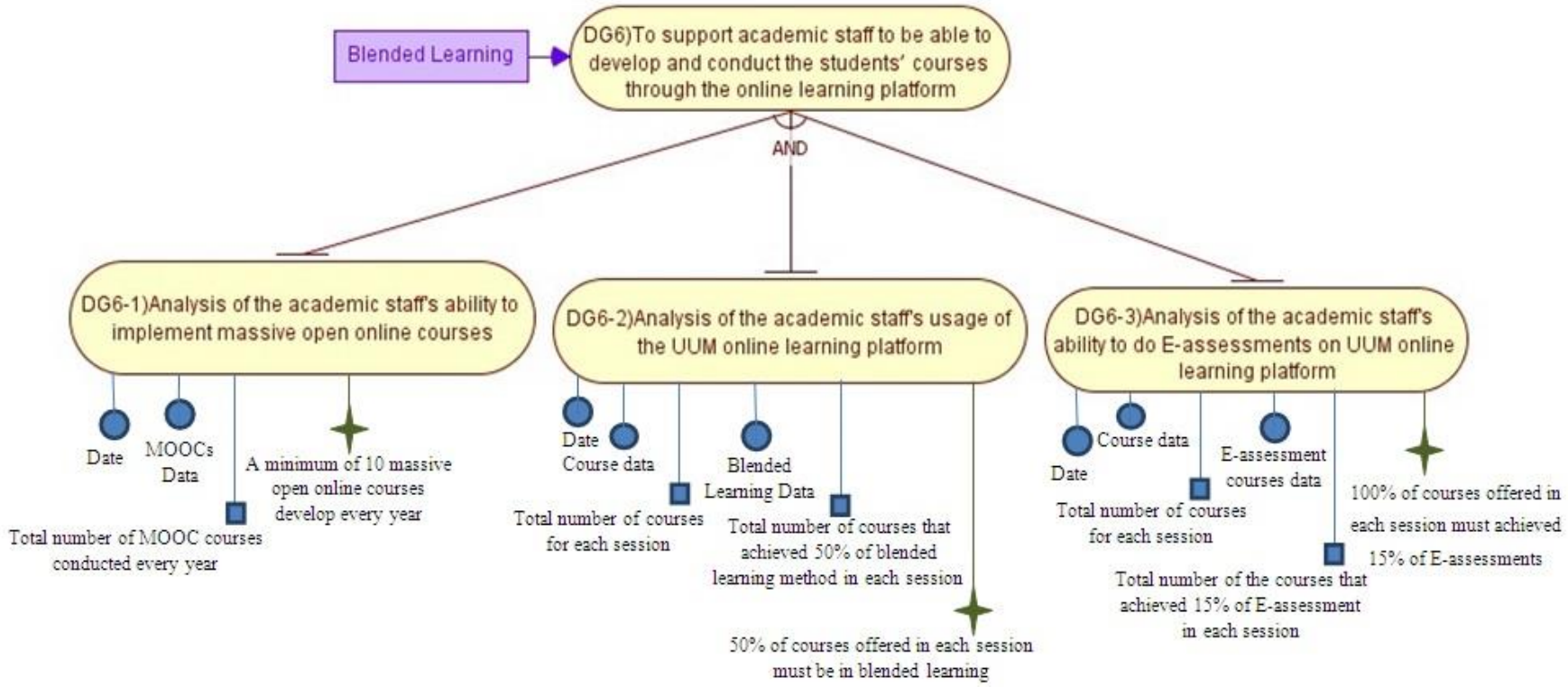


Figure 4.31. Further extended rational diagram for Deputy Director (Technical) actor from decision perspective focusing on the Blended learning goal

The requirement analysis and design as presented and extensively discussed in sections 4.2 and 4.3.The strategic goals both from the organisational and decisional perspectives were verified by the assistance director and deputy director of UTLC. This has validated the goal-oriented analyses findings from the domain and users' studies.

4.5 Mixed-Design

Requirements mapping, hierarchy construction and refinement are done through the supply-driven and demand-driven strategies to develop the data warehouse schema. The requirements were derived during organizational and decisional modelling are matched with the schema of the source database to generate the conceptual schema for the data warehouse. The facts, dimensions, measures, and KPIs included in the extended rationale diagrams produced by decisional modelling are mapped, where possible, onto the source schema.

For every Fact in the source schema contains the many-to-one associations between Fact and dimension and supporting by the attributes accordingly. Every measure is associated with Fact. This study extends an extraction of KPI from. And every KPI is associated with the measure. By mapping and refine the final goal-oriented diagram with the related source schemas, the data warehouse model for monitoring UUM's teaching and learning KPIs is produced as presented in the next section.

4.6 Data Warehouse Model

The data warehouse schema model are presented in Figures 4.32 to 4.35

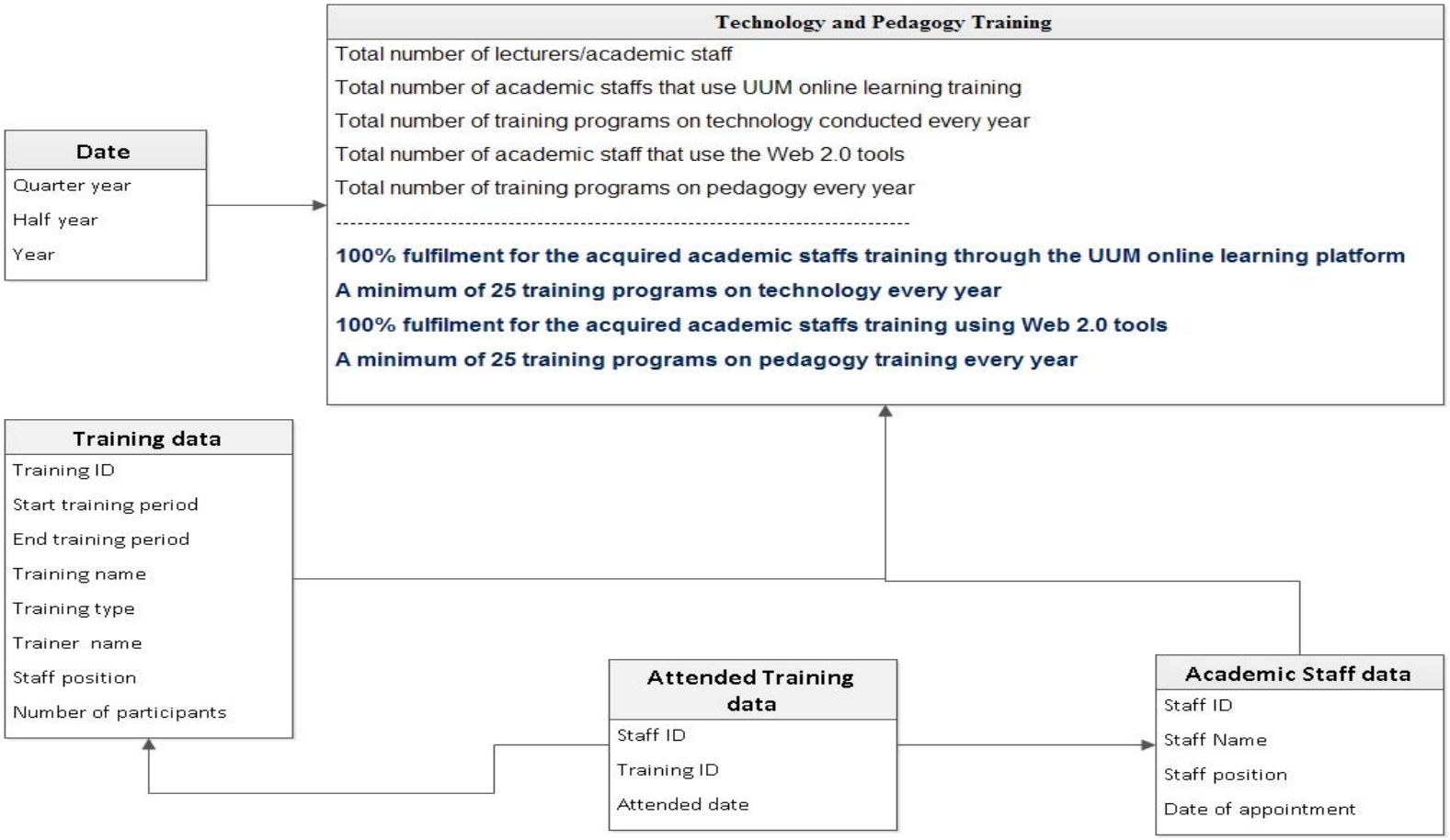


Figure 4.32. Star Schema: Staff Training by UTLC

Figure 4.32 represents the star schema of Staff Training by UTLC. After all the steps involved in the requirement and goal analysis for “Training academic staff to use technology in teaching” and “Training academic staff in pedagogy teaching” are done, this schema is produced. It attends to both organizational and decisional perspectives, and consists of the fact table “Technology and Pedagogy training”with four dimensions tables.

4.6.1 Discussion on Staff Training by UTLC Star Schema

The first dimension is Date table. It represents the time period which also serves as dimension for other tables of the measure KPIs. These tables are related to the goals analysed and designed in this schema. It will help the university teaching and learning center, as a unit, in monitoring these KPIs on quarter, bi-yearly and yearly basis.

From the Academic Staff Data table and the “Date of appointment’ attribute, we can produce the “Total number of lecturers/academic staff”. This can be labeled Measure 1 (M1). And attending to Training Data table is given by “Number of participants” that will produce “Total number of academic staff that use UUM online learning training or use Web 2.0 tools.” The “UUM online learning” or “Web 2.0 tools” will be determined by the “Training name” attribute in the dimension (Training Data table). The “Total number of academic staff that uses UUM online learning training” can be labeled Measure 2 (M2) and “Total number of academic staff that uses Web 2.0 tools” can be labeled Measure 3 (M3). The measures (M1 and M2) are mandatory to measuring “100% fulfillment for the acquired academic staffs training through the UUM online learning platform” as a KPI by dividing M2 by M1. This

presents the result in percentage (%), and measuring the KPI of “100% fulfillment for the acquired academic staffs training using Web 2.0 tools” is achieved through the same method. The difference is that this is done by dividing M3 by M1.

The Training Data table (dimension) produces “Total number of training programs conducted on technology” or “Total number of training programs conducted on pedagogy” as the attribute. The “Training type” in this dimension will be determined the training on “Technology” or “Pedagogy.” The “Total number of training programs on technology conducted every year” can be labeled Measure 4 (M4). This measure is mandatory to measure KPI of “A minimum of 25 training programs on technology every year.” The measure M4 is divided by the target (25) which is the KPI, and the result is presented in percentage. This is also applicable to KPI of “A minimum of 25 training programs on pedagogy every year” but its own measure will be the “Total number of training programs on pedagogy conducted every year”.

According to the previous descriptive result from this schema, these tables for measuring KPIs would help the decision makers by allowing more than a single chart to be made for monitoring these KPIs. Appendix B presents these measure tables with examples of their charts.

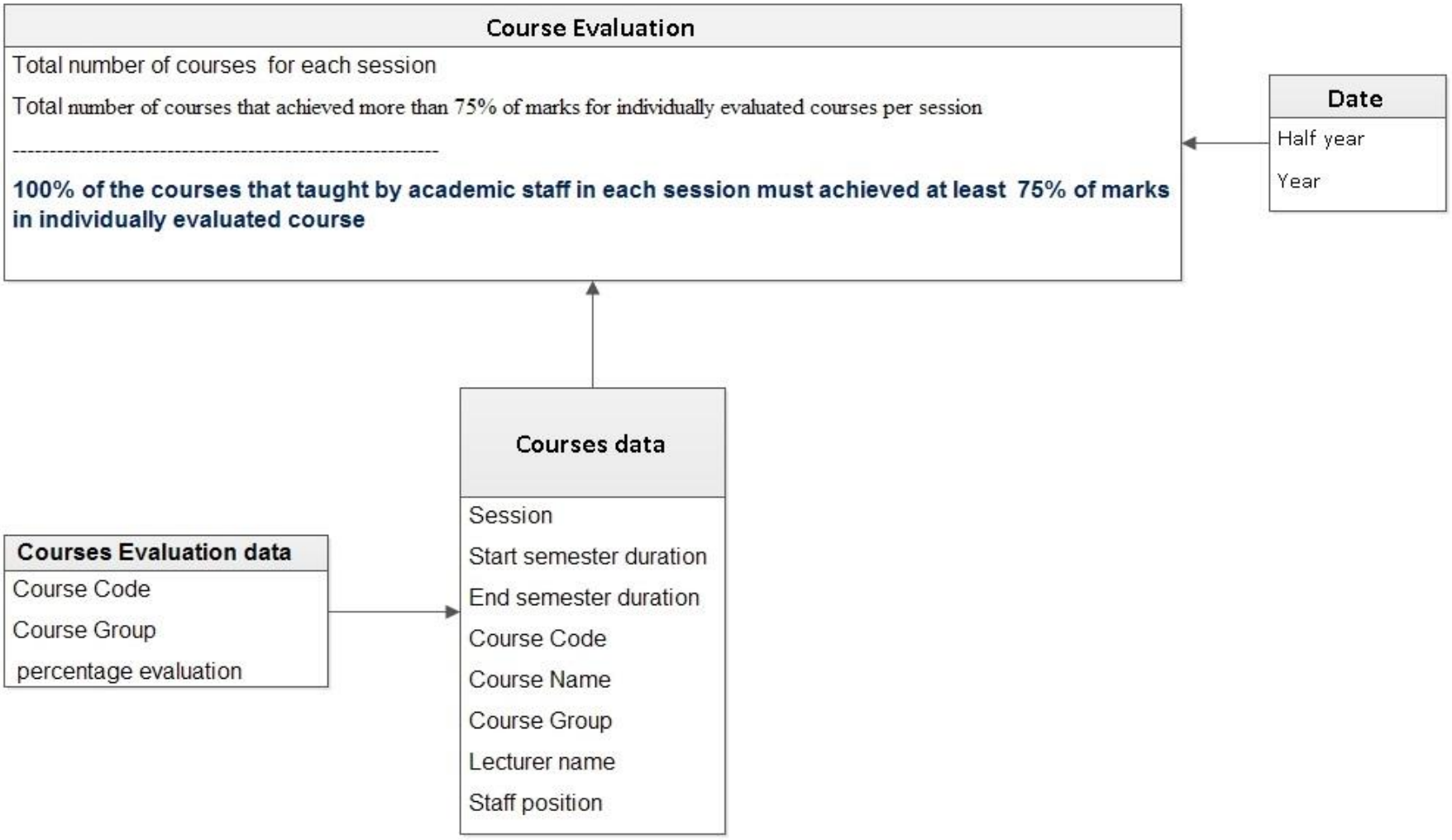


*Figure 4.33.*Star Schema: Course Evaluation

Figure 4.33 represents the star schema for Course Evaluation. This is achieved after all the analysis steps for Course Evaluationgoal in organizational and decisional perspectives are done. The schema consists of a fact table “Course Evaluation” with three dimensions tables.

4.6.2 Discussion on Course Evaluation Star Schema

The first dimension is Date table which represent the time period. This has more than one table for the measure KPI that is related to this goal. This schema will help the university teaching and learning center unit to monitor the related KPIs based on bi-yearly and yearly basis.

The Course Data table depends on the “Course Code ”and “Course Group” attributes. And from these, we can produce the “Total number of courses for each semester”, which can be labeled Measure 1 (M1).

Courses Evaluation Datatable can provide Course Data table by “Percentage evaluation” which will help to produce “Total number of courses that achieved more than75% of marks for individually evaluated courses per session” measure. This can be labeled Measure 2 (M2). The measures (M1 and M2) are mandatory in measuring “100% of the courses that taught by the academic staff in each session must achieve at least 75% of marks in individually evaluated course” as a KPI by dividing M2 by M1. The result is presented in percentage.

According to the previous descriptive result from this schema, these tables for measure KPI would help the decision makers by allowing them to make more than a

single chart in monitoring these KPIs. Appendix B presents these measure tables with examples of these charts.

