

Data Warehousing and Data Mining as Tools to Support Quality Assurance Systems at Universities and Higher Education Institutions

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Abstract: Quality Assurance systems are widely used by all major European Universities and are becoming a key competing factor among Universities. Integrated Information systems provide a huge amount of data that must be properly analyzed in order to support a Quality Assurance system.

This paper will put a special focus on integrated ICT systems based on reliable Data Warehousing and Data Mining procedures. Some areas of monitoring and improvement will be analyzed. Examples on the use of a Data Warehousing system as both a decision-supporting tool for QA strategy and as a reporting tool for all stakeholders will be provided.

Keywords: Quality assurance, University Information System, Student Management System, Data Ware house, Data Mining

1. Introduction

In 2007, The European Network for Quality Assurance has published a set of standards, procedures and guidelines, European Standards and Guidelines (ESG), to be followed by all European Universities [1].

Quality Assurance (QA) has since become a key issue within Universities, by covering not only research and teaching but also all internal processes needed to ensure that students receive an effective education. Furthermore, the purpose of any QA system is to provide ground for continuous improvement and, as such, does require a collection and subsequent processing of reliable data in order to provide meaningful snapshots of the situation. Information and Communications Technology (ICT) and, more specifically, software applications covering all academic processes, are highly beneficial at supporting the QA system. Moreover, Data Warehousing (DW) and Data Mining (DM) procedures can provide meaningful information on all aspects of QA.

The purpose of this paper is to show the effectiveness of DW and DM at supporting QA systems for Italian Universities. While the reality of Turkish Universities might be different, we feel that some of the concepts could either apply or offer some stimuli for further consideration.

2. Campus Management Tools

In the last years Kion SpA [2] has developed different ICT tools in order to support and control the implementation of the Bologna Process action lines. These includes procedures that manage the academic programs and the regulations established by the ministerial decrees and the European Credit Transfer System (ECTS) requirements which, in turn, support the processes of course-planning including the approval, monitoring and periodic review of programs goals and requirements. Such procedures support the management of the courses (including definition of learning programs, schedules of classes end exams, etc.), the registration of data on the academic staff and their scientific research publications, and handle data on students' registrations, academic careers and employment of graduates.

Some of the problems encountered when monitoring and reporting processes and outcomes in a HEI are typically related to difficulties at collecting reliable and certifiable data and to the existence of fragmented data sources distributed among different subsystems. To overcome these problems any Higher Education Institutions (HEI) needs the support of an Integrated Information System (IIS) and of a Data Warehouse (DW) that extracts data directly from the IIS, which contains updated and reliable information about study programs, syllabi, instructors, resources, students and graduates.

Part of the above listed information can be mined (i.e. analyzed), reorganized and reviewed through web based procedures aimed at sustaining both internal QA (programming, monitoring and self assessment) and external QA (evaluation by peers and external agencies). Tools must be tailored to the need of the specific QA model adopted.

Within the wider QA framework spectrum, this paper will put a special focus on the use of a data warehousing systems as a decision-supporting tool for QA strategy and as a tool to report quality outcomes providing information to stakeholders.

3. Data Warehouse in HEI

Here are some definitions about data warehouse systems and procedures.

Business Intelligence (BI) refers to the processes that allow an organization to access the data produced by its information systems (as well as other sources) in order to analyze them and share the results within the organization to support strategic decisions.

While information systems, also known as “operational” or “transactional”, typically function to insert or update data, the objective of BI is to extract from this “raw data” information which

may be hidden otherwise. The more complex the information an organization produces, the more pressing the need to organize it in a structured and accessible way to support its strategic choices and decision-making processes.

A data warehouse (DW) is defined as a software solution through which data is extracted from an organization’s information systems without interfering with its transactions. This data is then loaded into a smaller database (Data Mart), where it is transformed and put into relation to facilitate the exploration and analysis of the information it contains.

The term Data Mining (DM) is defined in literature as “knowledge discovery” in a database. Data Mining is the non-obvious extraction of potentially useful information, which exists in implicit, not-manifest form in the data.

Data warehousing (DW) and Data mining (DM) systems oriented to system governance, unlike other decision-support systems (DSS), are characterized by a superior ease of access and consultation than traditional databases. These tools do not require any programming skills to use them, since the majority of the queries is typically pre-set, and the access to information is rendered in visual mode (Windows-like) via web (intranet or internet) for a wide number of user.

The benefits of a DW and DM system are the essentially the following:

- Freestanding – no interference with the transactional activity of legacy information systems.
- Integration – information is presented in aggregated mode, reconciling potential inconsistencies, existing throughout the legacy information systems.
- Ease of use – no programming knowledge is required.

- Distributed access – visual access to information (via web) can be granted to multiple users through controlled profiles at different level of the organization.

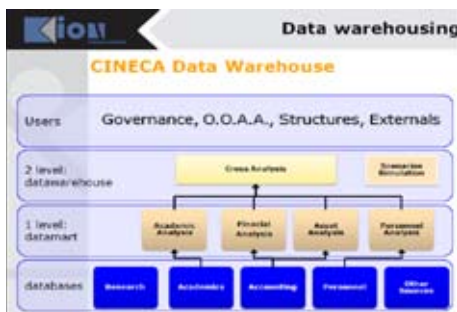
4. KION Data Warehouse Features

The KION Data Warehouse is an innovative suite of information-statistics systems conceived to strengthen and improve the management and control of universities through the monitoring and evaluation of costs, performances and results of the activities performed.

