Database Warehouse Environment (COMP10002)

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Chapter 1 – Setting the Scene

1.1 Introduction

This chapter aims to set the scene and introduce the role the University of West Scotland (UWS) plays within Higher Education (HE) in Scotland. Core business processes will be investigated and identified which help support the running of UWS. Key decision makers, their business objectives and key performance indicators in UWS will be identified.

1.2 Overview of the HE Sector

According to Universities UK (UUK, 2012) there are 115 universities in the UK and 165 HE institutions. Within these educational institutions, there are a total number of 2,493,415 students enrolled on degree programmes. The UK HE sector is one of the most popular destinations for international students, and the highest percentages of international student enrolments. UKCISA (2012) states that a total of 428,225 international students are studying in the UK, which constitutes 17 per cent of the UK HE sector.

The UK HE sector contributes a considerable amount to the British economy – analysis by HEFCE 2012 (Higher Education Funding Council for England) shows that universities contributed £3.3 billion to the economy in 2010-11 through the use of business services. However, this figure is part of a much wider economic impact in the HE sector. A publication produced for Universities UK (UUK, 2009) named ‘The impact of universities on the UK economy’ states that the HE sector contributes at least £59 billion to the British economy and generates 2.3 per cent of UK GDP (Baskerville, MacLeod and Saunders, 2011). As international students constitute 17 per cent of the student population, the Institute for Public Policy Research (IPPR 2011) calculated that international students bring almost £4.5 billion annually to the UK from institutional revenue and off-campus expenditure.

With the financial and competitive pressures in the HE sector, universities within the UK have taken a greater interest in Business Intelligence (BI). Economics is currently the most influential reason to adopt BI; adopting BI systems could help universities save money in the long run and also help assist with their financial information. However, the main focus of universities is it students. With BI universities can discover ways to track students’ progression, identify issues and intervene appropriately when necessary. With this aid, more students are likely to pass courses, increasing the pass rates for universities. This in itself pays off – students researching universities take notice of pass rates and course feedback – and are more likely to choose the higher rated university. This drives competition within the HE sector, and universities without these types of BI systems are not reaping the benefits offered (JISC, 2012).
1.3 UWS in the HE Sector

UWS is fairly unique within the HE sector in Scotland. The university is split into four campuses throughout Scotland: Paisley; the main campus, Dumfries, Hamilton and Ayr. On August 2007, the University of Paisley merged with Bell College which was based in Hamilton and is now the Hamilton campus for UWS (BBC, 2007). This puts UWS at a great advantage compared to other universities in Scotland. Having four campuses spread throughout the West of Scotland makes UWS more sustainable and the University better placed to face the challenges and the competitive nature of the HE sector (BBC, 2007).

The student population in UWS differs greatly from other universities throughout Scotland. Having four campuses allows UWS to capture a much larger student population compared to Edinburgh, which can only capture a demographic local to the area. This allows UWS to provide local access for more than 40% of the population, making it ideally placed to respond to demographic challenges in the HE sector (BBC, 2007).

UWS also has strong relationship with higher education colleges in Central Scotland. Students with HND’s (Higher National Diploma) are allowed to enter the third year of a UWS course that best suits their needs. UWS has the highest proportion of entrance from college, placing it in a unique situation compared with other Scottish universities especially regarding student makeup and the use of BI. Allowing students from college to enter the third year skews the student population and form of the university, and UWS is making efforts to reduce this trend. To do this, they turn data gathered into intelligence. Management services use this BI to allow them to determine what type of population they want, and how to maintain a balance that works for the social mission of the university (Davidson, 2012).

UWS’ Social mission is to:

“Provide distinctive higher education through inspirational teaching and learning. We’ll respond to individual needs and those of the communities we serve to transform people, communities and organisations, becoming a partner of choice across the West of Scotland, nationally and internationally” (UWS, 2012)

UWS also has a larger female population compared to other universities in Scotland due to the popularity of the School of Nursing. Since UWS have more mature students due to direct entry of students, UWS has the largest numbers of students from deprived postcodes within Scotland. In terms of funding, UWS receives 70% of its funding’s through public funding compared to St Andrews which receives around 20%. (Davidson, 2012)
1.4 UWS Business Processes

Like any business, UWS has systems in place to cater for thousands of employees. Systems must be in place to manage finances, human resources, and employment, and UWS is no different from other businesses. UWS employs systems to manage their finances, payrolls and admissions. The following list demonstrates why UWS is comparable to any other business.

1.4.1 Admissions and Enrolment – For admission, UWS employs a system named Banner. Banner allows UWS to capture data about the student and also enables business processes, such as student admissions. Once the student has filled in their UCAS application and this is received by UWS, data is entered into UWS’s Banner system by an admissions officer. Once the data has been entered, a programme leader can enter the banner system through a web browser and search for new applications. Information on the system includes students’ grades, which allows the programme leader to judge whether or not they are suitable for the course. Once the programme leader has made an offer to the student, a student can then enrol on a certain date. UWS now uses an online enrolment system which allows students to enter personal information and their choice of modules for their selected course without physically being in a UWS campus. After the student has entered their personal details and module choices, this information is sent to the banner system. Once this process is completed, programme leaders can view their choices. Additionally, Banner provides vital information for UWS. It allows staff, such as programme leaders; information about students so they can understand who the students are, why they have enrolled, the courses applied to, how they are performing, progression after university, and previous results attained. Using online enrolment systems increases the probability of accurate information for BI purposes. (Caira, 2012)

1.4.2 Human Resources and Payroll – UWS has a human resources and payroll system. This system enables a number of business processes within UWS. For example, it enables workforce planning process to ensure UWS has suitable access to lecturers or other staff members for departmental success. Additionally, it allows UWS to investigate student to staff ratios of the individual campuses or the university as a whole. The payroll system in UWS allows the university to carry out multiple payroll business processes. This system allows UWS to manage salaries for each individual employee, and keep records of previous payrolls for future reference. (Davidson, 2012).