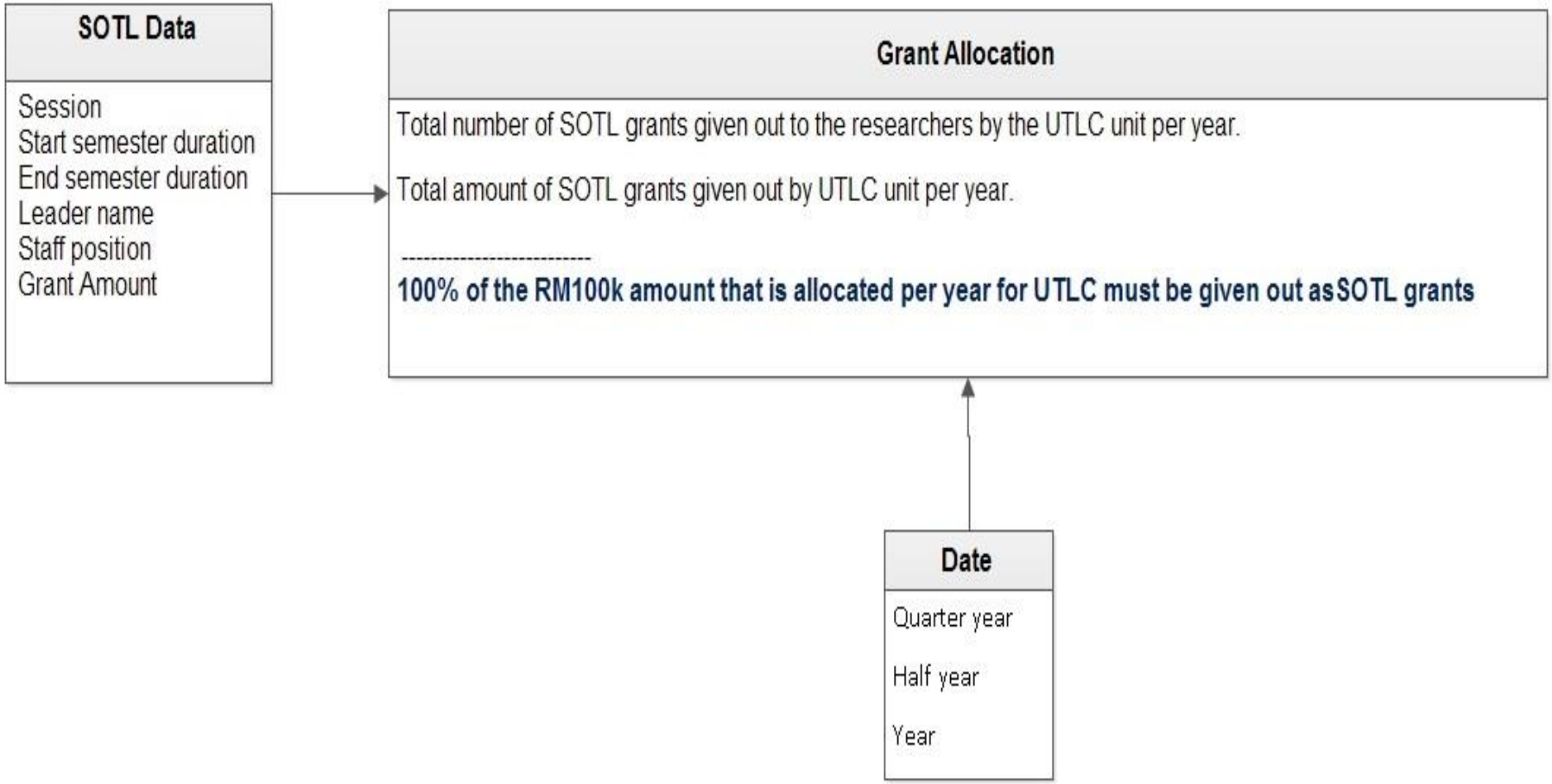


Figure 4.34. Star Schema: Grant Allocation

Figure 4.34 represents the star schema of Grant Allocation. This is the result after all the requirement analysis steps for “accessible grants to be given to the selected SOTL grants” goal are done, both in organizational and decisional perspectives. The schema consists of the fact table “Grant Allocation” with two dimensions tables.

4.6.3 Discussion on Grant Allocation Star Schema

The first dimension is Date table, and it represents the time period which produces more than one table for measure KPI related to the goal in this schema. It will help this unit (university teaching and learning center) to monitor these KPIs on a quarter year, a half of a year and/or yearly basis.

From the SOLT Data table, the “Grant Amount” attribute can produce the “Total amount of SOTL grants given out by UTLC unit per year” measure. This measure is mandatory to measure KPI of “100% of the RM100k amount that is allocated per year for UTLC must be given out as SOTL grants” by dividing this measure with the target (100,000) RM which is the KPI (the amount money that should this unit give it to the SOTL Scholarship Teaching and Learning researchers). The result is therefore given in percentage.

According to the previous descriptive result from this schema, these tables for measure KPI would help the decision makers by allowing them to make more than a single chart in monitoring the KPIs. Appendix B presents these measure tables with examples of these charts.

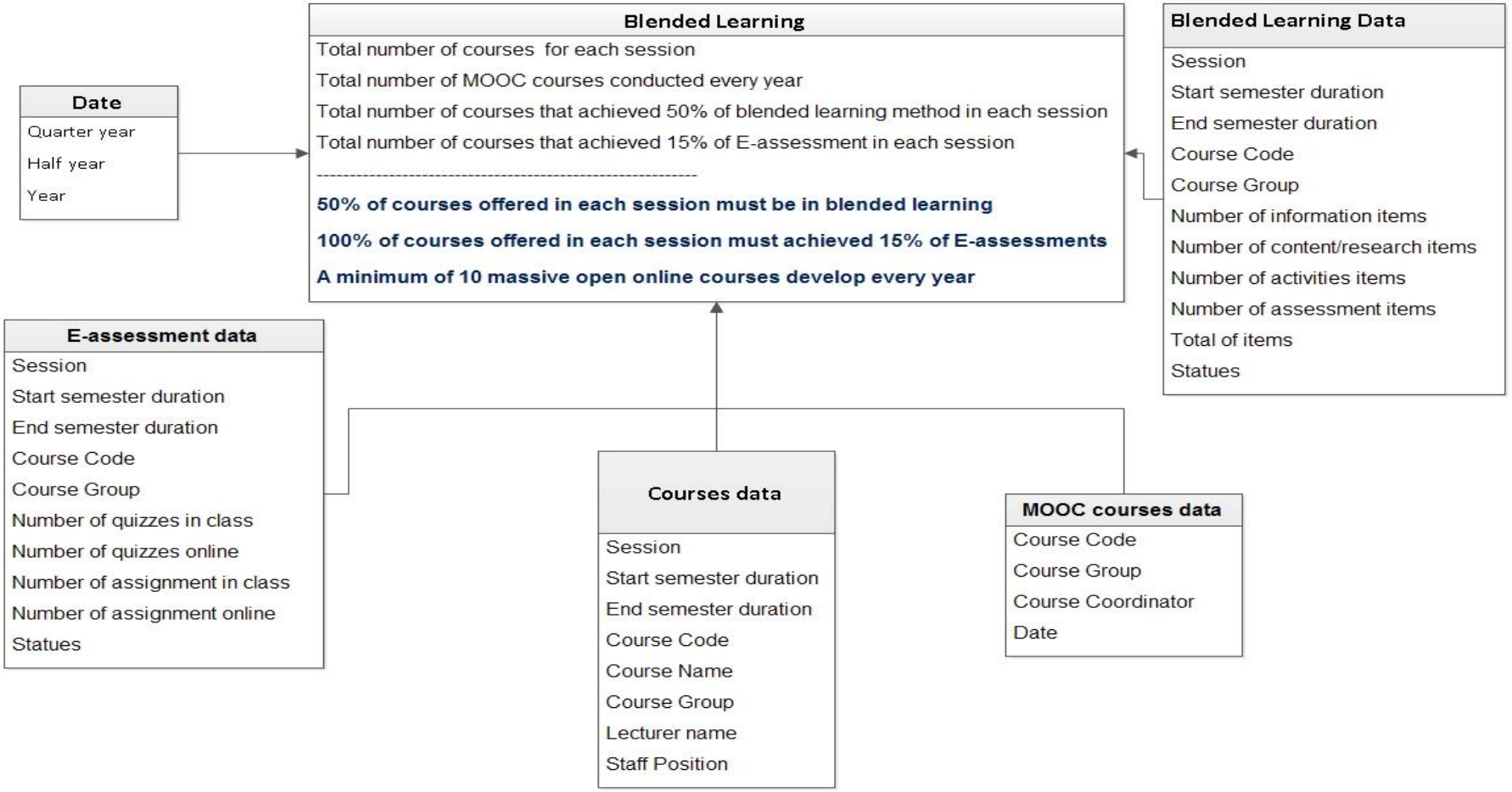


Figure 4.35. Star Schema: Blended Learning

Figure 4.35 represents the star schema of UTLC's Blended Learning. This is achieved after the requirement analysis steps for "The academic staff's ability to implement massive open online courses", "The academic staff's usage of the UUM online learning platform" and "the academic staff's ability to do E-assessments on UUM online learning platform"goals, through both organizational and decisional perspectives. It contains the fact table "Blended Learning" with five dimensions tables.

4.6.4 Discussion on Blended Learning Star Schema

The first dimension is Date table which represents the time period to produce more than one table for measure KPIs that are related to the goals in this schema. It will help this unit (university teaching and learning center) in monitoring these KPIs on quarter, bi-year and yearly basis.

From the Course Data table, the "Course Code" and "Course Group" attributes are produced, and the "Total number of courses for each semester "as Measure 1 (M1).

The MOOC Courses Data table has the "Course Code" and "Course Group" attributes. From this, the "Total number of MOOC courses conducted every year" is developed as measure and labeled Measure 2 (M2). This measure is mandatory to measure KPI of "A minimum of 10 massive open online courses develop every year". The measure M2 is divided by the target (25) which is the KPI, and the result presented in percentage.

Also from Blended Learning Data table, "Statuses" attribute is a dependant and produces "Total number of courses that achieved 50% of blended learning method in

each session" as a measure. This can be labeled Measure 3 (M3). The measures (M1 and M3) are mandatory in measuring "50% of courses offered in each session must be in blended learning" as a KPI by dividing M3 by M1. The result is therefore presented in percentage (%).

From E-assessment Courses Data table which the "Statuses" attribute depends on, there is "Total number of the courses that achieved 15% of E-assessment in each session" as a measure. This can be labeled Measure 4 (M4). The measures (M1 and M4) are mandatory in measuring "100% of courses offered in each session must achieve 15% of E-assessments" as a KPI by dividing M4 by M1. The result is then presented in percentage (%).

According to the previous descriptive result from this schema, the tables for measuring KPIs would help the decision makers by allowing them to make more than a single chart for monitoring the KPIs. Appendix B presents these measures tables with examples of these charts.

Lastly all these schemas have relationship with one another to produce more than one chart that helps this unit in monitoring more than one goal (KPIs). This chart shows how these goals affect each other. For example, the increased number of training programs on technology and pedagogy (Training goal) can be monitored to observe its possible effect on Blended Learning goal (see appendix B). These charts encompass these goals according to the relationship between them, and as it appear in Figure 4.6. The newly-proposed charts to this unit are not currently available in the presently-used system.

4.7 Summary of the Chapter

This study presents the process of analyses data warehouse schema for monitoring the UUM teaching and learning KPIs by using ReGADaK. To achieve this, the GRAnD methodology is extended, and the additional analysis extensively justified supporting the newly-KPI analysis. The study employed both the organisational and decisional modelling perspectives to analyse the goals, facts, measures and then KPIs. Consequently, the KPI values can be produced from the set of the goal analysis that extending from the measure analysis. Moreover, the KPIs are literally measures for organisational performance. Based on the requirement analysis and the mixed-design tasks, the data warehouse schemas were produced.

CHAPTER FIVE

EXPERT REVIEW

5.1 Introduction

This chapter contains the evaluation processes of the proposed data warehouse schema. It contains the verification process of the schema which is done by data warehouse experts. The findings of this evaluation process suggest the viability and practicality of the proposed data warehouse schema for university's teaching and learning's KPI monitoring.

5.2 Expert Review

The experts verify the correctness in the components and composition of the proposed data warehouse schema, especially as it relates with the objectives of this study. It supports the feasible practical implementation of the schema. The expert review is done through the designed instruments and the outlined metrics outlined in section 3.4.1 in chapter 3. (See Appendix A)

The metrics are: Explicit hierarchy, Symmetric treatment of dimensions, Multiple hierarchy in each dimension, Support for summary, Support for non-strict hierarchy, Supports for many-to-many relationship, Handling different levels of granularity and Handling uncertainty. The proposed data warehouse schema must meet the listed criteria for validity (Pedersen & Jesen, 1998).

According to Pedersen and Jesen (1998), explicit hierarchy means the data warehouse schema provides available relation between the different hierarchy levels

of the model. Symmetric treatment of dimensions means the schema allows summary attributes to be treated as dimensions; multiple hierarchy in each dimension implies that a lower dimension can roll up to a higher one. Example: for time, days can roll up to months, to year. Support for summary means the schema must give meaningful summaries to the user; support for non-strict hierarchy is that the schema has non-strict hierarchy because its members have cardinals. Supports for many-to-many relationship means the schema must support many-to-many relationship between facts and dimensions; handling different levels of granularity means a dimension of the schema can be summarized by another item with granularity; and handling uncertainty the model identifies uncertainties in the fact set, entity set, attribute set etc.

The three experts (labelled A, B & C in the findings section and with detail profile information in Appendix D) are chosen based on their background expertise in data warehousing generally, and university data warehouse design specifically. Two are industrial practitioners, and one is in academics. Expert review is chosen because it is a viable method of verifying and validating conceptual models in software engineering (Roger et al., 2010; Lazar, Feng, & Hochhneister, 2010).

5.2.1 Expert Review Findings

The findings from the expert verification exercise are presented in Table 5.1. The mean values are Expert A (4.75), Expert B (4.62), and Expert C (4.50). The findings showed that all the experts agreed that the proposed data warehouse schema is approximately “Very satisfactory”.

Table 5.1

Mean Values of the Expert Review findings

Metrics	**Expert A**	**Expert B**	**Expert C**	**Mean**
Explicit hierarchy	5	4	5	4.67
Symmetric treatment of dimensions	4	5	5	4.67
Multiple hierarchy in each dimension	5	5	5	5.00
Support for summary	5	4	5	4.67
Support for non-strict hierarchy	4	5	3	4.00
Supports for many-to-many relationship	5	4	5	4.67
Handling different levels of granularity	5	5	4	4.67
Handling uncertainty	5	5	4	4.67
Mean	4.75	4.62	4.50	4.62

All the metrics used in evaluating the proposed data warehouse schema attracted not less than 4 (Satisfactory). The most is “multiple hierarchies in each dimension” (5.00) which mean that a lower dimension can roll up to a higher one. Example: for time, days can roll up to months, to year. The least ranked in the metrics is “Support for non-strict hierarchy” (4.00) which means model has non-strict hierarchy because its members have cardinals. The researcher opines that being a conceptual schema (i.e. not a logical model) will not explicitly show the model’s cardinality and this could be responsible for the least ranking. Others like explicit hierarchy, symmetric treatment of dimensions, support for summary, supports for many-to-many relationship, handling different levels of granularity and handling uncertainty attract mean value of 4.62. This implies that the proposed data warehouse schema provides

available relation between the different hierarchy levels of the model, allows summary attributes to be treated as dimensions, give meaningful summaries to the user, support many-to-many relationship between facts and dimensions, can be summarized by another item with granularity, and model identifies uncertainties in the fact set, entity set, attribute set etc. In sum, the cumulative mean of the metrics which is 4.62 strongly suggests the proposed data warehouse schema is appropriate and satisfactory.

Figure 5.1 also shows a Radar graph which depicts a direct representation of the expert review findings showed in Table 5.1.

