Chapter 12
Integration of Information in Higher Education Institutions for Quality Evaluation

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Abstract Higher education institutions have adopted education, research, and cooperation as their main missions. Students, teachers, and non-teaching staff articulate for lecturing, researching, and developing projects and internships, according to the institution goals and strategy. Quality evaluation is of the utmost importance in the whole process, as it allows providing a competent and rigorous service as well as maintaining high level of attractiveness for additional funding, through cooperation and research projects. In this process, well-supported management through rigorous information is necessary, providing a sound basis for reasoning and improvement. In this paper we present a custom made application, which we call JagPAD, to integrate, process and visualize information from several departments and sections, such as student records, human resources, scientific repository, and others. This application is in use at the Polytechnic Institute of Bragança and constitutes a valuable tool for overall evaluation of the mission compliance.

12.1 Introduction

Higher education institutions (HEI) have three primary missions: education, research and cooperation (Kyvik & Lepori, 2010). While in different weights and strategic importance, most institutions try to cope with these missions to contribute

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for population education at high level, scientific and technological advances, and economic and social development.

The Basic Law for the Education System, in Portugal, was changed recently in order to implement the Bologna Process (Law 49/2005 of 30 of August and Law 74/2006 of 24 of March). The new structure was divided into three cycles of studies and was completely implemented in 2009/2010 (Neave & Amaral, 2012). The first cycle, known as Licenciado Degree, has 180 credits and a normal length of six curricular semesters of students' work (level 6 of the EQF). The second cycle, known as Mestre Degree, has from 90 to 120 credits and a normal length of three to four curricular semesters of students' work (level 7 of the EQF). The third cycle, Doutor Degree (level 8 of the EQF), is only conferred by universities and is conferred to those that, after finishing all the curricular units that integrate the study course of the Doutoramento (doctorate) course have successfully defended their thesis in the public act (Fig. 12.1).
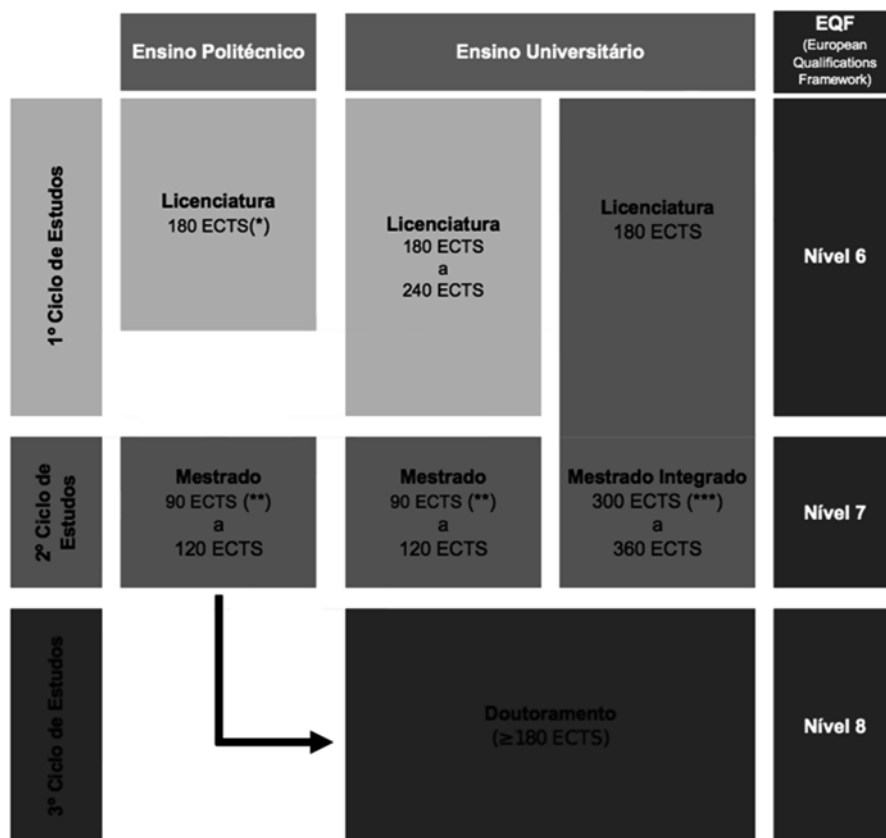

Fig. 12.1 Levels of study in Portugal

The research mission has always been embraced by higher education institutions in a way that governments, as well as private institutions, have begun to recognize the research role of these institutions, to provide them with research funding and to initiate various measures for enhancing research activities. Research remains the primary path not only to individual and institutional prestige but also to support teaching excellence.

