THIRD PLATFORM AND E-LEARNING ECOSYSTEM

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e-Learning Ecosystem

Introduction

e-Learning is the learning process revolution enabled by new technologies that, hopefully, will present an effective and efficient learning process that doesn't exist today [26]. Learning Management System (LMS) is responsible for learning activities. e-Learning is not just for students in universities. Technologies presented in e-Learning are helpful for lifelong learning, social learning, and organizations delivering training and education internally to employees and through professional services [65]. Continuing education is an important activity for the active involvement in a social environment and enhancement of competitiveness. e-Learning might be the only way for continuing education in many cases. A natural ecosystem is a biological community of interacting organisms and their physical environment. Digital Ecosystem is a digital environment populated by digital species that can be software components, applications, online services, information business models, and other components [71]. In other terms, a digital ecosystem is a widespread type of computing environment comprised of ubiquitous, geographically dispersed, and heterogeneous species, technologies, and services [22]. An ecological and holistic approach is required for an improved learning environment [11]. If e-Learning is to be effective in providing greater access to education and support educational programs that reflect broader strategic business goals, it is important that the e-Learning industry learns key lessons from its early adopters from business such as Customer Relationship Management (CRM), and Enterprise Resource Planning (ERP). Extending the digital ecosystem to e-Learning defines an e-Learning Ecosystem as the learning community, together with the enterprise, united by LMS [71].

Platforms are creating an entirely new blueprint for competition, one that puts ecosystems in head-to-head competition [69]. The Open Group defines a platform as the combination of technology infrastructure products and components that provide the prerequisites to host application software [1]. Third Platform is a loosely-defined computing platform that includes technologies becoming commonly available early in the second decade of the twenty-first century, mainly: Social, Mobile, Analytics, and Cloud (SMAC) [33]. Current models of e-Learning ecosystems lack the support of underlying infrastructures, which can dynamically allocate the required computation and storage resources for e-Learning ecosystems [21]. Third Platform is a promising platform for the e-Learning ecosystem. Monolithic and services-based LMS has turned into social and cloud-based Massive Open Online Courses (MOOC) that are available through mobile devices to serve hundreds of thousands of students with the help of Third
Platform. Remote and virtual Labs has become available through Third Platform too. This is just the beginning. Universities and learning institutions that fail to pay attention to the importance of Third Platform in e-Learning ecosystems will face tough sustainability challenges. Third Platform will certainly bring new players to the e-Learning ecosystem, open new opportunities, and make serious challenges to learning institutions. e-Learning providers, consumers, content developers, and stakeholders in e-Learning are experiencing the revolutionary era of Third Platform in e-Learning ecosystems.

In this article, e-Learning ecosystem evolution is highlighted, and an e-Learning ecosystem is proposed. Third platform components (SMAC) and how they fit in e-Learning ecosystem is presented in detail with examples of applied research and case studies. The technology stack of some of the famous MOOCs is presented. Importance of adopting third platform in e-Learning ecosystem and some the benefits is illustrated. Mechanisms to utilize Cloud Computing in Virtual Labs and how such a scenario can solve e-Learning challenges is introduced. Third platform concerns in e-Learning ecosystem is then discussed in brief. Research trends currently taking place to adopt third platform in e-Learning ecosystem is introduced. Glimpses of the future of third platform in e-Learning ecosystem are depicted.

Proposed e-Learning Ecosystem Components

A generalized view of e-Learning ecosystem domain that is based on the abstract definition of an ecosystem is presented in [11]. Natural ecosystem is classified into biotic and abiotic components and all their interrelationships is specified within physical boundaries. Transforming that to the learning domain, an abstract definition of e-Learning ecosystem consists of the stakeholders incorporating the whole chain of the learning process and the learning utilities, the learning environment, within specific boundaries, called learning environmental borders. As the biotic units in the ecosystem the learning communities and other stakeholders such as teachers, tutors, content providers, instructional designers, and pedagogical experts, form the living parts of the e-Learning ecosystem. The learning utilities comparable to the abiotic units (or the learning environment comparable to the physical environment) represent the non-living parts, which include the learning media (content and pedagogical aspects), technology, and tools applied in traditional teaching methods. The learning environmental boundaries – an analogy to the specified physical boundaries of the ecosystem – defines the physical and logical borders of the learning system. That is one of the system’s characteristics, which are in common specified as the e-Learning ecosystem conditions. These conditions are determined by external and internal influences, such as evolution of knowledge, educational goals, learning tasks, cultural
and sociological aspects, and expectations by society, private industry and business organizations, the government, public service and not-for-profit organizations. Finally, in order to define a concrete model, the temporal extent and the temporal and spatial scale of the system has to be specified. A simplified view of components in an e-Learning ecosystem consists of: Content Providers, Consultants, and Infrastructure [22].

1. **Content Providers:** Content providers offer content for learning solutions that is typically linked to competency development, personal development, or a critical business issue requiring improvement. There are three types of content providers: Branded Content Provider, Commodity Content Provider, and Custom Content Provider. Many e-Learning solutions utilize a combination of all three.
   a. **Branded Content Provider:** typically associated with a leading publisher or business school.
   b. **Commodity Content Provider:** a content aggregator that offers hundreds of titles, courses, and modules in a variety of formats.
   c. **Custom Content Provider:** an organization that will tailor internal content and/or develop new content based on a specific requirement. Each group of content providers provides a different value proposition.