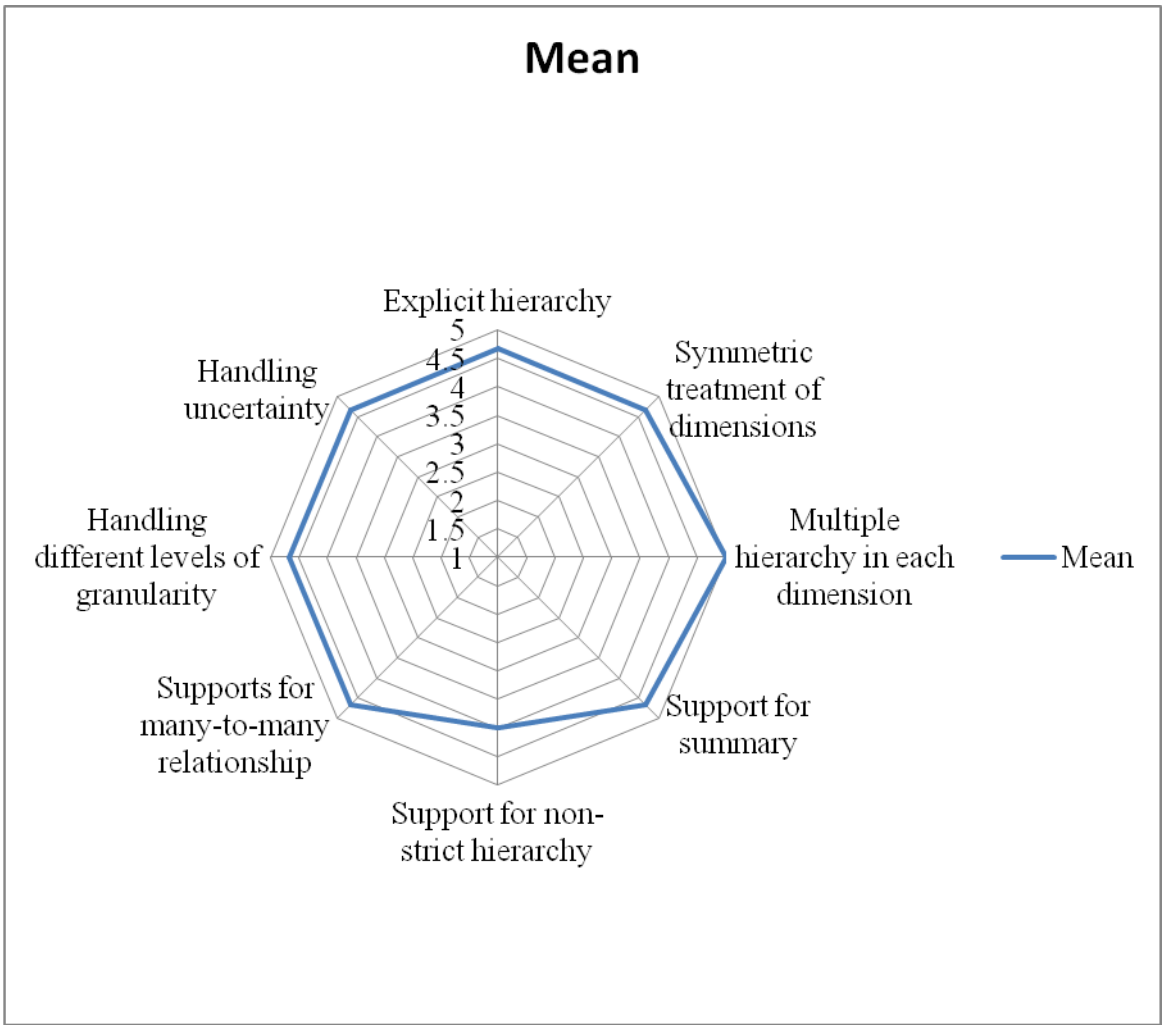


Figure 5.1. Radar graph for the Expert Review Findings

Interpreting the radar graph presented in Figure 5.1 can be done from the perspective of a wheel of competence for the proposed data warehouse schema, as Suryadi (2007) suggested. In a wheel, individual spoke is important and losing more than two spokes point to the possible impending damage of the wheel. This analogy can be used to further understand the radar graph that depicts the experts' reviews cumulative rankings of the schema's dimensions.

The strongest dimension, i.e. the most satisfactory, according to the expert review is multiple hierarchy in dimension, while others like support for summary, symmetric treatment of dimensions, explicit hierarchy, handling uncertainty, handling different level of granularity, and support for many-to-many relationship are less stronger, but satisfactory. The weakest, which can be seen as the faulty spoke, from the Suryadi's (2007) wheel of competence analogy, is support for non-strict hierarchy. This implies that the proposed schema has strict hierarchy because its members have cardinals. It suggests that the dimensions are not flexible enough.

5.3 Summary of the Chapter

This chapter describes evaluation processes of the proposed data warehouse schema. The processes are expert review, prototyping and usability evaluation. The experts used for the proposed data warehouse review are experts in data warehousing and business intelligence. Their feedback showed that the proposed schema has explicit hierarchies in its dimensions, has symmetric treatment of its dimensions, contains multiple hierarchies in each dimension, and supports correct summary, non-strict hierarchy, and many-to-many relationship between facts and dimensions. Also, it handles different levels of granularity in summarizing properties and uncertainty.

CHAPTER SIX

DISCUSSION AND CONCLUSION

6.1 Introduction

This chapter is the concluding part of this study. It discusses the answers to the research questions that are earlier posed by this study. The objectives of the study are thus revisited in view positioning its accomplishments. The limitations of the study and recommendations for future researches are then made.

6.2 Discussion

This study aimed developing a data warehouse schema that can be used in monitoring university's teaching and learning KPIs. The research questions that form the basis of conducting this study are:

a. How to design data warehouse schemas for monitoring university teaching and learning's KPIs?
b. Does the proposed data warehouse schema is correct for monitoring university teaching and learning's KPIs?

6.2.1 Research Question 1: How to design data warehouse schemas for monitoring university teaching and learning's KPIs?

Goal-oriented approach to requirement analysis in data warehouse (GRAnD) presented a generally-welcomed approach to analysing requirements and designing data warehouse using the goal-oriented method. In order to apply this method, the researcher started from identification of the main and sub actors (stakeholders from organizational perspectives and decision makers from decisional perspectives). Then, this is followed by the analysis of their strategic goals. It is on this basis that facts are analysed for each goal, and attributes are analysed from the organisational perspective. Also, dimension with measures that are related with the specific facts are analysed according to the dimension in decisional perspectives. Then, KPIs that are relevant to the facts are analysed, depending on the measures. The measures serve as the data usable for the monitoring of the KPIs. Based on this, the conceptual schema is designed. It maps the attributes from the organisational perspective for each of the respective goals with the befitting dimensions from the decisional perspective for the same goal.

This is this study's answer to how to design data warehouse schemas for monitoring University teaching and learning KPIs.

6.2.2 Research Question 2: Does the proposed data warehouse schema correct for monitoring university teaching and learning's KPIs?

Yes, the data warehouse schema is correct for monitoring university teaching and learning KPIs. After ensuring that the data warehouse attends to the goals and facts of the organisation and decision makers as shown in section 6.2.1 above, the schema

must comply with standard format. These schema structures are shown in Figures 4.32 to 4.35 for Staff Training by UTLC, Course Evaluation, Grant Allocation, and Blended Learning respectively.

The expert review thus essentially validate the correctness of the data warehouse schema using Explicit hierarchy, Symmetric treatment of dimensions, Multiple hierarchy in each dimension, Support for summary, Support for non-strict hierarchy, Supports for many-to-many relationship, Handling different levels of granularity, and Handling uncertainty as metric. From the findings of the expert review rankings of the schema dimensions, explicit hierarchy, symmetric treatment of dimensions, support for summary, supports for many-to-many relationship, handling different levels of granularity and handling uncertainty attract mean value of 4.62. This implies that the proposed data warehouse schema provides available relation between the different hierarchy levels of the model, allows summary attributes to be treated as dimensions, give meaningful summaries to the user, support many-to-many relationship between facts and dimensions, can be summarized by another item with granularity, and model identifies uncertainties in the fact set, entity set, attribute set etc.

Multiple hierarchies as a metric is ranked 5.00, meaning that the data warehouse schema allows a lower dimension to roll up to a higher one. Its support for non-strict hierarchy is 4.00, meaning that the schema has non-strict hierarchy because its members have cardinals.

So, the data warehouse schema, having been satisfactorily designed based on the organisation and decisional perspective through the goal-oriented approach as earlier discussed, is correct for monitoring university teaching and learning KPIs.

6.2.3 Revisiting the Objectives of the Study

In alignment with the research questions posed and answered by this study, the study's objectives are:

(a) To develop a data warehouse schema for monitoring university teaching and learning's KPIs using GRAnD approach, and
(b) To evaluate the correctness of the proposed data warehouse schemas for monitoring university teaching and learning's KPIs.

With the discussion given in section 6.2.2, this study develops a data warehouse schema for monitoring University KPIs using GRAnD approach. It extends the Giorgini et al. (2008) GRAnD to present ReGADaK used in the development of the data warehouse schema. The correctness of the proposed data warehouse schema is also evaluated and found usable, practicable and satisfactory.

6.3 Limitation and Recommendations for Future Work

Notably, to the best knowledge of the researcher, this study is the first to attend to goal-oriented analysis for both universities' teaching and learning KPIs monitoring and for university's data warehouse for KPIs design. This study cannot be compared based on the strength and weakness of its deliverables. However, there are observed limitations.

First, the study focuses only on the obtainable KPI-monitoring system for university teaching and learning centre (*to be the centre of excellence in teaching and learning*) which is sub goal in Universiti Utara Malaysia. Future study could expand the scope of the users' study to include the others sub goals for UUM. Finally, the future work

of this study is to develop an application to automate the design of this particular data warehouse from the goal analysis to the final design.

6.4 Conclusion

This study produced an extension of Giorgini et al.'s (2008) GRAnD tagged ReGADaK. It also proposed data warehouse schema for monitoring university's teaching and learning KPIs. A minimum viable prototype that demonstrates the applicability of the proposed schema is also produced. From due observation, it contributes to the decision support system and business intelligence bodies of knowledge. The prototype is able to demonstrate new KPI representations which are currently not used in the organisation's system.

Although this study still has understandable limitations and open for future works, it made practical contribution in terms of designed prototype and theoretical contributions in terms of the designed ReGADaK and proposed data warehouse schemas for monitoring university's teaching and learning KPIs.

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Appendices

Appendix A

Experts' Verification Instrument

EXPERT VERIFICATION INSTRUMENT FOR KPI MONITORING DATA WAREHOUSE CONCEPTUAL MODEL

This instrument is for the verification of the proposed KPI-monitoring data warehouse conceptual model. The instrument is of two (2) separate sections. Section A is to elicit your profile data while section B contains questions used to assess the adequacy of the proposed model in terms of correctness, modelling power and efficiency in information capturing and independence of design levels in the model. This is done using eight (8) different criteria adapted from Pedersen and Jesen's (1998) "Multidimensional Data Modelling of Complex Data."

All information supplied will be treated with utmost confidentiality, for the purpose of this research only, and with anonymous reportage in academic publications. Your attention is kindly appreciated.

Section A: Expert Profile

Name	
Institution	
Position	
Research Interest	
Experience (in Years)	
Email address	
Phone Number	

Section B: Having assessed the proposed data warehouse model, please, kindly rate the model through the following items using the 5-point Likert scale of 1 (Not satisfactory), 2 (Fairly Satisfactory), 3 (Neutral), 4 (Satisfactory) and 5 (Very satisfactory).

	Items	**Explanation**	**1**	**2**	**3**	**4**	**5**
1	The model has explicit hierarchies in its dimensions	There is available relation between the different hierarchy level of the model.					
2	The model has symmetric treatment of its dimensions	The model allows summary attributes to be treated as dimensions					
3	The model contains multiple hierarchy in each dimension	A lower dimension can roll up to a higher one. Example: for time, days can roll up to months, to year.					

4	The model supports correct summary	The model gives meaningful summaries to the user.					
5	The model supports non-strict hierarchy	The model has non-strict hierarchy because its members have cardinals					
6	The model supports many-to-many relationship between facts and dimensions	It supports many-to-many relationship between facts and dimensions					
7	The model handles different levels of granularity in summarizing properties	A dimension can be summarized by another item with granularity. Example: Grant accessed can be summarised by time, using date etc.					
8	The model handles uncertainty	The model identifies uncertainties in the fact set, entity set, attribute set etc.					

Signature:

Date:

Evaluator name:

Appendix B

Prototyping

A prototype for KPI information monitoring is developed based on the proposed data warehouse schema. Microsoft Excel Macro environment is used in developing the prototype.

i- Dimensions tables

Staff_ID	Staff Position	Date of appointment
1	Prof. Madya	01/01/2001
2	Pensyarah Universiti (DS45)	05/01/2001
3	Pensyarah Kanan	09/01/2001
4	Pensyarah	13/01/2001
5	Pensyarah Universiti (DS52)	17/01/2001
6	Pensyarah Universiti (DS51)	21/01/2001
7	Tutor (Tanpa Skim)	25/01/2001
8	Guru Bahasa	29/01/2001
9	Tutor (DA41)	02/02/2001
10	Prof Madya	06/02/2001
11	Tutor	10/02/2001
12	VisLec(Prof)	14/02/2001
13	VisLec(Senior)	18/02/2001
14	Profesor	22/02/2001
15	Professor	26/02/2001
16	Pensyarah DS54	02/03/2001
17	Pensyarah VK7	06/03/2001
18	Pensyarah DS52	10/03/2001
19	Pensyarah DS45	14/03/2001
20	Pensyarah DS51	18/03/2001

Figure B.1. Academic Staff Data Table

Training ID	Training Name	Start Training Period	End Training Period	Type	NO_Particebent
1	Bengke OBE : Curriculum ReviewUUM Online Learning	11/08/2013	15/08/2013	Teknologi	9
2	Bengkei Camtasia	26/08/2013	26/08/2013	Pedagogi	7
3	Bengkel Hands-on UUM Online Learning	14/08/2013	14/08/2013	Teknologi	13
4	Bengkel Learning & Teaching (UUM KL)	15/01/2013	21/01/2013	Teknologi	18
5	Bengkel Learning & Teaching Using Case Method	15/01/2013	15/01/2013	Pedagogi	20
6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi	15
7	Bengkel Pelaksanaan Sistem OBE Fasa	01/04/2013	01/04/2013	Pedagogi	8
8	Bengkel Pelaksanaan Sistem OBE Fasa 2	09/05/2013	09/05/2013	Pedagogi	13
9	Bengkel Pembinaan Portfolio	16/06/2013	16/06/2013	Pedagogi	20
10	Bengkel Pemurniaan Program Diploma Pascasiswazah Pengaja	24/07/2013	24/07/2013	Teknologi	15
11	Bengkel penggubalan program Diploma pasca siswazah penga	31/08/2013	31/08/2013	Teknologi	31
12	Bengkel Sistem OBE (SBM) Tool	08/10/2013	08/10/2013	Teknologi	26
13	Bengkel Sistem OBE (SOC)	15/11/2013	15/11/2013	Pedagogi	31
14	Bengkel Turnitin For Educators prevent Plagiarism, Engage Student	23/12/2013	23/12/2013	Pedagogi	13
15	Bengkel UUM Online Learning	30/01/2013	30/01/2013	Teknologi	36
16	Bengkel UUM Online Learning, ECEVAS dan OBE Sistem	09/03/2013	09/03/2013	Teknologi	41
17	Bengkel UUM Online Learning, eCevas dan Sistem OBE	16/04/2013	16/04/2013	Teknologi	56
18	Flipped Learning 3.0: Strategies and Tools	24/05/2013	24/05/2013	Pedagogi	5
19	Massive Open Online Course (MOOCs) Tool	01/07/2013	01/07/2013	Teknologi	10