1.4.3 Finance – For the finance system in UWS, the Agresso platform is used. This system allows UWS to manage university finances. For example, it allows inspection of how much income is brought into the university and how much money is spent. It also holds the costs of each course within the university. (Davidson, 2012).
1.5 Decision Makers, Business Objectives and KPI in UWS

**Professor Seamus McDaid CBE (Principle and Vice Chancellor of UWS)** - The UWS Principle has multiple objectives. **Goal setting** involves setting goals on yearly basis to help motivate programme leaders to recruit more students. The UWS Principle also wishes to **establish and maintain relationships** with colleges and schools to coordinate education services, some of which was discussed in section 1.3. Additionally, UWS would also like to improve **university development**. The principal’s objective is to motivate staff to make the university accomplish their development plan aims over a period of years. The Principal would also like to monitor the **graduation rate** as a key performance indicator (KPI). The principal monitors the effectiveness of individual schools, or investigates the graduation rate for each course within each school. Additionally, the principal also like to monitor the **admissions from established relations** to check how many students enrol from each of the schools or colleges that have established relations. Finally, **Staff Development** would be a major KPI. This would involve the training of staff, and analysis and evaluation of the impact of training.

**Tom Caira (Programme Leader/Senior Lecturer)** - A Programme Leader of UWS should have multiple business objectives. For **recruitment**, the Programme Leader visits local schools, arranges open days to recruit potential students and writes description of their programme for the UWS prospectus. Another objective is the **admission** of students - once recruited, the students are admitted to the course, and then enrolment takes place. **Programme viability and success** is also important. Programme Leaders should aim to make the programme viable for students, and also ensure that industry employs the students produced. Another objective would be **programme management**. The Programme leader would manage program on day to day basis, and also look into the future and change modules based on new technologies, and set personal annual goals to successfully achieve personal objectives. KPI’s for a Programme Leader would involve the monitoring of **applications** to determine how many students are interested in the course. **Overall programme numbers** would also be monitored to view the number of students in each year from when course started. **Progression statistics** would be monitored to establish the number of students progressing from first to second year of the programme. The Programme leader could also monitor **graduate employment**, which is possibly the most important KPI as it allows the leader to monitor whether students are employable after the course has been completed. *(Caira, 2012)*

**Dr Carolyn Begg (Lecturer)** - A lecturer of UWS would base their decision making objectives and KPIs on the individual models that they teach. A lecture would set a goal of a **pass rate** they hope to achieve within their modules. Furthermore, the **viability and success** of the module would also be an objective as the lecture must ensure that the material being used is still viable for progression into employment. Another objective would be the **admission** of students within the courses they teach. For KPIs, the lecture **would monitor the pass rate** of each individual module they teach at the end of a semester. The lecture would also monitor the **progression of students** who pass to see if they successfully achieve a degree. The lecturer would also monitor **attendance** of the students throughout the modules which could be used to identify further issues.
Chapter 2 – The Data Warehouse Environment

2.1 Purpose and Importance of BI

Business Intelligence Tools (BI Tools) are software programs which are specifically designed for an end-user to query, retrieve, analyse and report data. They allow managers and business analysts to monitor data stored in the data warehouse and make decisions based on data trends and relationships (Chaudurt, Umesgwar, and Narasayya 2011). These tools have the sole purpose of gathering all business knowledge stored in a Data Warehouse (DW) and allowing end users to generate reports, query data and analyse data specific to their Key Performance Indicators.

The purpose of BI is to allow end-users to answer a business question or fulfil a business objective. Some end-users have a number of objectives that they wish to monitor or have data to help answer, and this can be done with the aid of BI tools. Traditional methods of gathering data took longer when compared to BI tools, which help instantly generate reports for end-users. This reduces time to gather data and boosts productivity for the user.

Without BI Tools, the data stored in Data Warehouses is essentially useless. It is important for businesses that have a data warehouse to own appropriate BI Tools for their business. Without appropriate BI Tools, businesses would be unable to gain access to data, make decisions or actions based on the data stored. Howson (2008) states that both IT personnel and business users agree that the underlying architecture and data quality is an important technical aspect for a business to successfully use BI. In the next section some of the underlying technologies will be discussed. To store and access data, Business Intelligence architecture is a necessary component for BI Tools to fulfil their purpose. There are a broad range of tools and technologies for gathering, storing and analysing data. These technologies are required for the end user to access the data available using the BI tool. Howson (2008) states that for BI tools to be fully utilised, ETL (Extract, transform, and load) tools must be in place to prepare the data from Operational and Source systems, such as external data systems and operational databases. The technologies and products required to expose data from a data warehouse are detailed in the next section.
2.2 Technologies and Products Used to Expose Data

In order for BI tools to ‘expose’ the data to the end user in the way they wish to view it, a range of technologies in different layers of the data warehouse must be in place. As mentioned in 2.1, BI tools are software programs which are specifically designed for an end-user to query, retrieve, analyse and report data. To view data in the data warehouse, products must also be purchased for end-users to extract the data they need. There are a range of products available to suit different end-user needs, and some examples are detailed in this section.

The following technologies are situated within different layers of the warehouse. With each technology (apart from ETL), some examples of available products are given:

- ETL (Extract, transform and load)
- OLAP – Online Analytical Processing
- Data Mining
- Ad Hoc Query and Reporting
- Production Reporting
- Dashboards/Scorecards

2.2.1 ETL (Extract, transform, load)

ETL is a recommended technology to prepare data for end-users. ETL refers to three functions which are combined into a single tool. Its role is to extract data from different source systems, transform this data into a structure that is appropriate for reporting, and then finally load this data into a database or OLAP cube. The three stages are as follows (ETL Tools 2012):

**Extract** – Data is extracted from internal and external sources, which may be structured and/or unstructured. Queries are then sent to the source system using native connections, message querying or middle ware. The data extracted will be placed in a Staging Area, which tends to have the same structure as the source. Some users may only want data that is new or has been changed.

![Figure 2.1 – Sourced from BI Mentalist (2011)](image-url)
Transform – Once data is in the Staging Area, the data is available on one platform and on one database, which allows join and unison tables, filter and sort data using specific attributes and also pivots to another structure. This step in the process checks data quality and cleans if necessary. Once data is prepared, slowly changing dimensions can be implemented. This allows keeping track of reports and analysis when attributes change over time.

Load – Data is loaded into the warehouse and dimension tables. Data can be combined, aggregated and loaded into OLAP cubes. Once data is loaded querying and reporting is allowed.

For BI tasks to perform, data comes from multiple sources – typically from multiple operational databases across different departments. However, multiple data sources may contain data with varying degrees of quality, and often are inconsistent in representing the data at hand. This causes issues with integrating and standardising data in preparation for completing BI tasks, which can be rather challenging. To solve this issue, data must be reconciled for efficient data load, which is imperative for BI (Chaudurt, Umesgwar, and Narasayya 2011). Without ETL, the data from multiple sources could potentially be inaccurate. ETL is an essential process to ensure that end-users using BI Tools have clean and accurate data.

