Proposal for the Component-Based Integration Infrastructure in the Context of Moodle Environment as an E-Learning Open Source

Yusra Al-Roshdi[2] and Zuhoor Al-Khanjari[1]

Abstract— **E-Learning is the technology that is used for education purpose. The new and increased demands of education support the needs for more efforts to develop and improve this technology. This research focuses on some limitations regarding the existing software tools for practical sessions of Computer Science Education (CSE) in the Learning Management Systems (LMS). This problem is affecting the education in general and CSE as a special case. Software tools integration infrastructure is proposed to solve this limitation in the Open Source LMS: Moodle by using the component-based as the main integration approach that benefit from Moodle features as open source.**

***Index Terms*— Component-Based, Integration, Open Source, Moodle, Software tools**

IX. INTRODUCTION

E-learning is the new revolution in Education area. It supports the traditional learning and be a complement of it. Therefore, it needs a special effort to prepare its applications to fit the education purpose. Computer Science Education (CSE) is one area that uses the aspects of e-Learning to educate learners and to distribute knowledge to them. It involves theoretical and practical part for teaching its courses. Many LMSs are supported the theoretical content of the course. However, the software tools that support the practical sessions are not applied in most of the LMS. Therefore, CSE needs more effort to design its e-Learning application by integrating it with more graphical applications tools that could encourage learning by sharing knowledge and resources in the practical part. It is worth to state that the development of the online courses for the CSE is still considered as a difficult task. Although there are large varieties of software tools available for instructors of CSE, they are not integrated nor prepared completely as virtual labs [1].

This paper focuses on the development of a feasible system architecture prototype that extends the needed tools by integrating them as a part of the designed on-line courses for the CSE. The focus will be on Moodle as an open source LMS to help in adoptions of the new components. This architectural framework is expected to be simple, scalable, distributed resources and cost effective to work in any existing e-Learning platform and mainly on Moodle as the open source environment.

[2]Department of Computer Science, College of Science, Sultan Qaboos University, P.O. Box 36, Al-Khodh 123, Muscat, Sultanate of Oman (phone: 968-24141407; fax: 968-24141407; e-mail: m095653@student.squ.edu.om and zuhoor@squ.edu.om)

In the literature there are many attempts to solve this limitation regarding the practical sessions. One of them is Component-Based Approach. This approach is developing a new component in the LMS with same programming languages of it. This solution allows the users to use the tools needed for the practical sessions along with the online material in the same LMS environment.

In this paper, the Component-Based Approach will be investigated and applied on the Moodle environment from different perspectives such as: Design and Architecture, Implementation of proposed approach and the advantages and disadvantages according to the experimentation. Section II presents some related work. Section III introduces an overview about the open source in the e-learning. Section IV shows the design architecture and development method of proposed approach. Section V provides conclusions and future work.

X. LITERATURE REVIEW

Learning is one area that influenced by the technology revolution. The e-Learning is new revolution in education. Most of researchers try to expand the functionality of online education in general and CSE as a special case. They proposed architecture integration for new software tools or use third party tools and integrate them into the LMS [2-5].

In 2003, Akingbade and colleagues discussed the need for online visualization software for CS courses [6]. In 2005, Al-Khanjari and colleagues developed architecture for extended the functionality of E-Learning portal to support CSE [7]. In the following years the researchers proposed software tools to auto correct the programming languages in the LMS environment (e.g. Moodle) [8-10]. Georgantaki and Retalis showed some software tools for teaching CS courses, and they stated that there are difficulties of studying the CS courses without using the software tools for practical sessions to support the theory concepts [11]. For instance, to manage the theory content there is e-Portfolio tools such as: Google Drives, Wiki-spaces, blogs and others, which could be integrated into the e-Learning platforms [12]. In 2009, Robling and colleagues tried to improve software tools for CS exercise visualization [13]. Therefore, one of the new trends is to use online web tools for teaching, adopt that tool and integrate it into LMS [1].

In addition, Joint Information Systems Committee (JISC) is a research organization to support the education by using the new technology [14]. In 2013, Deperlioglu and Kose introduced a blended e-Learning for teaching "Data Structures and Algorithms" which included practical and theoretical topics that principally computer programming

  ISSN:1813-419X

students must know. A combination of face-to-face and online learning environments is provided to perform educational activities [15].

The component extension of any software system was introduced in 2005 by Doberkat and colleagues. The concept "E-Learning Software Engineering" was presented in their work. It focused on providing software tools for software course. The project was called "MuSoft" [16]. It works as a portal that they integrated other tools in it.