Figure B.2. Training Data table

Staff ID	Staff Position	TrainingID	Training Name	Star Training Periode	End Training Periode	Type
110	Prof. Madya	1	Bengke OBE : Curriculum ReviewUUM Online Learning	11/08/2013	15/08/2013	Teknologi
111	Pensyarah Universiti (DS45)	1	Bengke OBE : Curriculum ReviewUUM Online Learning	11/08/2013	15/08/2013	Teknologi
112	Pensyarah Kanan	1	Bengke OBE : Curriculum ReviewUUM Online Learning	11/08/2013	15/08/2013	Teknologi
113	Pensyarah	1	Bengke OBE : Curriculum ReviewUUM Online Learning	11/08/2013	15/08/2013	Teknologi
114	Pensyarah Universiti (DS52)	1	Bengke OBE : Curriculum ReviewUUM Online Learning	11/08/2013	15/08/2013	Teknologi
115	Pensyarah Universiti (DS51)	1	Bengke OBE : Curriculum ReviewUUM Online Learning	11/08/2013	15/08/2013	Teknologi
116	Tutor (Tanpa Skim)	1	Bengke OBE : Curriculum ReviewUUM Online Learning	11/08/2013	15/08/2013	Teknologi
117	Guru Bahasa	1	Bengke OBE : Curriculum ReviewUUM Online Learning	11/08/2013	15/08/2013	Teknologi
118	Tutor (DA41)	1	Bengke OBE : Curriculum ReviewUUM Online Learning	11/08/2013	15/08/2013	Teknologi
119	Prof Madya	6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi
120	Tutor	6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi
210	VisLec(Prof)	6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi
211	VisLec(Senior)	6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi
212	Profesor	6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi
213	Professor	6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi
214	Pensyarah DS54	6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi
215	Pensyarah VK7	6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi
216	Pensyarah DS52	6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi
217	Pensyarah DS45	6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi
218	Pensyarah DS51	6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi
219	Pensyarah Universiti (DS54)	6	Bengkel Learning & Teaching Using case method (UUM COB)	22/02/2013	22/02/2013	Pedagogi

Figure B.3. Attending Training Data Table

Session	Start Semester Duration	End Semester Duration	Course Code	Course Name	Course Group	Lecturer ID	Position
A131	17 Sept 2012	15-Jan-13	UKAL1014	ACCOUNTING FOR BUSINESS DECISIONS	A	1	Prof. Madya
A131	17 Sept 2012	15-Jan-13	UKAL1014	ACCOUNTING FOR BUSINESS DECISIONS	B	2	Pensyarah Universiti (DS45)
A131	17 Sept 2012	15-Jan-13	STID5014	ADVANCED DATABASE DESIGN	A	3	Pensyarah Kanan
A131	17 Sept 2012	15-Jan-13	STID5014	ADVANCED DATABASE DESIGN	B	4	Pensyarah
A131	17 Sept 2012	15-Jan-13	STID5014	ADVANCED DATABASE DESIGN	B	5	Pensyarah Universiti (DS52)
A131	17 Sept 2012	15-Jan-13	BDMM8023	ADVANCED INTERNATIONAL MARKETING	A	6	Pensyarah Universiti (DS51)
A131	17 Sept 2012	15-Jan-13	BDMM8023	ADVANCED INTERNATIONAL MARKETING	B	7	Tutor (Tanpa Skim)
A131	17 Sept 2012	15-Jan-13	STIW5024	ADVANCED PROGRAMMING	A	8	Guru Bahasa
A131	17 Sept 2012	15-Jan-13	STIW5024	ADVANCED PROGRAMMING	B	9	Tutor (DA41)
A131	17 Sept 2012	15-Jan-13	STIW5014	ADVANCED SYSTEM ANALYSIS AND DESIGN	A	10	Prof Madya
A131	17 Sept 2012	15-Jan-13	STIW5014	ADVANCED SYSTEM ANALYSIS AND DESIGN	B	11	Tutor
A131	17 Sept 2012	15-Jan-13	STIW5014	ADVANCED SYSTEM ANALYSIS AND DESIGN	C	12	VisLec(Prof)
A131	17 Sept 2012	15-Jan-13	SGDV2053	AGAMA DALAM PENDIDIKAN MORAL	A	13	VisLec(Senior)
A131	17 Sept 2012	15-Jan-13	SGDV2053	AGAMA DALAM PENDIDIKAN MORAL	B	14	Profesor
A131	17 Sept 2012	15-Jan-13	SSWR2063	AGAMA DAN KEBAJIKAN SOSIAL	A	15	Professor
A131	17 Sept 2012	15-Jan-13	SSWR2063	AGAMA DAN KEBAJIKAN SOSIAL	B	16	Pensyarah DS54
A131	17 Sept 2012	15-Jan-13	STIN3054	AGEN PINTAR	A	17	Pensyarah VK7
A131	17 Sept 2012	15-Jan-13	STIN3054	AGEN PINTAR	B	18	Pensyarah DS52
A131	17 Sept 2012	15-Jan-13	STIN3054	AGEN PINTAR	C	19	Pensyarah DS45
A131	17 Sept 2012	15-Jan-13	BECA2043	AGRONOMI	A	20	Pensyarah DS51
A131	17 Sept 2012	15-Jan-13	BECA2043	AGRONOMI	B	21	Pensyarah Universiti (DS54)

Figure B.4. Course Data Table

Session	Start Semester Duration	End Semester Duration	Course Code	Course Name	Course Group	Lecturer ID	Position	Percentage
A131	17 Sept 2012	15-Jan-13	UKAL1014	ACCOUNTING FOR BUSINESS DECISIONS	A	1	Felo DS54	60
A131	17 Sept 2012	15-Jan-13	UKAL1014	ACCOUNTING FOR BUSINESS DECISIONS	B	2	Pensyarah (DS45)	60
A131	17 Sept 2012	15-Jan-13	STID5014	ADVANCED DATABASE DESIGN	A	3	Timbalan Pengarah	60
A131	17 Sept 2012	15-Jan-13	STID5014	ADVANCED DATABASE DESIGN	B	4	PEGAWAI TEKNOLOG	60
A131	17 Sept 2012	15-Jan-13	STID5014	ADVANCED DATABASE DESIGN	B	5	Pensyarah Universiti	60
A131	17 Sept 2012	15-Jan-13	BDMM8023	ADVANCED INTERNATIONAL MARKETING	A	6	Pensyarah DS52	60
A131	17 Sept 2012	15-Jan-13	BDMM8023	ADVANCED INTERNATIONAL MARKETING	B	7	Pensyarah Universiti	60
A131	17 Sept 2012	15-Jan-13	STIW5024	ADVANCED PROGRAMMING	A	8	PENSYARAH KANAN	60
A131	17 Sept 2012	15-Jan-13	STIW5024	ADVANCED PROGRAMMING	B	9	PROF. MADYA	60
A131	17 Sept 2012	15-Jan-13	STIW5014	ADVANCED SYSTEM ANALYSIS AND DESIGI	A	10	Guru Bahasa (DG44)	60
A131	17 Sept 2012	15-Jan-13	STIW5014	ADVANCED SYSTEM ANALYSIS AND DESIGI	B	11	Pensyarah Universiti	60
A131	17 Sept 2012	15-Jan-13	STIW5014	ADVANCED SYSTEM ANALYSIS AND DESIGI	C	12	Pensyarah (DS45)	60
A131	17 Sept 2012	15-Jan-13	SGDV2053	AGAMA DALAM PENDIDIKAN MORAL	A	13	Professor	60
A131	17 Sept 2012	15-Jan-13	SGDV2053	AGAMA DALAM PENDIDIKAN MORAL	B	14	Timbalan Pengarah	60
A131	17 Sept 2012	15-Jan-13	SSWR2063	AGAMA DAN KEBAJIKAN SOSIAL	A	15	Pensyarah Universiti	60
A131	17 Sept 2012	15-Jan-13	SSWR2063	AGAMA DAN KEBAJIKAN SOSIAL	B	16	Pensyarah (DS45)	60
A131	17 Sept 2012	15-Jan-13	STIN3054	AGEN PINTAR	A	17	Guru Bahasa Knn	60
A131	17 Sept 2012	15-Jan-13	STIN3054	AGEN PINTAR	B	18	Guru Katering	60
A131	17 Sept 2012	15-Jan-13	STIN3054	AGEN PINTAR	C	19	Pensyarah Universiti	100
A131	17 Sept 2012	15-Jan-13	BECA2043	AGRONOMI	A	20	Felo DS61	100
A131	17 Sept 2012	15-Jan-13	BECA2043	AGRONOMI	B	21	Professor	100

Figure B.5. Course Evaluation Data Table

Session	Start Semester Durati	End Semester Durati	Course Code	Course Group	Information	Content/research	Activities	Assessment	Jumlah	Status
A131	17 Sept 2012	15-Jan-13	UKAL1014	A	1	7	271	2	281	BLENDED
A131	17 Sept 2012	15-Jan-13	UKAL1014	B	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	STID5014	A	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	STID5014	B	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	STID5014	B	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	BDMM8023	A	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	BDMM8023	B	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	STIW5024	A	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	STIW5024	B	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	STIW5014	A	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	STIW5014	B	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	STIW5014	C	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	SGDV2053	A	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	SGDV2053	B	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	SSWR2063	A	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	SSWR2063	B	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	STIN3054	A	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	STIN3054	B	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	STIN3054	C	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	BECA2043	A	0	0	13	0	13	NOT BLENDED
A131	17 Sept 2012	15-Jan-13	BECA2043	B	0	0	13	0	13	NOT BLENDED

Figure B.6. Blended Data Table

Session	Start Semester Dur	End Semester Du	Course Cod	Course Grou	Number Quizzes in cl	Number Quizzes on	Number Assignments in	Number Assignments o	statues
A131	17 Sept 2012	15-Jan-13	UKAL1014	A	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	UKAL1014	B	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	STID5014	A	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	STID5014	B	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	STID5014	B	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	BDMM8023	A	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	BDMM8023	B	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	STIW5024	A	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	STIW5024	B	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	STIW5014	A	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	STIW5014	B	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	STIW5014	C	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	SGDV2053	A	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	SGDV2053	B	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	SSWR2063	A	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	SSWR2063	B	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	STIN3054	A	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	STIN3054	B	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	STIN3054	C	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	BECA2043	A	1	1	2	2	E-asseeeme
A131	17 Sept 2012	15-Jan-13	BECA2043	B	1	1	2	2	E-asseeeme

Figure B.7. E-assessment Data Table

Course Code	Course Name	Course Coordinator ID	Date
STIV1023	Asas Sistem Multimedia	10	02/02/2013
STIV2013	Interaksi Manusia Komputer	25	15/02/2013
BKAL1013	Perakaunan Perniagaan/Business Accounting	43	15/03/2013
BJMP5023	Operation and Technology m??	100	04/04/2013
GFPA2233	Malaysian Foreign Policy	209	20/06/2013
SCCT1013	Teknologi Komunikasi Maklumat & Masyarakat	324	01/02/2014
SGDM2013	Asas Teknologi Multimedia dalam Pendidikan	678	14/04/2014
SQIT3033	Perolehan Pengetahuan Dalam Pembuatan Keputusan	900	20/04/2014
SSWP1033	Kesukarelawan	456	05/06/2014
BPMM1013	Pengantar Pemasaran	213	25/06/2014
BEEB1013	Prinsip Ekonomi	234	02/07/2014
BWBS3043	Islamic Banking Management	531	10/07/2014
BWSS2013	Philosophy of Business in Islamic Finance and Banking	12	25/07/2014
GFPA2233	Malaysian Foreign Policy	56	05/09/2014
GFMA2023	International Business	786	10/09/2014
GMJP3133	Project Financing	987	15/09/2014
GHOC1024	Prinsip Penyediaan Makanan	923	25/09/2014

Figure B.8. MOOCs Data Table

Figure B.9, on the other hand, presents the table for KPI measurement of the training program per year.

ii- The first result from Star Schema Technology and Pedagogy Training

Year	Total number of lecturers/academic staff (Target)	Total number of academic staffs that use UUM online learning training (Achieved)	Measure KPI for the acquired academic staffs training through the UUM online learning platform (Achieved)	100% fulfilment for the acquired academic staffs training through the UUM online learning platform (Achieved)	Total number of training programs on technology conducted every year (Achieved)	Measure KPI of total number of training programs on technology every year (Target)	A minimum of 25 training programs on technology every year (Target)	Total number of academic staff that use the Web2.0 tools (Achieved)	Measure KPI for the academic staff that use the Web2.0 tools (Achieved)	100% fulfilment for the acquired academic staffs training using Web2.0 tools (Target)	Total number of training programs on pedagogy conducted every year (Achieved)	Measure KPI of total number of training programs on pedagogy conducted every year (Achieved)	A minimum of 25 training programs on pedagogy conducted every year (Achieved)	A minimum of 50 training programs on technology and pedagogy every year (Target)	Total number of training programs on tecnology and pedagogy conducted every year (Achieved)	Measure KPI of total number of training programs on technology and pedagogy conduc
2013	1497	1015	68%	100%	18	72%	25	814	54%	100%	17	68%	25	50	35	70%
2014	1547	1295	84%	100%	22	88%	25	950	61%	100%	22	88%	25	50	44	88%

achieved	
not achieved yet	
not achieved	

Figure B.9. Table for KPI Measurement of Training Programs per year

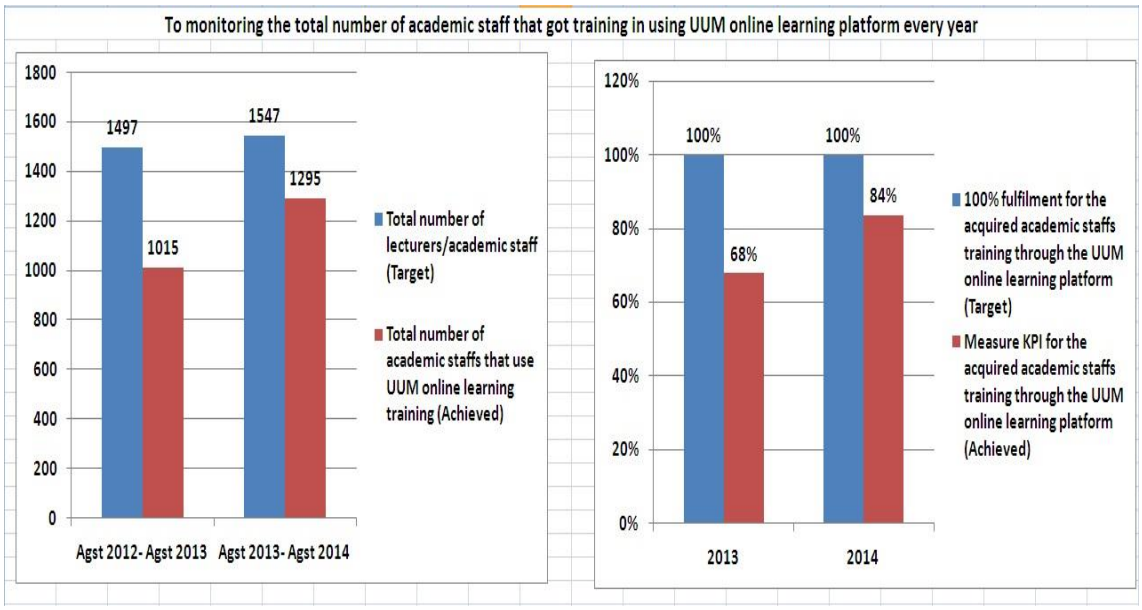


Figure B.10. The bar chart to monitor the total number of academic staff that got training in using UUM online learning platform every year

In this figure there are two charts to show the result (the Target and Achievement).The first in numbers, and the second in percentages. This is to present more than one view to the decision makers.