2.2.2 OLAP – Online Analytical Processing

OLAP is computer processing which enables users to selectively extract and view data with ease from a myriad of viewpoints (Rouse 2007). OLAP also allows interactive analysis through the use of multidimensional structures which store the data and relationships, also known as an OLAP Cube. Each side of an OLAP Cube is considered a different dimension with different levels of detail (Howson, 2008) (Stewart, 2008). The OLAP Cube allows end users to transform raw data into strategic information which could potentially help businesses decisions and operations through the use of an OLAP Viewer. OLAP can be defined in terms of functional characteristics expressed by the FASMI acronym – Fast Analysis of Shared Multidimensional Information (Pendse, 2008).

Fast – the system created is to deliver responses to the user within 5 seconds, and routine analysis should take no more than 1 second. More complex analyses should take no more than 20 seconds. Studies have suggested users can become impatient if data is not delivered within 30 seconds; even if they understand the complexity of the analysis. OLAP Systems must be fast in order to facilitate users’ needs.

Analysis – This means that the system can cope with demands relevant to the application and user. Users should also be able to conduct analysis without the help of IT technicians. Ad-hoc analysis is a requirement for OLAP analysis.

Shared – The system must implement security to ensure confidentiality of the data stored. The data within the warehouse must also be consistently maintained, and any changes made must automatically be incorporated into the warehouse.
Multidimensional – This is the most important characteristic for OLAP. The system must facilitate conceptual viewing of the data on any of the specified dimensions, and the system must support these specifications.

Information – Information refers to quick and easy access to all the data within the warehouse. The accuracy and relevance of the information in the decision support role is the most important measure. Users must receive their queries from the OLAP system in a useful form.

OLAP has a number of platforms used to store data to allow for multidimensional analysis, which greatly affects what and how users can analyse. Each of these architectures has individual trade-offs in terms of performance, calculations, the amount of data that can be analysed and the timeliness of data updates (Howson, 2008). There are four primary architectures in OLAP (Connolly and Begg, 2005) (Stewart, 2008):

**ROLAP (Relational OLAP)** – All calculations are done in relational databases, which causes large databases to have slow response times when queried. All calculations within ROLAP are pre-generated when the ROLAP cube is populated with data.

(Figure 2.2 – ROLAP. Sourced from Connolly and Begg, 2005)

**MOLAP (Multi-dimensional OLAP)** – Uses specialised structures and multi-dimensional systems which allow the organisation, navigation, and analysis of data. To enhance query performance, it is aggregated and stored according to predicted usage.

(Figure 2.3 – MOLAP. Sourced from Connolly and Begg, 2005)

**HOLAP (Hybrid OLAP)** – Hybrid OLAP combines ROLAP and MOLAP. HOLAP delivers data selected from a DBMS or MOLAP server to desktop as an OLAP cube. The OLAP cube is stored locally, where it can be analysed and maintained.

(Figure 2.4 – HOLAP. Sourced from Connolly and Begg, 2005)
DOLAP (Desktop OLAP) – Data cubes can be stored on the users’ local desktop, and supports multi-dimensional processing. This data cache is built at runtime, with extracts which are relatively small. Data is either distributed in advance or on demand through the internet.

(Figure 2.5 – DOLAP. Sourced from Connolly and Begg, 2005)

OLAP also hosts a number of operations which allow users to view their data in multiple ways, for example, organising dimension as a hierarchy. Since data is stored in cube form it allows for straightforward operations, and in turn this enhances productivity (OLAP Council 1995). OLAP Operations are as follows (Connolly and Begg, 2005):

Consolidation – This operation is involved in the aggregation of data in the OLAP Cube. A number of expressions can be performed, such as ‘roll-ups’ or other complex expressions which involve interrelated data. An example of this is rolling up offices to their respective cities, and these cities can also be rolled up to their respective country. (Figure 2.6 – Consolidation and Drilling Down. Sourced from Wikipedia, 2005))

Drill-Down – This operation is the reverse of the consolidation operation. Drill-Down displays the data that involves the data from the consolidated data.

Slicing and Dicing – This operation is also known as pivoting. This operation allows end-users to view the data from multiple viewpoints. Slicing and dicing is often performed along with a time line to analyse trends and patterns.

(Figure 2.7 – Slicing and Dicing (Pivot) Sourced from Wikipedia, 2005)
The most common and popular BI tool for OLAP viewing is the Microsoft Excel spreadsheets. Excel allows users to drill down into data and create Excel Pivot Tables to explore their data. Many OLAP Viewers are web-based, whereas Excel is desktop based, and has features like advanced charting and more advanced navigation capabilities (Howson 2008). For example, SAS Web OLAP Viewer allows users to interactively explore geographical maps, and drill-down in specific regions, visualising information in real time. Using a product like SAS Web Viewers allows users to view large pieces of data from multiple angles, whereas Excel users would need to create their own non-interactive graphs and charts. Excel may be more suitable for power users who wish to find specific information and are familiar with the Excel environment. For users who do not know how to use Excel, a SAS Web OLAP Viewer would be more suitable. However, most BI tools are available in suites, with Oracle’s Hyperion Essbase and Microsoft’s Analysis Services being the most popular.

(Figure 2.8 (Sourced from Geekpedia (2006) & 2.9 (Sourced from Howson (2005) – A comparison of Excel and SAS Web Viewer))
2.2.3 Data Mining

Data mining refers to extracting information from large pieces of data, then sorting through the data to discover meaningful patterns, trends and correlations (Gartner, 2012). Data mining allows businesses to focus on the most important information and helps them make decisions. There are a number of important characteristics involved in data mining. The most important characteristics are the perpetration of data for the facilities; the selection of algorithms (operations) used; scalability and performance; and having facilities to understand the results generated (Connolly and Begg, 2005). The Cross Industry Standard Process for Data Mining has defined 6 phases, but this can be simplified into 3 stages; Pre-processing, data mining and results validation (CRISP-DM, 2000). Data mining can be used to identify a number of relationships and involves a number of tasks identified by name here:

**Anomaly detection** – Unusual data records which may require further investigation are identified.

**Clustering** – Discover groups or structures within data which have similar relationships without using known structures in the data.

