ENHANCING THE FUNCTIONALITY OF MOODLE IN CSE

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ABSTRACT

This paper presents the essential information about Learning Management System (LMS). Many universities use LMS or Learning content management system (LCMS) to support courses offered. During the past decade education systems have been re-engineered for bringing efficiency, effectiveness and economy through usage of open source LMS. These enhanced services share cloud computing approach to provide an optimal e-learning management for generating creative and intelligent decisions. The paper explains how to improve and extend the function of Moodle to support Computer Science Education (CSE). LMSs support several software tools to manage theoretical materials of CSE. However, the practical software tools needed by the Computer Science courses are ignored or simply not considered in most of the LMSs. This paper suggests a solution to overcome the limitations regarding software tools required for practical learning aspects and programming assignments using VPL as a plugin.

Keywords: E-learning, Cloud computing, learning management System, LMS architecture, Open source, Moodle, Moodle in CSE, VPL, Plugins

1. INTRODUCTION

Cloud computing has changed the way applications are developed and accessed. They are aimed at running applications as services over the Internet on a scalable infrastructure. One of them is Education and learning as a service. Internet has helped education system a lot by introducing concept called Learning Management System (LMS). Many institutes started using these systems for serving different departmental needs. Online teaching and learning as an environment can be beneficial to both the students and teachers, which work well for the academic goals in terms of curriculum. Students like to take the courses which include the use of Information Technology and point out that activities offered through e-learning systems are more useful and valuable as compared to traditional classroom activities. This paper focusses on a shift in LMS paradigm from conventional proprietary LMS towards a modular open source LMS. Open source LMS is found beneficial as the source code is freely available on the Internet which the user can customize to suit their organizational needs. This paper emphasizes on one such popular open source LMS – MOODLE.

Moodle is a SCORM 1.2 compliant, free and open-source e-Learning software platform written in PHP. It helps educators to create online courses with a focus on interaction and collaborative construction of content, and is in continual evolution. Many institutions use Moodle as their platform to conduct fully online courses, while some use it simply to supplement face-to-face learning. Moodle allows the integration of a wide range of resources, from chats and forums to online booklets, a variety of questions, collections of problems and exercises, lecture notes; including any kind of text-based or Html formatted documents, multimedia resources such as graphics, video or audio, PowerPoint, or Flash-based applications and Java applets. Several LMS support software tools to manage theoretical materials of CSE but needs extra effort to prepare practical sessions for learners. For this purpose, the needed software tools could be built and plugged in to improve and extend the functionality of Moodle to support CSE. The paper also introduces the Virtual Programming Lab (VPL) as one of the plugins that is related to CSE.

DEFINING CLOUD COMPUTING PARADIGM

Cloud computing, often referred to as "the cloud," is the delivery of on-demand computing resources that includes everything from applications to data centers, over the Internet on a pay-for-use basis. It can also be defined as a large-scale distributed computing paradigm, driven by economies of scale, in which a pool of abstracted, virtualized, dynamically-scalable and managed Computing power, Storage capabilities, Software platforms and Services are delivered on demand to external customers over the Internet.[1]

A. BENEFITS OF THE CLOUD

- Cost Efficient - Proprietary products can be expensive as it costs companies a lot in terms licensing fees for multiple users. The cloud, on the other hand, is available at much cheaper rates and hence, can significantly lower the company's IT expenses.
- Almost Unlimited Storage – There is no need to worry about running out of storage space or increasing your current storage space availability [2].
- Backup and Recovery - Since data is stored in the cloud, backing it up and restoring the same is relatively much easier than storing the same on a physical device. And also, most cloud service providers are usually competent enough to handle recovery of information. Hence, this makes the entire process of backup and recovery much simpler than other traditional methods of data storage.
- Automatic Software Integration - No additional efforts to customize and integrate applications. Services and software applications that best suit a particular enterprise can be handpicked.
- Easy Access to Information - Once you register yourself in the cloud, you can access the information from anywhere, where there is an Internet connection.
- Less personnel training is needed. It takes fewer people to do more work on a cloud, with a minimal learning

curve on hardware and software issues.

- Disadvantages of Cloud Computing
- Technical Issues – Overall performances may be affected by the network speed.
- Security -To adopt this technology, company's sensitive information should be surrendered to a third-party cloud service provider. This could potentially put the company to a great risk.
- Service Cost - Data center subscription fee may be more expensive than the private hardware costs, on a long term basis.