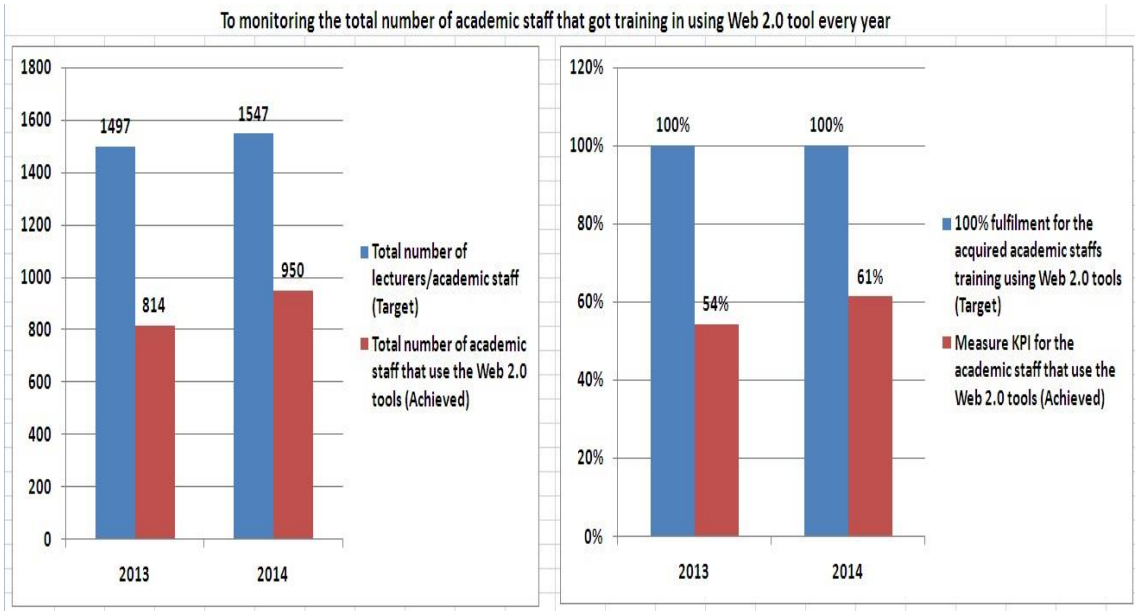


Figure B.11. The bar chart to monitor the total number of academic staff that got training in using Web 2.0 tool every year

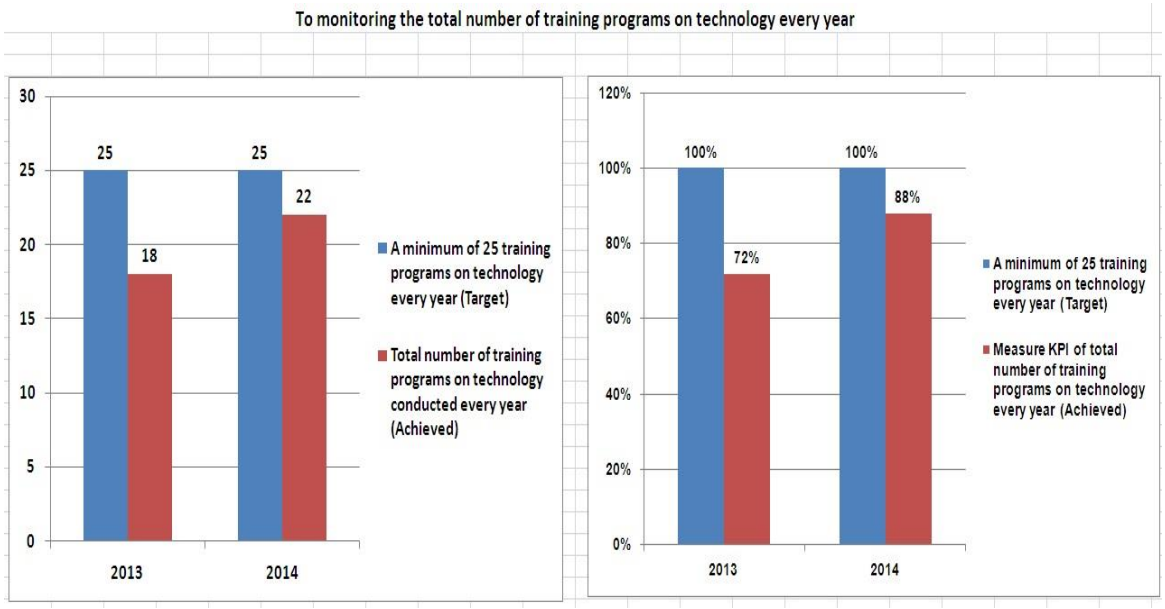


Figure B.12. The bar chart to monitor the total number of training programs on technology every year

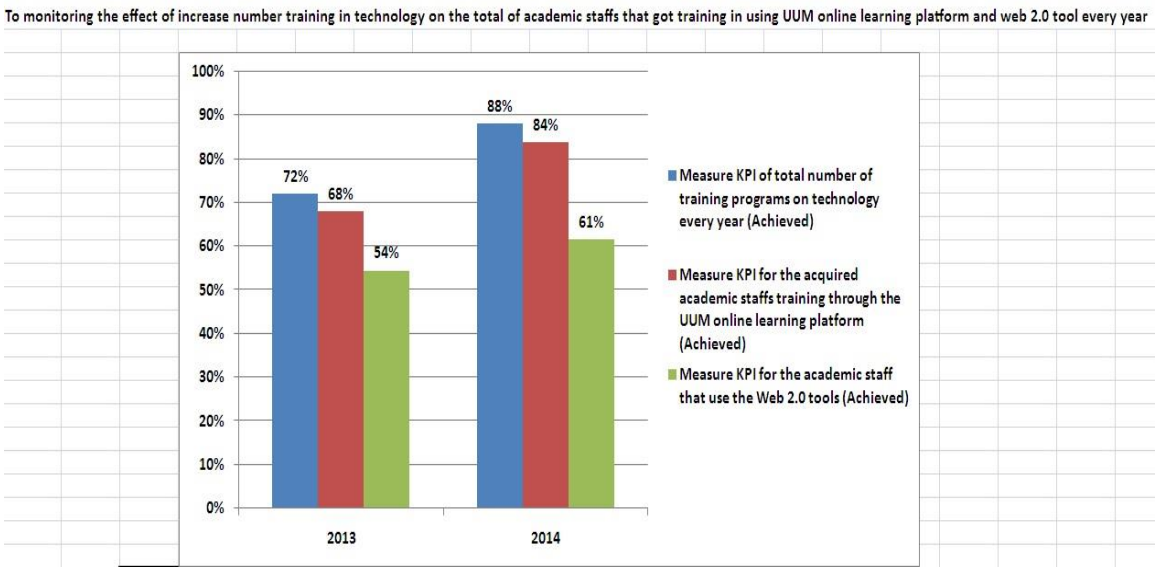


Figure B.13. The bar chart to monitor the effect of increase number training in technology on the total of academic staffs that got training in using UUM online learning platform and web 2.0 tools every year

This chart shows the relationship between Training programs on Technology and Total number of academic staff that got training in use UUM online learning

platform, Web 2.0 tools. The KPIs in one chart is to monitor the relationship between these goals and the effect on each other, this relationship is already identified by the goal analysis in chapter 4; Figure 4.6. From this chart, the affected unit can be duly guided. This is a contribution newly made by this study as evident in the domain study that current system lacks this.

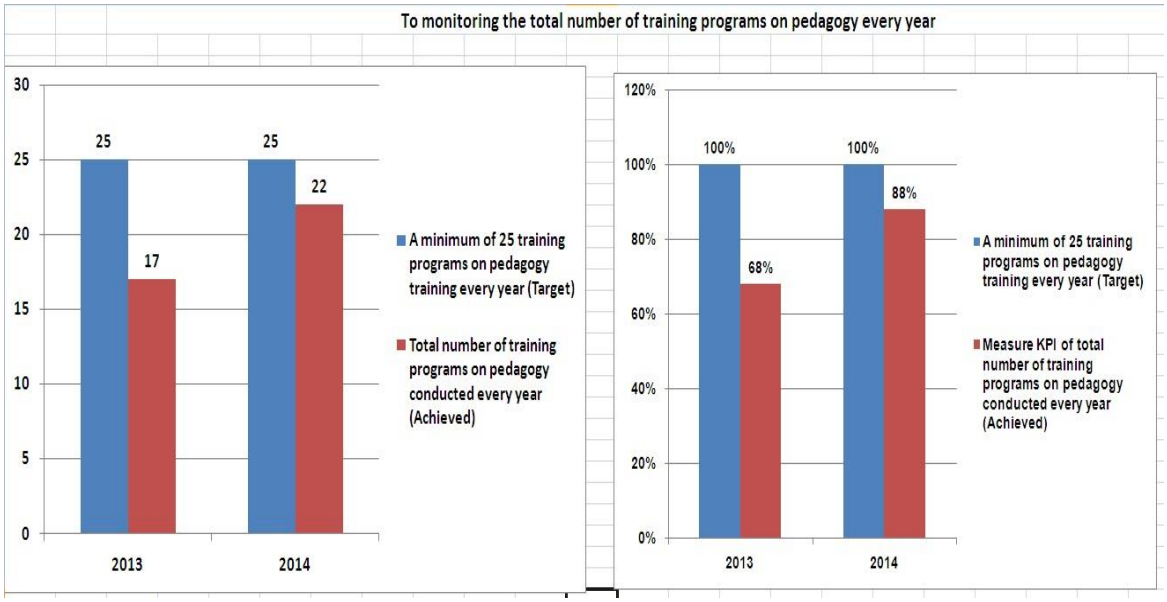


Figure B.14. The bar chart to monitor the total number of training programs on pedagogy every year

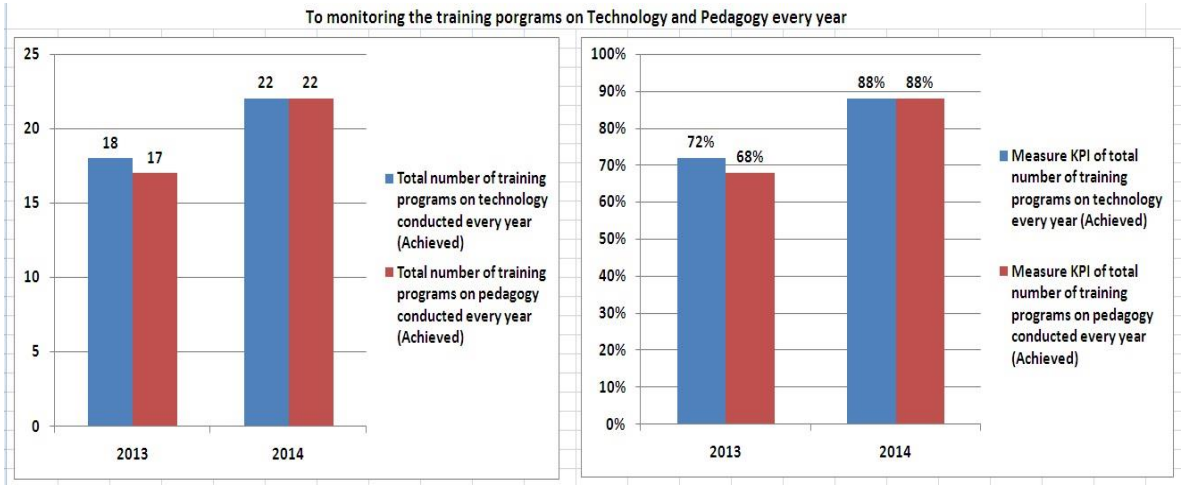
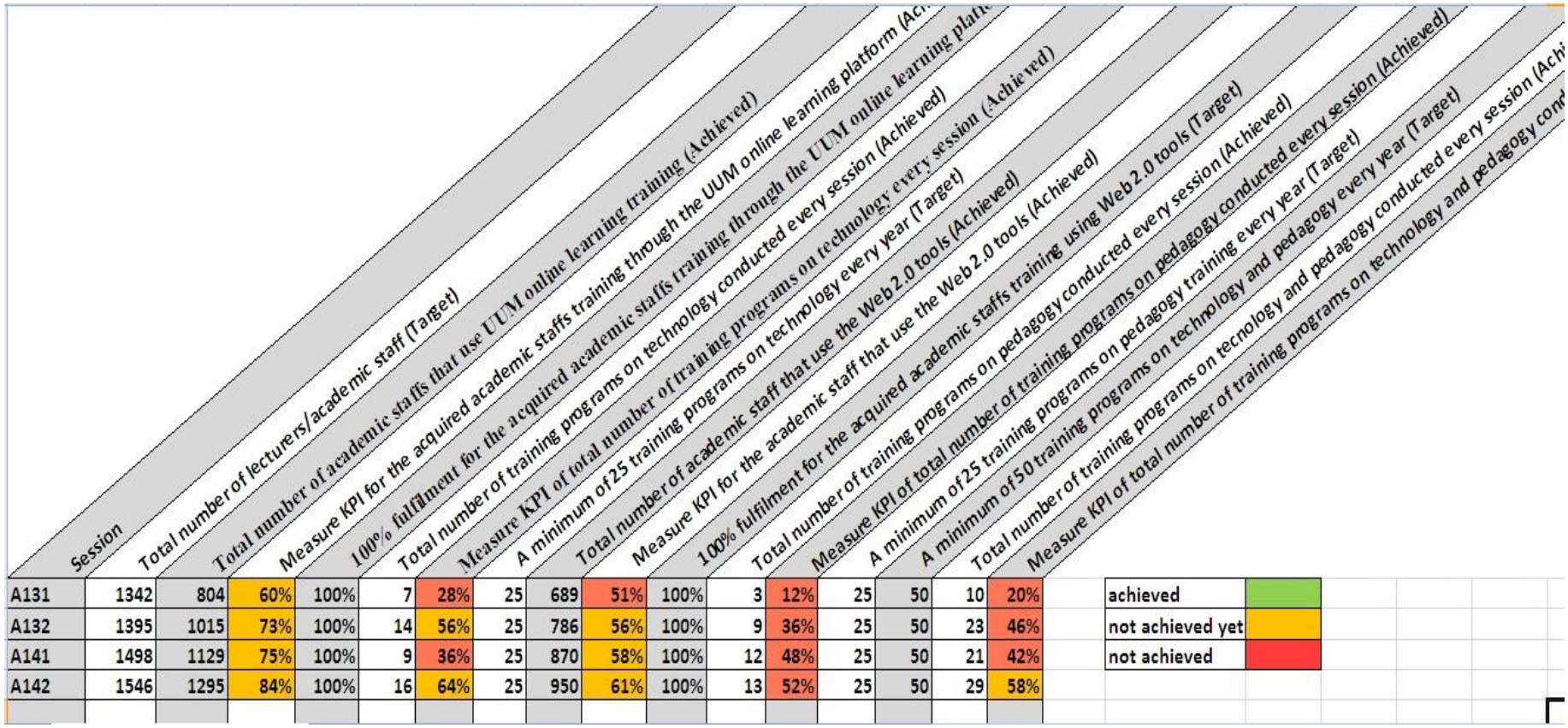


Figure B.15. The bar chart to monitor the training programs on Technology and Pedagogy every year

iii- The second result from Star Schema Technology and Pedagogy Training



Session	Total number of lecturers/academic staff (Target)	Total number of academic staffs that use UUM online learning training (Achieved)		Measure KPI for the acquired academic staffs training through the UUM online learning platform (Achieved)		100% fulfilment for the acquired academic staffs training through the UUM online learning platform (Achieved)		Total number of training programs on technology conducted every session (Achieved)		Measure KPI of total number of training programs on technology every session (Achieved)		A minimum of 25 training programs on technology every year (Target)		Total number of academic staff that use the Web 2.0 tools (Achieved)		Measure KPI for the academic staff that use the Web 2.0 tools (Achieved)		100% fulfilment for the acquired academic staffs training using Web 2.0 tools (Target)		Total number of training programs on pedagogy conducted every session (Achieved)		Measure KPI of total number of training programs on pedagogy conducted every session (Achieved)		A minimum of 25 training programs on pedagogy every year (Target)		A minimum of 50 training programs on pedagogy every year (Target)		Total number of training programs on technology and pedagogy conducted every session (Achieved)		Measure KPI of total number of training programs on technology and pedagogy conducted every session (Achieved)	
A131	1342	804	60%	100%	7	28%	25	689	51%	100%	3	12%	25	50	10	20%														
A132	1395	1015	73%	100%	14	56%	25	786	56%	100%	9	36%	25	50	23	46%														
A141	1498	1129	75%	100%	9	36%	25	870	58%	100%	12	48%	25	50	21	42%														
A142	1546	1295	84%	100%	16	64%	25	950	61%	100%	13	52%	25	50	29	58%														

achieved	
not achieved yet	
not achieved	

Figure B.16. Table for measuring KPI of Training programs per session

As shown in Figure B.16, the training unit achieves their goals (target) in training programs per session. The table in the column “Session” represents the time period of monitoring the affected KPI. The Total and Measures are the same as in monitoring KPIs of training programs per year. The only difference is one is calculated per year, the other per session.