**Classification** – Generalising the known structures within the data and applying it to the new data.

**Regression** – The regression task attempts to find a function which structures the data with the fewest errors.

**Summarisation** – This provides the data in a much more compact representation for BI end-user tools.

Having data mining tools is useful, as a data warehouses are well equipped for providing data as they hold high quality and consistent data once it has been through the ETL process. Using data mining in a data warehouse environment also allows production of data subsets which can be analysed when required (Connolly and Begg, 2005). A range of data mining tools which allow users to detect patterns and generate reports based on these patterns are available. Products like SAS Analytics allow users to detect relationships and trends within the data to influence business decisions, which could help improve business strategy.

(Figure 2.10 – Data Mining. Sourced from Fayyad et al., (1996))
2.2.4 Ad Hoc Query and Reporting

Ad Hoc Query and Reporting tools allow users to create reports that reflect specific search criterion, formats and results. Due to the ever changing pace of the business environment, business users demand the ability to create these queries and reports without using IT personnel. Using these tools allows users to make decisions for business and management purposes, thus it is essential to provide end-users with self-service information access (Howson, 2008). Howson (2008) states that reports only truly become ad hoc when tackling a one-off business question that will never be posed again, as the ad hoc query may become a fixed report at a later point. Tools such as BusinessObjects Web Intelligences or SAS Web Report Studio have a wide variety of formatting options, such as the ability to display multiple charts and graphs from different data sources within the data warehouse on a single page.

2.2.5 Production Reporting

Compared to basic formatting of Ad Hoc Query and Reporting tools, Production Reporting tools have sophisticated design capabilities. Production reporting tools can access transaction systems to create documents such as invoices, checks and bank statements. Production Tools can also be used within a data warehouse environment for reporting on details about data (Howson, 2008). Tools like SAS Web Report Studio can be used to create production reports for end-users who are not familiar with BI tools.

Untrained staff using production reporting tools may lead to resource intensive queries, thus IT staff would use this tool. IT personnel would use production reporting tools to generate management style reports (Howson, 2008). Howson created a table detailing the key differences between business queries and reporting tools and production reporting tools. (Howson, 2008)

Table 1 – Comparison of Production Reporting and Business Query and Reporting

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Production Reporting</th>
<th>Business Query and Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Author</td>
<td>IT Developer</td>
<td>Power user or business user</td>
</tr>
<tr>
<td>Primary Purpose</td>
<td>Document preparation</td>
<td>Decision making, management</td>
</tr>
<tr>
<td>Report Delivery</td>
<td>Paper or e-bill, embedded in application</td>
<td>Portal, spreadsheet, email</td>
</tr>
<tr>
<td>Print Quality</td>
<td>Pixel perfect</td>
<td>Presentation quality</td>
</tr>
<tr>
<td>User Base</td>
<td>Tens of thousands</td>
<td>Hundreds or thousands</td>
</tr>
<tr>
<td>Data Source</td>
<td>Operation Transaction System</td>
<td>Data warehouse or mart, occasionally transaction system</td>
</tr>
<tr>
<td>Level of data detail</td>
<td>Granular</td>
<td>Aggregated</td>
</tr>
<tr>
<td>Scope</td>
<td>Operational</td>
<td>Tactical, strategic</td>
</tr>
<tr>
<td>Usage</td>
<td>Often embedded within application</td>
<td>Most often BI as a separate application</td>
</tr>
</tbody>
</table>
2.2.6 Dashboard/Scorecards

Digital Dashboards are data visualisation tools which display the current status of set Key Performance Indicators. There are multiple types of dashboards to suit specific roles within a business. For example, an executive dashboard would display a unique set of KPIs tailored to an executive officer of a company. Dashboards present information in a format which is easy to read and servers are a visual starting point for end-users to get a greater sense of their KPIs before they drill deeper (Rouse, 2010). Dashboards provide many benefits, such as the ability to make more informed decisions based on the data shown, and also identify trends in relationships within the data. Additionally, the data displayed is automatically updated without any assistance from the end-user (Chiang, 2011). Below are examples of SAS Enterprise BI Dashboard and Oracle Business intelligence Enterprise Edition Dashboard.

Scorecards focus on a given metric and compare it to a forecast or target set by the end-user. This contrasts with a dashboard which presents these values in multiple ways. Scorecards can contain a measure, value, target and a visual indication of status within each row. Strategic scorecards contain metrics from key areas that drive a business, and also include strategic maps to show how interrelationships between metrics (Howson, 2008). Oracle also includes scorecards and strategic management as part of their Business Intelligence Enterprise suite.

(Figure 2.11 (Sourced from SAS (n.a.) and Figure 2.12 (Sourced from DataPrix(2009)))
2.3 Issues with BI tools

**User-friendliness** – One of the main issues with BI tools is user friendliness, or ease of use. Some BI tools may be too complex for the majority of business users who wish to analyse their data. End users who have limited experience with BI tools could struggle to use the software. End-users with this limited experience need BI tools which can prompt or guide them through basic tasks, as well as a customisable interface. If an end-user with limited BI experience were to use Microsoft Excel, they would struggle when compared with a power user who wishes to have a sophisticated set of BI tools to give them the flexibility to analyse data the way they want to (Horwitt, 2010).

**Cost** – Implementing BI tools within businesses can be very expensive. To implement these tools requires a tremendous amount of work and investment before the tools provide their value. Additionally, once the BI tools have been implemented in the system, the cost of training and informing staff must also be accounted for. However, many companies such as IBM, Microsoft and Oracle offer lower level entry products for businesses with smaller budgets (Horwitt, 2010).

**Misjudging functionality** – An additionally issue isn’t necessarily the tool, but the user. Implementing BI tools into a business requires a lot of domain expertise. It is important for companies to appropriately define the metrics they need, where to get the data and how to present it. If the wrong BI tool is implemented, time and money is wasted, which can be costly for a business. Additionally, BI tools tend to have a hard-coded architecture which leaves no room to adapt the software for different environments (Preston, 2012).