2. **Consultants:** There are four types of consultants in the e-Learning ecosystem: Strategy Consultant, Compensation Consultant, Information Technology (IT) Consultant, and Implementation Consultant.
   a. **Strategy Consultant:** Helps an organization develop a new business strategy. Strategy consultants typically begin with a model and tailor it to the specific circumstances. They are usually very good at the process of designing a new e-Learning structure, but weak when it comes to implementing it.
   b. **Compensation Consultant:** Specializes in developing compensation strategies designed to ensure employees are motivated to achieve business goals. Although compensation is often not directly linked to the other parts of the ecosystem, it should be reviewed to ensure people are motivated to help meet business goals. For example, an organization may have a strategy for developing and launching new products, but compensate employees on their ability to manage costs and assets.
c. **IT Consultant**: Helps organizations set up the infrastructure required to perform e-Learning and the processes to operate efficiently and seamlessly.

d. **Implementation Consultant**: Helps organizations put new systems, strategies, and plans in action. They work with IT teams and strategy groups to successfully implement a new system.

3. **Infrastructure**: The enabler for management, delivery and tracking of e-Learning. It consists of LMS that provides content delivery system and tools. Infrastructure can be categorized into LMS, Content Delivery System (CDS), and tools.

   a. **LMS** is a software solution that enables organizations to efficiently manage the process of training and development. The benefit of LMS is its ability to be online, providing instant access to data and information regarding the use and effectiveness of training. LMS also enables organizations to generate reports specifying who has been to which programs, how they did it, what else they are signed up for, and much more. LMS must be able to manage all forms of learning, including instructor-led, asynchronous, and synchronous e-Learning.

   b. **CDS** is online software that allows training to be delivered over the Internet. The two types of CDS are asynchronous and synchronous.

      i. **Asynchronous CDS** use open platforms and development standards to physically design and deliver the content for anytime access. Asynchronous content delivery systems provide many interactive features that leverage the full power of the Internet, such as chats, peer counselling, communities, coaching, and document sharing.

      ii. **Synchronous CDS** enable the simultaneous online delivery of content to a group of people at a specified time.

   c. **Tools** transfer core intellectual property into a Learning Object (LO). These tools are used to create content that fully engages the learner and increases memory. In an educational context, digital learning content is produced, administered, and manipulated in an intricate and changing environment.
Research directions found in scientific literature that is related to IT and e-Learning ecosystem are identified within three main research directions [65]:

1. IT ecosystem approach to **improve** the educational process which comprises the definition of elements of the educational process and reflection of interaction of the processes.

2. IT ecosystem approach to **support** the educational process which provides the application of natural ecosystem principles in analysis and development of educational IT.

3. **Analysis** and **modelling** of **knowledge flow** both at the university and in a production company.

It is clear from the previous discussion that there is no agreed upon definition of e-Learning ecosystem. However, by surveying different proposed e-Learning ecosystems, a general model can be obtained. Identifying the e-Learning ecosystem components varies greatly from one system to another. From our perspective, Third Platform will shape e-Learning ecosystem. Figure 1 presents a proposed e-Learning ecosystem as considered in this article. e-Learning ecosystem does not address training needs only, however it exceeds what is known as structured learning to reach wider areas. Figure 2 introduces the domains that e-Learning ecosystem needs to cover as presented in [61].
Figure 1: Proposed e-Learning Ecosystem Components

Figure 2: e-Learning Ecosystem Coverage Areas
Academic Alliance in e-Learning Ecosystem

Academic Alliance can be thought of as part of Strategic Alliance, where alliances involve the sharing of resources to achieve mutually relevant benefits. Academic Alliances are flexible ways to access resources outside of one’s own institution [52]. Academic Alliances are widely known and accepted in different fields, i.e. medical health [49], nursery [20], and nuclear science [14]. Academic Alliances are popular among universities. An Australian University experience with designing and aligning with academic alliance can be found in [20]. In Computer Science (CS) and IT fields, the top search results of Academic Alliance returns a list of:

1. EMC Academic Alliance
2. Microsoft Dynamics Academic Alliance
3. Academic Alliances – NetApp
4. Juniper Networks Academic Alliance
5. International Academic Alliance (IAA)
6. Cisco Networking Academy
7. Oracle Academy

The list of Academic Alliances is broader than that listed above, and keeps growing. In this section, the focus will be on technical related Academic Alliances. Academic Alliance can be thought of as a program backed by a large company or an enterprise "software and/or hardware vendor" to provide students with updated course curriculum that promotes a company's technology and enables students to become familiar with such technologies as early as possible. Pros of Academic Alliance programs include:

- **Curriculum** provided by enterprises, like those mentioned above, usually is managed by domain experts, with significant budget from the supporting company. Workshops for developing such curriculum involve both academic and technical experts. This scenario unfortunately is not applicable in many universities due to many reasons, mainly: lack of budget, lack of domain experts dedicated to developing courses, and the missing link between academia and industry.

- Providing an updated curriculum, e-Content, and teaching materials helps instructors during the teaching process, especially in the preparation phase, and in identifying topics to be taught during the course.

- Presented course content is very well organized, accurate, updated, and well-formed. Thus, it is particularly helpful especially for instructors new to the topic(s) in hand.
• Providing **Labs** when needed enables students to get involved in an interactive learning experience.

• Provided Labs that **map to modules / chapters** enables instructors to match both theory and practice.

• Getting **Labs from vendors is invaluable** because both instructors and students get to know how things they are learning in theory are implemented and applied in practice. Some of the most successful technologies are proprietary, and Academic Alliances offer the only way to get closer to the internals of those technologies.

• Provided **Labs are irreplaceable** most of the time. For example, working on Cisco Packet Tracer is a good alternative to purchasing real equipment, and working on EMC VNXe® Simulator, or downloading the EMC Isilon® Simulator is the only solution available for learning institutions in developing countries for gaining insight to EMC Information Storage and Management (ISM) technologies.

• Contents and Labs are usually **updated with each product release**. In today’s world, updated information is not optional.