The table would help the decision makers through the presentation in more than one chart. It affords them different views of monitoring the KPIs. These charts are presented Figures B.17 to B.22.

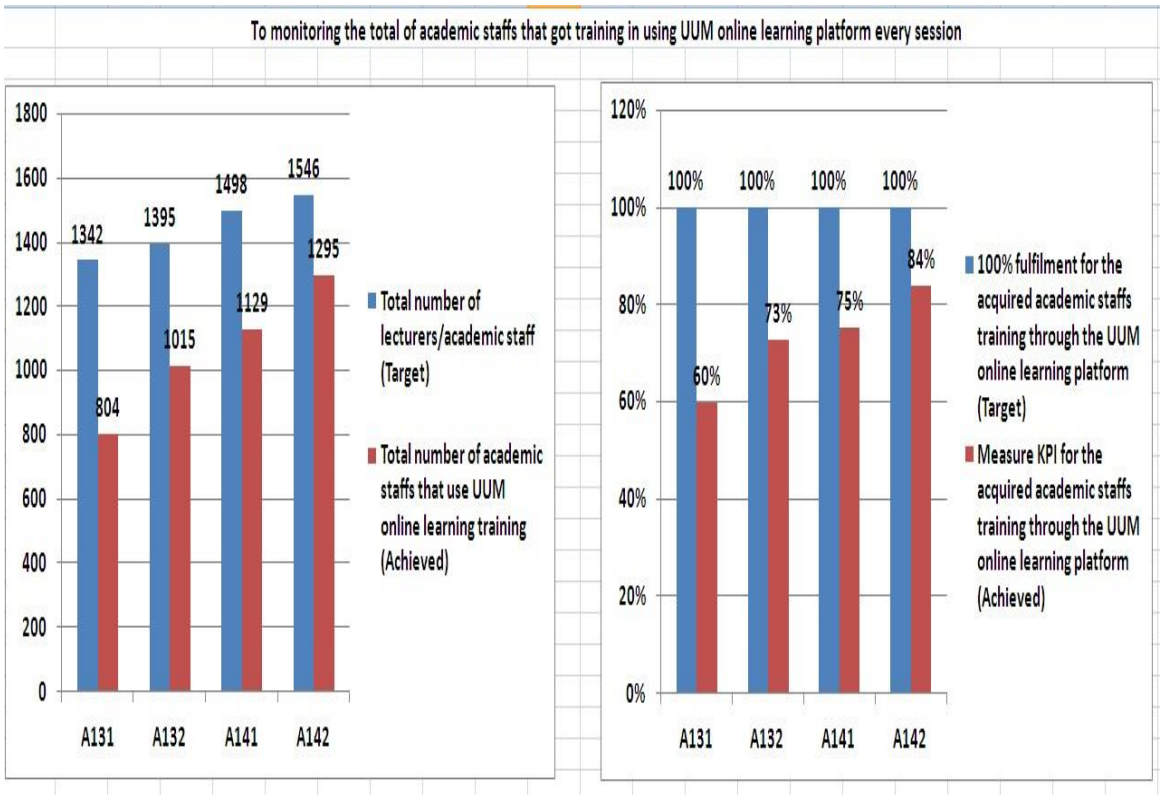


Figure B.17. Chart to monitor the total of academic staffs that got training in using UUM online learning platform every session

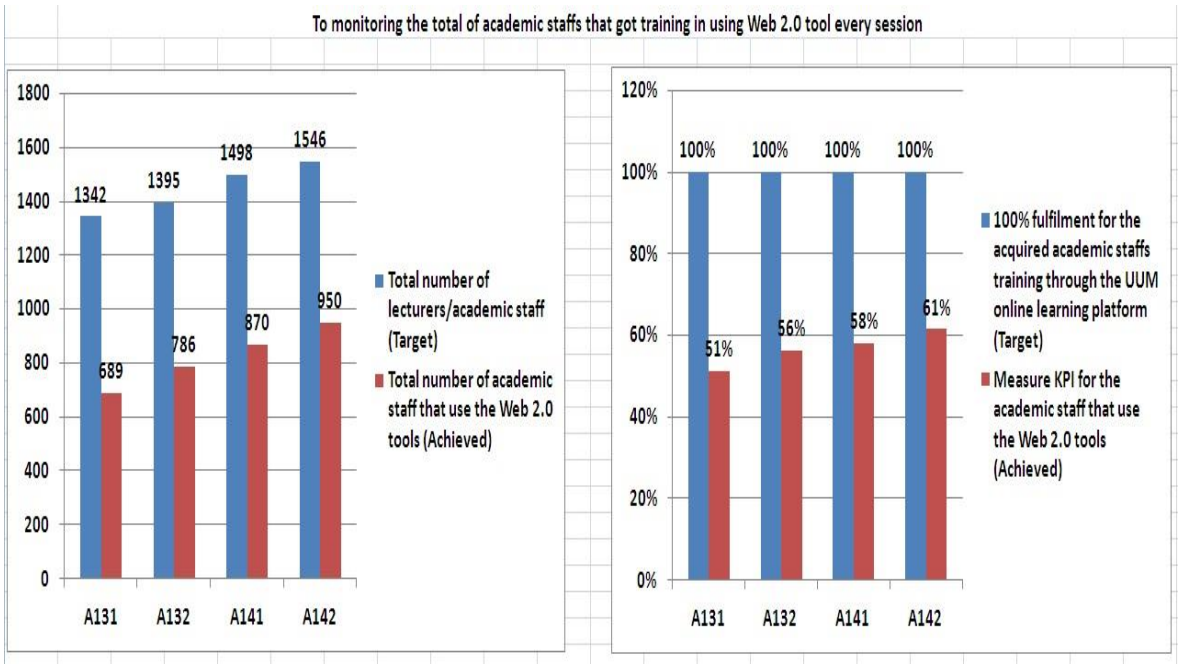


Figure B.18. Chart to monitor the total of academic staffs that got training in using Web 2.0 tool every session

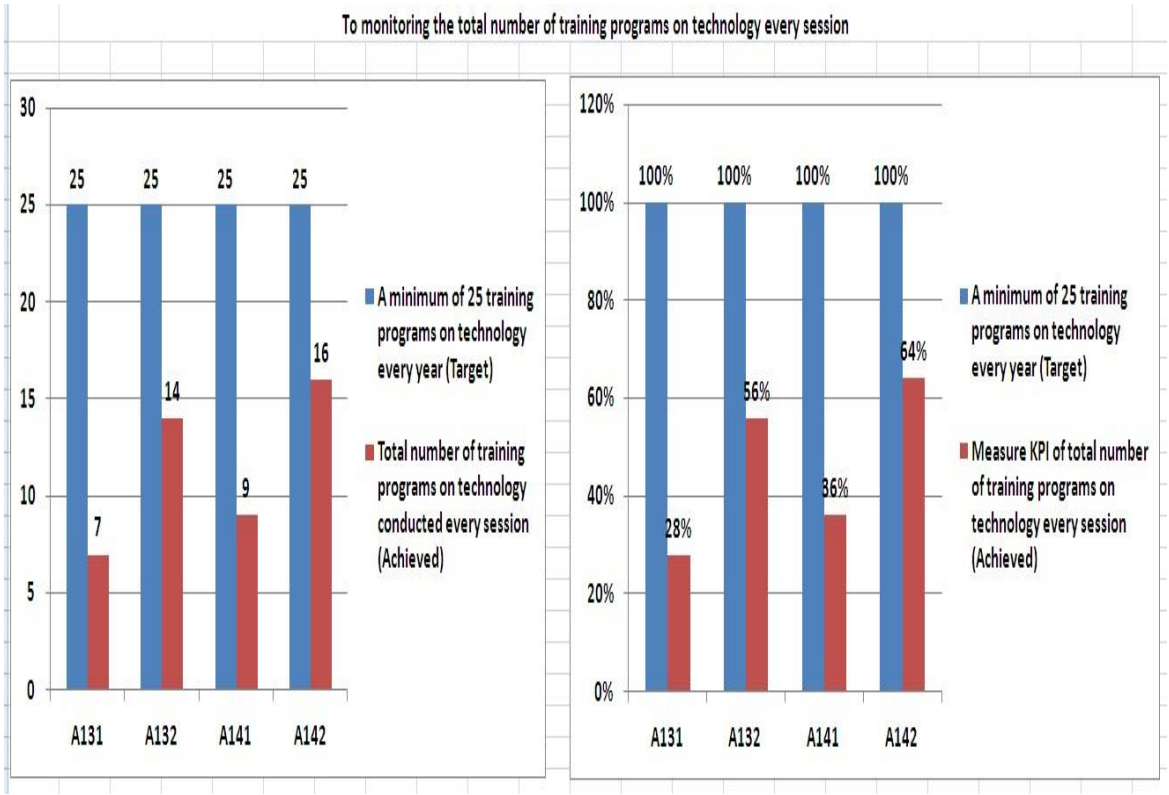


Figure B.19: Chart to monitor the total number of training programs on technology every session

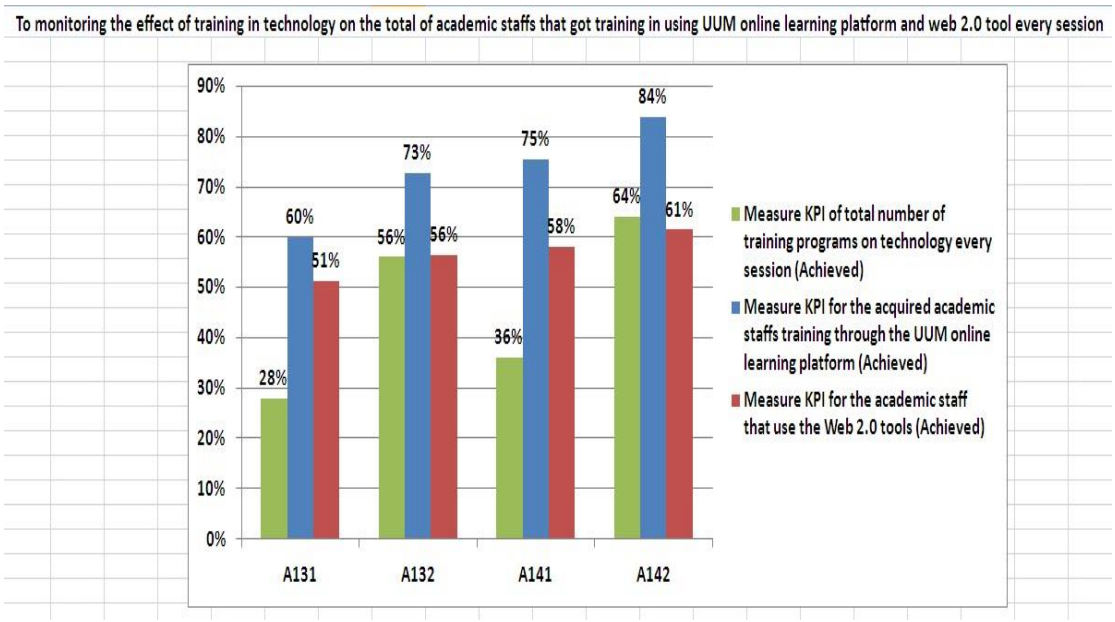


Figure B.20. Chart to monitor the effect of training in technology on the total of academic staffs that got training in using UUM online learning platform and web 2.0 tools every session

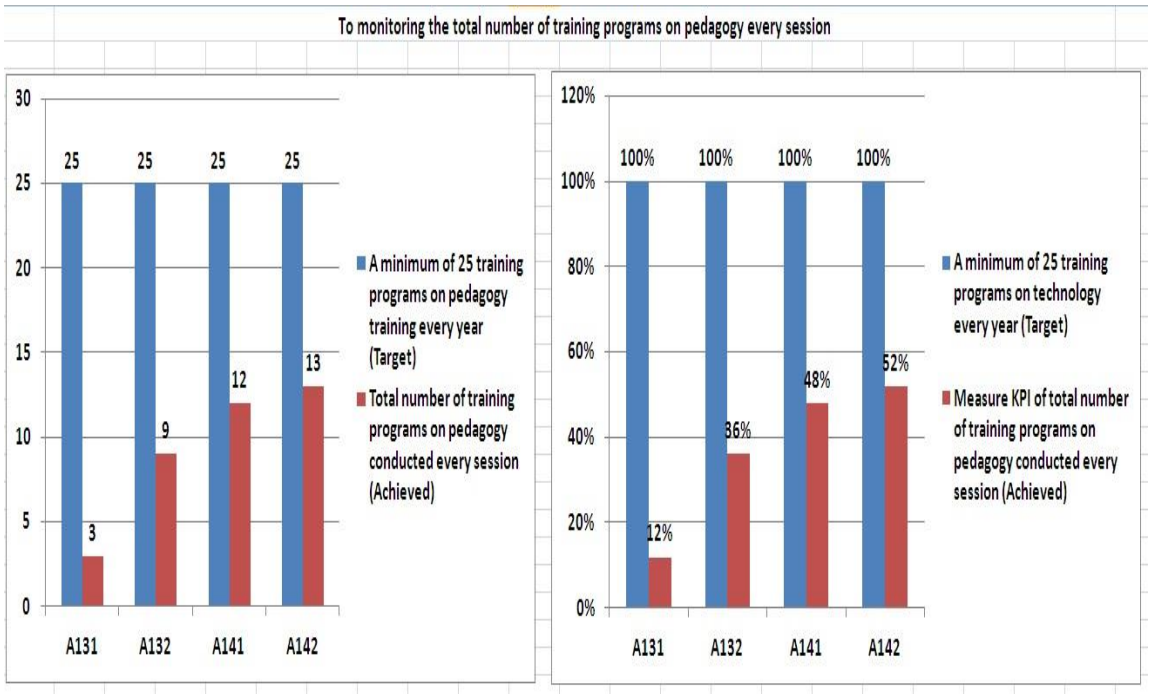


Figure B.21. Chart to monitor the total number of training programs on pedagogy every session

