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Supporting Educational Leadership in Secondary Education with OLAP

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ABSTRACT

Nowadays many school functions are supported by dedicated information systems. Business Intelligence (BI) is a widely used set of techniques and tools for the transformation of raw data into meaningful and useful information for business analysis purposes. They include Online Analytical Processing (OLAP) in order to provide historical, current and predictive views of business operations. Schools in secondary education can be viewed as small organizations where effective decision making is required at many areas and levels. Decision-making is one of the most critical processes taking place in a modern school. It is a necessary competence for school administrators and managerial staff especially in Education Directorates who often have to make decisions regarding the implementation of education strategies and policies. It is also important for teaching staff and school curriculum designers in order to plan teaching methods and monitor student performance. Study The aim of this project is the research of feasibility of applying OLAP Decision Support Systems in Education and Education Management, any possible benefits as well as possible enhancements. The outcome is the design and implementation of an enhanced OLAP system applied in a specific educational setting based on our case.

Keywords: OLAP; Business Intelligence; Secondary Education; Decision Support

INTRODUCTION

New technologies and information systems have changed dramatically all areas of human activity. The impact on the educational domain is no exception and enormous amount of research is carried out in order to utilise new technologies in all possible activity areas from operational activities such as teaching to administration and strategic planning. Managing schools and leadership is a modern complex task. The basic functions included in administrative educational leadership, we would say that they consist in the provision of adequate financial resources to anticipate problems will likely arise, but also in the design of appropriate responses to them. At the same time, the functions of administrative educational leadership include the distribution of financial resources, as well as efficient management of both the whole school, and of his infrastructures and his students. These goals are achieved through the adoption of effective models of communication with the whole educational community, and methods for optimizing the overall operation of the school. Finally, the literature refers to as basic functions of the educational leadership model to minimize changes that could disrupt the normal curriculum, but also the design and adoption of that educational policy, which is required for the function of school [1].Nowadays most of the school functions are supported by dedicated school information systems.

The typical data generated in such an environment, enables education decision makers to have access to a vast amount of information concerning students; teachers, administrators. I also involves school finances and operations. Finally there is lots of data which refer to communities served by educational institutions. Numerous studies deal with decision making and how the data produced from such systems can affect decision making in educational structures raging from single school entities to state educational policies. [2], [3], [4] These data, however, have limited use—and could possibly be

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detrimental—if decision makers do not understand the benefits and limitations of data, the types of data relevant for the decisions they are confronted with, and how data can be appropriately used for decision making [5].

Business intelligence (BI) is the set of techniques and tools for the transformation of raw data into meaningful and useful information for business analysis purposes. BI technologies are capable of handling large amounts of unstructured data to help identify, develop and otherwise create new strategic business opportunities [13]. The goal of BI is to allow for the easy interpretation of these large volumes of data. Identifying new opportunities and implementing an effective strategy based on insights can provide businesses with a competitive market advantage and long-term stability. Online Analytical Processing (OLAP) can be regarded as today's modern Decision Support Systems. OLAP is part of Business Intelligence Systems. [10][11] [12].

Schools in secondary education can be viewed as small organizations where effective decision making is required at many areas and levels:

- decisions regarding incoming students e.g. number of students, location of residence, originating schools, number of girls and boys, performance indexes
- current student data, number of girl students, number of boys students, current student overall-subject performance, attendance rates, overall marks, subject marks, absences
- number of graduating students, destination schools, number of failed students

The aim of this project is the research of feasibility of applying OLAP Decision Support Systems in Education and Education Management, any possible benefits to educational leadership and administration as well as possible enhancements. The main approach is to support decision making by utilizing information processing in a secondary education setting using specialized software tools. The outcome will be the design and implementation of an enhanced OLAP system for secondary education information systems.

APPROACH OVERVIEW

Our approach was applied in a real life scenario and concluded in three main steps.

The first step was to analyse the school data. Real data from school activity were gathered in a database. Analysis was necessary in this step in order to determine the relevant data and analyze their structure so that they would be used in the Data Warehouse.

The second step was to design an OLAP multidimensional structure to be used for data analysis. The applicable measures were identified together with dimensions, possible hierarchies, etc and the cubes were processed. Imports of data and DW ROLAP schema were also implemented. The final step was to utilize these cubes into OLAP reporting of the analysed data.

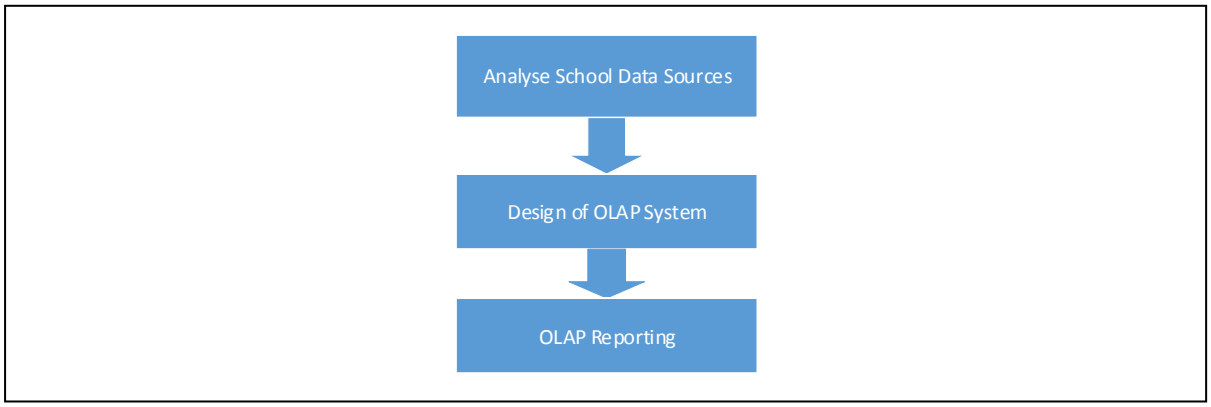

Figure1. *Approach Overview*

DATA WAREHOUSES AND OLAP

Data Warehouses (DW) characterize a set of decision support technologies, which together with Analytical Data Processing provide the end user the possibility of obtaining valuable information from data, usually collected from the databases of a company that promotes the strategy decision making.

Using practical terms a data warehouse is a copy of data gathered from transactions of an organization, structured in such a way to accommodate complex queries and analysis of data.

According to Singh data warehouse is a decision support environment, which uses as sources of stored data from different sources. These data are organized to decide the format of information in order to assist him in making decisions. [6][7].

In today's business world the volume of data that are stored in warehouses and databases, is growing rapidly. Therefore there is a need for finding a way to manage this data efficiently and without problems in short response times. The client server architecture although solved various problems related to data management, lacked in response to questions issues. With the creation and use of the useful information for business analytical processing OLAP stored in a way that is readily accessible.

Codd et al. were the first to set the requirements to be met by a system to qualify as OLAP system. According to Codd et al. [8] an OLAP system must support multi-dimensional representation of information. OLAP tools are designed to support the decision support process, taking into account data from standard or special procedures of enterprises and organizations. This is accomplished by providing users with different OLAP functions, such as the popular roll up, drill down, slice, and pivot. Typically, each OLAP function is comprehensive and one can easily understand its operation, but the use of sophisticated OLAP tools require complex combinations of different OLAP functions, which are not easily manageable directly to users.

In terms of OLAP implementation advanced OLAP tools exist today raging from the sophisticated Oracle Business Intelligence tools and Microsoft Analysis Services to open source and freeware tools such as Mondrian and ICE cube community edition which were used for the purposes of this project.

DESIGN AND IMPLEMENTATION OF THE OLAP DSS FOR SECONDARY EDUCATION SCHOOL

The main aim of this project was the design and implementation of an OLAP system for supporting decision making within the school environment. The data sources and data originate from school data sources. The time span of the respective data reaches twelve year recent period. We deliberately relied on real existing data sources instead of introducing artificial experimental data. This choice may hinder the overall DSS application but the main benefit was the investigation of the feasibility of the approach to a real situation examining real data. The main components used in this approach were the source data contained in a relational database (MS Access), the OLAP analysis software package and the reporting tools, mainly MS Excel. The source data had to be analysed depending on their usefulness for analysis and extracted for OLAP processing. The OLAP system was responsible to transform the input data into OLAP cubes. Finally the query results were presented using MS excel in order to demonstrate in our case study actual results and possible uses of the proposed system in school decision making.

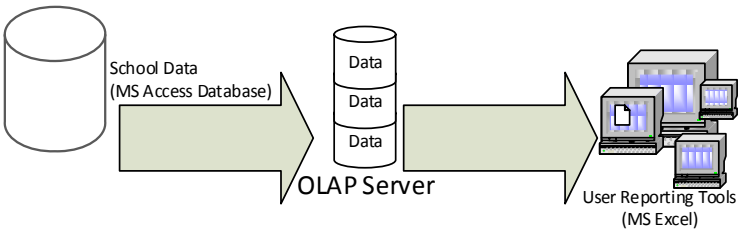

Figure2. *OLAP Implementation Overview*

The development of an OLAP model involves three phases, design and development of the database, the OLAP modeling, and finally the implementation of OLAP model via an OLAP application

ANALYSIS OF THE DATA SOURCES

The first step towards the implementation of an OLAP system is to define the source data and analyse its applicability. The original school database was implemented in Microsoft Access. The time span of the data refers to the school years from 2001-2002 to 2011 - 2012. They include information about 802 students who attended in the years mentioned above along with 96 school teachers. The database includes the teachers personal information, their specialty, their qualifications etc.

For students the database holds a full list of their personal data, their class of attendance and a section in which each student belongs to each school year for their scores separately for each course for each

quarter and final scores, as well as data about whether promoted to the next grade. Also there are data on students that indicate the attendance-absences gathered separately in each school year. Figure 3 depicts partially the aforementioned database schema.

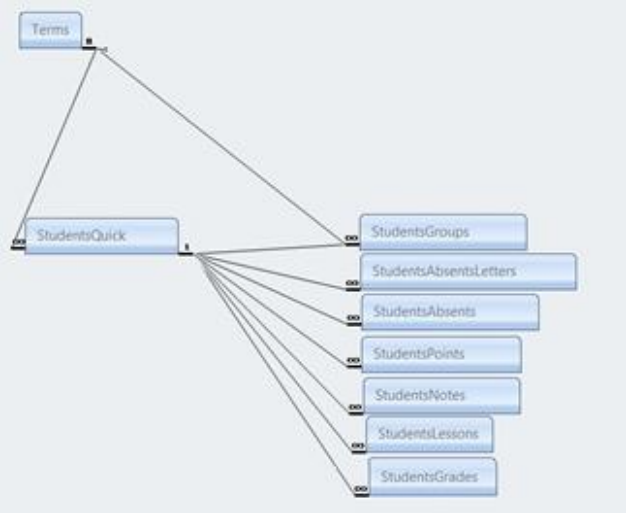

Figure3. *School Database Schema (Data Source)*

Example data structures include:

- Grades and Students Absences per Subject per Year.
- Students Personal Data and Averages

MULTIDIMENSIONAL OLAP DESIGN

After defining the source data for analysis we must import them to an appropriate OLAP package. The OLAP package will create a new database suitable for multidimensional analysis and query rather than two dimensional, relational query. It will prepare the data in order to be readily available for all possible analysis scenarios and feed the reporting software module with respective reports. For the purposes of this project Microsoft Analysis Services was used among other software pack to define the multidimensional database.

MOLAP, ROLAP and HOLAP architectures are supported by the Microsoft Analysis Services. Based on a set of Component Object Model interfaces for uniform data access to heterogeneous information resources and extensions of Object Linking and Embedding) for OLAP, Analysis Services access divergent data sources using it's OLE DB/ODBC component. Interaction with client tools is achieved through OLE DB/ActiveX controls. OLDE DB also provides the ability to create additional database services. Using this tool we were able to import our Microsoft Access database into the SQL server for Analysis.

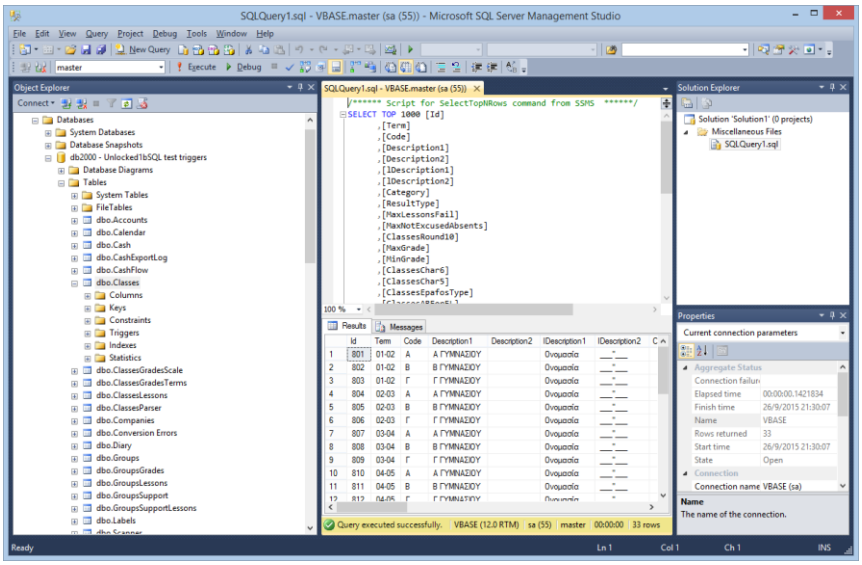

Figure4. *Managing the School Data source with MS SQL Server Management Studio*

Using this wizard we can directly define our Microsoft access database as the source. After successfully connecting to the access database we can then use another wizard for defining the actual elements of the data source called a data source view as shown in figure 5.

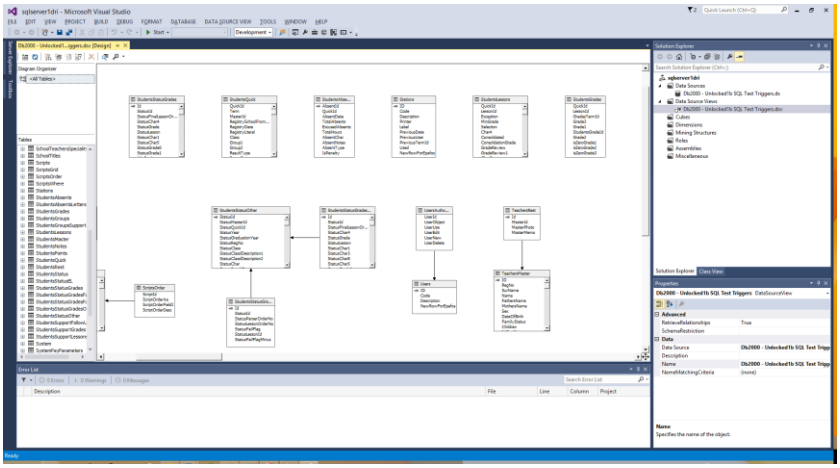

Figure5. *Data Source View*

This view contains all the database tables that are necessary for data analysis. Tables that are not important are not contained in this view. Apart from the tables, tables relations are also defined here. Another important step is to define the dimensions that will be used in all future measures and cubes. This can also be done very easily using the cubes wizard as shown in figure 6.

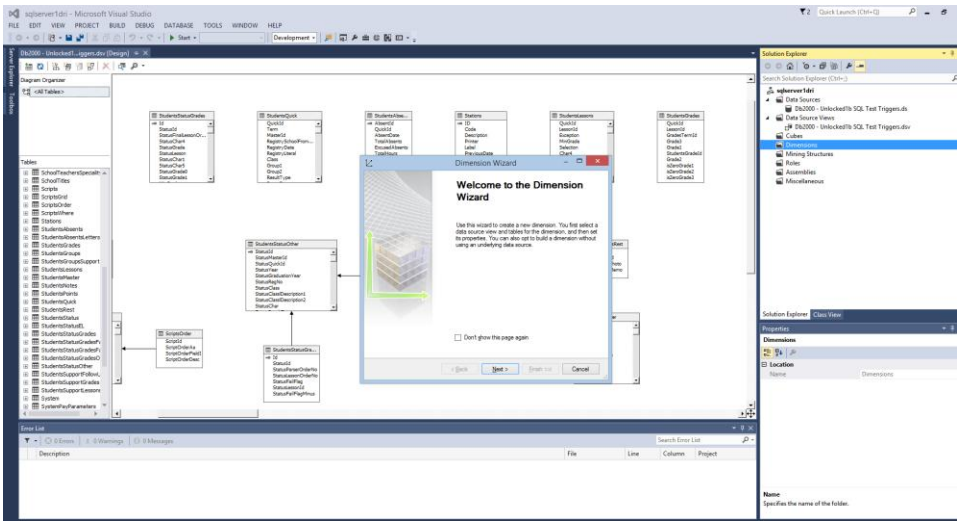

Figure6. *Dimension Definition*

After defining a dimension it is also necessary to process it to complete its creation. The same procedure can be applied to designing cubes). At the end of the process we will be able to process our cubes and analyse them.

THE DESIGN OF OLAP REPORTS

The use of data in order to plan school related processes and in fact to inform instruction is the critical reason we collect the data. The collection of student performance data without using it to inform instruction would be a waste of valuable teacher time although this happens very often in many schools. The importance of the classroom monitoring data lies on the fact that it guides us to realise the students levels are with regard to the content standard indicators staff are responsible for teaching so that we can make informed decisions on planning the next steps. It also helps planning all of the possible school processes such as term budgeting, staff allocation, planning, allocation of school rooms, school activities, etc.

Although reporting capabilities may be endless we demonstrate just a few examples that demonstrate the usefulness of the approach. For example in figure 6 we can analyze the origins and residency areas of the student population so result can lead to decisions regarding the school start and end times, the

decision for routing the transportation options e.g. school bus leasing, the planning of school events, the planning of communication options, the introduction of special care of remote teaching methodologies for isolated students.

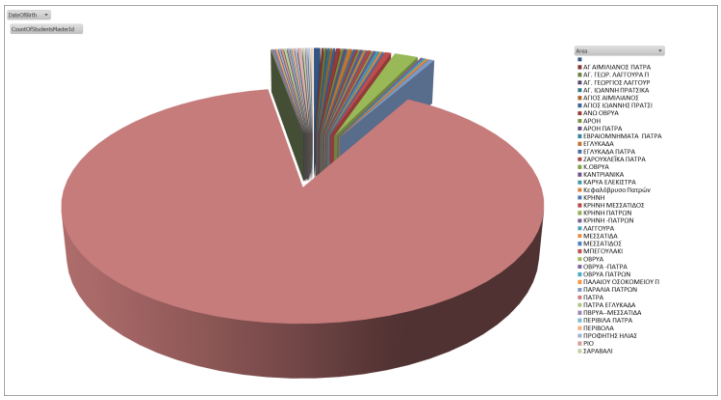

Figure7. *Analysis of Students Residency Areas*

Another example is the examination of the allocation of Grades among subjects. This allows us to have a better view of teachers marking habits as well as to examine the performance of stunts in these subjects. Figure 8 shows a diagram with the marks obtained in all lessons in a specific year.

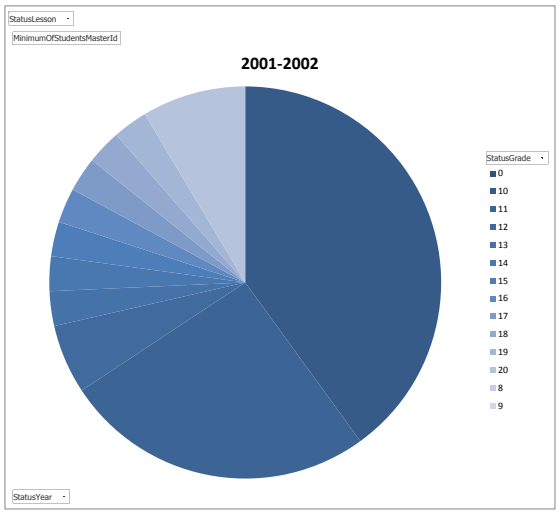

Figure8. *Student Grades per Year*

A very important area for analysis is the students absences. Absent students can be a very serious problem in some schools and in some situation it can lead to failed class or even abandoning school all together. For example in figure 9 we can examine the number of absences per class per school year as shown.

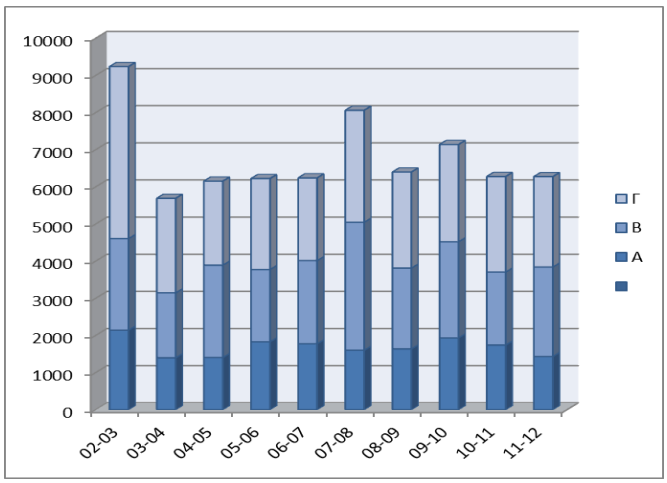

Figure9. *Number of absences per class per school year*

CONCLUSION

One of the most critical processes taking place in a modern school is decision-making is. Education Directorates often have to make decisions regarding the implementation of education strategies. Thus it is a necessary competence for school administrators and managerial staff. It is also important for teaching staff and school curriculum designers in order to plan teaching methods and monitor student performance. Analysis of student data can give answer to number of questions such as:

Analysing student data can give answer to number of questions such as:

- Content standard indicator(s) that the teacher was assessing?
- Percentage of students demonstrated proficiency?
- Implications of student performance for instruction?
- Population of students have failed to achieve this performance?
- Diagnostic information about examinations of student work ?
- Individual student performance, as a basis of what do we need to do next to move the student to proficiency?
- Based on the class performance, what re-teaching do I need to do?
- Demonstration of proficiency After students assessment of initial situation,?
- Is re-teaching or other interventions resulting in improved student performance?
- Performance comparison by subgroups (e.g., by racial group, gender, students with disabilities, ESL students, or students in the free and reduced meals program), does show any groups not performing as well as the whole group? If so, how are we going to respond?
- Are there any students who are not attaining proficiency across indicators?
- What diagnostic information do we have about them to inform instruction?
- What interventions have we tried? What interventions do we plan to try next?

In this paper we attempted to apply modern Decision Support Systems to assist decision making at the secondary education level. Decision support functionality is realized by offering OLAP reporting tools for solving particular school related tasks as well as by allowing users to navigate through the data, query it, generate interactive visualizations and explore those for retrieving interesting details.

Although these technologies belong to the Business Intelligence Technologies whose primary target is to support business decisions, we attempted to apply them in an educational environment by viewing it as a special type of organization. Thus the second step was to apply these technologies to a case study involving real school data, kept in databases. The information kept in this database was initially analysed in order to identify key information concerning students, lessons, grades, absences and teaching staff. After the identification of important information, an OLAP system was used in order to analyse this critical information using analytical queries. The result of these queries were interactive numerical and graphical reports. These "multidimensional" reports could be used so that we build an information background, capable enough to support us in many facet of school related decision making processes. Decisions, among others, may include the following categories:

- Instructional: Learning resources; student awards & recognition; enrichment activities.
- Resources: Budget development and evaluation; grant writing; employee recognition; recruiting, selecting, recognizing and using volunteers and community resources.
- Governance and management: Discipline plan; attendance policy; community relations and communications; special events; scheduling; school-based fees; school safety issues.

Most systems are built in such a way so that they gather as much data as possible without considering which data is relevant as information an relying on user-centered approaches would to help at a later stage. Nevertheless, although the initial data views were very limited, we had the opportunity to apply a system in a real life situation and observe the results. Analysis was performed in real time and end

users were required minimal knowledge of computer usage. The application of the OLAP model provided a direct analysis of data supporting decision-making processes free of technical issues. However data selection, cleaning and integration might consume a large proportion of the development effort especially when combining data from various sources and various schools. Better data organization should combine more tables and define dimension hierarchies. In fact School Information Systems are often flooded with data, offering more data than decision-makers can effectively synthesize and use.

The fact that OLAP systems provide instant information models for changes in source data, it enables managers to monitor modern aggregated data at any time to take administrative decisions on the root of the problems. Based on our study OLAP systems proved their ability to present combined results with the multidimensional character serve the administrative needs of educational units or organizations.

More specifically, the directors of educational units or organizations by using centralized and up to date data would be able to draw up more accurate financial budgets. Even with regard to the educational process they will be able to identify weaknesses and make structural changes where needed. Educators will be able to group students in relation to a characteristic and discovering weaknesses such as too many absences or low scores in a course or in the general average and to make motions such as creating supportive teaching departments. Finally the use of aggregated data that would have resulted from processing in OLAP systems will contribute to better evaluation of the teaching staff, managers will be able to discern whether the poor performance of some students due to teaching staff or students learning difficulties. Future work may

- Include more data sources. We can provide data from online learning systems, combine school's data with other schools and compare data to other school areas or countries.
- Provide better data cleaning. Invest time and effort into cleaning data which are acceptable for the school information system – database but they are not acceptable for analysis, e.g. proper input for religion, or family status. This cleaning can be combined with database tables which will include better views of the data and allow dimension hierarchies.
- Disseminate results. Connection of the current OLAP system with reporting tools, web based reporting tools so that result are disseminated within the school community.
- Identify critical decision factors. Better understanding of measures and their consequences, e.g. classroom population vs student performance. Isolate the critical factors and possible impacts so that reporting can focus on those factor and thus gain better control of the outcome of the decision making process.

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AUTHORS' BIOGRAPHY

Vaios Papaioannou, was born in Larisa, Greece, in 1968. He studied Physics in the University of Ioannina where he obtained his first degree in 1992. In 1993-95 he attended successfully his M.Sc. Course in Computation at the University of Manchester Institute of Science and Technology (UMIST). His M.Sc. Thesis was based on the development of a Computer Aided Software Engineering (CASE) tool for Temporal Database Systems. In 1998 he received his Ph.D. from the Department of Computation, partially funded by UMIST, for his research on the development of a Hypermedia Environment for Software Requirements Engineering based on Ontologies. He has numerous publications in Conferences and Journals. His research interests are ontologies, education and internet software development. He is currently employed in the Secondary Education whilst he was also a visiting professor for the Hellenic Open University and the Technological Institute of Patras, Greece. He is currently the head of informatics and new technologies centre for the Achaia prefecture, Greece and he is also participating in many local and European funded projects.

George - Peter K. Economou, was born in Cagliari, Italy, in 1966. He received the Electrical and Computer Engineering diploma (5-year degree) and the Ph.D. degree from the University of Patras, Patras, Greece, in 1990 and 1995, respectively. His doctoral dissertation covered the design, development, and teaching of decision support systems. He is currently a Lab Professor with the Computer Software Division, Computer Engineering & Informatics Department, University of Patras, and a visiting Professor with the Hellenic Open University, Greece. He has played a major part in the fruitful outcome of a number of European Union funded projects, sponsored either by the University of Patras or Greek small and medium enterprises (SMEs). His research interests include decision support systems structuring, neural-networks processing, teleworking (telemedicine) development platforms, very large scale integration (VLSI) architectures for the integration of teleworking platforms, and computer networking. He has authored or co-authored over 50 papers in international books, journals, and conferences. Dr. Economou has received several scholarships and official grants.