• Usually, Academic Alliance comes with a **Certification Program**. Sometimes, a new certificate is presented to students, as is done via Associate-level certification through the EMC Academic Alliance Program. A discount for the associated EMC Proven® Professional certification exam is available too. Giving students the opportunity to be certified before graduation is a good thing as it helps students in building their career.

Though there are many positives of Academic Alliances and seem to be a necessity, Academic Alliances cons are also many, and may turn out to be program killers. Cons of Academic Alliances include:

• **Academic Rules**: Sometimes, universities are introduced to a wonderful curriculum, but unfortunately they cannot find a course that fits the provided curriculum. Instructors dealing with Academic Alliances that are backed by companies that are not well known, or at least that are not familiar to decision makers, find difficulties adopting such academic alliances in their faculties.

• **Theory vs. Practice**: Though there shall be no contradiction between both theory and practice, it is a matter of balancing both in the course. Such balance is maintained only by the instructor. Sometimes, instructors need to focus more on theoretical aspects of the subject, i.e. network protocols. Other times, they feel the need to focus more on the practice of the subject. Such balancing depends on different manners, for example the
number of course sequels available to teach certain topics, who is teaching the previous course, who is going to teach the following one, and if there is integration between those courses and perhaps other courses.

- **Personal Opinions**: Though universities follow standards in adopting courses, content, and other activities, it is still the instructor who has to work hard to achieve success in the subject when presented to Academic Alliance. Instructors going through such effort must be truly convinced of what they are doing. Some instructors prefer teaching from text books and references. Others find Academic Alliance a very good opportunity.

- **Personal Dedication**: Usually, Academic Alliances are dependent on instructors. When instructors leave their educational institutions, the program stops there, or at least faces real challenges.

Pros and cons are many, and they vary by university. Another important point to consider when adopting Academic Alliance is how learning institutions are going to integrate the curriculum. Curriculum Integration can go through one of three options / models:

- **Course Replacement**: This is the preferred choice for Academic Alliances, where universities adopt the curriculum completely within an academic year / semester / term. Academic Alliances prefer that choice because it guarantees that students will be presented to the entire course, with no modifications or contradictions when the course is modified by the instructor. However, some Academic Alliance courses are not well suited for the task, especially because universities have to strictly follow course specifications set earlier.

- **Course Integration**: This is the most difficult solution for instructors because they have to thoroughly examine the academic alliance curriculum, find points of strength and emphasize them, and points of weakness and covers them. Points of strength and weakness are not related here to accuracy or inaccuracy of provided information. Rather, they are related to matching what instructors are planning to teach and emphasize generally in the course. Another challenge for this model is that instructors will need extra time compared to the course replacement option.

- **Optional Courses**: Some universities find it more appropriate to list certain curriculum as elective courses with fewer credits.
EMC is putting enormous effort into the EMC Academic Alliance, a widely accepted program found in many universities and countries all over the world. List of instructors and universities adopting EMC courses can be found on EMC Community Network (ECN) and EMC Education Services websites. Strategies to adopt EMC Academic Alliance courses in universities vary from one another, based on different parameters, i.e. student preparation, number of courses available, and many other things. Academic Alliances are becoming integral part of the e-Learning ecosystem.

Third Platform in e-Learning Ecosystem

Introduction

Platforms are creating an entirely new blueprint for competition, one that puts ecosystems in head-to-head competition [69]. Platform is the enabler of a software ecosystem. The Open Group defines a platform as a combination of technology infrastructure products and components that provide the prerequisites to host application software [1]. Gartner uses the term “Nexus of Forces” to describe the convergence and mutual reinforcement of social, mobility, cloud, and information patterns that drive new business scenarios. Gartner says that, although these forces are innovative and disruptive on their own, together they are revolutionizing business and society, disrupting old business models and creating new leaders. Gartner sees the Nexus as the basis of the technology platform of the future. The UNIX operating system provided a standard platform for applications on a single computer. Servers, PCs, and the Internet provided a second platform for web applications and services. Third platform is needed to support applications and services that use cloud, social, mobile computing, big data, and the Internet of Things [2]. Rapid technological change and proliferation of information resources are lineaments of our contemporary society. Multimedia on the Internet, telecommunications, wireless applications, handheld electronics, social network software, Web 2.0, and so forth are all radically redefining the way people obtain information and the way to teach and learn. Particularly, the widespread Web 2.0 applications have the capacity for educational institutions and corporations involved in training to extend the possibilities of e-Learning [73]. E-Learning ecosystem must cover the different ways people learn. Figure 3 presents different ways of learning for different people.
The use of IT has become an integral part of the educational process [65]. The idea of realizing Analytics and Mobility in the highly modularized yet integrated Social Networking services on Cloud-based systems helps improve real-time access to actionable knowledge on Business Impact Management (BIM) choices through various channels [39]. Enterprises should be able to create, evolve, adopt, and use solutions based on current and future emerging technologies to achieve business value. These solutions should [2]:

- Enable Boundaryless Information Flow.
- Allow users to mix and match technology products and services.
- Support the business innovations that enterprises want to make, including changes in the style of business operations.

**Third Platform Components**

Third platform is a loosely-defined computing platform that includes technologies becoming commonly available early in the second decade of the 21st century [33]. The convergence and mutual reinforcement of technical phenomena such as social media, mobility, cloud computing, big data analysis, and the Internet of Things is predicted to drive growth in IT spending through to 2020 [2]. Social computing and Mobility entities are seen as effective drivers of productivity, accessibility, and engagement, while Analytics and Cloud Computing are enabling real-time decision making at minimal costs [39].