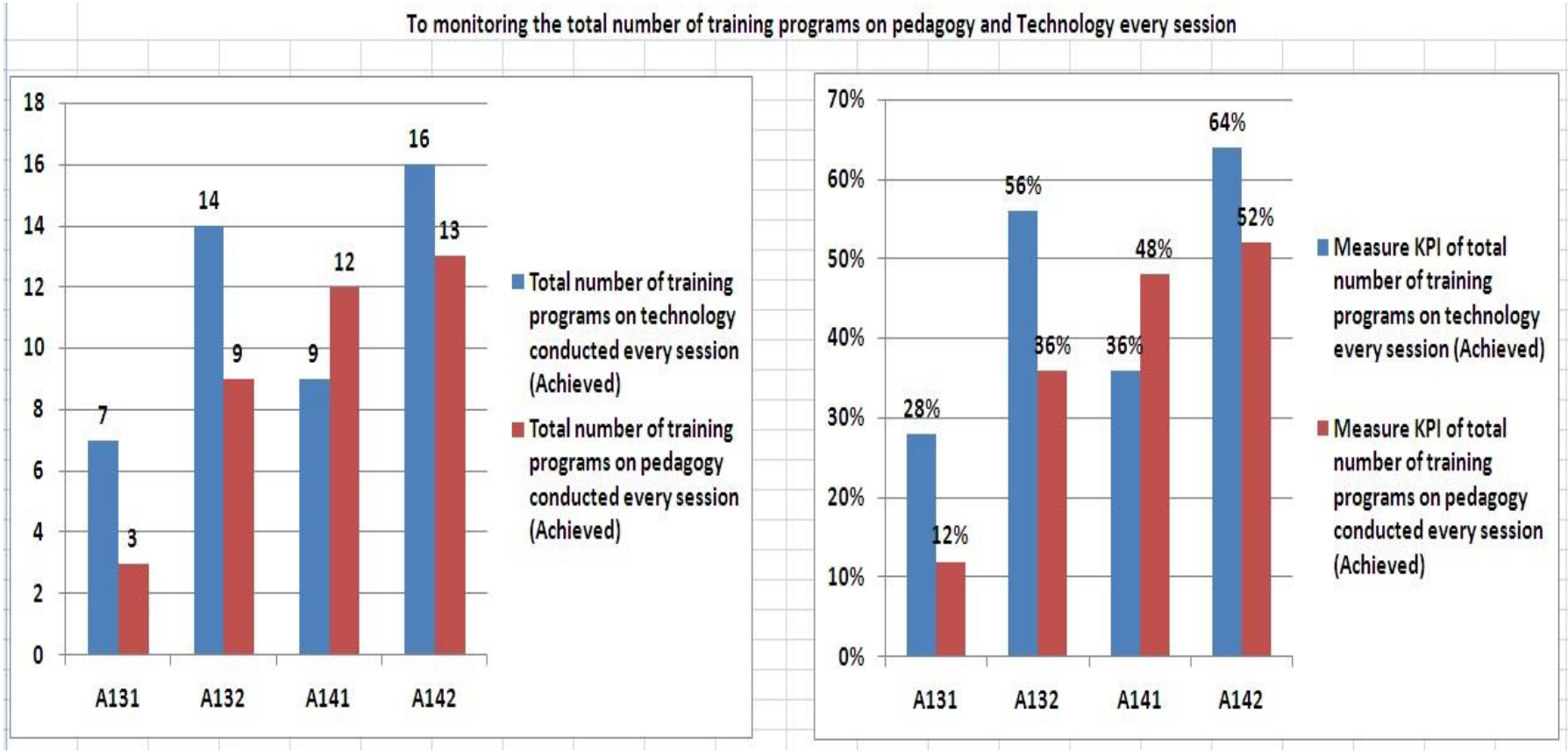
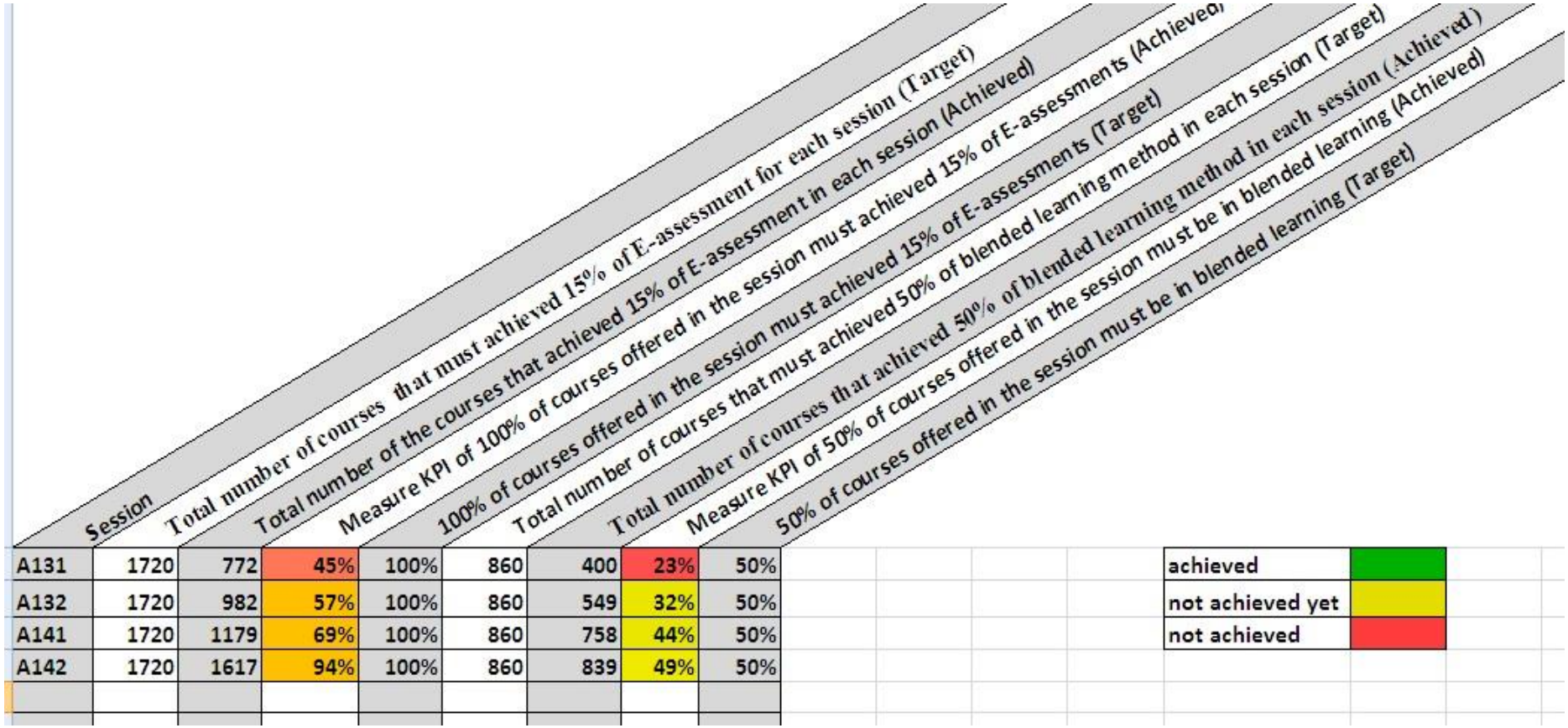


Figure B.22. Chart to monitor the total number of training programs on pedagogy and Technology every session

iv- The first result from Star Schema Blended Learning



Session	Total number of courses that must achieved 15% of E-assessment for each session (Target)	Total number of the courses that achieved 15% of E-assessment in each session (Achieved)	Measure KPI of 100% of courses offered in the session must achieved 15% of E-assessments (Achieved)	100% of courses offered in the session must achieved 15% of E-assessments (Target)	Total number of courses that must achieved 50% of blended learning method in each session (Target)	Total number of courses that achieved 50% of blended learning method in each session (Achieved)	Measure KPI of 50% of courses offered in the session must be in blended learning (Achieved)	50% of courses offered in the session must be in blended learning (Target)
A131	1720	772	45%	100%	860	400	23%	50%
A132	1720	982	57%	100%	860	549	32%	50%
A141	1720	1179	69%	100%	860	758	44%	50%
A142	1720	1617	94%	100%	860	839	49%	50%

achieved	
not achieved yet	
not achieved	

Figure B.23. Table for measuring KPI of Blended learning per session

This would help the decision makers with presentation in more than one chart for the monitoring of the KPIs. These charts are presented in Figures B.24 to B.27.

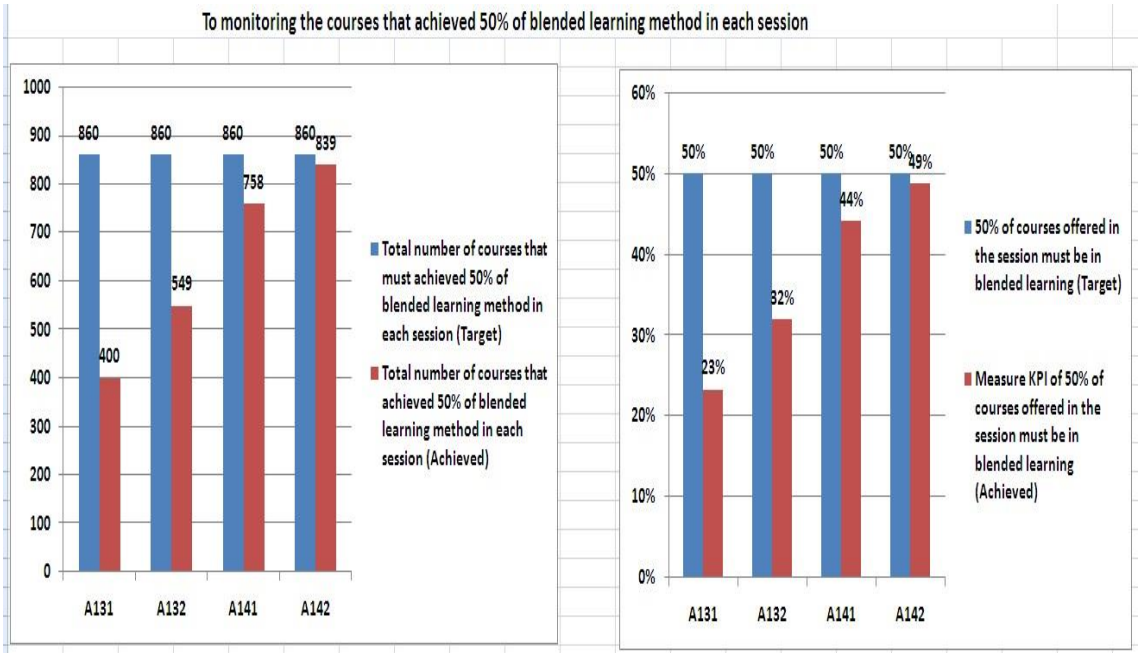


Figure B.24. Chart to monitor the courses that achieved 50% of blended learning method in each session

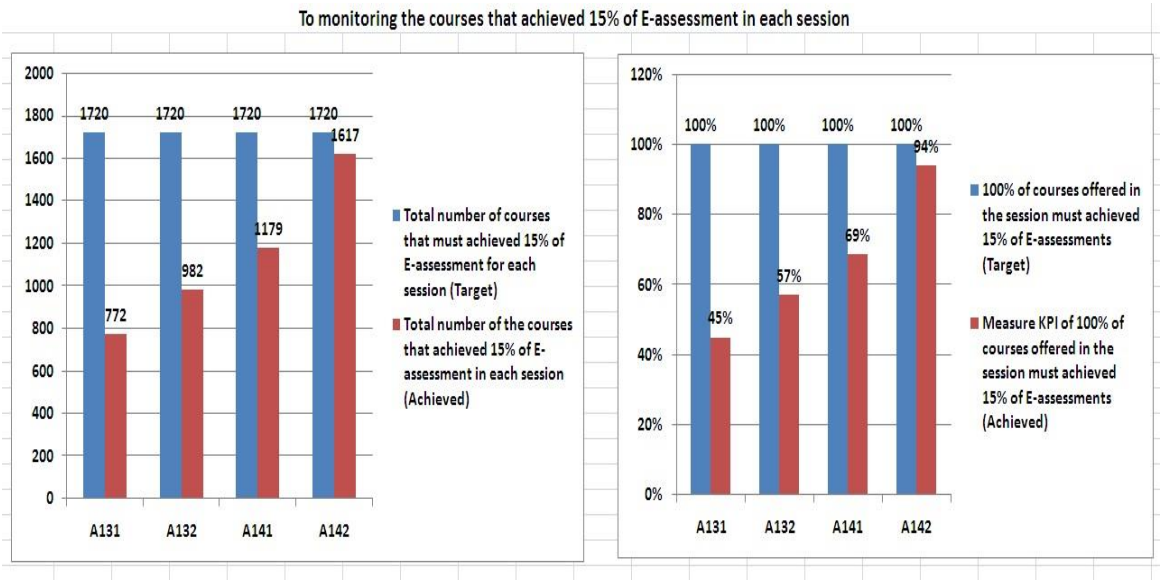


Figure B.25. Chart to monitor the courses that achieved 15% of E-assessment in each session

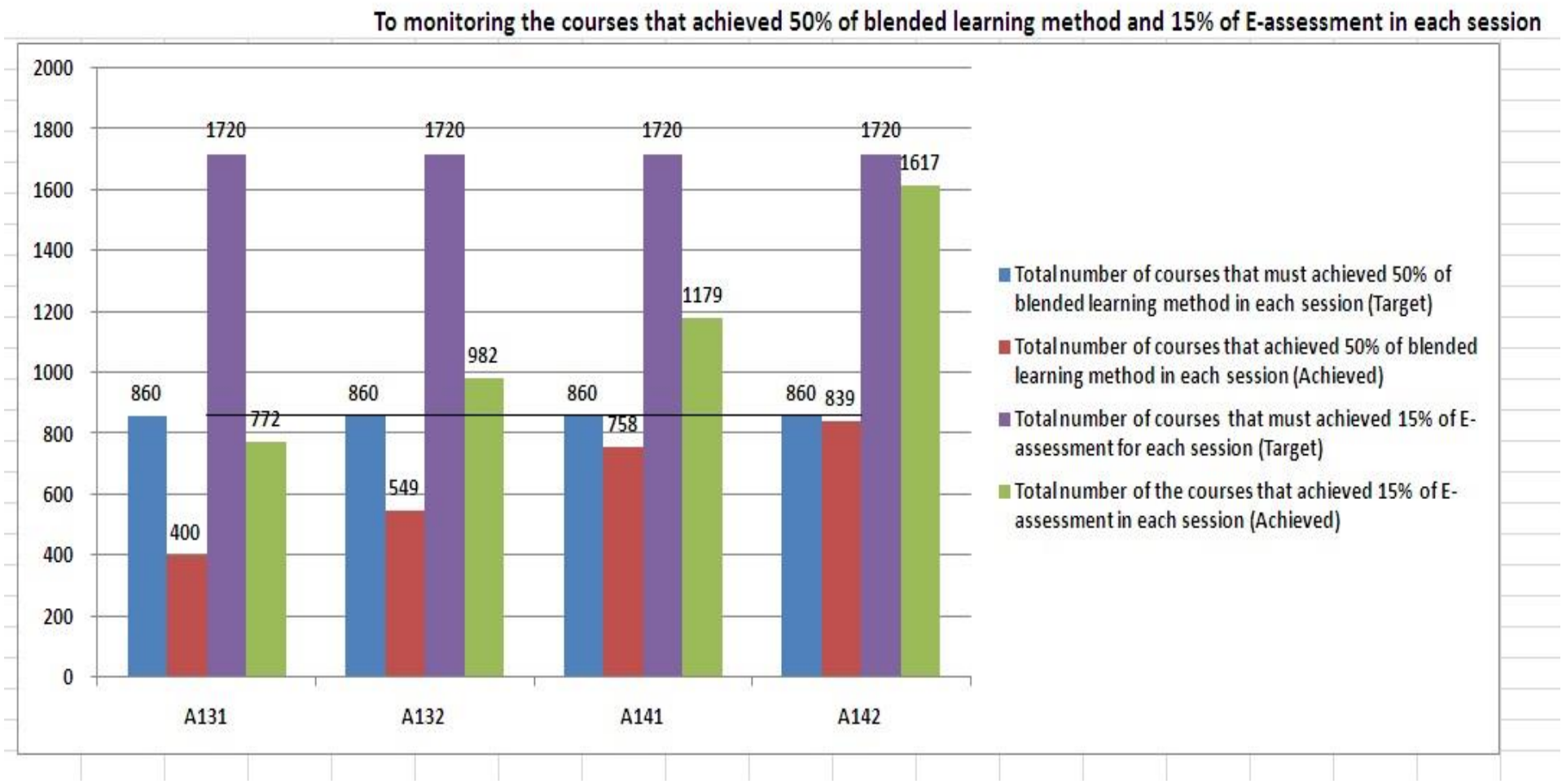


Figure B.26. Chart to monitor the courses that achieved 50% of blended learning method and 15% of E-assessment in each session