**Foresight** – Some BI tools place a lot of emphasis on old data, known as historical data. For example, if a user is using a mobile dashboard it could display out-of-date sales figures for their products. This out-of-date data could potentially cause issues, especially for mobile users who use mobile BI products. Additionally, query and reporting tools generate reports which are then turned into hard copies for employees. This hard copy displays data which may have changed since the hard copy was created (Preston, 2012).
2.4 New trends

With the rise of popularity in Cloud Computing and mobile devices, it is no surprise this trend would also apply to BI. According to a survey by BI Leadership, over a third of organisations use a BI tool situated in the Cloud. Also, 65% of organisations have plans to increase their usage of BI Cloud tools in the next year (Klipfolio, 2012). This may be due to the advantages offered by using cloud based BI tools. Firstly, deploying a tool in the Cloud is relatively simple and convenient. The tools are also easier to scale, providing access to KPI no matter what devices is used (Klipfolio, 2012).

The Cloud and mobile devices are obviously a natural fit, and research suggests that by 2013 one third of all BI tools will be on mobile devices (Klipfolio, 2012). It may be changing workplace dynamics that is fuelling mobile BI adoption, as mobile BI tools give end-users the ability to manage their decision making and KPI monitoring effectively at any location. Businesses have obviously noticed the potential, and a survey found over 30% of the correspondents had plans to deploy a mobile BI tool for their business (Klipfolio, 2012).

Another trend is big data. With user-generated data from sites such as YouTube, and social networking sites like Twitter, data is constantly changing and businesses must adopt new technologies to help reduce the time, effort and cost of integrating this data within a warehouse. Once the data is integrated, businesses can analyse this data created by users to develop trends or relationships (Sonderegger, 2012).

Open source tools are another growing trend. Businesses are accepting services like SaaS and open source software, and adoption of open source tools has grown. Some open-source tools provide services such as reporting, scorecards and dashboards, adding pressure to large business such as IBM or Microsoft who provide the same type of software for a higher price (Sonderegger 2012).

Predictive analytics allows businesses to foresee and prepare for future events. With predictive analytics, businesses can generate forecasts, real time monitoring on what-if scenarios, and report and analyse data on a regular basis. Additionally, it helps analyse trends within operations and allows them to build financial models and accurate forecasts which in turn can help product planning and buying predictions (Preston, 2011).
Chapter 3 – The Data Warehouse Environment for UWS

3.1 Introduction

The Director of Planning and MIS at UWS wishes to create a data warehouse for the university. Currently, the systems within UWS work separately and do not connect with each other. The Director of Planning and MIS wishes to change this by creating a data warehouse so end-users can access the data without having to use multiple interfaces to interact with each data source. This report will focus on the technologies required for the front end of the UWS data warehouse – the BI tools. This report will identify appropriate technologies and products for UWS to make full use of BI tools, issues that are particular to UWS and new trends which may interest UWS. The some of the technologies suggested exist within different layers of the data warehouse; however these technologies are important for UWS to successfully achieve BI through the use of BI tools.

To provide the necessary details a single UWS business process has been chosen - The Admissions and Enrolment process, along with a UWS Decision Maker – a Programme Leader. To provide further details, business objectives and KPIs will be used to illustrate the purpose and importance of BI.

3.2 Purpose and importance of BI for UWS

UWS does not currently have appropriate technologies to successfully achieve BI. They have a number of systems which are not connected and do not have common interfaces, which makes it difficult for a programme leader to make decisions. UWS aims to successfully achieve BI to allow a programme leader (and other end-users) to successfully answer a business question or fulfil a business objective through the use of BI tools. A programme leader has a number of business objectives that they wish to answer or need aid to answer, and this can be achieved with BI tools by decision maker like a programme leader. For example, a programme leader of UWS may wish to find information about student admission. The programme leader can use BI tools to retrieve data about a specific student which could be used to aid a business objective and decision, like admitting a student to a course. Typically, this type of information is stored on the source system (in this case, Banner) and data can be analysed with technologies within the data warehouse like OLAP. Additionally, the program leader can use data to fulfil their Programme Viability and Success business objectives. The programme leader can review this data and use KPI to judge whether modules within their programme are successful. Additional KPIs include overall programme numbers or progression statistics. With BI, programme leaders can review data and make decisions based on the data produced, essentially fulfilling the purpose of BI.
It is important for UWS to successfully achieve BI for a number of reasons. Traditional data gathering methods involved manual compiling, analysing and writing reports by users. With BI and BI tools, a programme leader can pull data from the warehouse and almost instantly create reports. Examples are a report of how many students have applied for the course or a report of the overall course numbers. As BI allows the reporting of historical data, overall course numbers from the current year can be compared with previous years. This process is important for a programme leader of UWS as it boosts productivity. If the programme leader compiled this data manually, it would potentially be very time consuming. Using BI tools frees time and resources, allowing the programme leader to be more productive on other business objectives. BI is also important for UWS as it allows access to better information, which can potentially be used to increase its competitiveness within the HE sector. For example, for the Programme Viability and Success business objective, having access to data is important. The Programme Leader can evaluate this data and ensure the programme that he or she runs is viable within the specific industry (e.g. computing). Access to this data allows UWS to be competitive and adjust programmes based on industry feedback. KPIs from BI also allow for better decision making. BI tools allow a programme leader to keep track of goals that they have set – essentially helping the programme leader to achieve their aims.

3.3 Technologies and products appropriate for UWS

For UWS to successfully achieve BI through the use of BI tools, a set of appropriate BI tool technologies must be used to successfully feed data to the end-user. As stated before, some of these technologies are not situated within the front-end layer but are essential for providing data. Below is an example of typical business intelligence architecture.

(Figure 3.1 – Data Warehouse Architecture. Sourced from Chaudurt, Umesgwar and Narasayya (2011)
This section will detail technologies and products appropriate for the UWS data warehouse environment.

3.3.1 ETL – Extract, Transform and Load

Even though a Programme Leader or a Principle of UWS would never interact with the ETL process, it is still an essential technology for a data warehouse. End-users want clean and accurate data to allow business decisions for their business objectives. Without ETL, the data may be inaccurate and inconsistent, making it harder for end-users to make decisions, and potentially wasting more time for the decision maker. ETL is an essential process as the data goes through a data quality check to ensure the data is accurate and clean. Additionally, slowly changing dimensions are implemented by ETL. This is crucial as it allows end users to track reports they have created, and also allows analysis of attributes when they are changed, for example though a dashboard or scorecard. Data from the UWS source systems can be combined, aggregated and loaded into OLAP cubes.