**Social Computing**

Social computing refers to computing related to or using social media. Social media are a development of Internet and web technology. They provide a means of interaction among people in which they create, share, and exchange information and ideas in virtual communities and networks [2]. Social Computing helps organizations adopt real-time collaboration and
feedback. In terms of collaboration, the move toward a Social Business is evident from the increasing use of social media tools within an organization. Social Media is already disrupting traditional models of marketing and selling [39]. Social networks have been widely studied since the twenty’s in disciplines such as sociology or economics. In the last years, the increase in the use of Internet and user interactions enables computer scientists to use Social Network Analysis (SNA) techniques for Data Mining (DM) and knowledge discovery in large Internet social networks. Usually, social networks offer services such as list of friends, people surfing, messages, events management, and media uploads. The future of social networks in the Internet is promising. SNA is a research area that has received significant attention, especially in the past few years. The correspondence between real-world social relations and social media ties has been confirmed on several occasions [47].

Undoubtedly, there is an inherent social network in any e-Learning system [17]. Social networks are graph structures whose nodes or vertices represent people or other entities embedded in a social context, and whose edges represent interaction or collaboration between these entities [13]. Though most online courses allow students to work at their own pace, they provided no student-to-student interaction until social media came along. Social networks has risen to mutuality in a very short time, thanks to rapid development of mobile communication and IT. Today, social networks have developed to become a new and true definition of “sharing”, “collaborating”, and “conversation” in the new form. While social networking means conversation, share, and collaborate, it is naturally the polar opposite from highly controlled education. Therefore, integrating social networking to exist controlled programs of e-Learning suggests chaos, especially in the already-unstable world of e-Learning [48]. On the other hand, in online collaborative learning, strategies promoting the feeling of connectedness and belonging appear to be critical for learners. As a result, social presence has appeared to be a social and communication factor that is particularly critical to a distance learner’s perception of psychological distance with their instructor and other learners [64].

Social networks are highly dynamic, evolving relationships among people or other entities. This dynamic property of social networks makes studying these graphs a challenging task. Complex analysis of large, heterogeneous, multi-relational social networks has led to an interesting field of study known as SNA. Able to be applied to analysis of the structure and the property of personal relationship, web page links, and the spread of messages, SNA is a research field in sociology that applies the cutting edge aspects of both CS and IT. Recently, SNA has attracted increasing attention in the DM research community. From the viewpoint of DM, a social network
is a heterogeneous and multi-relational dataset represented by graph [38, 74]. Tools used to support social media in e-Learning cover a wide range of different applications, including discussion forums, chat, file sharing, video conferences, shared whiteboards, e-portfolios, weblogs, and wikis. Such tools can be used to support different activities involved in the learning process [26]. The question of organizing e-Learning tools involves the problem of integration vs. separation and distribution [27, 29]. SNA views social relationships in terms of network theory, consisting of nodes (representing individual actors within the network) and ties (which represent relationships between the individuals. These networks are often depicted in a social network diagram, where nodes are represented as points and ties are represented as lines. SNA answers questions such as:

- **Prestige**: Who are the central actors in the network?
- **Influence**: Who has the most outgoing connections?
- **Prominence**: Who has the most incoming connections?
- **Outlier**: Who has the least connections?
- **Density**: What proportion of possible ties actually exist?
- **Path Length**: How many actors are involved in passing information through the network?
- **Community**: Which actors are communicating more often with each other?

Social networks and SNA will play important role in e-Learning, especially when it comes to continuous learning and lifelong learning. Social networks provide an important concept known as informal learning. Informal learning is learning that is conducted through knowledge acquisition and sharing, problem solving, and online open discussions and arguments. Such learning needs to be recorded and activated. e-Learning that is based on Third platform certainly addresses this aspect. Analysis of social networks in e-Learning is analyzed in [6] highlighting the effect of social networks in e-Learning. [18] shows that students get more involved in the e-Learning process that is empowered by social networks. Different modelling approaches are used for SNA. An evolutionary web graph approach is presented in [48]. Representing social community by a digraph is a popular idea. Highlighting connections between edges by weights and analyzing them is an effective way in SNA to discover how the network as a whole will likely behave. Another model for investigating patterns in networked learning is presented in [19]. The focus is to explore the advances that SNA can contribute within e-Learning through networked learning community. The aim is to find how members share and construct knowledge. Many projects have been implemented to help educators
improve the learning environment through utilizing SNA. A new method for analyzing social network and mining its data over the web is presented in [68]. Similar techniques can be applied in an e-Learning environment. SNA will help enhance the learning process.

**Mobile Computing**

On-the-fly access to management data and business applications can be realized through mobile computing. Hence, in coming years, the focus will be on providing enterprise-class features and support for mobile data and applications [39]. Mobile computing is achieved through the connection of portable computing devices to servers via mobile radio networks and the Internet. It is based on the convergence of computing and mobile telephone technology [2]. Better services and smaller, cheaper devices have led to an explosion in mobile technology that far outpaces the growth of any other computing cycle. Based on the current rate of change and adoption, the mobile web will be bigger than desktop Internet use by 2015 [73]. The International Telecommunication Union (ITU) estimates that there are 6.8 billion mobile subscriptions worldwide, equivalent to 96 percent of the world population, which is 7.1 billion according to the ITU. This is a significant increase from 6.0 billion mobile subscribers in 2011 and 5.4 billion in 2010. Mobile technology disruption can be better understood from the following statistics [39]:

- Over 1.2 billion people access the web from their mobile devices.
- Global mobile traffic now accounts for 15% of all Internet traffic.
- 60% of mobile shoppers use their smart-phones while in a store; another 50% while on their way to a store.