In 2008, Corbara and colleagues described new module in Moodle to support teaching computer organization course [17]. This Module carried a wide range of activities and assessments in computer courses.

In 2009, Rößling and Vellaramkalayil proposed new Module in Moodle for algorithm course. This module depends on providing tools that help in teaching algorithm course [18].

Furthermore, Prieto-Blazquez and colleagues proposed an integrated structure for virtual laboratories of programming in Computer Engineering and Software Engineering. They discussed the issues regarding the use of that laboratory in teaching the practical work [19, 20].

In 2011, Fest proposed integration of Java applet tools to help in learning the Dynamic Geometry Software (DGS) then integrated as a component into the interactive learning activities [21].

In 2012, Lavrishcheva and colleagues proposed a website portal that supported teaching Computer Science courses using different tools [22].

In 2013, some researchers explained how to extend the functionality of Moodle to facilitate the assessment of Matlab programing [8].

XI. E-LEARNING AND OPEN SOURCE LMS

There are many LMS platforms available in two main categories of LMS: 1) Open source initiatives and 2) Commercial platforms. The importance of open source in e-Learning appears in the customization of that LMS by designing tools of the courses according to the students' needs. Therefore, the open source LMS helps in the adoption of any requirements of the education area in its platform [23].

Most organizations choose an open source e-learning platforms for many reasons:

1. The commercial e-Learning platforms need to rely on the provider of that LMS for any maintenance or customization.
2. As code is available in open source LMS many developers use that feature to test the code after any modification or integration of the new component.
3. Open source LMS allows the users to customize the platforms according to the organization brands and style.
4. It helps in integration of the new component using different integration approaches as mentioned in [24, 25].

Open source LMSs are typically built on extendable frameworks allowing developers to adjust and modify the LMS to suit their specific needs. Nowadays, many LMSs make their source code available for modifications under the various displays of open source licenses and for customization to fit the users' needs [26]. The development of the e-Learning area needs to be integrated and adopted with many resources and different kinds of subsystems to support learning process [27]. As in the traditional e-Learning application, the system is monolithic as one unit system. However, the modern system needs to be more flexible and supports customization. This could be achieved since open source system provides the source code [26].

Moodle is the most successful LMS as an open source. This feature helped in facilitating the development and maintenance of the Moodle according to the users' needs. On the other hand, it provides a research area to extend the software tools of the CSE [25, 28]. Therefore, this research paper concentrates on the Moodle as the area of development.

A. Moodle

Moodle is a Learning Management System (LMS) and stands for Modular Object-Oriented Dynamic Learning Environment. It is an open source system under General Public Licenses (GNU).

Moodle application is organized as core system with many plugins as the users' need to support different functionality such as: Assignments, Quizzes, Calendar, Themes, Registration, Course and Activity, etc. Moodle is developed in PHP programming languages. It uses the common three tier client/server architecture [28]. Add to that Moodle is based on object-oriented programming.

Each organization needs to move towards the customization of its e-Learning application according to the goals and targets of that organization. The extension of new tools is one of those customization features [31]. The features of being open source will facilitate the development and the maintenance of it according to the customers' needs. This provides a research area to extend the software tools of the CSE [28].

1) Moodle Advantages and Limitations

Moodle is chosen for the following reasons [32]:

1. It is open source software that allows the modification of the code and distributes it under General public Licenses GNU.
2. Compatible with a range of 75 languages in 175 countries.
3. It has excellent documentation and strong supporting security and administration.
4. It can be run in any system that supports PHP languages.
5. It uses a single database to store data.
6. It is available in most of learning institutes.
7. It can support unlimited users.
8. It has strong plug-ins features and supports integration of external tools.

The Limitations of Moodle include:

1. Non-IT Teacher will face difficulties to install and use Moodle or customize it.
2. The installations manuals contain a lot of technical conception that are seen difficult with some technicians.

3. Moodle will not support the learning process without designing its course and support it by different software tools.

B. System Requirements

The experiment to apply the proposed architecture depends on the Moodle v2.6. This Moodle installed using XAMPP package (1.8.3). This package includes the basic requirement for Moodle installation such as web server (Apache), the database (MySQL) and PHP programming language. The experiment is conducted in environment of Windows Server 2008 R2. After preparing the Moodle environment, Moodle was installed completely with its plugins. Then the Component-Based approach applied with the Compiler software tool which called Virtual Programming Lab (VPL) to support CSE process.