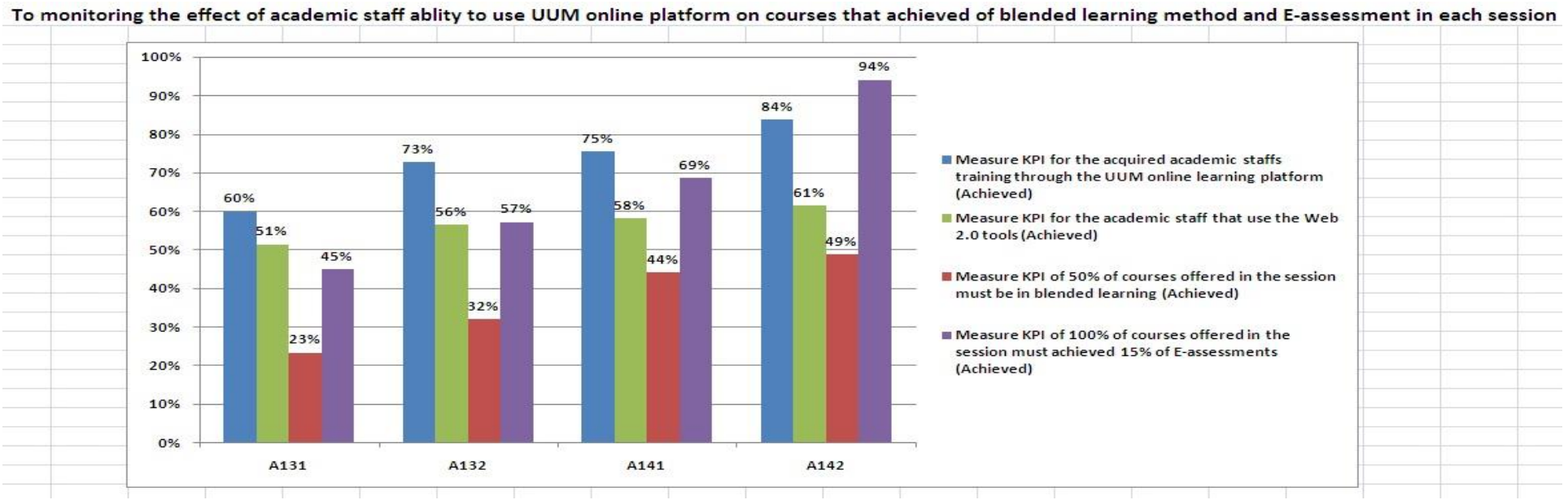


*Figure B.27.*Chart to monitor the effect of academic staff ability to use UUM online platform and Web 2.0 tools on courses that achieved blended learning method and E-assessment in each session

v- The second result from Star Schema Blended Learning

Year	Total number of MOOC courses conducted every year (Achieved)	Measure KPI of Total number of MOOC courses conducted every year (Achieved)	A minimum of 10 massive open online courses develop every year (Target)
2013	5	50%	10
2014	12	100%	10

achieved	
not achieved yet	
not achieved	

Figure B.28. Table for measuring KPI of MOOCs courses per year

This table would help the decision makers in monitoring these goals (KPI) through different chart presentations. These charts are represented in Figures B.29 to B.31

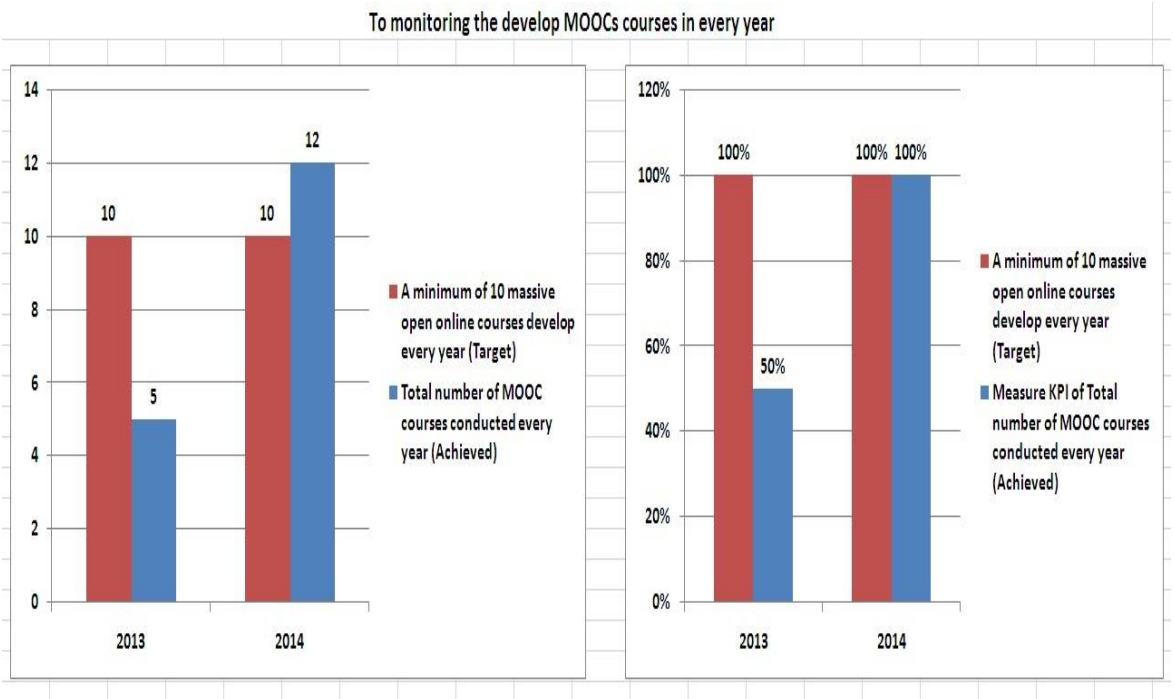


Figure B.29. Chart to monitor the development of MOOCs courses in every year

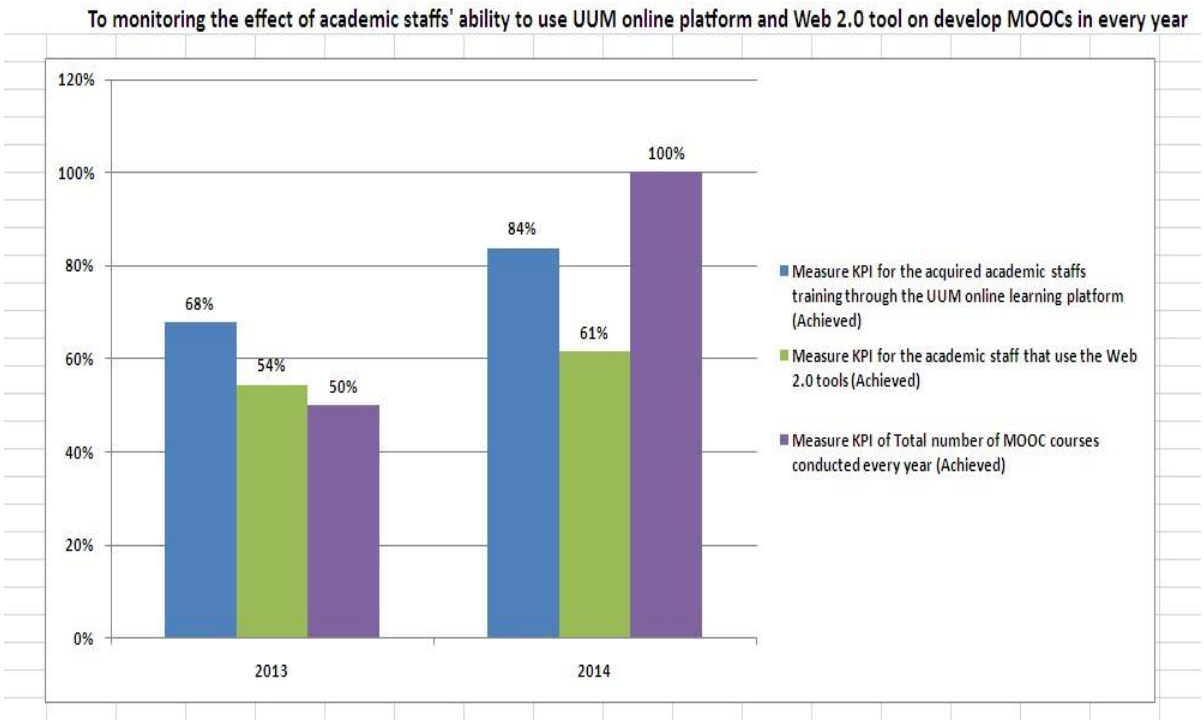


Figure B.30. Chart to monitor the effect of academic staffs' ability to use UUM online platform and Web 2.0 tool on development of MOOCs every year

vi- The result from Star Schema Course Evaluation

Year	Total number of courses for each session (Target)	Total number of courses that achieved at least 75% of mark in course evaluation for individual course in each session (Achieved)	Measure KPI for Total number of courses that achieved at least 75% of mark in course evaluation for individual course in each session (Achieved)	100% of the courses that teach by academic staff in the session must achieved at least 75% of mark in course evaluation for individual co
A131	1720	1300	76%	100%
A132	1720	1427	83%	100%
A141	1720	1479	86%	100%
A142	1720	1679	98%	100%

achieved	
not achieved yet	
not achieved	

Figure B.31. Table for measuring KPI of Course Evaluation per session

This table would help the decision makers with presentation done with different charts for the monitoring of the goal (KPI). The charts are presented in Figures B.32 to B.33

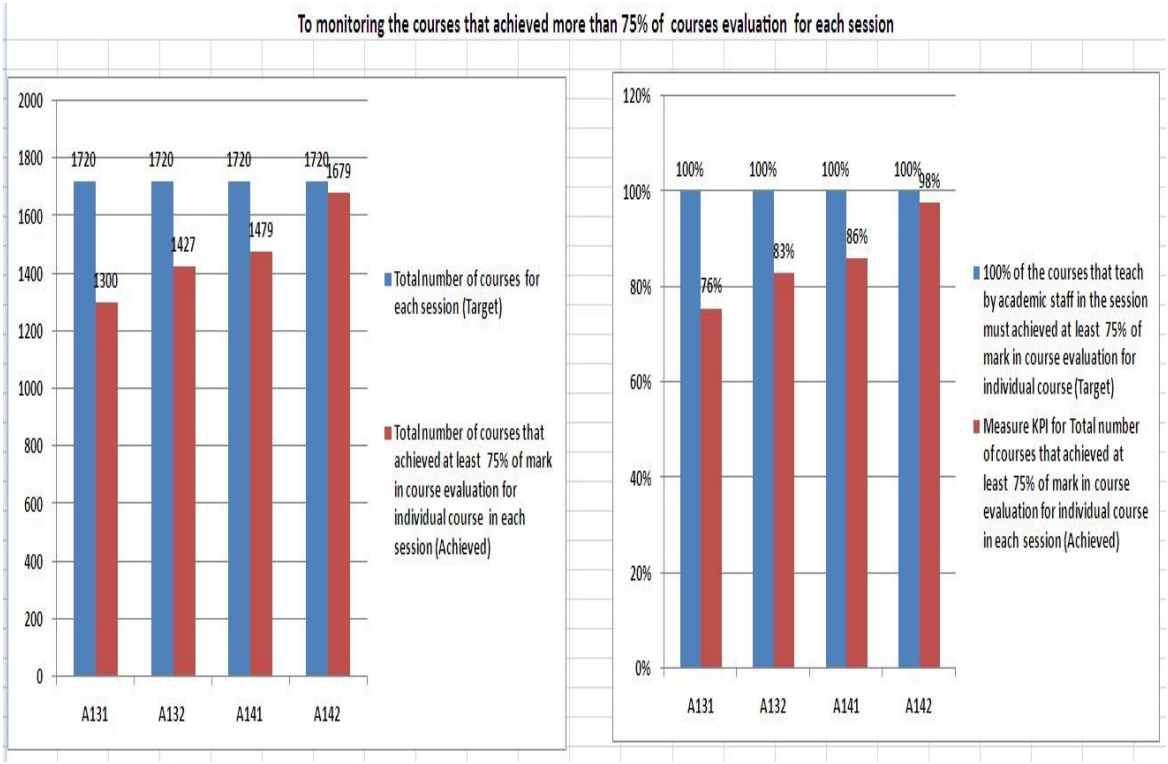


Figure B.32. Chart to monitor the courses that achieved more than 75% of courses evaluation for each session

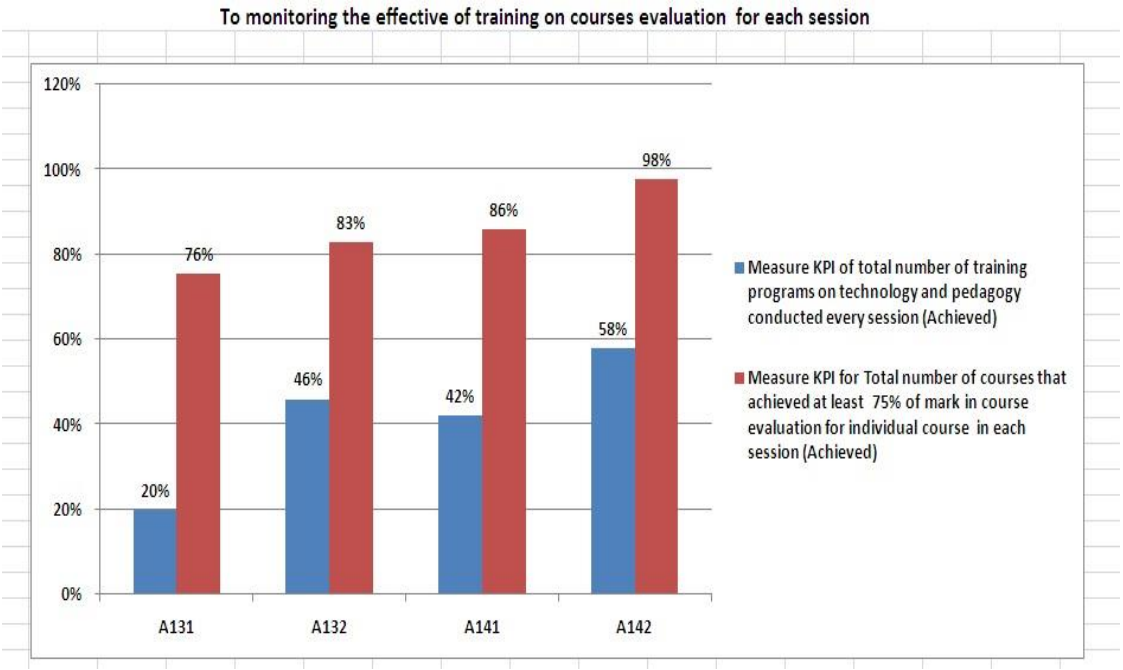


Figure B.33. Chart to monitor the effectiveness of training programs on courses evaluation for each session

Table B.1

Usability Evaluation Findings

Metrics	**Items**	**Mean**	**Cumulative Mean**
Ease of Use	Overall, I am satisfied with how easy it is to use this system.	2	2.3
	It is simple to use this system.	2.25	
	It was easy to learn to use this system.	2	
	The system can be used without any technical assistance.	3	
Correct Information Representation	It is easy to find the information I need.	2.25	2.05
	The information provided with the system is easy to understand.	2	
	The system highlights important information	1.725	
	The organization of the information is good.	2.25	
Overall	Overall, I am satisfied with this system.	2.25	

Appendix C

Usability Evaluation Instrument

EVALUATION INSTRUMENT FOR THE DATA WAREHOUSE-BASED KPI MONITORING PROTOTYPE

This instrument is for the evaluation of the designed Data Warehouse-based KPI monitoring prototype. The instrument is of two (2) separate sections. Section A is to elicit your profile data while section B contains questions that you are enjoined to answer after due interaction with the designed prototype. The usability items are adopted from Lewis' (1993) IBM Computer Usability Satisfaction Questionnaire. Any information supplied will be treated with utmost confidentiality, for the purpose of this research only, and with anonymous reportage in academic publications.

Your attention is kindly appreciated.

Please tick (✓) at the appropriate box.

SECTION A: Participant's Background

1. Name: _____.
2. Email: _____.
3. Age:_____
4. Gender: Male [ ] Female [ ]

5. Educational Background:

_____.

6. Years of experience:

a. Less than 5 years [ ]

b. 5-10 years [ ]

c. More than 10 years[ ]

SECTION B: Evaluation

EASE OF USE

1 Overall, I am satisfied with how easy it is to use this system.

STRONGLY AGREE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY DISAGREE**

2 It is simple to use this system.

STRONGLY AGREE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY DISAGREE**

3 It was easy to learn to use this system.

STRONGLY AGREE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY DISAGREE**

4 The system can be used without any technical assistance.

STRONGLY AGREE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY DISAGREE**

CORRECT INFORMATION REPRESENTATION

5 It is easy to find the information I need.

	STRONGLY							**STRONGLY**
	AGREE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**DISAGREE**

6 The information provided with the system is easy to understand.

	STRONGLY							**STRONGLY**
	AGREE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**DISAGREE**

7 The system highlights important information

	STRONGLY							**STRONGLY**
	AGREE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**DISAGREE**

8 The organization of the information is good.

	STRONGLY							**STRONGLY**
	AGREE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**DISAGREE**

OVERALL

9 Overall, I am satisfied with this system.

	STRONGLY							**STRONGLY**
	AGREE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**DISAGREE**