3.3.2 Online Analytical Processing and Data Mining

This is perhaps the most important and appropriate technology for end-users in UWS. Through the use of an OLAP viewer, end-users can extract and view data from multiple viewpoints. Furthermore, end-users can interact with the data through BI tools since the data is stored in a multi-dimensional structure known as an OLAP cube. Since OLAP cubes have different dimensions they allow end-users - such as a programme leader or lecturer – to transform the raw data from the OLAP cube into strategic information to potentially help decision makers. This technology is also appropriate and beneficial as the system can deliver responses within 5 seconds. When UWS decision makers use an OLAP viewer it increases their productivity since the system delivers the data quickly. Furthermore, there is many staff at each of the UWS campuses and OLAP tools are built so the system can cope with the demand relevant to the application and the end-user. When end-users use an OLAP viewer, they have quick and easy access to all the relevant and accurate information to support their role.

UWS can store the data on multiple architectures which allows for greater analysis, and can greatly affect what users can analyse and how they can analyse. The four architectures are Relational (R)OLAP, Multi-dimensional (M)OLAP, Hybrid (H)OLAP and Desktop (D)OLAP. As ROLAP conducts all calculations in a relational database, this may not be appropriate for UWS as the response times are slow. MOLAP is more appropriate for UWS as it uses specialised structures which allow the end user to organise, navigate and analyse the data on their OLAP viewer. HOLAP is a combination of ROLAP and MOLAP, whereas DOLAP cubes are stored on the users’ desktop. This extracts small pieces of data which are delivered on demand through the internet. This is also suitable for UWS as there are OLAP products which specifically use a web-browser.
OLAP tools let end-users view their data in multiple ways, and typically OLAP operations provide this function in OLAP Viewers. With the consolidation operation, end-users have the ability to perform multiple expressions, such as ‘roll-up’ and ‘drill-down’. This functionality would benefit UWS as it would allow end-users to view different levels of detail. For example, a programme leader could drill-down into information about a student and display their grades. They could also roll-up the data by viewing information about their campus, and roll-up further to where the student lives. The ‘Slicing and Dicing’ operation would also benefit UWS end-users, as OLAP tools would allow the end-user to ‘pivot’ the data to view it from different angles. It also allows end-users to analyse trends and patterns within the data. This is beneficial for UWS as it allows end-users such as programme leaders to identify patterns in results or progression in each individual.

An additional suitable technology for UWS is data mining, which refers to extracting information from large pieces of data, then sorting through the data to discover meaningful patterns, trends and correlations. Using data mining tools would allow UWS to focus on information important for a decision maker to make their decisions. For UWS, it may be beneficial to integrate OLAP and Data Mining capabilities into the server instead of having separate systems. These can complement each other in multiple ways, for example an OLAP tool could pinpoint problems with pass rates in a certain module. Using data mining, programme leaders could then gain insight on the behaviour of individual students and identify patterns within the module.

There are a range of products available for OLAP and data mining tools, but for the sake of standardisation the recommended products are from the same organisation – SAS. Furthermore, each product recommended is web based. This is beneficial for UWS since the software does not need to be installed on multiple computers. SAS Web OLAP Viewer enables decision makers to view different perspectives of multi-dimensional data through web applications accessed through a standard web browser. No software needs to be installed. Decision makers can swap between different presentations of data, for example a bar graph or a table. Decision makers can also expand the data to compare current and historical data, and track patterns within the data. Decision makers can also use conditional highlighting to specify if they want figures that meet certain criteria to stand out, quickly drawing the eye to important information. An example of this would be monitoring the attendance rates of each class. Decision makers can also focus their analysis by ‘drilling down’ to another view for more detailed information about specific classes or students. Filtering features are available for end-users to focus on the most relevant data for their needs. Furthermore, decision makers can add their own columns and make their own calculations to help make business decisions. Because the SAS OLAP Viewer is browser based, decision makers can share data with other decision makers. One feature also allows decision makers to export data if they wish to use Excel to drill down further.
For Data Mining, SAS Enterprise Miner software can be used. SAS Enterprise Miner allows end-users to uncover unknown patterns, opportunities and insights to aid evidence-based decisions within UWS. End-users can use data mining capabilities to quickly identify relationships or opportunities within the data. Also, with the data mining process, a feature allows decision makers to create highly accurate descriptive and predictive models based on the data. Additionally, with SAS Enterprise Miner, UWS can analyse historical data and predict future outcomes based on the patterns identified.

3.3.3 Ad Hoc Query and Reporting

Ad Hoc Query and Reporting is an appropriate technology for UWS decision makers. UWS decision makers could use Ad Hoc Query and Reporting tools to create reports which reflect specific search results, like how many students have applied for a course. Using this tool allows decision makers to create these reports on demand, and also make decisions for business and management purposes. However, Ad Hoc Query and Reporting tools are generally used for one time questions from the fixed report created using an ad hoc query.

An appropriate product for UWS would be the SAS Web Report Studio. SAS Web Report Studio will enable decision makers in UWS to quickly perform ad hoc queries and generate reports based on up-to-date data. SAS Web Report studio can also share generated reports with other decision makers within UWS. Business users can access current and accurate information by referring to logical descriptions of the data sources.
Additionally, the information is prepared in information maps which would be prepared by analysis within UWS. With SAS Web Studio, decision makers can ask questions and receive on demand results without having to understand or create statistical models. This software would be suitable for programme leaders who wish to produce reports for higher level employees.

3.3.4 Production reporting

An additional technology that would be appropriate for UWS is Production Reporting. Typically production reporting tools have more sophisticated capabilities in terms of design compared with the basic formatting offered by query and reporting tools. These tools are more likely to be used by IT personnel within UWS to deliver reports based on transactions within the university. Typically, this type of tool is used for operational business processes within UWS, compared with the Ad Hoc Query and Reporting tools which are used for more tactical and strategic business decisions within UWS.

SAS Web Report Studio can also be used for Production Reporting. The analyst within UWS can create complex reports and then share them with the decision makers who require them. Using SAS Web Report Studio is beneficial for UWS since separate software does not need to be purchased for this separate function.

3.3.4 Dashboards and scorecards

Dashboards and scorecards are possibly the most appropriate technology for decision makers at a high level. Dashboards are data visualisation tools which display a set of KPI custom created by a decision maker within UWS. In UWS, some decision makers may prefer tools without a complicated user interface where they can quickly glance at information to help make decisions. There are multiple types of dashboards which can be tailored to suit the needs of multiple decision makers within UWS. These dashboards present information in an easy-to-read format and serve as a visual starting point for decision makers to review their custom made KPIs before they drill in deeper. Using dashboards will allow UWS decision makers to identify trends in the data and make more informed decisions. Also, dashboards do not need to be updated by the end-user since dashboards do this automatically without any assistance from the decision maker.