XII. METHODOLOGY

1) Component-Based Approach

The solution that proposed in this research and which is introduced in some previous work [13, 16, 22, and 30] is suggested to build the software tools in the same environment of LMS. Especially, if that LMS is as open source, so the course designer will be able to customize the E-learning system while the source code will be available as open source. Therefore, the needed software tools could be built as a whole component then integrated it in the LMS using the API integration approach. This solution will let user to use the software tools in the same environment of LMS. In contrast, this approach may reduce the performance of the LMS because a lot of students will run the same software in the same time.

a) API Integration

The Component-Based architecture is based on the API integration which allows the different components in the system to interact with each other through the Application Programming Interface (API). This integration needs to define the interface for each component and then use it in the system. The interface is the signature of the methods that component offered. As Huerts and colleagues showed that there are two different approaches of integration, one of them is API integration. This approach is used to make the functionalities of the e-Learning public by defined interface. However, the integration happens in terms of a code written in the same language in which the e-Learning platform has been built. Moreover, API is used to extend the basic functionalities provided by platform or expose the external application [33].

This approach will be used to link between the LMS (e.g. Moodle) and the new established component. Therefore, after coding, the new tool must be integrated to Moodle API core using its interface.

2) Design and Analysis

The designing of the proposed approach is showing in Figure 1. It follows some process to integrate that needed tools in the LMS. First, the LMS should be analysis and studied its structure to know the LMS style and its techniques. Then, the software tools should be prepared according to the programming languages of the LMS. After that, the new component should be integrated into the LMS system by integrating it to the API of the core system. Finally, the link to the software tools should be provided in the corresponding course.

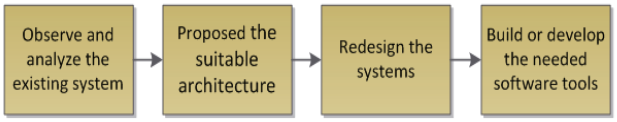

Fig 1. Development Phases of the Component-based Software Tools

Figure 2, shows the abstract overview of the proposed architecture to integrate the needed software tools using component-based approach.

There are many ways to build the software tools and integrate it in the LMS using the Component-Based Approach. The developer could search for plugins of

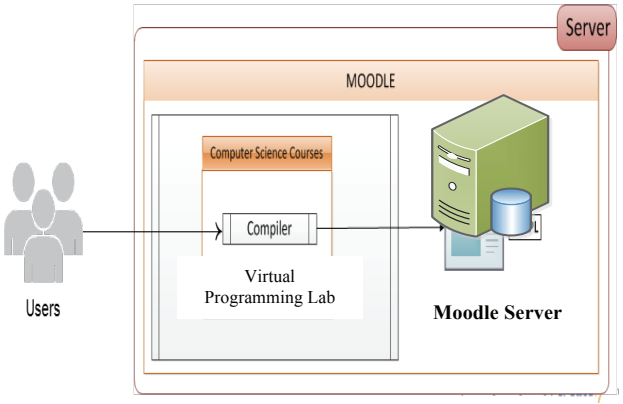

Fig 2. The abstract overview of the proposed integration approach

Moodle that provided by different providers. Then add that plugin tools to the existence plugins from the Moodle application. Moreover, the developer could develop the needed software tools and create its API that communicates with application core. Add to that, the whole block could be built to adopt more functionality to the software tools especially and course material in general.

Figure 3 displays plugin tools integration approach. This figure shows the overall architecture of the integration between the users and the component of the Moodle.

3) Experimentation on Plugin Tool

To prepare the LMS with the needed tools for the CSE such as compiler, first identify the programming language and coding style of the LMS. For instance, Moodle uses PHP as main programming language. Then, develop the needed software tools and provide it with needed functions. Next, add that tool as a new activity module and use its Application Program Interface (API) to access Moodle core so that it can access it easily from specified Moodle's course. After that, student can easily open the tool and work in the same environment.

An example of the integration using this approach is the plug-in tool called Virtual Programming Language (VPL). VPL is a compiler plug-in developed in the Moodle environment to support the CSE and any other course activities. It allows students to compile different programming languages such as: C, C++, Java, SQL, etc.