B. SERVICES OF CLOUD

Cloud computing systems are implemented and structured over (3+2) layers. They have 3 service layers Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) and 2 complementary functional layers Client Layer and Server Layer.

1) Client Layer - A client consists of computer hardware / software that rely on cloud computing for application delivery. Examples include computers, phones, notebooks, PDAs and other devices.

2) Software-as-a-Service (SaaS) – It delivers software as a service over the Internet, eliminating the need to install and run the application on the customer's own computers and simplifying maintenance and support.

3) Platform-as-a-Service (PaaS) – It delivers a computing platform and/or solution stack as a service, often consuming cloud infrastructure and sustaining cloud applications. It facilitates deployment of applications without the cost and complexity of buying and managing the underlying hardware and software layers

4) Infrastructure-as-a-Service (IaaS) – It delivers computer infrastructure - typically a platform virtualization environment - as a service. Rather than purchasing servers, software, data-center space or network equipment, clients instead buy those resources as a fully outsourced service.

5) Server Layer - The server's layer consists of computer hardware and/or computer software products that are specifically designed for the delivery of cloud services.

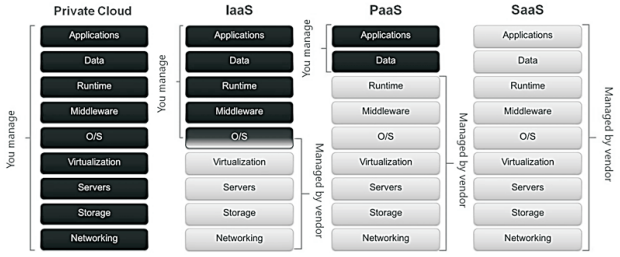

Figure 1: Cloud computing 3-layered Architectural Stack [4]

LEARNING MANAGEMENT SYSTEM (LMS)

LMS systems are known by various names, including course management system (CMS), learning content management system (LCMS), virtual learning environment (VLE), virtual learning system (VLS), learning portal, or e-learning platform. Each term might have a slightly different meaning, depending on your interpretation. An LMS is comprehensive, integrated software that supports the development, delivery, assessment, and

administration of courses in traditional face-to-face, blended, or online learning environments. Institutions use LMS software to plan, implement, facilitate, assess, and monitor student learning. It also incorporates elements to support interaction and co-operation such as forums, wikis or quizzes. The software centralizes course preparation; educational content and resources; the delivery and tracking of student activities, such as discussion and collaboration; the administration of assessment activities; and the accumulation and presentation of marks and grades. All of these activities are conducted behind a virtual wall that provides a measure of authentication, security, and privacy. Recent LMS software also provides an array of information about student activities that instructors and administrators can view from different perspectives. This information can be analyzed to detect patterns that might suggest how students can be better supported. The LMS helps institutions maintain the integrity of their educational programs and enables faculty to effectively and efficiently develop courses, deliver instruction, facilitate communication, foster collaboration, and assess students. An LMS can be used to support traditional face-to-face instruction, as well as blended and online educational environments.

A. PROPRIETARY, CLOUD-BASED AND OPEN-SOURCE LMS

Deciding whether to obtain a proprietary, open-source or cloud-based LMS depends educational priorities and how the software is configured, any of the three forms might meet institutional needs.

1) Proprietary LMS:Proprietary LMS software is developed and owned by a profit-generating entity that does not let users access and make adjustments to the computer code that determines the structure of the software and the activities it can execute. It is a closed system from the perspective of the organization that deploys it. Examples of these types of LMS include Blackboard and Desire2Learn.

2) Cloud Based LMS - Cloud-based learning management systems are hosted on the Internet and can be accessed by logging into a service provider's site. Rather than having to install course design and management software, instructional designers can simply use their Internet browsers to upload course content, create new courses, and communicate with learners directly. This is all done through a secure LMS, which also gives designers the ability to store information on the cloud, which can be remotely accessed by other, approved users.

3) Open-Source LMS: Open Source LMS is a technology where the source code is “open”, that is, the code is available to the public and free to be modified. Improvements can be made by developers and it can be spread or sold to the wider community. Open Source LMSs can also be converted to social-learning platforms. For example learners can chat, blog, connect to social network sites (Facebook etc.) and have polls on open source LMS.

B. LMS STANDARDS

Designers and developers of online learning materials have variety of software tools that allow them to create learning resources that might otherwise require extensive programming skills. There are a number of vendors who provide software tools and instructional materials that do not share a common mechanism for finding and using the resources.

