The use of multidimensional models to increase the efficiency of management support systems

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***Abstract*—**Business Intelligence enables universities to measure, monitor and manage their performance more effectively. The paper presents a framework for developing a business intelligence solution for universities. This framework could be applied in universities in order for them asses their current business intelligence implementation level and even identify the requirements to be met for reaching a desired business intelligence level. The paper identifies six Business Intelligence maturity levels. Each level is described by the following elements: top management involvement, user training, information quality, metrics, information infrastructure and Business Intelligence technology. For the case of the Academy of Economic Studies from Bucharest it has been studied the possibility of reaching a higher business intelligence maturity level by implementing a multi dimensional analysis model for providing a better information support for university management decision making.

***Keywords*—** business intelligence framework, multidimensional data model, data warehouse, dashboards, university management.

I. INTRODUCTION

Nowadays, the management of a University is as critical as the management of a big business company. Most universities operate with large and complex organizational structure that is segmented into faculties or departments. The Romanian higher education system is going through profound changes these days, but the worldwide universities are under the negative influence of the economic crisis and are facing significant challenges in maintaining their position in the marketplace. Therefore, universities need accurate and timely information about their marketplaces in order to:

- make informed decisions in the short-term;
- plan for the long-term;
- continue to provide educational opportunities that are relevant for students;
- continue to attract and retain students.

Business Intelligence can be vital for education institutions as well as for businesses. University leadership is usually reluctant to invest in business intelligence initiatives because these projects are long-time efforts involving important budgets. Usually, they are content to use basic reporting facilities to have a vision of university activity. But, there are several factors that have to encourage university leadership to use BI such as competition and expectations from students and employers. Using the BI, our universities should be able to analyze the unemployment rates of the school graduates and link to specializations that they had studied. Such analysis serves for strategic planning of the university and also can be used for comparing the quality of education in different universities. Development and Deployment of a BI system is a challenge for Romanian universities

The Data-Warehousing Institute has defined Business Intelligence (BI) as "the tools, technologies and processes required to turn data into information and information into knowledge and plans that optimize business actions" [9][2]. The range of capabilities that can be defined as business intelligence is very broad. BI includes:

- *BI tools* (enterprise reporting tools, ad hoc query tools, statistical analysis tools, OLAP tools, spatial-OLAP analysis tools, data mining tools, text mining tools, dashboards, scorecards and predictive analytics/advanced analytics);
- *Standalone analytical applications* for a particular domain or business problem. For example, Financial Analytics, HR Analytics, Service Analytics, etc;
- *Real-time BI/operational BI* (BI embedded in operational applications and BI embedded in business process management);
- *Performance Management* has a number of names including: Corporate Performance Management (CPM), Business Performance Management, Enterprise Performance Management (EPM) and Strategic Enterprise Management (SEM-SAP) [23]. The Gartner, the information technology research company, has defined CPM as an "umbrella term covering the processes, methodologies, metrics and technologies for enterprise to measure, monitor and management business performance" [23]. CPM incorporates the following technologies: business process management (BPM), business rules management (BRM), business intelligence and data warehousing;
- *SOA-based BI*. Business Intelligence became more powerful by the use of the SOA. The analysis of business processes and business rules offers support for the business analysis needed to create a BI solution, business rules helping in defining the dimensions and metrics [17]. Business Intelligence triggers changes in business processes and BPM invokes services. BPM and SOA work very well together because SOA abstracts individual tasks and activities as services. A SOA approach is generally considered from a technology/IT perspective, whereas BPM is treated as the domain of the business

users and processes. Business users are the consumers of processes and services.

Figure 1 presents the spectrum of BI technologies.

In the coming years, the emerging BI trends identified by Gartner include [10]:

- mobile analytics,
- in-memory analytics,
- BI embedded in collaboration and social software and cloud-based BI. All the three cloud-computing services models: IaaS (infrastructure as a service), PaaS (platform as a service) and SaaS (software as a service) offer important benefits like: lower costs, pay per use, fast deployment, easy maintenance, etc.