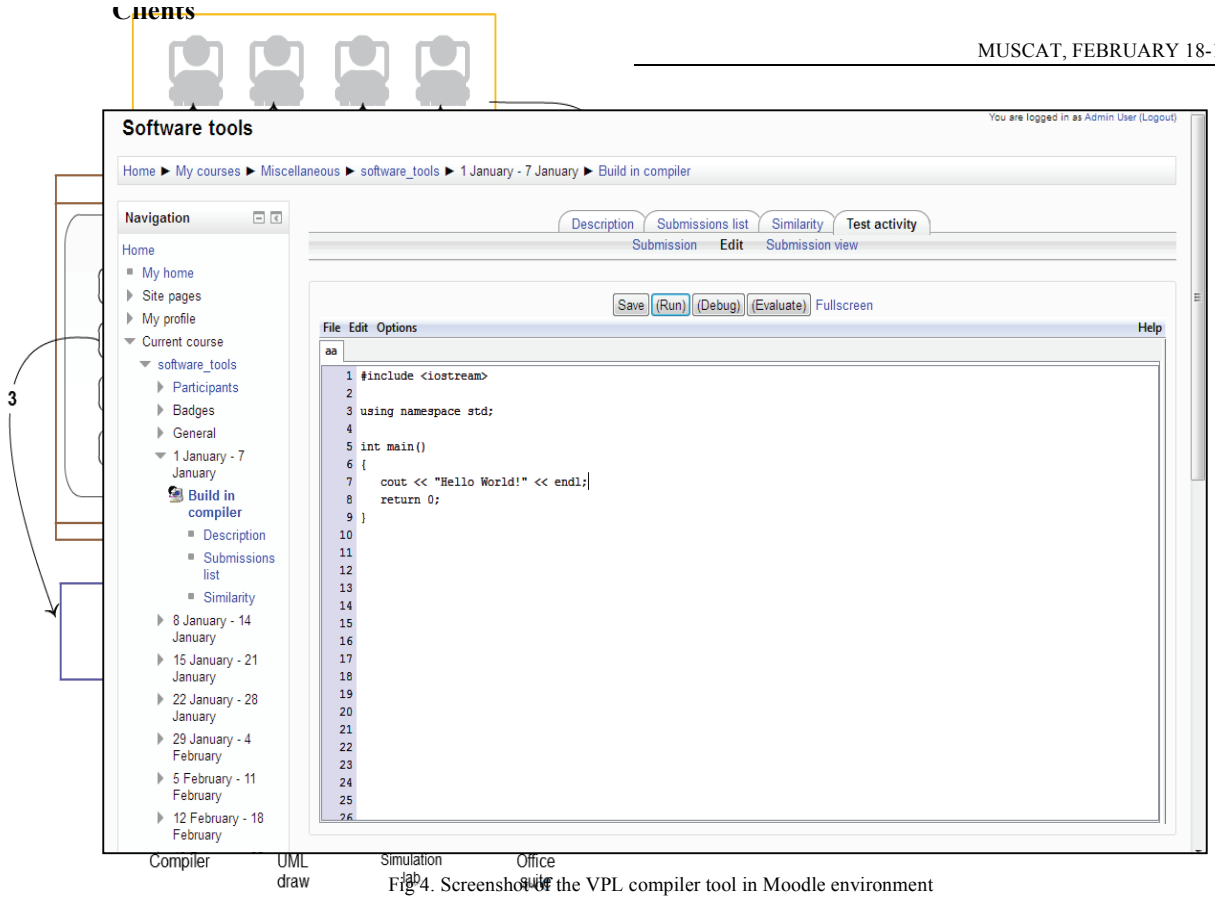

Fig 4. Screenshot of the VPL compiler tool in Moodle environment

Fig 3. The overall architecture and methodology of the proposed integration approach

Also, students can submit programming exercises and assignments through it.

This attempt may reduce the performance of the LMS and lead to a bottleneck in it since it will be utilized by the students who will run the software tools concurrently.

To develop new plugin in Moodle, the PHP language should be used in the software tool development. First, develop the tool with the its function as a component or separate project. Then communicate with Moodle core system with its APIs function. After that, the version of function should be modified to detect the new version of the system during the installation in the files *version.php*. So, the new component should be added in the file *admin_tree*. Then, the designers or developers can detect the new tools to add it to their course. In file *event.php* the event handler must be identified for new modules. Also, the database tables could be edited if the tools produce information that needs to store in the database. These changes must be updated in the files *install.xml* and *install.php*. However, the version of Moodle must be detected before and modification because it differs from one version to other. Finally the tool is available as one of the Moodle Functions, so the developers or course designer can add it easily to the related course.

Figure 4, shows the VPL compiler tool that is provided by Moodle community to the CS course students for programming practice and assignment submission.