Hence, a number of organizations started advocating standards for the learning technology which are desirable for inter-operability, convenience, flexibility and efficiency in the design, delivery and administration. The most preferable and unbeaten standard is SCORM (Sharable Content Object Reusable Modules). It is a set of technical standards developed for eLearning software products. In its essence, SCORM enables interoperability between eLearning software products. Specifically, the model determines how online learning content and Learning Management Systems (LMS) communicate with each other.

C. LMS ARCHITECTURE

It comprises four key components, the Front End Interface (FEI), the Information Processing Center (IPC), the Learning Management System (LMS), and the Open Adapter Pool (OAP) [3].

1) IPC - The IPC consists of enterprise applications that are deployed on the institute infrastructure. In addition to providing information about faculty and students, the IPC fills other responsibilities as well.

- AV Server - Server is used to provide streaming audio and video. It is made available through a player that can be embedded virtually into any web site.
- CR Server - The content Repository Server is used as a repository for documents and files. Users can share documents using a static URL which links directly to a document.
- Validity Server - These systems contain simple identity information and provide authentication services to other enterprise systems.
- ERP Server - The ERP server for the university contains the current student and employee information as well as the course to user relationship.

2) Learning Management System: The LMS serves as a provider of internal system and administration services. Courses, Staff & Students' information is stored locally and is synced with student, faculty and administrators' information from the institute's ERP server. The interfaces to the LMS provide the groups and courses with the tools that the users in the group will use.

3) Front End Interface: The presentation layer of the LMS is completely separate from the core systems. This allows the institute to tie their existing CMS system and the LMS into the institute web space. The flexibility that this architecture provides would promote a single and consistent view to all the tools the university and the web have to offer in a consistent and integrated environment.

4) Open Adapter Pool (OAP): The proposed architecture focuses on the core value proposition of the LMS and not providing proprietary learning tools. In Indian context there is a need to provide the course and group context to external tools in a low cost manner. This is possible now through available web services as well as Social Networks like Facebook, Orkut, and Twitter etc.

CLOUD ARCHITECTURE FOR LMS

A. CLOUD LAYERS FOR LMS

Cloud based e-learning includes the hardware and software resources to develop the traditional e-learning infrastructure. The students can use the education materials of e-learning systems as it is virtualized in cloud

server and others can also utilize this service on the rental basis from the cloud vendors.

Cloud based e-learning architecture [6] is mainly classified into five layers as shown in Figure 2:

1) Hardware Resource Layer: It handles the essential computing hardware resources like physical memory and CPU. Physical servers, network and storage are grouped with the help of virtualization and it is called as an upper software platform. Physical host pool is expanded dynamically and memory is scalable at any time to add additional memory in order to offer the uninterrupted power to cloud middleware services for the cloud based e-learning systems.

2) Software Resource Layer: Operating systems and middleware is used to create this layer. Grouped interface is offered to the software developers by combining various software solutions with the help of middleware technology.

3) Resource Management Layer: It plays a vital role to get loose coupling of hardware and software resources. It brings the uninterrupted on-demand software distribution for different hardware resources by means of virtualization and scheduling concept of cloud computing.

4) Service Layer: Service layer is categorized into three levels namely IAAS, PAAS, SAAS. It helps the cloud clients to use the various forms of cloud resources like software, hardware and infrastructure resources for their products.

5) Business Application Layer: It mainly consists of content creation, content delivery, education platform, teaching evaluation and education management.

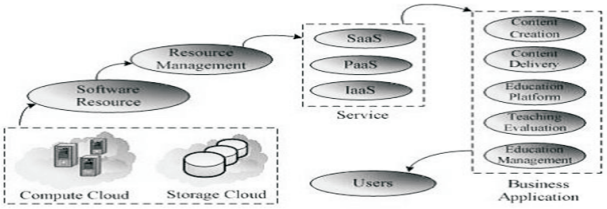

Figure : Cloud Layers for LMS

B. DEPLOYMENT OF CLOUD BASED LMS

Providers of e-learning portals could choose from three possibilities to integrate a learning management systems used by them into computing clouds support.

1) E-learning on a private cloud - If an organization has got good equipped data center, it can build own private cloud for universal use and LMS infrastructure can be utilizing this resource. However, this solution is equal to using some virtualization tool such as VMware, Oracle Virtual Box, Xen, etc. to run LMS on a computer cluster or server of the organization.