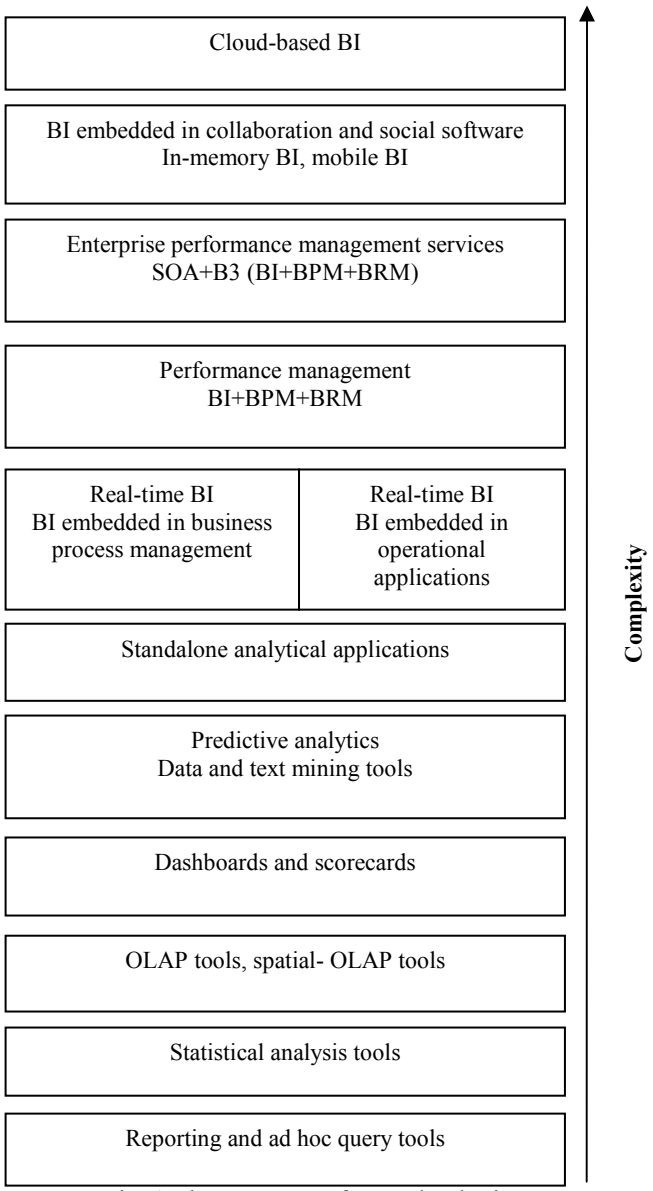

Fig. 1 The spectrum of BI technologies

Our universities should be able to capture and analyze their data on all levels. They should be able to create reports and analysis of their activities, taking into consideration figures like:

- The evolution of the number of students that completed successfully the studies;
- The evolution of the number of students applying for some specialization;
- The evolution of the number of students actually enrolled in a particular study year, etc.

More than that, universities need a framework that defines the layers and the components that are to be integrated and aligned to deliver a strategic vision and plan for implementing BI system. The second section 2 provides a framework that guides the implementation of a BI solution in universities.

The assessment is one of the most important activities in education. The following sections present how a university can use business intelligence to assess an e-learning platform and how his impacts its business intelligence maturity level. The third section briefly presents a multidimensional data model to assess an e-learning platform from the viewpoint of usage. The forth section presents how a university can use dashboards to assess an e-learning platform activity.

II. A BI FRAMEWORK FOR UNIVERSITIES

The starting point in elaborating our BI framework was represented by BI maturity models. The available literature on BI is very broad, but there are few papers that focus on the BI maturity models. These models provide organizations a perspective on the status and the perspectives of their BI initiative.

Table I presents a parallel between four BI maturity models: **TDWI BI maturity model**, **Gartner BI maturity model**, **AMR Research BI maturity model** and **HP Business Intelligence maturity model**. Each of models is described by the following elements:

- aspects covered by model,
- criteria for individual maturity level classification,
- maturity levels,
- BI technology and
- BI consumers.

The common characteristics of these models are that they are using different terminologies, they are developed by BI consulting firms and all of them are methodologically weak.

For example, the Data Warehousing Institute proposes a six-stage BI maturity model - **TDWI BI maturity model.** In the proposed model, maturity is defined through the type of system, architecture, users, scope, BI focus, BI output and analytical tools [7]. The TDWI BI maturity model shows the trajectory that most organizations follow when evolving their BI infrastructure: prenatal, infant, child, teenager, adult and sage.

The aspects covered by the **AMR Research model** are: organization issues and culture. The model focuses on business performance management [12].

The Hewlett-Packard Development Company proposes a five-stage BI maturity model. The aspects covered by the **HP BI maturity model** are: business requirements, information technology, strategy and program management [13].

The **Gartner BI maturity model** defines "the people, processes and technologies that need to be integrated and aligned in order to bring a better defined strategic vision and plan for implementing business intelligence initiatives" [11]. The model includes three layers: people layer, processes layer and technology layer.

Table I. Examples of BI maturity models

Maturity model	Aspects covered by model	Focus on	Criteria for individual maturity level classification	Maturity levels	BI technology	BI users
HP- Business Intelligence maturity model	-business requirements -information technology -strategy and program management	Business and technical aspects	-BI technology -BI consumers	Stage 1-"operation"	-ad-hoc tools -spreadsheet -department DM -OLAP tools	-managers -executives -a small group of analysts
				Stage 2-"improvement"-"measuring and monitoring the business"	-ad-hoc solutions -DM/data mart -operational data stores -DW -ETL tools	-managers -executives -a small group of analysts
				Stage 3-"alignment"-"integrating performance management and intelligence"	-enterprise DW -scorecards -integrating reporting solutions	-executives -managers -"frontline" employers
				Stage 4-"empowerment"	-real-time BI -BI embedded in BPM -BI is fully integrated within enterprise portal -advanced analytics	-empowering "frontline" users
				Stage 5-"transformation"-enterprise services	-SOA-based BI -predictive analytics -BI embedded in BPM	all users
TDWI-Business Intelligence maturity model	-scope of BI initiative -Business value -BI architecture -sponsorship	Technical aspects for maturity assessment	-type of system -analytical tools -architecture -scope -users -BI focus -BI output	Prenatal – "What happened?"	reporting tools	a small group of analysts
				Infant – "What will happen?"	spreadsheets	a small group of analysts
				Child-"What did it happen?"	-data marts -OLAP tools	knowledge workers
				Teenager-"What is happening?"	-data warehouse -- dashboards	use of BI is spread among regular users
				Adult-"What should we do?"	-enterprise DW -scorecards	-use of BI is spread among regular users -a special BI team
				Sage-"What can we offer?"	-analytic services -SOA-based BI	all users