Growth of mobile technologies such as the Kindle, the iPhone and other smartphones, web-enabled tablets, GPS systems, video games and wireless home appliances, and the growth of the mobile web is amazing [73]. Mobile Learning (M-Learning) is an approach to e-Learning that simply utilizes mobile devices, yet it can also be viewed as a different learning experience [46]. According to [66], although the mobile wealth creation/destruction cycle is still in its earliest stages, the proliferation of better devices and the availability of better data coverage are two trends driving growth [73]. M-Learning adoption began earlier than the era of smart-phones. If it is possible to force a series of interactive SMS exchanges between the learner and LMS to achieve completion of a task or goal, the learner will take part and complete the task [67]. M-Learning has been used as a pre- and/or post-activity to other types of learning [59]. Three wireless and mobile-based application systems that can serve in M-Learning are presented in
Assessment for learning can be thought as a post-learning activity that can be achieved via mobile phones. A Service Oriented Architecture (SOA)-based LMS that integrates mobile assessment in e-Learning is presented in [55].

**Big Data Analytics**

Data Mining (DM) is the automatic or semi-automatic analysis of large quantities of data to extract previously unknown interesting patterns such as groups of data records (cluster analysis), unusual records (anomaly detection), and dependencies (association rule mining). This usually involves using database techniques such as spatial indexes. These patterns can then be seen as a kind of summary of the input data, and may be used in further analysis or in machine learning and predictive analytics. DM might identify multiple groups in the data, which can then be used to obtain more accurate prediction results by a Decision Support System (DSS) [24]. Neglecting the dependence structure of the data, and assuming the independence of data instances can lead to inappropriate conclusions. The structure of inter-relation between many application domains such as biology, marketing, and learning, refers to existence of groups as a densely connected set of nodes when there are sparse connections between different groups [45]. DM has been focused on the learning materials, or on the student’s learning paths in an effort to find out more about student behavior. Emergence of social networks has reflected the way we interact in reality to the web. Mining social networks activities help to share interests between groups of people with common features. Enterprises are moving from historical and near-time reporting to real-time analytics that enable real-time decisions with the ability to predict future trends processing large volumes of market dynamics gaining traction with customers [39]. People want to take advantage of data obtained from new sources, including social media and the Internet of Things, to make business decisions, and to make them quickly. However, [2]

- They do not know how to find patterns in and predict trends from the data.
- They do not know how much to believe the data.

Enterprises have begun using analytics for everything from driving growth, to reducing costs, revamping sales, improving operational excellence, recruiting workforce, to completely transforming their business strategy. More recently, government departments and Non-Governmental Organizations (NGOs) across the world have started using analytics, from optimizing public welfare programs, smart city planning, reducing traffic congestion, expanding cost-effective healthcare and education for remote areas, to fighting and preventing crime [39].
Big data refers to data that is so large that it is difficult to work with using ordinary IT systems available today. There is a growing body of analysis, visualization, and distributed processing software that enables extraction of useful information from such data. Often, those extracting the information do not know what they are looking for, so algorithms are modified and refined as the search proceeds and as potentially interesting aspects of the data come to light [2]. Table 1 shows the three V’s of Big Data [39].

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
<th>Attribute</th>
<th>Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Volume</strong></td>
<td>The sheer amount of data generated or data intensity that must be ingested, analyzed, and managed to make decisions based on complete data analysis.</td>
<td>The world is generating 1.8 Zeta bytes of information – with continuing exponential growth – projecting to 35 Zeta bytes in 2020.</td>
<td>Increase in data sources, higher resolution sensors.</td>
</tr>
<tr>
<td><strong>Velocity</strong></td>
<td>How fast data is being produced and changed and the speed at which data must be received, understood, and processed.</td>
<td>Accessibility: Information when, where, and how the user wants it. Applicable: Relevant valuable information for an enterprise. Time-Value: Real-time analysis yields improved data driven decisions.</td>
<td>Increase in data sources. Improved connectivity. Enhanced computing power of data generating devices.</td>
</tr>
</tbody>
</table>
| Variety               | The rise of information coming from new sources both inside and outside the walls of the enterprise creates integration, management, governance, and architectural pressures on IT | Structured – 15% of data today is structured, i.e. rows, columns  
Unstructured – 85% is unstructured or human generated information  
Semi-structured – The combination of structured and unstructured data is becoming the norm | Mobile, social media, videos, chat, genomics, sensors |

**Table 1: The Three V’s of Big Data [39]**

The three V’s distinguish Big Data Analytics from DM while highlighting how to use DM to present its basis. DM and analytics in e-Learning is widely used, accepted, and has already helped e-Learning. Educational Data Mining (EDM) is already known and surveys of its utilization in e-Learning can be found in [51, 54]. Analytics is the core of knowledge discovery process. In [75], a new methodology of using web mining is presented to support the learning environment through enhancing web use. DM is very useful in the field of education especially when examining a student’s learning behavior in an online learning environment. This is due to the potential of data mining to analyze and uncover hidden information of the data itself which is hard and very time consuming if done manually. EDM is defined as an emerging discipline, concerned with developing methods for exploring the unique types of data that come from the educational setting, and using those methods to better understand students, and the settings in which they learn. EDM often stress the improvement of student models which denote the student’s current knowledge, motivation, metacognition, and attitudes [54].
DM has been applied to data coming from different types of educational systems. On one hand, there are traditional face-to-face classroom environments such as special education and higher education. On the other, there is computer-based education as well as web-based education such as well-known LMS, web-based adaptive hypermedia systems, and intelligent tutoring systems. The main difference between them is the data available in each system. Traditional classrooms only have information about student attendance, course information, curriculum goals and individualized plan data. However, computer and web-based education has much more information available because these systems can record all the information about a students' actions and interactions onto log files and databases. The application of DM in e-Learning systems is an iterative cycle. The mined knowledge should enter the loop of the system and guide, facilitate, and enhance learning as a whole, not only turning data into knowledge, but also filtering mined knowledge for decision making. The EDM process consists of the same four steps in the general DM process [60]:

1. **Collect data:** LMS is used by students and the usage and interaction information is stored in the database.
2. **Preprocess the data:** The data is cleaned and transformed into an appropriate format to be mined.
3. **Apply DM:** DM algorithms are applied to build and execute the model that discovers and summarizes the knowledge of interest to the user (instructor, student, and administrator). To do so, either a general or a specific DM tool, or a commercial or free DM tool can be used.
4. **Interpret, evaluate, and deploy the results:** The results or model obtained are interpreted and used by the instructor for further actions. The instructor can use the information discovered to make decisions about the student and course activities to improve student learning.