Finally, the cooperation mission includes international, regional, social, culture, and science promotion and cooperation with enterprises. In broad terms, cooperation aim to bring together higher education institutions and enterprises in order to promote entrepreneurship, creative thinking and innovative approaches as part of the curriculum for students and as a skill for teachers/researchers and to reinforce the link between studies and employment needs.

12.1.1   Quality in Higher Education

The concept of Quality Management (QM) in Higher Education, although it is diverse, is assumed with the purpose of securing and improving teaching and learning. A Higher Education Institution (HEI) which encompasses quality management may follow various theoretical and conceptual approaches, ideals, blueprints or inspiration in the implementation process (Pratasavitskaya & Stensaker, 2010). The application of popular industrial and economic quality management models have been increasing and several institutions have adopted such models, aiming at customers' satisfaction. However, due to the specificities of the customers and organization, these models have failed in several aspects, not achieving the expected results (Seymour, 1991). In fact, the customers present a different requirement and purpose of the investment they are doing. Moreover, the characteristics of the institution, related to the resistance to change, insufficient administrative commitment and others are specificities that separate these institutions from industrial quality management approaches.

The sectorization of the HEI mission also differentiates between types of quality values, focusing, essentially, on academic, managerial, pedagogic and employment (Brennan & Shah, 2000). Each of these values varies in requirements, authority, and others. Academic quality is related to knowledge generation and scientific development, and is under the professorial authority. Managerial quality has institutional focus and is associated to the organization policies and procedures. Focusing on people, the pedagogical quality is related to building skills and competencies, of educationalist influence. Finally, the employment of graduates and postgraduates is also an important quality value, dependent on successful learning outcomes of graduates.

From an external approach, several legal diplomas were defined to ensure quality in HEI. Law 38/2007 of 16 of August, describes the evaluation of HEI quality, through the assessment of the degree of compliance of their mission through

parameters related to their performance and the results arising therefrom. Evaluation includes several parameters and indicators, such as (Allison & Kaye, 2003):

- The teaching staff scientific level
- The learning methodology and the student evaluation process
- The teachers qualification and adequacy and the produced scientific, technological, and artistic activity
- The adopted strategy for quality improvement and how it is enforced
- The international cooperation, efficiency, and organization of the management body
- The infrastructures and pedagogical and scientific equipment, among others

The consequences of quality assessment are reflected in the accreditation of courses and institutions, of the responsibility of the National Agency for Evaluation and Accreditation of Higher Education (A3ES). The A3ES is independent of the government and has the role to perform a quality evaluation of all HEI and respective courses.

From the higher education institutions perspective, quality enforcement demands the involvement of all the actors: the management body, teachers, students, non-teaching staff, and external community, around a strategy for quality. The required tools and resources are available to the management body, considering that information is central to this process (Mishra, 2007). Information is initially collected, processed and analyzed and then used to extract knowledge, that ultimately influence mechanisms through reasoning. Information is collected and organized according to the institution mission, related, in particular, to academic information, scientific, technical, and artistic, and cooperation (Yanosky, 2009).

12.1.2   *Information and Data Analytics*

Knowledge is fundamental to decision making and strategic planning. Managers need to analyze and to transform raw data, from several sources and with different types, into knowledge. HEI generate a huge amount of raw data, which is usually sectorial and scattered by several departments and administrative offices. Although it is apparently independent, data integration can help capture the complexities of different approaches, which may result in optimizations that are not obvious and that can help defining institutional policies and procedures. This results in the definition of good management practices towards increasing the overall quality.

The conversion of raw data into knowledge depends on some form of analysis, usually based on artificial intelligence and data mining to produce outputs (Hosseinioun, Shayeghi, & Rostam, 2012). Several questions are constantly raised by managerial staff in a HEI. As an example, consider the following:

- What are the total teaching hours by teacher, department, and faculty?
- Which teachers are currently in training and for how long?

- What is the student dropout rate per area and faculty?
- What is the number of different courses each teacher is responsible for?
- What are the students' conditions of access to higher education?
- What is the current state of scientific production of the teaching staff?

In order to answer these questions, data has to be gathered, integrated, and analyzed by automated tools that generate reports or useful and insightful visualizations. These tools are software application, designed for specific processes so that the information can be adequately analyzed and presented. These custom-made tools are usually very expensive to develop and demand a strong knowledge of the institutions' organization, processes and data structure (Guster & Brown, 2012). Moreover, there is a substantial difference between the kinds of metrics and indicators that are meant to measure students' information needs when compared with traditional consumers (Barneveld, Arnold, & Campbell, 2012).