2) E-Learning on a Public Cloud - If the provider prefers to save budget for acquisition, maintenance, running, cooling, administration of the required hardware and shift cost to rent a service, the public computing cloud is suitable solution.

3) E-Learning on a Hybrid Cloud – The provider uses a combination of two or more public, private or community cloud components bounded together by standardized technology and managed as a single unit. However, each cloud remains a unique entity.

C. SECURITY IN CLOUD BASED E-LEARNING

Security is one of the primary concern in the greater context of cloud computing as it

relates to cloud based e-learning. When shifting e-learning in the cloud, main security concerns are about confidentiality, integrity and availability. Security remains as an integral component of the top ten IT issues in 2012 [7] [8]

1) Abuse and Nefarious use of cloud: Cloud services providers are often targeted for their weak registration system and limited fraud detection capabilities. This paves way to the spammers, malicious code authors and other cybercriminals.

2) Insecure Software Access: Various software interfaces and APIs are used by the cloud users in e-learning to access and manage the cloud services and hence these APIs needs to be secured and should include features of authentication, access control, encryption and activity monitoring.

3) Data Loss or Leakage: Operational failures, unreliable data storage and inconsistent use of encryption keys will lead to a data loss. Operational failure includes deletion, incomplete deletion or alteration without any backup of the source e-learning content. It may be either intentional or unintentional.

4) Hijacking: Controlling the users account through the unauthorized access by the hackers is referred as account or service hijacking. It includes phishing, fraud and exploitation of software vulnerabilities.

II. BACKGROUND TO THE STUDY

A. SHIFTING FROM CONVENTIONAL LMS TO OPEN SOURCE LMS

The traditional LMS is built on an age old model. There are two specific problems with this model, first it is monolithic within a learning institution and second it is generic across learning institutions. Several limitations of this model are –

- The principles of modular design that caused exponential advances in the computer industry are notably absent.
- The most valuable resource of a learning organization, the learning content, is held hostage by a single corporate entity in a proprietary format.
- Content customization cannot be done as only the vendor has control over the content.
- Teachers and students are not free to choose the right / best / preferred tool for each teaching or learning activity they undertake
- A license for a proprietary LMS ties you down to a single vendor for support, service and maintenance.

B. BENEFITS OF OPEN SOURCE LMS

- LMS's based on open source software do not require a licensing fee. This reduces the overall cost per user.
- Open source software is distributed freely and any new functionality in an upgrade, costs nothing to implement.
- Risk associated with the potential for proprietary product disruption because of a merger, or collapse — open source systems provide a lower risk option since the source code "belongs" to everyone.
- Open source LMS is usually built by a community of practitioners and therefore knowledge sharing and troubleshooting

can be possible through online forums and discussion groups that cater specifically to users

- Open source LMSs are designed in such a manner that it is easier to fix problems or source codes. Organizations who have technically competent people can easily acquire the ability to troubleshoot on their own without having to rely on the developer.
- It is easier to develop add-ons and integrate other open source plug-ins without affecting core system files.

C. LIST OF OPEN SOURCE LMS

Sl. No.	Open Source LMS	Developed By	Description
1	Moodle	Moodle Pty Ltd	Comes with a full kit of features. Supports SCORM 1.2 and AICC, but 3rd party add-ons can expand the interoperability standards and features for Moodle
2	LRN's LMS	LRN	A customizable learning portal that can be customized to fit the needs of the individual learner.
3	ATutor's	ATutor	Add-ons to ATutor LMS such as A Content , a content management system and ATutor Social, a networking component has been added
4	BusinessLMS	LMS Global	LMS for businesses
5	Canvas CV	Instructure Inc.	An open source LMS that is free for instructors.
6	Sakai CLE	The Sakai Foundation	Supports SCORM 1.2/2004 through the use of add-on features.
7	Caucus	Caucus	Focuses on learner interaction and conversation to motivate learning. Keeps the learner engaged by adding the element of constant conversations between peers.

TABLE : LIST OF OPEN SOURCE LMS [9]

III. MOODLE – AN OPEN SOURCE LMS

Moodle (Modular Object-Oriented Dynamic Learning Environment) is a SCORM 1.2 compliant, free and open-source e-learning software platform, also known as a Course Management System, Learning Management System, or Virtual Learning Environment (VLE). Moodle was originally developed by Martin Dougiamas to help educators create online courses with a focus on interaction and collaborative construction of content, and is in continual evolution.

It is an e-learning tool that can offer simple and safe solutions to any institution, no matter how large or small, be it an individual teacher or a huge university. Moodle facilitates online collaborations, which can be teacher-to-student, teacher-to-teacher or student-to-student.

A. SALIENT FEATURES

- Modern, easy to use interface - Designed to be responsive and accessible, the Moodle interface is easy to navigate on both desktop and mobile devices.
- Personalized Dashboard - Organize and display courses the way you want, and view at a glance current tasks and messages.
- Collaborative tools and activities - Work and learn together in forums, wikis, glossaries, database activities, and much more.
- All-in-one calendar - Moodle's calendar tool helps you keep track of your academic or company calendar, course deadlines, group meetings, and other personal events.
- Convenient file management - Drop and drop files from cloud storage services including MS Skydrive, Drop box and Google Drive.
- Simple and intuitive text editor - Format text and conveniently add media and images with an editor that works across all web browsers and devices.
- Track progress - Educators and learners can track progress and completion with an array of options for tracking individual activities or resources and at course level.
- Bulk course creation and easy backup - Add courses in bulk, backup and restore large courses with ease.
- Multilingual capability - Allow users to view course content and learn in their own language, or set it up for multilingual users and organizations.
- Customizable site design and layout - Easily customize a Moodle theme with your logo, color schemes and much more - or simply design your own theme.
- Free plugins and APIs -Some of the popular applications are GotoMeeting, WebEx, Adobe Connect, Skype, etc.

B. MOODLE VERSUS OTHER LMS

1) Open Source - the code is freely available. As a result, it is free to download, there is global support for it from enthusiasts and professionals and it is customizable.
2) Assign roles to users – Grants and revokes power to users for access
3) Import contents – Activities designed in XML format can be directly imported into Moodle
4) Language filter – allows to ban certain words or change the language to suit all users
5) RSS – provides with an automatic email notification of any changes in the website
6) Tags – Users will be able to tag other users and events and create personalized pages

C. MOODLE REQUIREMENTS

Minimal configuration of server for LMS Moodle is: 160 MB HDD, 256 MB RAM, but the larger HDD is desired, because of size of learning contents. Recommended size of RAM is 1 GB. The rule is 1 GB RAM per 50 connected users. Type of server instance determines the price of computing cloud service.

It is clear, that this configuration is suitable for the experiment, only. The installation has got a couple of steps [5]:

- Registration and verification via phone;

- Design of an instance
- Purchase of static IP
- Connecting to the new instance via Putty. The private key is important to make the connection within SSH protocol.
- Installation of the new server instance. The server is created from template.
- Thereafter, the installation of LMS Moodle continues in standard manner.

IV. SOFTWARE TOOLS IN COMPUTER SCIENCE EDUCATION

Computer Science Education (CSE) is related to a collection of scientific disciplines concerned with the education of computational and technology knowledge and its applications. CSE involves two main parts for teaching its courses as follows:

1) Theoretical Part: is concerned with the theory content and knowledge that are needed for the courses. To organize the theoretical content, many LMSs provide a set of software tools such as:

- Office suite (Presentations, e-books, worksheets, PDF)
- Multimedia (video, audio),
- Wikis and others.
- Practical Part:It is concerned with the knowledge and practice that the learners gain through practical sessions in the lab using the computer applications. Many Computer Science courses need different software tools working in different system environments and can be classified into the following categories:
- Stand-alone Software Tools: Simulators, assemblers
- Large Software Tools: Ada Language System, Mathematica, SPSS, Compiler and Digital Library.
- Special Software Tools: Virtual Labs, Science Demos, Multimedia Software Packages

A. LIMITATIONS OF EXISTING LMS TO SUPPORT CSE

However, while all existing LMSs can be used to support CS education, they are not specially geared to support the teaching of CS such as: [10]

- the ability to integrate dynamic visualizations and simulations of algorithms and data structures
- the offering of programming homework assignments that ask students to submit code- optionally with an integrated automatic functional assessment
- support for providing code examples for “copy and paste" into the students' workspace
- support for assigning students into groups or teams for example for exercise groups in larger lectures or for lab teams
- Providing the ability to submit an uploaded assignment to another server or process for grading.
- Support for specific subareas of CS, such as formal languages, modelling (e.g., UML), or simulations.

B. PROPOSED SOLUTION TO EXTEND MOODLE TO SUPPORT CSE

To overcome the above limitations regarding the practical sessions, Moodle can be enhanced by integrating it with the needed

software tools so students could use them anytime and anywhere. Figure 3 demonstrates the phases required to develop and integrate the software tools as plugins in the Moodle LMS [11].

Phase 1 : The Moodle should be observed and analyzed in order to explore all its functionality and its architecture.

Phase 2 : The suitable extended architecture for Moodle system should be proposed and the needed software tools should be explored and/or developed.

Phase 3 : The Moodle system should be redesigned and customized to be ready to accept building new component.Phase 4: The needed software tools should be implemented using the same programming languages and coding style of the Moodle system to facilitate the communication between new component and system core and different components of the system.

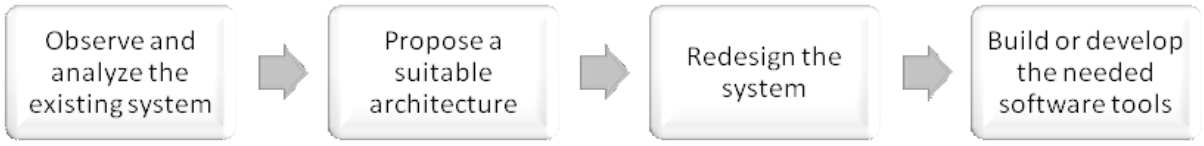

Figure 3: Phases to develop a plugin

C. PLUGINS IN MOODLE

To prepare the Moodle with the needed tools for the CSE such as a compiler, the developers have to use the same programing language and technologies (i.e. PHP) that Moodle uses. In this case the developers could develop a compiler and make it as one activity plugins that they could add to the course of CS whenever needed. Figure 4 presents how the course developer can prepare and add the new tool to Moodle environment. It also shows how the student can access and use the tool in the same Moodle environment. For example, the Virtual Programming Lab (VPL) [12] is one of the plugins that is related to CSE.

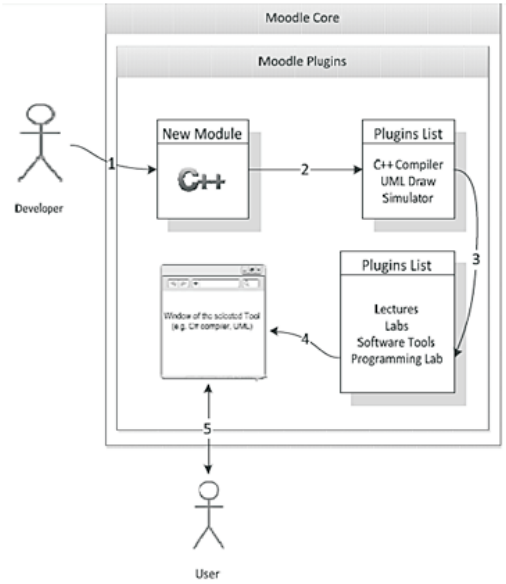

Figure 4:Development Process of New Module

D. VPL INMOODLE

It is a compiler that allows students to compile different programming languages and submit the assignments through it. This plugin software tool is part of the activity module and it is built with the same programming language of Moodle. Its salient features are:

- Enable to edit the programs source code in the browser
- Students can run interactively programs in the browser
- You can run tests to review the programs.
- Allows searching for similarity between files.
- Allows setting editing restrictions and avoiding external text pasting.
- Batch evaluation of submissions
- Backup and restore
- The index of VPL activities now shows the number of submissions and submissions not evaluated.

Supported languages include Ada, C, C++, C#, FORTRAN, Haskell, Java, Pascal, Perl, PHP, Prolog, Ruby, Scheme, Shell script, SQL and VHDL.

V. CONCLUSIONS

The paper contributes to explore the functionality of LMS to support software tools that are helpful in computer Science area. Students those were introduced to online teaching environment through Moodle had encouraging, optimistic and positive approaches and attitudes towards Moodle and sequentially had better and enhanced learning and understanding of the course material. Though Moodle cannot replace face-to-face learning, entirely, the most promising thing students underlined is the availability and ease of access of the available teaching materials, exercises and updated information regarding their course from effectively anywhere outside the classroom. The paper also focuses on shortcomings of Moodle in CSE and suggests use of VPL plug-in to overcome the same. This could help learners in CSE to gain knowledge through practical sessions. In this direction, this paper suggests building and integrating the needed software tools in the Moodle as a new component.

However, the proposed solution has a few limitations such as:

- 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 Moodle, since it will be utilized by the students who are running the software tools in Moodle environment.

Future scope of this paper is to extend the functionality of VPL to incorporate programming languages that are currently not supported.

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