A. *Advantages and Disadvantages*

Advantages:

- The proposed work in this paper helps the students to access the software tools of the CSE online from any place and at any time. This will help in improving the students' knowledge about different practical concepts of the CSE.
- It provides the needed software tools in the Moodle environment following its coding style and using PHP programming language.
- User's data can be shared between the plugins of Moodle.

Disadvantages:

- Plugging software tools could produce a bottleneck on the Moodle because the students will remain logged-in doing their work in the same environment of Moodle.
- The new added component will consume the resources of the Moodle and need a huge capacity and performance facilities.
- The new added component could reduce the performance of the Moodle, since it will be utilized by the students who are running the software tools.
- This approach could increase the development effort when they integrate the tools in the Moodle. So, it needs to redesign and recode the needed software tools.
- Teachers might not be able to develop the needed tools without the help of the developer.

XIII. Conclusion and Future Work

The study is aimed to extend the main idea behind the development of e-Learning platforms tools to be useful in the academic life. This research showed that many Learning Management Systems (LMSs) have a limitation in the

availability of the software tools for practical sessions for education in general and for computer science education as a special case. Therefore, this paper proposed architecture of the Component-Based integration approach to integrate the needed software tools into the LMS environment to help learners gain knowledge through the practical session. Also, it depends on the Moodle environment as an open source LMS to help in the integration process by accessing its code. This research could be used as the base of extending other discipline area for improving the practical session in other education area such as Engineering, Science Education, Medicine, etc. Moreover, by using the Cloud Computing (CC) technology, the material and tools of e-Learning could be shared in different LMS environments. Add to that, the security is an important issue that the system's developers should concern about in order to prepare and transfer the data in a trusted and secured way. Therefore, these issues could be studied and improved in the future.

References:

[1] Riabov, V. V. and Higgs, B. J. (2010). *Software Tools and Virtual Labs in Online Computer-Science Classes.* Learning Management System Technologies and Software Solutions for Online Teaching: Tools and Applications, 332.

[2] Baving, T., Cook, D. and Green, T. (2003). *Integrating the Educational Enterprise: Technical Report*, University of Cape Town, and Department of Computer Science.

[3] Huan, X., Shehane, R. and Ali, A. (2011). *Teaching computer science courses in distance learning*. Journal of Instructional Pedagogies, 6.

[4] Pätzold, S., Rathmayer, S. and Graf, S. (2008). *Proposal for the Design and Implementation of a Modern System Architecture and integration infrastructure in context of e-learning and exchange of relevant data*. Paper presented at the ILearning Forum.

[5] Tawfik, M., Sancristobal, E., Martin, S., Diaz, G. and Castro, M. (2012). *State-of-the-art remote laboratories for industrial electronics applications.* Paper presented at the Technologies Applied to Electronics Teaching (TAEE).

[6] Akingbade, A., Finley, T., Jackson, D., Patel, P. and Rodger, S. H. (2003). *JAWAA: easy web-based animation from CS 0 to advanced CS courses.* Paper presented at the ACM SIGCSE Bulletin.

[7] Al-Khanjari, Z., Kutti, S. and Hatam, M. (2005). *An extended e-learning system architecture: integrating software tools within the e-learning portal*. In IAJI.

[8] Ramos, J., Trenas, M. A., Gutiérrez, E. and Romero, S. (2013). *E-assessment of Matlab assignments in Moodle: Application to an introductory programming course for engineers*. Computer Applications in Engineering Education, 21(4), 728-736.

[9] Schwieren, J., Vossen, G. and Westerkamp, P. (2006). *Using software testing techniques for efficient handling of programming exercises in an e-learning platform.* The Electronic Journal of e-Learning, 4(1), 87-94.

[10] Sodoké, K., Riopel, M., Raîche, G., Nkambou, R. and Lesage, M. (2007). *Extending Moodle functionalities to adaptive testing framework. Paper presented at the World Conference on E-Learning in Corporate, Government*, Healthcare, and Higher Education.

[11] Georgantaki, S. and Retalis, S. (2007). *Using educational tools for teaching object oriented design and programming*. Journal of Information Technology Impact, 7(2), 111-130.

[12] Queirós, R., Oliveira, L., Leal, J. P. and Moreira, F. (2011). *Integration of eportfolios in learning management systems Computational Science and Its Applications*-ICCSA 2011 (pp. 500-510): Springer.

[13] Rößling, G. and Kothe, A. (2009). *Extending Moodle to Better Support Computing Education.* Paper presented at the ITiCSE'09, proceeding of the 14th annual ACM SIGCSE (Innovation and Technology in Computer Science Education), USA, New York.