The differences of the data generated in HEI when compared with the business and industrial fields have given place to the definition of specific analytics methodology and definition (Guster & Brown, 2012). This term, applied to the concept of data-driven decision making, relies on data mining techniques to provide managers access to indicators, either historical or real-time, of how the business (higher education institution) and its units (colleges, schools, or departments) are performing (Barneveld et al., 2012).

12.1.3 Data Visualization

In addition to the data gathering and processing towards knowledge extraction, data visualization is a valuable tool to represent and interpret data. Sight is, probably, the most valued human sense. The huge amount of information that is absorbed by the eyes and processed by the human brain is higher than any other sense. A single picture can be used to convey large quantities of information. From a photograph of a landscape to the graphical representation of numbers, images provide a high bandwidth communication channel.

Data visualization can be defined as the process of generating images from data. Consequently, there is a correspondence between data and is representation (Marty, 2009). The user's cognitive capacity is more effectively harnessed to obtain, explore and interpret information (Teyseyre & Campo, 2009). The main problem to solve for data visualization is to define the visual structures that will be used to correspond data to a location in an image. Not all data will have representation, although some will have easy framing and visual meaning (Card, Mackinlay, & Shneiderman, 1999). For example, geographical data is easily represented in positions in a map. Hierarchical data is also easy to represent in a tree or graph.

The possibility of interaction with the user is also an issue. It is possible to have a static view, to print on paper, for example, a transformable view, allowing

changing values of mapping parameters, or manipulated, in which the user can modify the parameters that regulate generation the view (scale, color, …).

The process to make data essential to foster quality in Higher Education Institutions is to integrate it, extract knowledge and represent it in a useful format for students, teachers, and management.

12.2   Data Integration

The diversity of raw data in a HEI is immense and the structure is, sometimes, difficult to apprehend, making it difficult to integrate. We classify academic information as all the information that is related to the teaching process. In this context, the central entity is the student, and we gather information about several indicators, such as student enrolment (type, sex, age, region of provenance, …), educational success (percentage of approvals, dropout rate per year, …), and teachers' schedule and load. Many other indicators and statistics can be obtained through the history of students' records.

Under scientific, technical and artistic information we include the qualification of teachers, their degrees, date when each degree was obtained, how long did it take, and others. We also maintain record of the number, category, start and end date of each contract. A complete record of scientific publications, scientific projects and research units is also registered and accounted. This information allows directing resources to more demanding or urgent areas as well as to balance workload among teachers and departments. Another legal aspect, enforced by Portuguese law, is the teaching staff evaluation process. Teachers are evaluated every 3 years in many aspects, including scientific, technological, organizational, cooperation and teaching. It is essential, for the management body of HEI, to have a complete record of the activities performed by teachers.

Cooperation is also considered in the form of a record of cooperation projects, internationalization, internship organization and supervision among others. Many of the cooperation projects are responsible for research and development funding, in addition to supporting local economy and social development. Students are usually involved in such projects or initiatives, in the form of curricular internships or research grants.

Usually, all this information is scattered through several departments and sections of the HEI. Most of the times there is no business intelligence methodologies that can build on this information meaningful or useful information. In the following sections we describe a custom-made data integration tool, which we call JagPAD, that has the ability to integrate information from students' records, teachers' productivity in all the areas, institutional scientific repository management, and contract management. We start by describing the elementary database entities and proceed gradually to describe some of the features of the application.
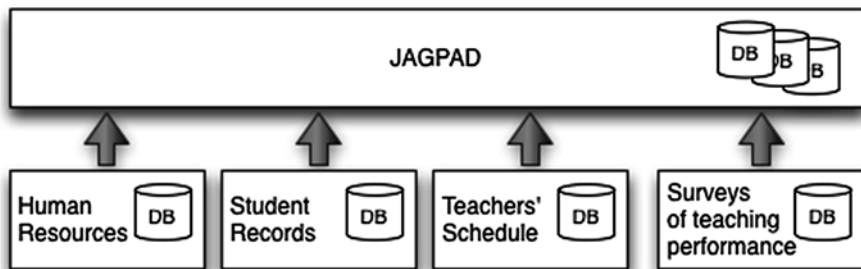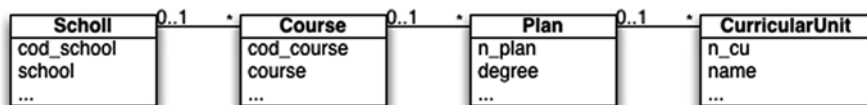
Fig. 12.2 Data integration in JagPAD

Fig. 12.3 Curricular structure

JagPAD collects data from several databases in the HEI, each under management of a different department or section (Fig. 12.2). The information is stored in a local database, to allow making complex, inter-database queries without overloading the original database. Moreover, this approach allows creating middle-level tables, with preprocessed information that further enhances the quality and the speed of access to the information.