Scorecards can also be used by UWS to give decision makers metrics and compared these with a forecast or target set by the decision makers. This is different from dashboards since they display values in multiple ways. Strategic scorecards are also beneficial for UWS since they can contain metrics on key areas of UWS and have strategic maps to show interrelationships between these metrics. SAS BI Dashboard is a suitable product for UWS since it contains a scorecard add-on if the decision maker wishes.
3.4 Issues particular to UWS

One of the main issues with UWS is the lack of a common user interface for their BI tools. For users to access the multiple source systems within UWS, different BI tools must be used. Furthermore, some end-users are using tools they are unfamiliar with and so cannot effectively peruse their business objectives. It is important for UWS to not only standardise their BI tools, but also within the back-end components such as ETL, data quality and the data warehouse platform (Howson, 2008). Because UWS uses different vendors for their systems and different BI tools to access their system, they may not be receiving a single version of the truth – which requires a consistent representation within the BI tools and the data architecture (Howson, 2008).

Because UWS is not using standardised BI tools, issues with decision making may arise as some staff within UWS is not familiar with the tools available. This means that they cannot effectively make business decisions or answer business questions, and also means some staff may be using traditional methods of data gathering to make these decisions. This is perhaps due to a lack of training on how to operate the multiple systems and multiple interfaces, resulting in inaccurate BI data. If decision makers are using inaccurate BI data, there could be issues with outcomes of the decisions made. This is why it is important UWS trains their staff once they have implemented a set standard of BI tools within their data warehouse environment.

In addition to the lack of a standard interface, when a decision maker signs into a BI tool within the UWS system, information unique to their role is not displayed. This may result in end-users receiving the wrong data since the only way to filter and view the data is to export all data to an Excel spread sheet to do further data analysis. This further defines the issue of lack of training, as some staff may not be familiar with the process of exporting data and using the Excel software. This is an additional reason why UWS should pursue a common standard interface to allow decision makers to effectively answer their business questions.
3.5 New trends of particular interest to UWS

Mobile BI is a new trend which may be of particular interest to UWS, since some decision makers’ travel between the four campuses. Sometimes decision makers of UWS may not be able to access a desktop version of their BI tools. With mobile BI, decision makers could make business decisions by using the BI tool software on their mobile device or tablet. This may be more useful than a static paper report, as the BI tool could display more up-to-date information if the decision maker has access to an internet connection.

Social media sites can be used to gather information on relationships or trends. With big data and social media analytics on the rise, UWS could use these technologies to their full advantage. UWS could collect this type of data to view people’s thoughts and opinion about UWS online. With this data they could make improvements based on the feedback gathered.

The products suggested throughout this report are web based with access systems within the UWS institution. However, there is a growing trend for businesses to store data in the cloud. Storing data in the cloud could potentially save money on maintaining the UWS systems since the vendor hosting the data would maintain the system hardware. The only expense for UWS is the monthly or annual bill to use the vendors’ service. Using these types of services may be easier for decision makers whilst they are at home. If decision makers currently want to access the UWS system, they must access a VPN to securely enter the UWS system. If data is stored in the cloud, decision makers need only access the BI tool on the web browser and sign in with their unique login to view their data.

3.6 To Conclude

This report has detailed the purpose and importance of BI for UWS, along with appropriate technologies and products UWS can use to fully utilise BI. Furthermore, issues of UWS have been discussed, along with new trends which may be of interest to UWS. The summary of the main points in the report can be found in the presentation, which will also detail the recommended approach for UWS to take to successfully achieve BI.
UWS receives 70% of funding from public
UWS has the largest number of students from deprived postcodes within Scotland
UWS has a large female population due to the popularity of the School of Nursing
balance for UWS' social mission
UWS has strong relations with HE colleges; however, this may change to maintain a
balance challenges in the sector

This puts UWS at a competitive advantage; more sustainable and better placed to
face challenges in the HE sector

UWS in the HE Sector
and gain competitive advantage
Could help Universities save money in the long run; help improve student success
Financial and competitive pressures have pushed Universities to adopt BL
HE sector contributes at least £55 Billion to the British economy
Total of 2.8 million students, including international students, in the UK
There are 155 universities in the UK, and 165 HE institutions

The HE Sector & UWS
UWS Business Processes and Decision Makers

Business Objectives
Key Performance Indicators

Business Processes

- **Admissions and Enrolment** – Students submit their UCAS application, data is entered into UWS banner system and Programme Leaders can offer students a place on their course. Once completed, students can then enroll online.

- **Human Resources and Payroll** – Enables business processes like workforce planning; allows UWS to investigate Student to Staff Ratio. Payroll allows UWS to manage salaries for individual employees plus previous records for future reference.

- **Finance** – By using the Agresso system it allows use to manage university finances, for example how much income is brought in and how much is spent.

Decision Makers

- **Professor Seamus McDaid CBE ( Principle and Vice Chancellor of UWS)** – Set University Wide Goals, Establish Relations with HE Institutions, Improve University Development, Graduation Rate, Admission from Establish Relations, Staff Development

- **Tom Caira (Programme Leader/Senior Lecturer)** – Recruitment, admission, Programme Viability and Success, Programme Management; Overall Programme numbers, Progression Statistics of Students, Graduate employment

- **Dr Carolyn Begg (Lecturer)** – Set Goal for Pass Rate, Viability and Success of Modules, Admission of Students, Pass rate of Students, Progression of Students, Attendance
Data Warehouse Environment

Presentation Slide 3

Purpose and Importance of BI for UWS

- BI tools are software programs designed for an end-user to query, retrieve, analyze, and report data. Allows end-users to make decisions based on data from a data warehouse.
- BI tools allow users to generate reports, query, and analyze data specific to their KPIs.
- BI allows users to answer business questions or fulfill a business objective. BI is faster than traditional data gathering methods thus reduces time and boosts productivity.
- BI tools are designed for an end-user to query, retrieve, analyze, and report data.
Data Warehouse Environment

OLAP (Online Analytical Processing) benefits decision makers as it allows for quick glances at information which includes historical data for comparison. Allow for quick glances at information which can expand current data in different perspectives. E.g., bar graph or chart. They can explain current data using OLAP Viewer like SAS Web OLAP Viewer end-users decision makers to view.