Maturity model	Aspects covered by model	Focus on	Criteria for individual maturity level classification	Maturity levels	BI technology	BI users
Garter - BI and PM maturity model	-enterprise metrics -people -processes -technology	-BPM -Business and technical aspects for maturity assessment -need to integrate with other frameworks	Unspecified	unaware	spreadsheets	-IT staff -managers executives
				tactical	reporting tools	-IT staff -managers, -executives -limited users
				focused	dashboards	BICC
				strategic	BI embedded in BPM	-BICC -use of BI is spread among regular users
				pervasive	BI embedded in BPM	-all users -suppliers, -business partners and customers.
AMR Research- Business Intelligence/ PM maturity model	-organizational issues -culture	BPM	unspecified	Level 1/"reacting"- "when have we been?"	ad-hoc tools	unspecified

The people layer includes three main groups of users: analysts, users and IT staff. The Gartner BI maturity model also recommends a business intelligence competency center (BICC /BI center of excellence).

A BICC is a cross-functional team with specific tasks, roles, responsibilities and processes for supporting and promoting the effective use of Business Intelligence across the organization. The BI center combines business, IT and analytical skills and establishes a collaborative work environment. The Gartner framework also identifies three groups of processes: business and decision processes, analytic processes and information infrastructure processes.

The starting point for we used for our BI framework was the Gartner BI maturity model. Figure 2 presents this framework.

A. The University Strategy and KPI

One way of viewing BI in context of education environment is that of using BI for decision support of universities' management. To use the BI in this way a set of appropriate metrics needs to be used. Identifying and monitoring key performance metrics is crucial for the university administration.

The university senate board manages the creation and definition of university strategies and objectives. The performance metrics need to be derived from the university strategies and from an analysis of the key business processes required to achieve those strategies. Therefore this performance information must be presented to academic supervisor staff in a concise, intuitive format to support the university management processes. The basic function of performance metrics is to assist in determining how well a particular university or department/faculty has achieved its respective goals. Key Performance Indicators (KPI) must be established for each key business process. Monitoring key performance metrics is crucial for the university management. In addition to the KPI, a university should monitor a broad range of metrics.

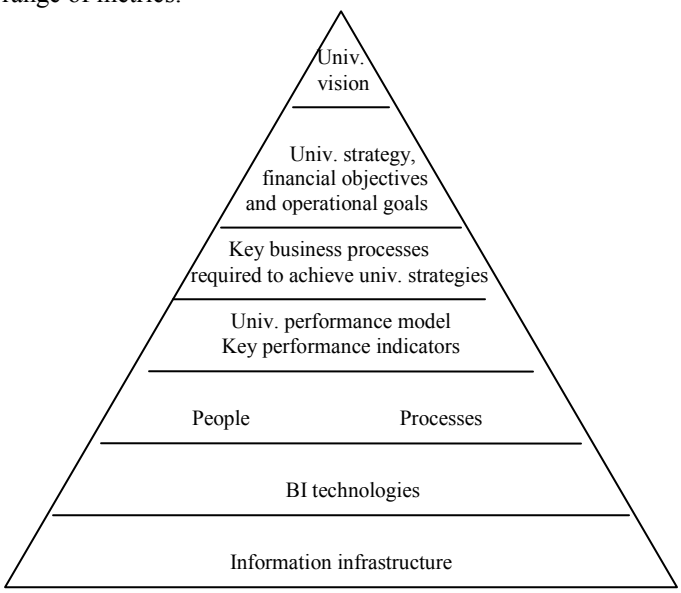

Fig. 2 A BI framework for universities

B. The people and the processes

A university has many users such as: university leadership, administrative staff, academic staff and students. The users will have different roles in analytic, business and decision processes. The users will also require different modes of analysis, different modes of delivery of information and different data. For instance, university leadership requires analysis facilities. Administrative staff requires reporting facilities and ad hoc query facilities. IT staff should have a detailed understanding of how users and analysts work and a detailed understanding of their roles in processes. IT staff should also have a detailed understanding of didactic processes and other related processes.

The key business processes are the **didactic processes**. The key didactic processes are: *defining curricula*, *registration*, *examination* and *completion of studies*. The related processes are: student fees and other related processes (social department, library, etc).

A BICC for university will not be responsible for the creation of specific campus wide metrics, business processes, etc, but will become *a knowledge base of BI activities* across campus.

The BICC team should provide advice and support for all matters related to BI such as:

- data management (data acquisition processing, data integration, data quality, etc) ;
- information delivery;
- metadata management;
- data governance (policies, security& privacy, ownership, etc);
- enterprise BI platform management (system monitoring, security, software updates, change management, etc).

C. Information infrastructure

Information infrastructure addresses how the data architecture and data integration infrastructure ensure efficiency and agility to react to changing business requirements.

An information infrastructure includes: an enterprise data warehouse or/and a data mart or/and an operational data store (ODS) or a real-time data warehouse. A university needs a university data warehouse that provides a centralized source of information for the supervisory staff of the university and for the organizational and administrative structures. It also supplies the data necessary for reporting, analysis and developing the university strategic plan and supports the analytical activities regarding the three major components in the university context: didactics, research, and management. The university data warehouse is fed from various transactional data sources such as: Human Resources, Financial Department, and Academic information system-called SIMUR in our university (student services, research management, resource allocation, e-learning, etc), but also external sources (other institutions performance data, workforce and employment data, etc).

D. BI Technologies

Dashboards are the preferred method for delivering and displaying business intelligence to users. A university can use dashboards as main components of a BI solution.

Eckerson defined a dashboard as "a multilayer application built on a business intelligence and data integration infrastructure that enables organizations to measure, monitor, and manage business performance more effectively" [8].

From a decision maker's perspective, the dashboards provide a useful way to view data and information. Outcomes displayed include metrics, graphical trend analysis, capacity gauges, geographical maps, percentage share, stoplights and variance comparisons. In the coming years the dashboards will become essential in our universities. Dashboards will allow University leadership to monitor the contribution of the various activities in university.

Table II provides a quick way for universities to analyze their current situation and see what requirements are necessary for reaching a desired BI level. The table presents six BI maturity levels. Each level is described by the following elements: top management involvement, user training, information quality, metrics, information infrastructure and BI technology. In level 6, Business Intelligence capabilities reach their highest level wherein BI is delivered as services. Business Intelligence and performance management have become a strategic initiative. Business Intelligence is fully embedded within business processes, for all processes. Business Intelligence is also integrated within the university portal. A performance metrics framework exists across all areas of the university. Users are well trained and are able to access the information they need.

Business maturity levels influence the quality of information. A higher level of BI maturity will lead to higher information quality.

III. THE MULTIDIMENSIONAL MODEL

Our university uses Moodle as e-learning platform. The University management is interested in an assessment of the distance learning. This section presents a dimensional data model for assessment of Moodle platform from the viewpoint of usage. The choice of a dimensional data model was based on the need to analyze data at the scale of the entire university.

The introduction of an e-learning environment at a university influences a variety of processes: registration of students for courses, the workload of teachers, how knowledge acquired during such a course is assessed, etc. The next sections present how a university can use the dashboards and a multidimensional data model to assess an e-learning platform from the viewpoint of usage. Using the dashboards we can estimate:

- How often students have accessed the e-learning platform?
- Which resources are used more?
- Which teachers are most active in terms of usage time?

In the traditional learning process, students are evaluated through tests, exams, etc.

Table II BI framework –maturity levels

Levels	Top management involvement	Users	Information quality	Metrics	Information infrastructure	Applications	BI technology
Level 1- information anarchy	-IT department is responsible for reporting	-no skills	-duplicate data -inconsistent /incorrect data -no data integration	-no performance metrics	-no	-operational systems for administrative departments (finance, HR) /admission	-spreadsheet -simple reporting tools
Level 2- ad-hoc	-low support -IT department is responsible for reporting	-users are often not skilled enough	-management does not trust the quality and consistency of the information.	-metrics are used on the department level only no common metrics	-data integration tools	-for optimize one process -different applications across the university	-reporting tools -ad hoc query
Level 3 –standards	-the information technology vice-rector- coordination and standardization of technologies -focused on a limited part of the university	-users are trained for basic functionalities of systems	-data is not integrated	-inconsistencies in metrics of individual departments	-data mart -operational data store -metadata	-across multiple processes (student service, resource allocation, etc)	-reporting tools -ad hoc query tools -OLAP tools -statistical tools -dashboards for optimize the efficiency of individual departments, but is not related to the broad university goals
Level 4- alignment	-a clear business strategy for BI development -university leadership involvement	-trained for data processing -BICC	-information is available to all employees of the university -data management policy and data quality metrics	-common metrics exist -a performance metrics framework for critical business processes	-an enterprise information infrastructure -operational data store -DW -metadata	-across all critical business processes (didactic processes and related processes)	-include BI into critical business processes -integration of BI, BPM, BRM -dashboards -other BI tools
Level 5-strategic	-BI, PM, analytics have become a strategic initiative -university leadership involvement	-well trained ; interactively access; -BICC	-quality information for all levels of management -data are completely integrated	-a completed performance metrics framework across all areas of the university	-enterprise data warehouse -enterprise wide metadata -integrate unstructured content with structured data	-across all processes	-BI embedded in business process management (for all business processes) -BI is integrated within the university portal -dashboards -other BI tools
Level 6- services	-BI, PM, analytics have become a strategic initiative -university leadership involvement	-well trained -interactively access to information and analysis -BICC	-quality information for all levels of management -data are completely integrated	-a completed performance metrics framework across all areas of the university	-enterprise data warehouse -enterprise wide metadata -unstructured and structured data are integrated	-across all processes	-university performance management services -SOA+B3 -cloud-based BI

In distance learning, e-learning systems allow to evaluate student's interaction with the e-learning environment. E-learning environments usually have a built-in student tracking tool that enables the teacher to view data such as a student's first and last login, the number of accesses, etc.

BI allows universities to analyze and correlate teachers' online activities with course evaluations and student results. For instance, we can identify who are the "risk" students. We can also analyze which tools are used depending on student age, gender and ethnicity. It is difficult to select suitable metrics and methods for the assessment of e-learning.

Over the past years many studies have focused on the assessment of the e-learning impact on the learning process and student's evaluation [14], [15], [18], [19], [20], [21], [22]. Lei proposed data mining analysis for evaluation of e-learning [14]. The log files were used as data sources. Sheard proposed statistical analysis [21]. The data sources were: Web logs, student demographics and survey results. There are few studies which proposed the use of data warehouse [20], [22].

Moodle is an Open Source Course Management System with a variety of communication tools, collaboration tools and evaluation tools. The Moodle database has around 200 tables: a set of tables for each activity module (assignment, chat, choice, forum, lesson, etc); a set of tables for users, roles, role-capabilities, course, course category; a set of tables for logging system, etc [3].

Moodle keeps detailed logs of all activities that students perform on the e-learning platform. Each record in the log contains a time stamp and other fields that hold information about activity at that instant. Course logs show activity within the course. It allows teachers to see what resources are being used and when. For instance, the activity report lists how many times each course activity has been viewed and the last time it was viewed [3]. But the Moodle statistics utility is somewhat limited. There are no drill-down or roll-up operations, it doesn't use complex visual components as gauges or stoplights and when compared to the dashboard technology, it does not look appealing anymore.

The research data were collected with reference to only one course: *Economic Informatics*, Faculty of International Business and Economics, first semester of 2010-2011. Data can be obtained from three source systems: Moodle database, Moodle logs and the SIMUR database from which data about courses, people and study programs can be extracted. A multidimensional data model is proposed for the storage of these data.

You can choose to display the logs on a page or download them in text or Excel format. In order to use data log for the course activity analysis, all participants, all days, all activities and all actions for one course were selected and the logs were downloaded in Excel format. The Excel file was converted in CSV format. The CSV file was imported into an Oracle database.

Many log file records can occur for a single action. Due to this problem, all records with the same IP address, same course, same tool, same hour, same day, same month and same year are considere to be a single activity. For instance, actions can be: assignment view, blog view, resource view, resource update, etc. The attribute *Data* is timestamp (for example 24-NOV-10 04.11.32). The following records are a single activity- *assignment view Tema 4*:

Courseid Data IP address Name Action
100109010F111208C 24-NOV-10 04.11.09
109.99.154.184 Adina Cindea assignment view Tema 4
100109010F111208C 24-NOV-10 04.11.32
109.99.154.184 Adina Cindea assignment view Tema 4
100109010F111208C 24-NOV-10 04.11.59
109.99.154.184 Adina Cindea assignment view Tema 4
100109010F111208C 24-NOV-10 04.12.12
109.99.154.184 Adina Cindea assignment view Tema 4
100109010F111208C 24-NOV-10 04.35.16
109.99.154.184 Adina Cindea assignment view Tema 4

Some new attributes were defined. The attribute ***Start date*** of an activity is defined as:
First_Value(Data) Over(Partition By name, Action, Information, Extract(Day From Data)|| Extract(Month From Data)|| Extract(Year From Data) Order By Data).

For example, the *start date* for *assignment view Tema 4* is 24-NOV-10 04.11.09.

The ***duration (as interval)*** of an activity is defined as the difference between the first value and the last value of each partition:

First_Value(Data) Over(Partition By name, Action, Information, Extract(Day From Data)|| Extract(Month From Data)|| Extract(Year From Data) Order By Data Desc)- First_Value(Data) Over(Partition By name, Action, Information, Extract(Day From Data)|| Extract(Month From Data)|| Extract(Year From Data) Order By Data)

The ***duration (in seconds)*** is defined as:
*EXTRACT (hour FROM duration) *3600+ EXTRACT (minute FROM duration)*60+ EXTRACT(second FROM duration)*

For instance:
Name Action Duration Seconds
Adina Cindea assignment view Tema 4 4 0 0:24:7.0 1447

The multidimensional data model is implemented in the Oracle RDBMS using a constellation schema (figure 3). The multidimensional data model consists of three fact tables: *Utilization Fact* table, *Activity Fact* table and *Grade Fact* table.

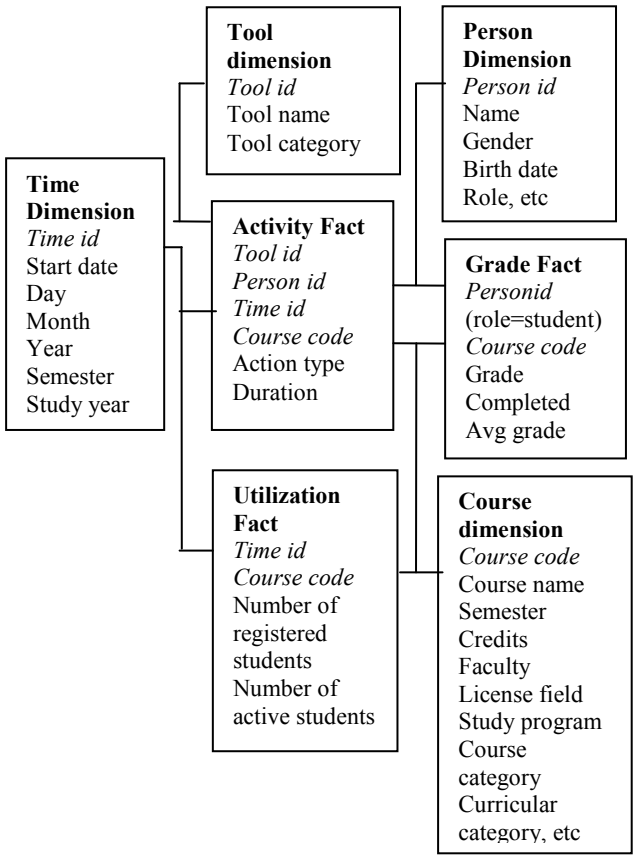

Fig. 3 The multidimensional data model

The measures of the *Utilization Fact* table are:

- *Number of registered students*. The registered students are users registered in Moodle as student.
- *Number of Active students.* The active students are registered students who have accessed a course at least once. These measures can be extracted from Moodle database.

The *Activity Fact* table includes information about student activities in Moodle platform. The measures of the *Activity Fact* table are:

- *duration* (in seconds) and
- *type of action* (view, add, update, delete, etc).

These measures can be extracted from Moodle logs.

The *Grade Fact* table includes information about student grades. The measures are:

- *student grades for each Moodle course* and
- *average grade for all courses*.

The attribute *Completed* describes whether a grade is satisfactory (*completed=yes*) or unsatisfactory (*completed=no*). These measures can be extracted from Moodle database.

The dimensional data model also specifies the "granularity" (level of detail) for each measure. There are four attribute dimensions: *Time, Tool, Course and Person*.

i) ***Tool dimension*** contains information about Moodle resources (chat, forum, glossary, lesson, blog, assignment, test/quiz, survey, etc). The assignment tool allows students to upload digital content for grading. Each course has its own set of glossaries. Wiki can be a powerful tool for collaborative work. Each user has his own blog, which is non-course specific. Moodle has also two tools specifically designed for collecting feedback from students: surveys and choices.

ii) ***Course dimension*** contains information about courses.

The attribute *Course category* can have five values: DF-fundamental, DG-general, DS-specialized, DE-economic/management, DU- humanist.

The attribute *curricular category* can have three values: DI-imposed, DO-optional and DL-free choice.

iii) ***Person dimension*** contains information about all course users.

The attribute *Role* stores user roles, for instance, administrator, editing teacher (discipline coordinator), non-editing teacher (tutor), student and guest. User roles can be extracted from the Moodle database.

iv) We can also add ***Session dimension*** which contains information about IP address and type of session (home or school). The IP address allows for identification of the place where the e-learning platform was accessed (faculty, computer lab, etc.).

Hierarchies were created for attribute dimensions to make it possible to analyze data at different levels.

- The *Tool* hierarchy consists of two levels: tool and category. Tools can be classified by category, for example, communication tools (chat, forum and blog), evaluation tools (test/quiz and assignment), feedback tools (survey and choice) and collaboration tools (wiki).
- The hierarchy of the *Time dimension* consists of four levels: start date, day, month, semester, study year.
- The hierarchy of the *Course dimension* can have, for instance, the following levels: course, curricular category, course category, license field and faculty.

For instance, the records of the *Time dimension table* are:

Timeid	*startdate*	*day*	*month*	*year*	*semester*	*study year*
307	*20-NOV-10 15.24.45*	*20*	*11*	*2010*	*1*	*2010-2011*
312	*24-NOV-10 00.48.36*	*24*	*11*	*2010*	*1*	*2010-2011*
316	*22-NOV-10 17.08.54*	*22*	*11*	*2010*	*1*	*2010-2011*
323	*02-DEC-10 18.00.10*	*2*	*12*	*2010*	*1*	*2010-2011*

IV. DASHBOARDS

The results of the activity analysis can be presented in an effective way by using dashboards, which provide friendly interfaces, easy to read and interpret. The dashboards for assessment of e-learning should be classified into the following fundamental groups: top management, faculty, distance learning (ID) department and teacher.

The dashboards for top management can provide information about: number of registered students per semester, number of active students per semester, number of active teachers per semester, number of registered students per semester and faculty, number of active students per semester and faculty, etc.

The dashboards for faculty can provide information about: activity per course and person, activity per tool and person, activity of the most active teachers in tools (total time), etc. The ID department organizes the distance learning process and ensures quality. The ID department is interested in the way in which Moodle is used: the tools used more often, the final grades of students, monthly activity, etc.

The dashboards for teachers can offer information about: activity of a particular student (time in minutes) with tools, activity among all students with course tools, etc.

This section presents only two examples of dashboards. The dashboards are developed using a free BI tool – Qlikview. The dashboards display only one indicator: **duration**. You can view: activity per person, tool and course; total activity per semester, course and teacher; total activity per role and course; total activity per role, month and course; average duration per month; number of active students per month, etc.

We selected: semester=1, month=12 (December), tool category = "communication", course name="Economic Informatics" and role="student".

Figure 4 displays:

- activity (duration in minutes) per student and tool;
- activity per student and communication tools category;

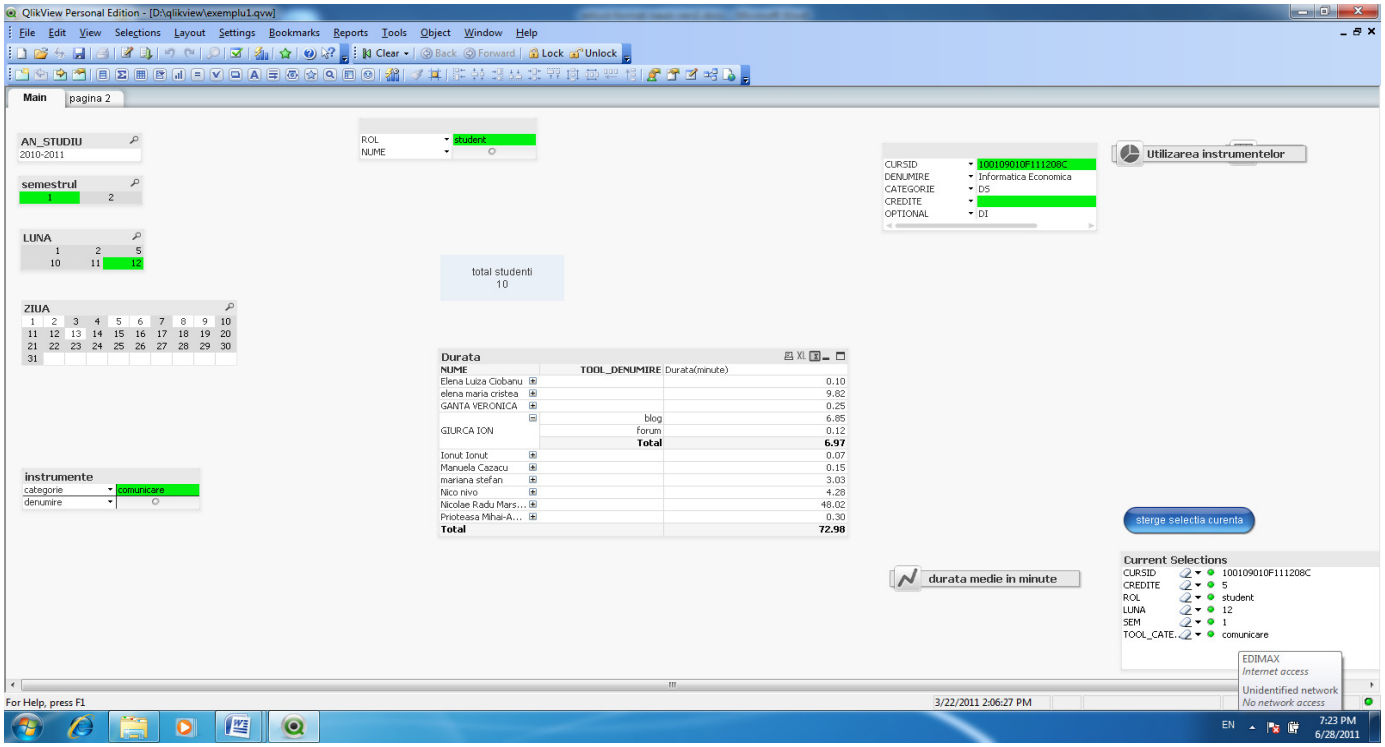

Fig. 4 An example of dashboard

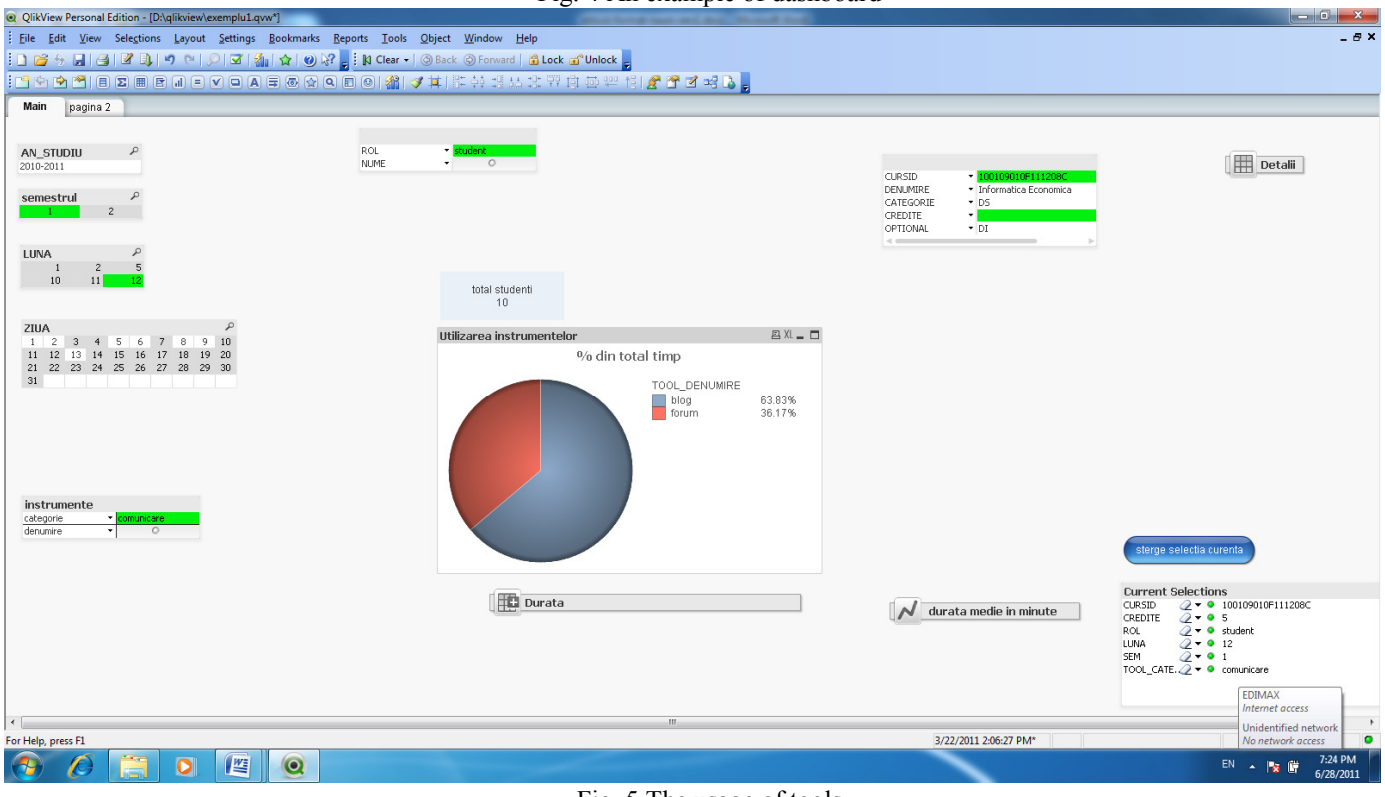

Fig. 5 The usage of tools

- total activity per communication tools category;
- number of students which used the communication tools in December, 1st semester.

Dynamically, you can change the semester, the month or the day, you can change the course, you can select a role (for example student), you can select all students or only a student and you can change the display from pivot table or straight table to a bar chart. Figure 5 displays the usage of communication tools for role="student" and course name ="Economic Informatics".

The flexibility and the advantages of multidimensional modeling and dashboards for the analysis of academic activity performances are obvious. But the presented multidimensional model offers answers to an isolated activity, to an individual department. How can the benefits be extended to the entire university level? By reaching a higher business intelligence maturity level. Our university is implementing an integrated information system for university management (SIMUR), so the integration of data and processes across university departments will be accomplished. This will help in solving data inconsistencies and unavailability and will offer an university information infrastructure and a consistent operational data store.

Still, business intelligence consists only of isolated efforts, limited to individual departments or needs. When assessing the university business intelligence maturity level using the proposed framework, it is situated to the 3rd level: standards. The framework shows the main requirements for reaching a higher BI level: define a clear BI strategy, include Bi into critical business processes and so on (see Table II).

V. Conclusion

This paper presented a framework for developing a Business Intelligence solution for universities. The paper also presented how a university can use dashboards and multidimensional models to assess an e-learning platform. The paper identified the potential data sources and methods for the extraction and integration of data.

A survey on quality assessment of e-learning can be also used. The survey results can be analyzed together with the metrics which characterize an e-learning platform from the viewpoint of usage. This topic will be the subject of further research.

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