The information retrieved from all these databases is converted to a structure of entities, where each entity groups data related the concept it represents. For example, a School provides several Courses. Each course's Plan changes through time, and it is composed of several Curricular Units (Fig. 12.3). In this chapter we chose not to extensively describe all the attributes of all the entities because it would be too verbose.

The student records are associated to the previous structure, including a set of more entities, such as Enrolment (information about student enrolment), Grade (student grades and evaluation), Subscriptions, Country, District, and others. Still in relation to school, another branch of information stores information about the scientific structure, namely, Departments and Teachers. Additionally, there are many entities associated to a teacher, such as the workload (DistServ). Around the Teacher entity there are several other entities, to store information about research and cooperation Projects, qualification (Title), contracts (Category), organizational functions (Position), research units with which he collaborates and others (Fig. 12.4).
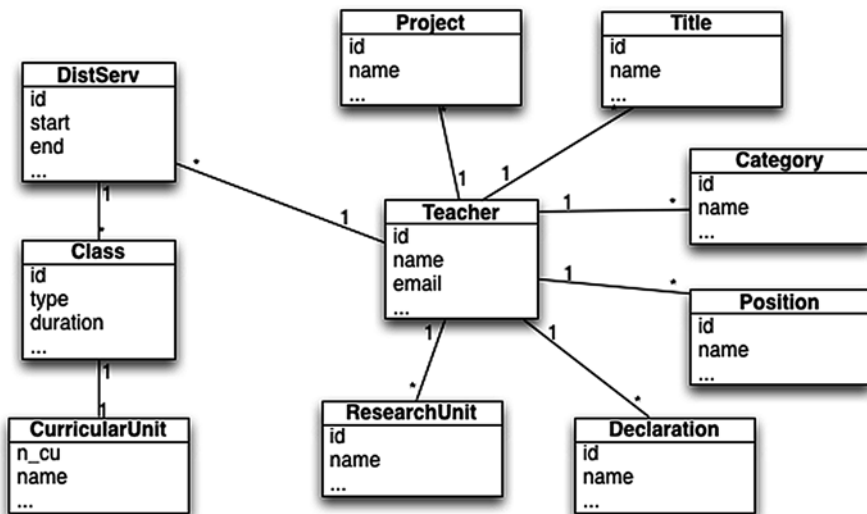
Fig. 12.4 Teacher related information

12.3 Features and Functionality

JagPAD presents a Graphical User Interface (GUI) with rich and flexible controls that allows the user to make prebuilt queries and to generate reports. Each report contains tables, charts and graphs, to better illustrate the meaning of the information. JagPAD is structured in several independent modules, albeit they are interrelated, that can work stand-alone or in articulation with others. At the moment, it has the StoresQueries, Repository, HRM and TeacherService modules, described in the following sections.

12.3.1 Stored Queries

This module is built on the student records and academic information. It allows getting a full set of statistics and information from a large historical database (Fig. 12.5). On the left side of the window there is a tree of queries. Queries can be added or changed at runtime, without needing to rebuild or redeploy the application. On the top of the window, it is possible to add filter conditions to the query, by selecting the school course, plan, and curricular unit. Results are shown in the lower area in tabular format. Data can be exported to PDF, XLS, and ODS, to be able to be processed in a spreadsheet. This module is also used to generate annual reports for the course commissions, containing several indicators related to success, dropout characterization of students and others.
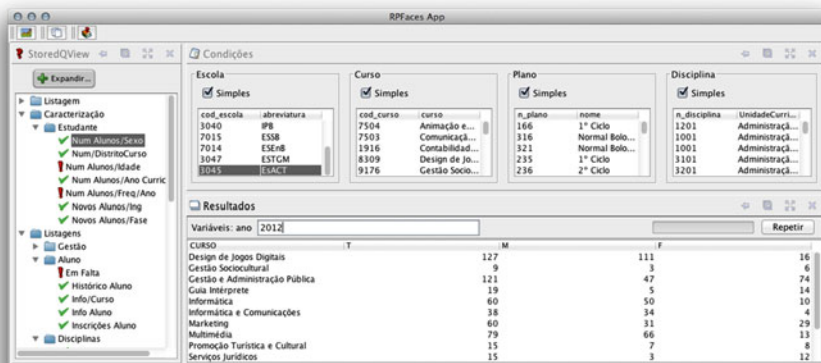
Fig. 12.5 Stored queries