[54] pursues a twofold goal, the first is to preserve and enhance the chronicles of recent advances in EDM development; the second is to organize, analyze, and discuss the content of the review based on the outcomes produced by a DM approach. Thus, as a result of the selection and analysis of 240 EDM works, an EDM work profile was compiled to describe 222 EDM approaches and 18 tools. A profile of the EDM works was organized as a raw database, which was transformed into an ad-hoc database suitable to be mined. As result of the execution of statistical and clustering processes, a set of educational functionalities was found, a realistic pattern of EDM approaches was discovered, and two patterns of value-instances to depict EDM
approaches based on descriptive and predictive models were identified. One key finding is that most of the EDM approaches are ground on a basic set composed by three kinds of educational systems, disciplines, tasks, methods, and algorithms. The review concludes with a snapshot of the surveyed EDM works and provides an analysis of EDM strengths, weaknesses, opportunities, and threats, whose factors represent, in a sense, future work to be fulfilled.

The use of electronic media in education has a strong impact on student performance. Prior research has investigated the impact of forum reading and posting, as well as access to reading resources, on academic performance. However, little is known about the relationship between the temporal frequency of these activities and individual student’s performance. In addition, some studies have proposed different categorizations of student activities and proved the usefulness of these characterizations for predictive purposes and better understanding of the learning process. One of the biggest concerns when teaching courses in a virtual learning environment is to create and develop instruction in a way that it improves the overall learning experience and results. [36] addresses this concern by drawing upon factors influencing academic performance; more specifically, it focuses on objective factors related to the interaction between the student and the system (number of resources visited in the learning platform, and number of forum posts and views). The results show that there is a recurrent pattern in the frequency of behaviors and performance across different courses.

Cloud Computing

Over the past few years, the trend of Cloud Computing has gained momentum and has become a familiar phrase in IT [7, 37, 63]. Cloud Computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [3, 44, 53]. The essential concept of Cloud Computing is that IT resources are made available, within an environment that enables them to be used, via a communications network, as a service. A cloud service has the five essential characteristics of on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service [2]. Market trends indicate the surge in cloud adoption include [39]:

- $180 billion is the estimated global cloud services market by the end of 2015.
- 84% of CIOs are cutting application costs by moving to the cloud.
• According to Gartner Research, SaaS-based delivery will experience healthy growth through 2015 when worldwide revenue is projected to reach $22.1 billion.

• IDC Research found that Infrastructure as a Service (IaaS) will grow to $5.4 billion between now and 2017 while Platform as a Service (PaaS) will grow to $1.1 billion.

With Cloud Computing, several service delivery models can be realized, delivering Infrastructure, Platform, and Software as a Service to support learning environments and optimized use of the university’s IT resources, using load balancing and even over-provisioning [63]. Cloud Computing service models can be grouped into:

• **Cloud Software-as-a-Service (Cloud SaaS):** An IT service in which the consumer is provided the capability to use the provider’s applications running on a cloud infrastructure [3]. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g. web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings [2].

• **Cloud Platform-as-a-Service (Cloud PaaS):** An IT service in which the consumer is provided the capability to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider [3]. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment [2].

• **Cloud Infrastructure-as-a-Service (Cloud IaaS):** An IT service in which the consumer is provided the capability to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications [3]. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g. host firewalls) [2].
[35] surveys the state of the art on the use and research of Cloud Computing in education following a systematic methodology. After a comprehensive search of the scientific literature, 112 works were selected for the review. The survey identifies and analyses the advantages and risks that the use of Cloud Computing may have for the main stakeholders in education, which can be useful to identify the scenarios in which the use of Cloud Computing in an educational context may have significant advantages. Another e-Learning Ecosystem based on Cloud Computing as an infrastructure is proposed to be composed of three layers: Infrastructure layer, Content layer, and Application layer [21]. It is also with four ad hoc modules: monitoring module, policy module, arbitration module, and provision module.

- **Infrastructure layer** is the resource pool of an e-Learning ecosystem. The infrastructure is managed by the Cloud Computing platform. Hardware and software virtualization technologies are used to ensure the stability and reliability of the infrastructure. Supplying computation and storage capacities for higher layers, it is the energy source of an e-Learning ecosystem.

- **Content layer** mainly consists of e-Learning contents, such as Web file systems, database systems, Web Services, and so on. Except for content storage and maintenance, this layer exposes the standard interfaces and APIs of content for higher layers.

- **Application layer** consists of e-Learning services, systems, tools, and so on. It also provides functions and interaction interfaces for users or other programs.

- **Monitoring module** keeps track of executions of requests, real-time configuration information, and resource utilization levels of species, including the health of CPU, memory, I/O, and so on.

- **Policy module** establishes and maintains the teaching and learning strategies, the run-time and resource scheduling strategies. According to the data from monitoring module and the strategies of its own, policy module establishes specific solutions, and then triggers provision module. Policy module also decides which species get higher priorities on resource scheduling according to some e-Learning policies in order to safeguard the running of critical businesses. Policy module is the core of an e-Learning ecosystem.

- In the **Arbitration module**, some policies are made by experts manually; requests from users are completed; and some disputes among species within the e-Learning ecosystem are solved. Arbitration module amends, adjusts, and improves resource allocation and management. It also establishes usage modes for different kinds of users.
based on the learning styles, learning preferences, and cognitive levels. Arbitration module is an efficient complement to the policy module, while the privilege of its policy is higher than that in the policy module.

- **Provision module** starts the execution of resource allocation solutions set by the policy module and arbitration module and deploys resources referred to users or species automatically in a short time. If the request comes from a user, some related information such as IP, user name, and password will be supplied.

Many groups have started implementing these new technologies to further decrease costs through improved machine utilization and reduced administration time and infrastructure costs [31]. Cloud Computing is the environment that enables customers to use applications on the Internet such as storing and protecting data while providing a service [43]. Cloud Computing has become a convenient way to realize instructional principles in learning environments that follow the constructivist view of learning, supporting on demand, self-controlled learning environments. Figure 4 presents some of Cloud Computing adoption effect in e-Learning ecosystem.

![Figure 4: Cloud Computing Adoption Effect on e-Learning Ecosystem](image.png)
Proposed e-Learning Ecosystem Architecture

Different LMS software architectures using different technologies and design patterns have been presented over the years. LMS has shifted dramatically from single monolithic systems into adaptive and intelligent services-based systems [56]. SOA has changed the way LMS is implemented dramatically, because of the need to integrate different systems and activities within e-Learning [29]. SOA-based LMS is presented in [55, 57]. e-Learning ecosystem is not only about LMS. Comparison between the different software systems that forms e-Learning ecosystem and the functionalities of each one and how they integrate with each other can be found in [26]. e-Learning ecosystem is the result of integration of different management systems. Though not an exhaustive list, these include:

- University Management Information System
- LMS
- CDS
- Quality Assurance and Accreditation Management System
- Digital Library Management System
- Activities Management System
- Assessment Management System
- Exam Management System
- Portfolio Management System

Cloud Computing is used to provide users with computer resources on-demand over the Internet. While e-Learning systems usually require many hardware and software resources, many educational institutions cannot afford such investments. Cloud Computing is the best solution for them. Lecturers and researchers can leverage Cloud Computing to enhance e-Learning experience. Integrating SOA and Cloud Computing under the orchestration and governance of Business Process Management (BPM) has proven efficient and effective over the years [27, 29, 30]. An example of an attempt to model an adaptive learning process using Business Process Modeling Notation (BPMN) and apply it into SOA based LMS is presented in detail in [28].

Figure 5 depicts the proposed e-Learning ecosystem architecture which consists of three groups of services, from left to right: internal, cloud-hosted, and external groups. e-Learning ecosystem-supportive software consists of interoperable services working together to achieve the required goals. Services are grouped into layers with each layer forming certain
functionality. Services can be hosted internally in the organization, or on the cloud. In both cases, services have to deal with learners’ activities on external sites. The large black arrows represent the middleware that connects the components. e-Learning ecosystem-supportive software needs to include intelligent services [28] which can vary from services that help the system to adapt for each student, to services that will enable decision makers to take the appropriate decisions based on the results of big data analytics. Different artificial intelligence (AI) techniques and learning algorithms can be utilized to support intelligent e-Learning. Examples of intelligent services that can exist in e-Learning ecosystem software are presented in [25, 28, 58]. Nine intelligent services utilized in different e-Learning functionalities are grouped into two categories based on their aims: Instructor Services and Student Services [28].

Figure 5: Proposed e-Learning Ecosystem Architecture
Instructor Intelligent Services include:

- **Intelligent Learning Objects (LOs) Classifier**: Combines both supervised and non-supervised learning algorithms with fuzzy logic to classify LOs.
- **Intelligent Online Lecture LOs Advisor**: Enables the Adaptive Online Lecture Model to present different pedagogical aspects via:
  - Recommending LOs based on students’ learning preferences.
  - Involving students in the learning process from the beginning of the lecture.
  - Preparing for the next lecture, so students feel the lecture’s additivity.
- **Intelligent Student Performance Tracker**: Intelligently tracks students’ learning profiles and preferences and verifies completeness.
- **Intelligent Cheating Depressor**: Intelligently identifies students that cheated during online assessments based on their history, consumed assessment duration, and scored marks.

Student Intelligent Services are:

- **Intelligent Time-to-Learn Topic Calculation**: Guides students to the time needed to learn topics. This service helps students establish the variance between the time they expect to learn, and the time they actually take to learn.
- **Intelligent Study Plan Advisor**: Guides students through branching decisions in courses based on previous study plans, learning profiles, and preferences of current students.
- **Intelligent Agenda Study Time Planner**: Helps students identify study times and control interruptions to improve performance. It integrates with available activities to update students’ calendar automatically.
- **Intelligent Meeting Manager for Suspended Students**: Intelligently schedules a meeting with one of the instructors for suspended students.
- **Intelligent LOs Recommender**: Intelligently recommends LOs to satisfy course prerequisites that are not fulfilled by students, and to suggest further readings for students based on their learning preferences.
Cloud Computing and Virtual Labs
The main objective of this section is to present how Cloud Computing provides on-demand virtual desktops for problem solving, and on-demand virtual labs for special courses. The focus is how cloud services can be used, how they can be integrated into the existing infrastructure, and how new didactic models could look. The proposed solution offers significant savings when compared to the cost of physical infrastructure procurement and maintenance. Being able to provide lab setups for external students, and after regular lab times is an interesting point. Students might access their lab scenarios from everywhere; home, during breaks, and so forth. In the proposed approach, IaaS provides Virtual Machines (VMs) on demand for students. These machines are customized for courses and laboratory exercises and provisioned to build virtual laboratories. PaaS goes a step further and offers students a framework to deploy their developed programming exercises on a well-defined environment. Finally, SaaS makes software services, i.e. lecturing assist tools or development tools, available for multiple users. Cloud Computing allows flexible and adaptive use of computing resources on demand and thus supports powerful learning environments in terms of a constructivist conception of learning in an effective way. Cloud management systems provide different services that are categorized into the well-known cloud service models; SaaS, PaaS and IaaS. Obviously, the more specialized the model (e.g. SaaS), the less customizable by the student.