[14] JISC. (2012). *Joint Information Systems Committee*, 2014, from http://www.jisc.ac.uk/

[15] Deperlioglu, O. and Kose, U. (2013). *The effectiveness and experiences of blended learning approaches to computer programming education.* Computer Applications in Engineering Education, 21(2), 328-342.

[16] Doberkat, E.-E., Engels, G., Hausmann, J. H., Lohmann, M., Pleumann, J. and Schröder, J. (2005). *Software Engineering and eLearning: The MuSofT Project [1]*. Language, 1, 2.

[17] Corbera, F., Gutiérrez, E., Ramos, J., Romero, S. and Trenas, M. A. (2008). *Development of a new MOODLE module for a basic course on computer architecture.* Paper presented at the ACM SIGCSE Bulletin.

[18] Rößling, G. and Vellaramkalayil, T. (2009). *First steps towards a visualization-based computer science hypertextbook as a Moodle module.* Electronic Notes in Theoretical Computer Science, 224, 47-56.

[19] Rodriguez-del-Pino, J. C. (2010). *New Virtual Programming Lab (VPL) module,* 2013, from https://moodle.org/mod/forum/discuss.php?d=154988&username=guest

[20] Prieto-Blazquez, J., Herrera-Joancomartí, J. and Guerrero-Roldán, A.-E. (2009). *A Virtual Laboratory Structure for Developing Programming Labs.* International Journal of Emerging Technologies in Learning.

[21] Fest, A. (2011). *Adding intelligent assessment: a Java framework for integrating dynamic mathematical software components into interactive learning activities*. *ZDM, 43*(3), 413-423.

[22] Lavrishcheva, E., Ostrovski, A. and Radetshiy, I. (2012*). Approach to E-Learning Fundamental Aspects of software Engineering*. (1-10).

[23] Graf, S., & List, B. (2005, July). *An Evaluation of Open Source E-Learning Platforms Stressing Adaptation Issues*. In ICALT (Vol. 5, pp. 163-165).

[24] Al-Khanjari, Z., Al-Roshdi, Y. and Kraiem, N. (2014). *Virt-Res: Developing Extended Architectural Design for Computer Science Virtual Resources Using SOA.* International Journal of Software Engineering and Its Applications, Vol.8, No.9 (2014), pp.125-136. doi: http://dx.doi.org/10.14257/ijseia.2014.8.9.10

[25] Al-Khanjari, Z. and Al-Roshdi, Y. (2014). *Extending the Functionality of LMS to Support Computer Science Education Using Plug-in Tools*. *2014, 6*(2)

[26] Dagger, D., O'Connor, A., Lawless, S., Walsh, E. and Wade, V. P. (2007). *Service-Oriented E-Learning Platforms: From Monolithic Systems to Flexible Services.* Internet Computing, IEEE, 11(3), 28-35. doi: 10.1109/mic.2007.70

[27] Teng, M., Ye, Z. and Junzhou, L. (2005). *A SOA-oriented e-learning resource integration infrastructure and its service discovery model.* Paper presented at the Proceedings of the Ninth International Conference on Computer Supported Cooperative Work in Design

[28] Alario-Hoyos, C., Bote-Lorenzo, M. L., Gómez-Sánchez, E., Asensio-Pérez, J. I., Vega-Gorgojo, G. and Ruiz-Calleja, A. (2012). *GLUE! an architecture for the integration of external tools in virtual learning environments*. Computers & Education.

[29] Moodle. (2013). *About Moodle* Retrieved 16/11/2013, 2013, from http://docs.moodle.org/25/en/Resources

[30] Palumbo, M. and Verga, F. (2013). *Creation of an integrated environment to supply e-learning platforms with Office Automation features.* Interactive learning Environment.

[31] Caballé, S. (2008). *Combining generic programming and service-oriented architectures for the effective and timely development of complex e-learning systems*. Paper presented at the Conference on Complex International and Software Intensive Systems, 2008. CISIS 2008.

[32] Zedan, H. and Al-Ajlan, A. (2007). *E-Learning (MOODLE) Based on Service Oriented Architecture.* Proc. of the EADTU's 20th Anniversary Conference, Lisbon, Portugal, Lisbon-Portugal.

[33] Huertas, F. and Navarro, A. (2013). *Integration Mechanisms in e-learning Platforms.* International Journal of Computer Information Systems and Industrial Management Applications. , Volume 5, 714-721.