12.3.2 Teachers' Service Allocation

According to Portuguese law, teachers can accumulate up to 12 h per week of contact hours. Service allocation is discussed in the school departments and approved in the scientific council. After approval, service allocation is used to produce teachers, classrooms and students schedules. Teachers are assigned to departments according to specific scientific areas. For example, it is possible to find departments of Informatics and Communication, Mathematics, Visual Arts, or Biology. Due to this structure, each teacher can supervise and lecture curricular units from different courses and each curricular unit can be lectured by more than one teacher. It is useful, from a management perspective, to get the broad picture of teacher/curricular unit relation, inter-department and through different courses (Fig. 12.6).

In a single school there can be as much as 35 courses (CET, Licenciatura and Mestrado), totaling over 800 curricular units and 180 teachers. This amount of entities makes it very difficult to get a clear view of the situation. JagPAD allows building a graph connecting teachers, courses and curricular units, in an easier way to picture the service allocation (Fig. 12.7). The graph is browsable, meaning that it can adapt the topology (manually or automatically), and changing the center, and consequently, the connections, through a simple click of the mouse. The information can also be exported in tabular format, used, for example to fill the self-evaluation report required by the A3ES.
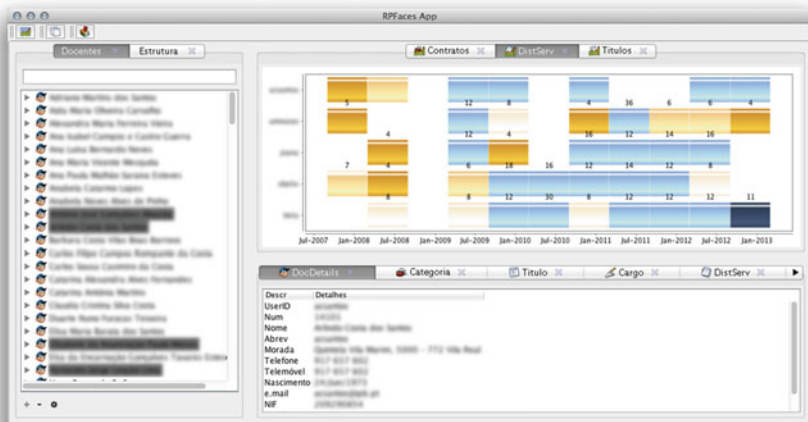
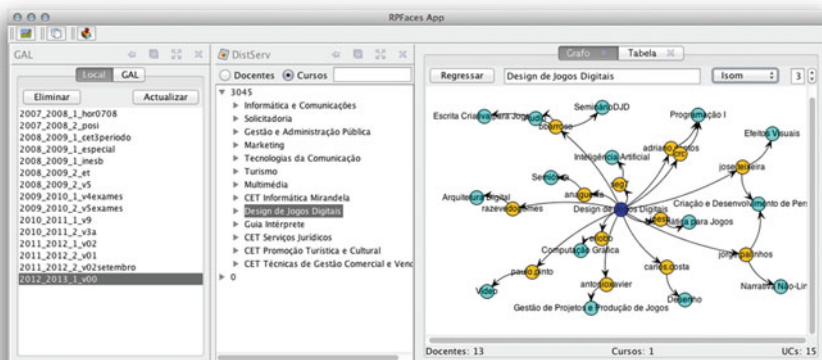**Fig. 12.6** Teaching service allocation historical data

Fig. 12.7 Teacher service allocation

12.3.3 Scientific Repository

The scientific repository (Digital Library of IPB) promotes and provides open access to scientific literature produced by the IPB academic community, promoting integration, visibility, and sharing of scientific information and granting the preservation of intellectual memory of the institution. According to the IPB regulations, only the papers and publications currently in the scientific repository are used for teacher's evaluation. Papers are valued differently, according to the prestige of the

Fig. 12.8 Scientific repository

Fig. 12.9 Human resources management

publication and citation index. JagPAD allows retrieving statistics from the scientific repository, per teacher, per department, or per school, giving the percentage of indexed papers and the overall percentage of publications among the different schools. This allows assessing the balance between schools and areas (Fig. 12.8).

12.3.4   Human Resources Management

This particular module organizes all the information related to the teachers' qualification, contracts, organization activities, the full history of service allocation and others (Fig. 12.9). To facilitate visualizing the information, it also presents the data in a bar chart, showing all the transitions, beginning date, end date following a color code.

12.4 Conclusions

Management of higher education institutions poses several difficulties, resulting from the threefold mission of education, research and cooperation. The diversity of actors (teachers, students, non-teaching staff, and community), generates very different information and situations, sometimes difficult to integrate. Usually, HEI are not ready to adopt a business intelligence view of the degree of compliance of the defined strategy and missions, relying on outdated and on unrelated pieces of information.

In this chapter we describe a custom made application to integrate information from several departments and sections, such as students' records, teachers' service allocation, scientific repository, and others. The application allows making queries and generating reports with integrated information that can provide valuable insight into how the institution works and the degree of compliance with the adopted quality strategy. This application is currently in full use in the IPB, as a support for the management body and, in particular, for the courses commissions and pedagogical council.

The rich graphical user interface and the possibility to interact with the parameters that generate information allow for getting immediate knowledge concerning several parameters and even relate them with other domains. Moreover, for more complex analysis, data can be exported to spreadsheet software of statistical processing packages, such as SPSS or R.

References

Allison, M., & Kaye, J. (2003). *Strategic Planning for Nonprofit Organizations: A Practical Guide and Workbook, Second Edition* (p. 320). Wiley. Retrieved from http://www.amazon.com/Strategic-Planning-Nonprofit-Organizations-Practical/dp/0471445819

Barneveld, A. Van, Arnold, K., & Campbell, J. (2012). Analytics in higher education: Establishing a common language. *EDUCAUSE Learning Initiative* (January), 1–11. Retrieved from https://qa.itap.purdue.edu/learning/docs/research/ELI3026.pdf

Brennan, J., & Shah, T. (2000). Managing quality in higher education: An international perspective on institutional assessment and change. Retrieved from http://eprints.lse.ac.uk/55501/

Card, S. K., Mackinlay, J., & Shneiderman, B. (Eds.). (1999). *Readings in Information Visualization: Using Vision to Think* (1st ed., p. 712). Morgan Kaufmann. Retrieved from http://www.amazon.com/dp/1558605339

Guster, D., & Brown, C. (2012). The application of business intelligence to higher education: Technical and managerial perspectives. *Journal of Information Technology Management, XXIII*(2), 42–62. Retrieved from http://jitm.ubalt.edu/XXIII-2/article4.pdf

Hosseinioun, P., Shayeghi, R., & Rostam, G. (2012). Organizational decision based on business intelligence. *Proceedings of World Academy Science, Engineering and Technology, 6*(5), 292–294. Retrieved from http://www.waset.org/publications/10362.

Kyvik, S., & Lepori, B. (2010). *The research mission of higher education institutions outside the university sector*. In S. Kyvik & B. Lepori (Eds.) (Vol. 31). Dordrecht: Springer Netherlands. doi:10.1007/978-1-4020-9244-2.

Marty, R. (2009). *Applied security visualization* (p. 523). Upper Saddle River, NJ: Addison-Wesley.

Mishra, S. (2007). *Quality assurance in higher education: An introduction*. Bangalore, India: National Assessment and Accreditation Council (NAAC).

Neave, G., & Amaral, A. (2012). *Higher education in Portugal 1974-2009—A nation, a generation* (p. 427). In G. Neave & A. Amaral (Eds.) Springer. Retrieved from http://www.springer.com/education+&+language/higher+education/book/978-94-007-2134-0

Pratasavitskaya, H., & Stensaker, B. (2010). Quality management in higher education: Towards a better understanding of an emerging field. *Quality in Higher Education, 16*(1), 37–50. doi:10.1080/13538321003679465.

Seymour, D. T. (1991). TQM on campus: What the pioneers are finding. *AAHE Bulletin, 44*(3), 10. Retrieved from http://eric.ed.gov/?id=ED340270.

Teyseyre, A. R., & Campo, M. R. (2009). An overview of 3D software visualization. *Visualization and Computer Graphics, IEEE Transactions on, 15*(1), 87–105. doi:10.1109/TVCG.2008.86.

Yanosky, R. (2009). *Institutional data management in higher education* (pp. 1–13). Retrieved from http://net.educause.edu/ir/library/pdf/ECM/ECM0908.pdf