The solution is composed of four Analysis Modules (Data Marts) that are integrated with each other and adaptable to the individual situations, which take advantage of correct and certified data coming from a common repository. Each module is composed of a set of complex indicators which describe and monitor a specific area of university management. The four modules are:

- Student careers and academics
- Personnel's careers and salaries
- Financial-economics
- Research.

On top of these four Data Marts, KION offers a transversal DW which allows to perform cross-analysis on the information residing in the 3 underlying systems.



The system's performance has been recently enhanced with the introduction of a powerful

system of “what-if” simulations capable of predicting future scenarios in order to support universities in the complex management of their structures.

5. Data Warehouse HEI Stakeholders

The DW system can be configured through flexible authorization rights and level of details granting controlled access to each of the areas.

The spectrum of user profiles is wide. Following are some examples of possible usage scenarios in the student career's and academic areas:

- Main university governance bodies: the decision-makers are certainly interested to access aggregated information directly and immediately upon request (on-demand), without depending on third parties and having to wait for the results of the inspection to be made available.
- Faculty and Department bodies: the tool allows to optimize the “Programs of Studies Offering” based on updated information
- Program of Studies Officers: monitor the educational paths and student careers leading to the finding of critical cases – or cases of excellence alike – at individual student level.

The QA Evaluation Bodies heavily rely on the support of the DW system in the evaluation and reporting activities; the tool allows performing cross-system analysis by putting into relations data from different areas (personnel, accounting, student offices, research, assets, etc.) and setting performance indicators to monitor trends. Example of such indicators are: number of credits released by teacher, personnel cost composition, cost by program of study, research publications by structure, self-financing capacity by structure, relationship between cost and incomes by structure or area, number of exams by student, marks distribution, etc

The results of the data analysis are then organized into custom reports (quantitative and qualitative) which integrate and document the Quality Assurance process. Such reports can be published in a form readily accessible to the public in order to provide reliable and transparent information to the stakeholders and to the internal and external auditors of the reports.

The reliability of the information is ensured by the DW support which extracts the raw data from the legacy information system.

Transparency of the information has become a fundamental need and represents a standard in the QA practices shared at European level. In this respect, the web is possibly the most effective mean of communication (yet not the only one used), which will likely become the “de facto” standard in reporting quality outcomes in form of key findings, conclusions and recommendations.

6. Some QA Report Samples

Three examples were drawn from a specific academic field; for each case, the defined objectives and related indicators are reported and visualized by the real software application (screenshot).

In the first one, analysis criteria focus on enrolments, to see some important dimensions of the incoming student’s population. From a strategic point of view, the QA objectives chosen by university management are:

- To increase registrations to all courses (both 1 and 2 level degrees) by 10,5 %. in 2007-2008 from a base of 13535 students in 2004-2005

Year	1st Level	2nd Level	Total
2004-2005	13535	...	...
2005-2006	...	...	...
2006-2007	...	...	...
2007-2008	...	...	...

The second example is focused on the career’s progresses, measured by the number of credits gained from students across academic years.

- Increasing the average credits gained year over year means to reduce the entire studying period length (thereby benefiting students) and to get more financial resources from the Ministry.

Year	Average Credits	Number of Students
2004-2005
2005-2006
2006-2007
2007-2008

In the third example the indicator suggested is the number of “regular graduates” (which means “on time” with respect to the intended academic length of the course) in relationship with the numbers of new enrolments.

By monitoring this data the QA system evaluates the efficiency of the learning program and the competence level of graduates

Course	New Enrolments	Regular Graduates
...
...
...

7. Decision-Making

Following is an example of a cross-analysis report that connects together data from the Academic activities module and the financial module. The report compares the departments from a cost-by-student and cost-by-graduate perspectives (only teaching and researching staff cost are taken into account).

A screenshot of a software application window displaying a data table. The table has multiple columns and rows, with a prominent yellow highlight on a row. The interface includes a menu bar at the top and a toolbar below it. The data appears to be a cross-analysis report comparing departments from different perspectives.

8. Challenges and Improvements

The experience has shown that the monitoring process of a QA system is heavily dependant on the relevance of the indicators selected to assess the strategy toward a particular objective. Setting the right indicators is closely linked with the objectives the HEI wants to achieve in order to trace the path to a successful implementation of QA strategy.

The DW is a decision-support tool, NOT a strategy; mastering the objective-definition process is the most critical step in the whole approach.

A further level of integration in the QA strategy could be achieved by linking the tools to the strategy, that is coupling the DW reports with a Balanced Score Card (BSC), where the DW fuels the data and the BSC provides the indicators.

Another issue to be mastered is the minimization of all the factors related to data cleanliness—which is directly linked to the ultimate reliability of it; while this is a minor issue, it is also one of the hardest to prevent.

References

- [1] ESG Standards and Guidelines for Quality Assurance in the European Higher Education Area ENQA, 2nd edition (2007) www.enqa.eu
- [2] KION SpA, based in Bologna, Italy, is the leading Italian company in the field of Student Management Systems (SMS) with more than 75% market share. Kion Spa in 2008 has opened a subsidiary in Turkey, Kion already active in the market with a scheduling and monitoring system (U-GOV UP) and a Student Management System (U-GOV SMS)
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