OLAP operations also provide users to view their data in multiple ways. The OLAP Desktop OLAP and OLAP – Online Analytical Processing.

The four architectures are: Relational OLAP, Multidimensional OLAP, Hybrid OLAP and can store data in these structured for greater analysis.

OLAP combined, aggregated and loaded into OLAP cube for further analysis.OLAP operations are consolidation (roll up and drill down) and slicing and Dicing (pivot).

ETL (Extract Transform and Load) is an essential technology for UWS. End-users want clean and accurate data.
Data Mining

Data Mining refers to extracting large pieces of data and sorting through to discover meaningful patterns, trends, and correlations. Using data mining allows UWS to focus on important information for decision making. For example, OLAP and Data Mining systems, as they complement each other in many ways. For instance, OLAP could pinpoint problems, and data could then give the user an insight into the business problem.

Ad Hoc Query and Reporting

Using this allows UWS to create reports which reflect specific search criteria. Using this tool, decision makers to create reports on demand, to make decisions for business and management purposes. They are generally used for ad hoc querying and generating up to date reports. It also allows decision makers to quickly perform ad hoc queries and generate reports with other users within UWS with current and accurate referring to logical descriptions provided.
Dashboards and scorecards can be used to add drill-down for easier use.

Interrelationships between metrics. SAS BI dashboards is an interactive product for both off-these-strategic scorecards would be beneficial for LWS as they produce strategic maps to show.

Target set: This is different from dashboards as they can display values in multiple ways.

Scorecards can be used to give decision makers metrics and compare these with a forecast or

present an easy-to-read form of information to identify trends and make informed decisions.

Dashboards are data visualization tools which display custom KPIs created by a decision maker

Dashboards and scorecards software is not required for this purpose.

them with other decision makers who require them. This is beneficial for LWS since additional

SAS Web Report Studio can also be used. An analyst can create complex reports and share

an analyst within LWS to deliver reports based on transactions within LWS.

the basic formatting of ad hoc queries and reporting. These tools are more likely to be used by

Production reporting enables more sophisticated capabilities in terms of design compared to

Expose data for LWS Technologies and Products used to
Data that is unique to their role.

More, if decision makers are not familiar with the BI tool they may not be able to source further information that is unique to their making.

If staff are unfamiliar with the different BI tools, this could result in inaccurate decisions.

There is a lack of a common users interface for BI tools. To access the multiple systems.

**Issues Particular to UWS**

Dashboard - This could result in inaccurate decision making.

**Forecasting** - Some tools place emphasis on historical data. For example, a model.

**Misleading Functionality** - Some companies do not appropriately define their metrics.

**Cost** - Tools can be expensive. The cost of training and informing staff is a cost.

**User friendliness** - BI tools may be too complex for some users, inexperienced users would struggle compared to power users, which could result in inaccurate BI tools.

Presentation Slide 7
Data Warehouse Environment

Storing Data in the Cloud – UAVs could potentially store data in the cloud without the need of having an architecture to maintain in-house.

Social Media – Can be used to gather information of relationships or trends. UAVs could collect this type of data to view opinions of UAVs to help make improvements.

Predictive Analytics – Allows business to analyze trends within operations to build accurate forecasts.

Open Source Tools – This trend has grown since open source tools provide the same functionality from software from Oracle, IBM, etc.

Big Data – Data is constantly growing, businesses are adopting new technologies to help reduce time, effort, and cost of integrating this data within a data warehouse.

Mobile BI – One third of BI tools will be mobile by 2013. Changing workplace dynamics. Using mobile BI adoption gives end-users the ability to manage their decision making and KPIS effectively from any location.

65% planning to increase their use in the next year. Deploying tools in the cloud is currently the cloud – Over a third of business has BI tools situated in the cloud with.

New Trends of Particular Interest

Presentation Slide 8
Drill down into information less complicated.

It is also recommended for LW to implement a system which displays information that is unique to the decision maker. Logically, currently decision makers must export a file to Excel which contains all the data about students within the University. Displaying data that is unique to the respective user within an OLAP viewer will make the process of filtering and excel which contains all the data about students within the University. Displaying data that is unique to the decision maker. Logically, currently decision makers must export a file to Excel which contains all the data about students within the University. Displaying data that is unique to the respective user within an OLAP viewer will make the process of filtering and help them make decisions faster. This has resulted in inaccurate, bi, hence why it is recommended training is provided.

A common issue with LW is the lack of knowledge when it comes to their BI tools. This will result in LW not receiving a single version of the truth. Different vendors for their back-end systems and front-end systems. This will result in LW using different back-end components, such as ETL and the data warehouse platform. LW uses a common standard interface across all of LW's tools. It is also important for LW to standardise in terms of BI tools. LW uses a common standard interface across all of LW's tools. It is also important for LW to standardise.

In order for LW to successfully implement BI tools a number of issues must be addressed.
With these steps UWS could potentially have successful BI for all users.

Step 10 - Business Intelligence Success! (Hopefully)

Step 9 - Provide training for decision makers for full utilisation of BI tools

Step 8 - Implement BI Front-end tools

Step 7 - Select appropriate, common interfaced tools based on their needs

Step 6 - Identify the needs of key decision makers for appropriate BI tools

Step 5 - Implement OLAP Server (preferably from same vendor as ETL and DWH)

Step 4 - Implement Data Warehouse Platform (preferably from same vendor as ETL)

Step 3 - Implement ETL systems

Step 2 - Decide on appropriate vendor for ETL systems, OLAP BI tools and Data Mining

Step 1 - Correlate source systems

For UWS to successfully achieve BI a number of steps must be taken to implement new systems before deploying BI tools.

Steps to Successful BI
The OLAP Viewer embeds visual mapping to let users view measures geographically.

Figure 2.9

Figure 2.10
Data Warehouse Environment

Figure 2.11

Figure 2.12
Figure 3.1

Figure 3.2
Figure 3.3

[Table showing monthly sales for different product types and months.]

Data Warehouse Environment

(COMP10002)
5.0 References


Note that these figures were cited for 2007/8, which is the last year for which data was available.


Tom Caira Guess Talk Audio File.mp3. (2012) [Internet] Available: