Enhancing the Learner's Performance Analysis Using SMEUS Semantic E-learning System and Business Intelligence Technologies

Fisnik Dalipi(✉), Sule Yildirim Yayilgan, and Zenun Kastrati

Faculty of Computer Science and Media Technology, Gjovik University College, Gjovik, Norway
{fisnik.dalipi,sule.yayilgan,zenun.kastrati}@hig.no

Abstract. Ontologies represent an efficient way of semantic web application on e-learning and offer great opportunity by bringing great advantages to e-learning systems. Nevertheless, despite the many advantages that we get from using ontologies, in terms of structuring the data, there are still many unresolved problems related to the difficulties about getting proper information about a learner's behavior. Consequently, there is a need of developing tools that enable analysis of the learner's interaction with the e-learning environment. In this paper, we propose a framework for the application of Business Intelligence (BI) and OLAP technologies in SMEUS e-learning environment. Hence, on one hand, the proposed framework will enable and support the decision-making by answering some questions related to learner's performance, and on the other hand, will present a case study model for implementing these technologies into a semantic e-learning environment.

Keywords: E-learning · SMEUS · Ontology · OLAP · Data analysis

1 Introduction

E-learning platforms are widely used by higher education and other research-oriented institutions to enhance the efficiency of institutional services related to teaching and learning, and to improve quality of teaching. Nowadays, many of the e-learning systems available on market lack in specific functionalities for the creation and delivery of dynamic, modular learning paths that match the knowledge needs in a contextualized (according to learner's current activities) and individualized (according to learner's experiences, competences profiles, learning history and personal preferences) way [1].

Ontologies represent an immense opportunity by bringing great advantages to e-learning systems. Their implementation is seen as a better solution for organizing and visualizing didactic knowledge, and for this knowledge to be shared and reused by different educational applications. The usage of ontology represents an efficient way of semantic web application on e-learning [2]. This is reflected on the realization of ontology-based description for the learning materials or the knowledge base. Additionally, semantic notations are added for each learning object. In terms of organizational aspect, ontology application allows the categorization of learning resources in personalized learning forms,

© Springer International Publishing Switzerland 2015
P. Zaphiris and A. Ioannou (Eds.): LCT 2015, LNCS 9192, pp. 208–217, 2015.
DOI: 10.1007/978-3-319-20609-7_20

which are being accessible to the students upon their request, depending on their profile and need to learn. In this way, the needed learning resources are easily identified, and the access time to the learning resources is reduced. Even though ontologies and semantic web can solve, among others, the process of structuring data in e-learning environments, yet there are many other problems to be addressed and solved. In order to support the innovation process in a e-learning platform on getting proper information about a learner's behavior, we extend our previous work [3] to apply business intelligence techniques to the SMEUS e-learning system. Accordingly, on one hand, the proposed framework will enable and support the decision-making by answering some questions related to learner's performance, and on the other hand, will present a case study model for implementing these technologies into a semantic e-learning environment. SMEUS is a semantic e-learning system that we have developed to focus on and address the issues of integrating ontological principles with e-learning standards, and to show how semantic concepts can bypass the problem with unstructured educational data and different techniques of knowledge representation.

The rest of the paper is organized as follows. Section 2 reviews about the related work. The process of designing the business intelligence solution and the connection with SMEUS is represented in Sect. 3. In Sect. 4 we provide some valuable results. Finally, we conclude the paper and give some future research issues in Sect. 5.

2 Related Work

The literature reports some works in order to solve mentioned problems in e-learning systems. Some tools such as MATEP [4], GISMO [5] and Sinergo/CoIAT [6] have been proposed. However, the researchers in these works are not incorporating any type of semantic aspects and BI tools to help track, measure and analyze the activities performed by learners. There are also some works performed on ontology and BI analytical applications in [7, 8] by implementing ontology to find appropriate data from different sources and semantically integrate the needed data into OLAP cube. Furthermore, tools like SBI [9], BIKM [10], SEWASIE [11] are worth mentioning.

There are also several case studies of using educational data mining in Moodle course management system to identify and analyze the learner's behavior. Authors in [12, 13] try to answer some of these questions by identifying related indicators and by offering tools that allow analysis and interpretation of results through data warehouse and OLAP technologies. To increase both efficiency of the university services related to teaching and learning and to improve its overall quality, they propose frameworks for applying business intelligence in e-learning platforms. Nevertheless, the authors provide models, which are out of the ontology based semantic web technologies scope and they lack to address the explicit definition of conceptualization on a specified domain and assembling learning objects.

3 Towards an BI Semantic Model

Semantic web supports the innovation process in a learning environment, having the property for data creation and management that are machine understandable. Semantic web also

possess all the properties for creating and reusing the e-learning materials and contexts, enabling the enhancement of metadata linked with e-learning materials and expanding the current potentials of e-learning systems. The e-learning field involves many process resources, such as LOM (Learning Object Metadata), SCORM (Shareable Content Object Reference Model), RDF (Resource Description Framework), XML, OWL (Web Ontology Language), etc. LOM includes metadata for learning objects and represents a standard for educational management system and learning objects. Learning objects are digital contents or entities deliverable online, having the property of being reused in different contexts, for learning, education or training. Ontologies' usage in educational systems may be approached from various points of view: as a common vocabulary for multi-agent system, as a chain between heterogeneous educational systems, ontologies for pedagogical resources sharing or for sharing data and ontologies used to mediate the search of the learning materials on the Internet [14].

With regards to e-learning, semantic web ensures a technology where the learning object is [15]:

- *Described with metadata* – due to the distributed structure of RDF, description can be expanded and consequently new description can be added. This allows a creative use of content in a new way.
- *Annotated* – each identified resource by URI can be annotated with personal notes and links by everyone.
- *Extended* – the structured content with XML is allowing multiple versions to exist. Successive changes in the content can be executed with the help of RDF schemes, allowing private, grouped, or author versions of a certain document. The versions history is represented as a tree with known and unknown branches, which can be traversed with special version tools.
- *Shared and communicated* – to anyone who has expressed an interest in such content. Since the metadata are expressed with standard format, which is independent of basic schemes, even simpler applications can understand portions of complex RDF graphs.
- *Certified* – there is no reason why only big organizations should certify learning resources. Individuals, such as teachers, should certify learning contents as a qualitative learning resource, which is suitable for a certain educational work.

3.1 System Structure and Design

Our prototype SMEUS is developed to be used as an innovative system for knowledge retrieval and other e-learning aspects, including online testing. The system structure is presented in Fig. 1. As integral part of the system are design interface, system metadata, description of learning contents and learning methods. Within the interface design, we have developed special options for testing, online consulting and at the end, we propose a semantic representation of learning, by applying ontology. The semantic character of learning or the semantics of the learning object includes our proposal for describing learning materials within ontology domain. This provides us with a semantic representation of the content by adding semantic notation to each learning resource. The ontology is used for identifying the structure of learning module and defining the needed vocabulary

for the student to conceptualize the learning modules. Another ontological approach is introduced for learning materials, which is part of the systems metadata. Here, we included also the system access alternatives, results registering and the communications.

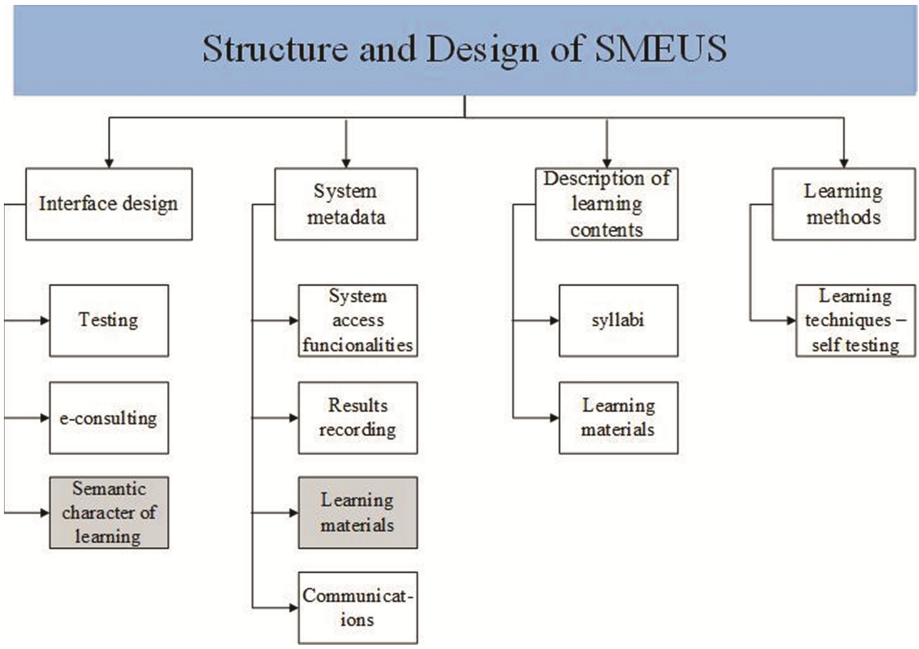

Fig. 1. System access functionalities

The section with description of learning contents includes some options where we store syllabi of subjects and learning materials. The learning method section includes self-testing for students, which is an option of preparation for them before they are subject to the real examination.

With SMEUS we aim to go beyond limitations that some e-learning application have. The semantic learning character class includes the knowledge of learning theory, language, scientific discipline, auxiliary technology, etc. Each of these can be connected in many ways with fields of ontological modeling. If we consider the scientific discipline, the content here is distinguished by type and level. In the content type, we may have: rules, processes, procedures, concepts, etc. whereas in the content level, there may appear the levels of content complexity, i.e. basic, average and advanced level.

In order to focus the learning expectations or results towards the improvement of understanding the learning material, the learning models, goals and contents should be structured or defined with an adequate pedagogical methodology. Regarding the auxiliary technologies, they support the presentation technique of learning contents with different technology, such as, ontologies, metadata and learning object warehouses (see Fig. 2).

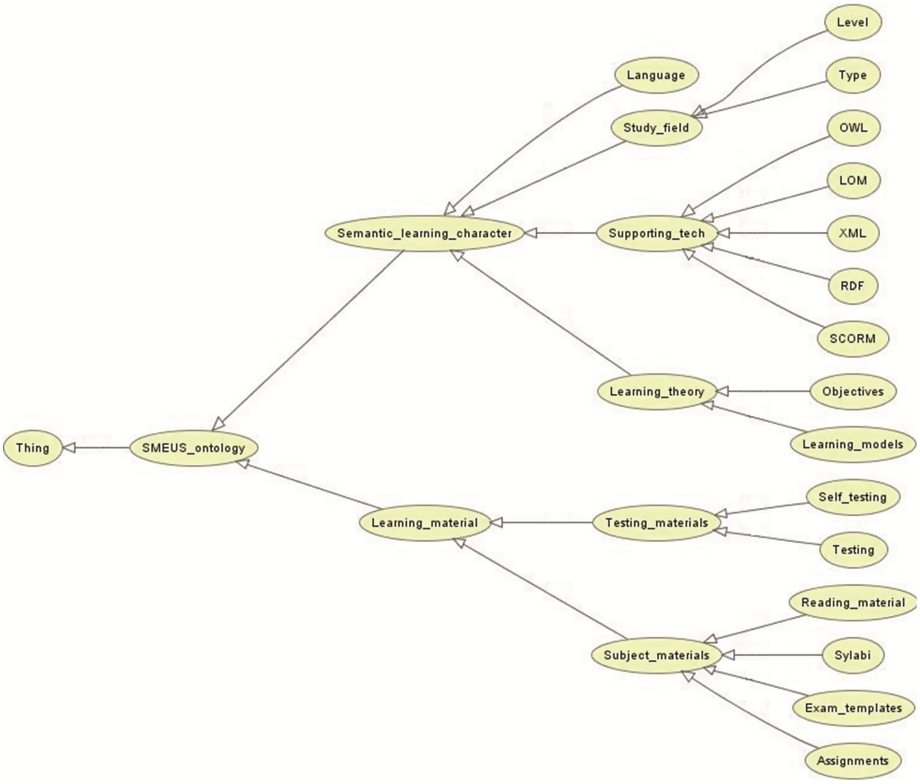

Fig. 2. SMEUS ontology

3.2 Designing the BI Solution

The objective of a business intelligence process is to refine business data and information into useful and valuable knowledge and intelligence for decision making [16, 17]. There are several proposed definitions in the literature about process steps and models in implementing BI. However, in this work we follow the idea proposed by [18], who proposes a lifecycle model as shown in Fig. 3. The first activity to create a BI solution is the requirement specifications phase. In this phase, a document is produced with example analytical questions and desired reports that would provide the needed elements for building the data warehouse schema. This document involves questions related to the time students are spending to read or view learning materials, which learning resource they like to visit and use more, how often they use collaboration tools etc. The second step or activity is dimensional modeling. This encapsulates designing a dimensional schema, which is based on the analysis of business requirements and consists of a central fact table and its related dimensions.

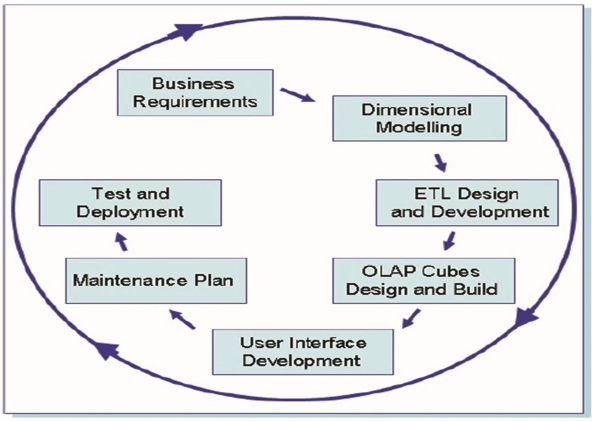

Fig. 3. BI lifecycle [18]

An example of a developed schema in our project is shown in Fig. 4, which contains details about learning activities.

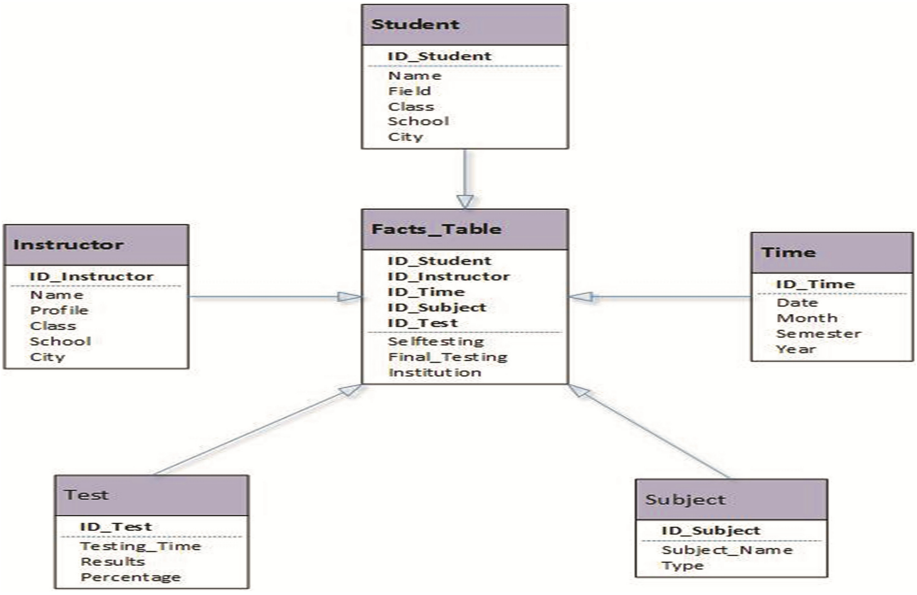

Fig. 4. Facts table schema

After the dimensional schema is designed, we start and define the development of ETL (Extract-Transform-Load) processes. During this phase, we also apply common data preprocessing tasks such as data cleaning, user identification, session identification, path completion, transaction identification, data transformation and enrichment, data

integration and data reduction. Once these steps are completed, we use SQL Server BI edition for multidimensional analysis.

3.3 An Architecture for Semantics and BI Integration

In order to increase both flexibility and performance of e-learning environments, we propose a framework for applying BI in semantic e-learning environments. The workflow scenario of our model is given in Fig. 5.

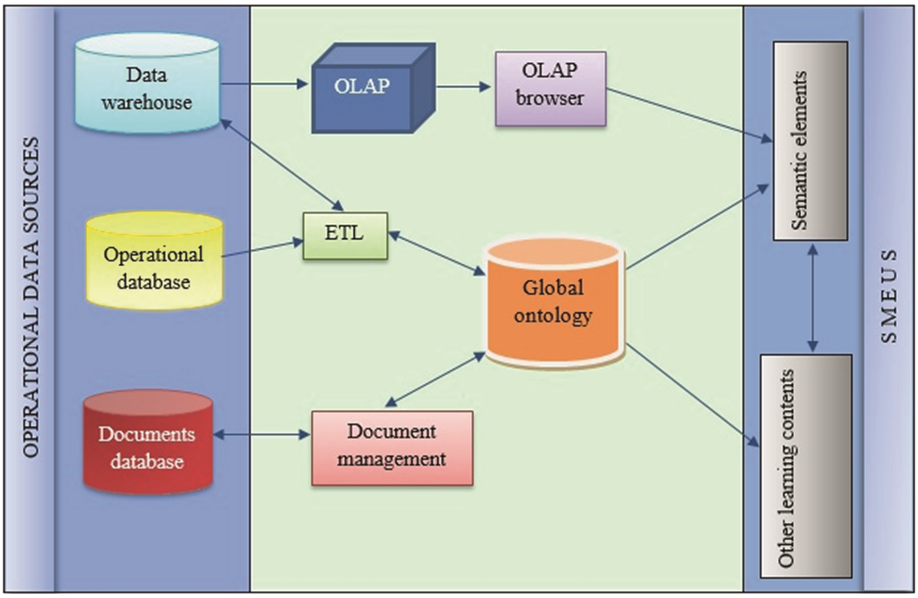

Fig. 5. Proposed workflow scenario for semantics and BI integration in e-learning environment

This model is based on the idea of web-based systems that integrate two information sources: (1) from OLAP browser, which extracts data from data warehouse, and (2) from the document management system, which enables access to the unstructured data in documents database. Considering the sensitive nature of the educational data in terms of privacy, especially those from the testing results, the heterogeneous character of the data on one hand, and to keep the global ontology updated on the other hand, we propose that ETL process to be executed two times. Firstly, for data warehouse creation and secondly, prior to integrating data into the global ontology. The process of data extraction and access control for the documents will be coordinated from the document management system, which will support RDF based metadata, thus, we use the global ontology.

The global ontology, which is an indispensable part in our model, contains the global data model and the mappings of metadata from document management system and metadata that are generated during the second process of ETL. In addition, it includes

other information about learning objects. Many of the objects that are located in educational data warehouses are used for extracting various documents of the same nature. These objects can easily be created or updated; even at the first ETL process, prior to the data warehouse creation.

4 Results

Based on the suggested analytical questions that were established in the first step of the BI lifecycle, we generate several reports that would help us to answer them. We examined and analyzed the activity of 865 students over the 15 week spring semester of 2014. The conducted research provide instructors various reports related to different aspects of the learners/students behavior, by giving them the possibility of assessing learner's performance and progress. These reports using the proposed model provide information for different aspects of the student behavior, such as, the time they spend for reading or viewing learning materials online, participation in online collaborative activities and virtual classrooms, information on how frequently students do online self-testing, read and write messages, etc.

By referring to these reports, part of which are demonstrated in Fig. 6, we can conclude that 86 % of student spend their time with reading or viewing materials, but the majority of them is using this option at the end of the semester or before the exam session. Concerning the participation to collaborative activities, such as forums and messaging, on average more than 69 % are using this application, and this option is most heavily is used during weekdays. Around 14 % of students spend less than 30 min a week with online testing within the first weeks, and this percentage increased in weeks to come. During the 10^{th} week of the semester, around 73 % use online testing, and in remaining 5 weeks this percentage grows to 87 %.

This explains the fact that as the exam session is approaching, students become more aware for their preparation and try to do online self-testing more frequently. From the teacher's perspective, by using such information, they can adopt different learning methodology of uniform distribution of teaching assignments during the semester to improve performance of students in terms of avoiding the accumulation of student's works or activities for the end of semesters.

The results of our study will give the teachers the availability to assess and track even more the student performance and to monitor the existence of certain user activity trends, for instance when to expect to have more participants in virtual classrooms, more online tests, discussions in forums, exchanged messages, etc. Hence, it is also easily to predict when to consider the system maintenance.

5 Conclusions and Future Works

In this paper, we presented an approach of application of BI tools in semantic e-learning systems to analyze and monitor the learner's behavior and performance. The ontology we presented is used to design an e-learning system and to play a significant role in representing different educational concepts. Our framework demonstrate the idea how

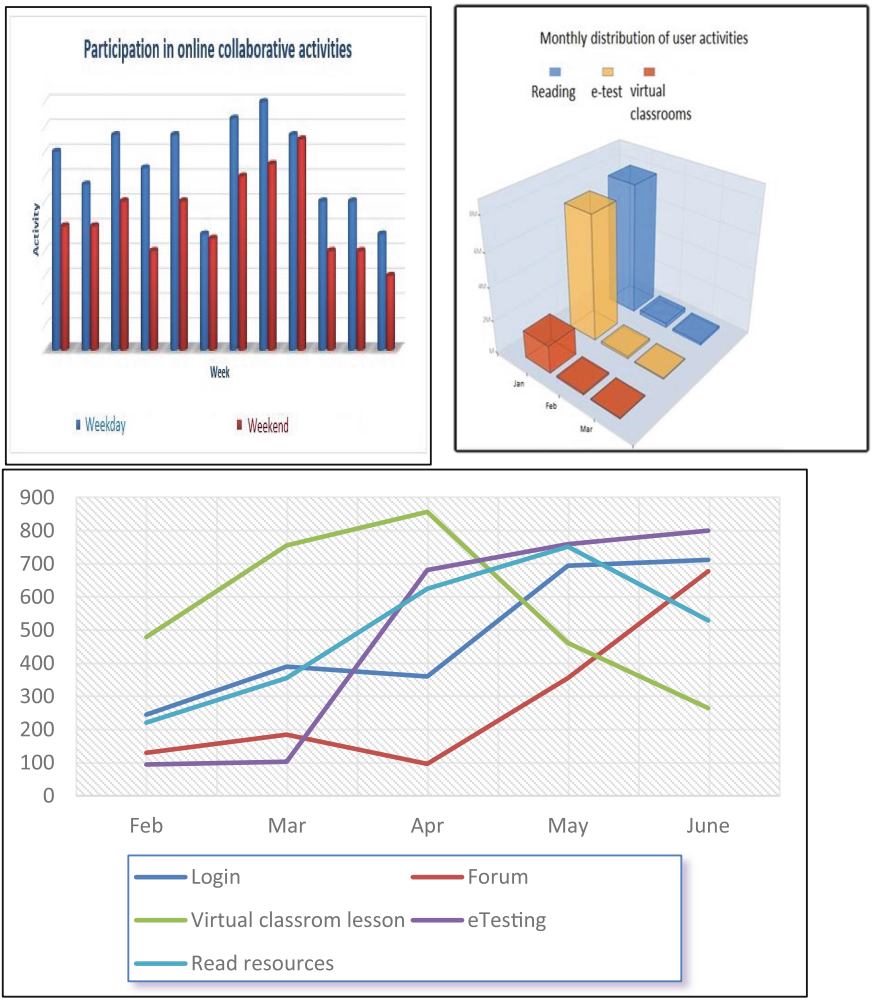

Fig. 6. Different generated reports

ontology or semantic concepts can bypass the problem with unstructured data, and different techniques of knowledge representation; and the idea of solving the lack of analytical and reporting tools in LMS, providing the instructor with detailed reports about students progression and performance.

In the future, by enlarging the number of students involved in this analytical study, we consider applying data mining techniques to extract more patterns and rules to enhance our analysis on learner's performance. In addition, having in mind that BI solutions have started to advance into the Cloud, we plan to adopt and extend SMEUS to be a semantic and cloud-based business intelligence solution.

References

1. Zilli, A., et al.: Semantic Knowledge Management: An Ontology-Based Framework. IGI Global, Hershey (2009)
2. Sanchez, M., Breis, J., Sanchez, J., Espinosa, P.: Practical experiences for the development of educational systems in the semantic web. New Approaches Educ. Res. **2**(1), 23–31 (2013)
3. Dalipi F., Idrizi F., Rufati E., Asani F.: On integration of ontologies into e-learning systems. In: Proceedings of the 6th IEEE International Conference on Computational Intelligence, Communication Systems and Networks, Tetovo, Macedonia (2014). ISBN 978-1-4799-5076-8
4. Zorilla, M.E., Alvarez, E.: MATEP: Monitoring and analysis tool for e-learning platforms. In: 8th IEEE International Conference on Advanced Learning Technologies, Santander, Spain (2008)
5. GISMO. http://sourceforge.net/directory/os:windows/freshness:recently-updated/?q=GISMO. Accessed 28 September 2014
6. Avouris, N., et al.: Logging of fingertip actions is not enough for analysis of learning activities. In: Proceedings of Workshop Usage Analysis in learning systems, Amsterdam (2005)
7. Toivonen, S., Niemi, T.: Describing data sources semantically for facilitating efficient creation of OLAP cubes. In: 3rd International Semantic Web Conference (ISWC2004), Hiroshima, Japan, November 2004
8. Priebe, T., Pernul, G.: Ontology-based integration of OLAP and information retrieval. In: The DEXA 2003 Workshop on Web Semantics, Prague, Czech Republic, September 2003
9. Sell, D., et al.: SBI: A semantic framework to support business intelligence. In: ACM Proceedings of the First International Workshop on Ontology-Supported Business Intelligence, OBI 2008, Karlsruhe, Germany (2008)
10. Cody, W.F., Kreulen, J.T., Krishna, V., Spangler, W.S.: The integration of business intelligence and knowledge management. IBM Syst. J. **41**(4), 697–713 (2002)
11. Bergamaschi, S., Quix, C., Jarke, M.: The SEWASIE EU IST project. SIG SEMIS Bull. **2**(1), 59–69 (2005)
12. Nebic, Z; Mahnic, V. Data warehouse for an e-learning platform. In: Proceedings of the 14th WSEAS International Conference on Computers: Part of the 14th WSEAS CSCC multiconference, vol. II (2010)
13. Falakmasir, M.H., Moaven, S., Abolhassani, H., Habibi, J.: Business intelligence in e-learning (case study on the Iran university of science and technology dataset). In: SEDM 2010 2nd International Conference on Software Engineering and Data Mining, Chengdu, China, June 2010
14. Cakula, Sarma, Salem, Abdel-Badeeh M.: E-learning developing using ontological engineering. WSEAS Trans. Inf. Sci. Appl. **10**(1), 1–13 (2013)
15. Naeve, A., Nilsson, M., Palmer, M.: E-learning in the semantic age. CID, Centre For User Oriented It Design, Stockhom (2001)
16. Pirttimäki, V. Business intelligence as a managerial tool in large Finnish companies. (Doctoral dissertation). TUT DPub, Tampere University of Technology, Publication 646 (2007)
17. Sangar, A.B., Iahad, N.B.A.: Critical factors that affect the success of business intelligence systems (BIS) implementation in an organization. Int. J. Sci. Technol. Res. **2**(2), 176–180 (2013)
18. Zorrilla, M.E.: Data warehouse technology for e-learning. In: Zakrzewska, D., Menasalvas, E., Byczkowska-Lipinska, L. (eds.) Methods and Supporting Technologies for Data Analysis. SCI, vol. 225, pp. 1–20. Springer, Heidelberg (2009)