Problem Definition
Middle East and North Africa (MENA) region confront from many educational problems in technical fields, especially in the Information and Communication Technology (ICT) domain. The traditional solution for enriching the society with high caliber ICT professionals has been to provide international training centers and academies providing proprietary courses at prices greatly exceeding the average income of developing countries. The high cost comes from several factors:

- Price of the course materials
- Cost of properties (office, power, labs, machines, etc.),
- Value of the training service.
- Small number of attendees per course for higher quality training.
Most of these factors are unavoidable and form the dilemma of ICT training not only in the MENA region but also worldwide. e-Learning solutions that the educational sector is trying to embrace are very traditional and old-fashion, based on stored courses or live course streaming systems. Such systems provide ugly desktop or Web 1.0 interfaces at high cost to the educational institution and end user. Students in the field of ICT education need to learn problem solving techniques and those cannot be learned without interaction with real-life computer problems on training labs. Those skills include troubleshooting skills, which are considered one of the most problematic skills in terms of requirements from the lab perspective as the instructor needs to put the machine into a broken state to test or train students on capabilities of troubleshooting. The need of a virtualized lab solution is crucial in this particular case. Current solutions are not exciting from the user perspective. Statistics show that students tend to spend an inordinate amount of time on Facebook and similar social media websites than on e-Learning and educational online systems. This has taught us that a blend of social media and education is crucial to enhancing user experience and ultimate efficiency of the educational process.

**Proposed Solution**

The first part of the solution is “Virtual Lab” that takes programs running on college hardware and beams the virtual images to any computer desktop across the Internet, enabling students to create and save work as though the programs were running on their own hard drives. Software performance depends on the bandwidth of the Internet connection as opposed to computer processing power, so even students with older computers can use advanced software without difficulty. However, a high performance infrastructure at the provider side is needed. The second part of the solution is Cloud Computing that will be utilized to provide the virtual labs. Cloud is a powerful combination of computing, networking, storage, management solutions, and business applications that facilitate a new generation of IT and consumer services. These services are available on demand and are delivered economically without compromising security or functionality. To take full advantage of Cloud Computing, enterprises need to evolve their IT strategy to achieve greater business value through the improved cost-savings and productivity that cloud services offer. Service providers need to offer and monitor Cloud Computing services to effectively serve their customers while improving profitability.
Cloud Computing is the key to an innovative solution to the current problem illustrated earlier and a proper design and implementation might be a life-changing solution to technology education around the world. The Cloud Computing model incorporates technologies such as “Virtualization”, “Software-as-a-Service”, that can solve many of the current problems we are facing in traditional technology training methodology and the sub-optimal e-Learning solutions in common use today. Utilizing Cloud Computing model for e-Learning provides several advantages, mainly an Internet-scale solution that can easily scale to thousands or millions of online concurrent system users enabling wide-scale revolutionary deployment to masses of students. The proposed solution is to provide an e-Learning solution that leverage current IT infrastructure, and presents enhanced pedagogical aspects of e-Learning.

Technical Objectives
The proposed solution incorporates different technical objectives to meet the required goal. Technical objectives include:

- Build a web-scale, cloud-based LMS with a modular design and multilingual, highly customizable, front-end Web-based UI with cutting edge web technologies, i.e. HTML5/CSS3 and AJAX.
- Integrate cloud-based Virtual Labs with LMS to provide an interactive intelligent virtual training environment for ICT training that include Computer Networking, Computer Programming, Server Administration, Database Administration, and advanced technical ICT courses.
- Offer on-demand cloud-hosted Virtual Labs with support for snapshots, enabling students to easily take snapshots at any moment during the lab time, in effect freezing the lab and providing a point-in-time that they can return to later, or share via the built-in collaboration platform with their instructor or peers.
- Virtual Labs that include a complete virtually isolated network with multiple machines to demonstrate given deliverable by course designer / instructor.
- Utilize the Cloud Computing “Pay-as-you-go” business model so users only pay for the time they use on Virtual Labs, thus providing cost-effective access to the large number of computing resources during ICT training.
- Build a content delivery and hosting network for true infinite scaling; federated content hosting might also be added on the platform later.
- Building mobile support through standard web implementation that leverage the capabilities of smartphones.
Proposed Architecture
The proposed architecture is intended for designing and configuring a Cloud Computing system that serve the educational purposes of universities in an economical and cost-efficient manner. It delivers a range of functionalities and services that map well onto Cloud Computing requirements and expectations. In the proposed solution, Virtual Labs are hosted on a publicly accessible cloud-based computer infrastructure that is connected through a high-speed, high-throughput redundant Internet connection. The on-demand instances of Virtual Labs run on a cluster of physical servers that are hosted in remote or local data centers. The physical infrastructure is designed for high-availability, redundancy, and future scalability. Virtual Labs can be accessed from many Internet-enabled devices, including smartphones (iPhone, Android, etc.) and any computer. Figure 6 depicts a high level overview of the proposed Virtual Labs-based LMS architecture.

Proposed architecture as depicted in Figure 6 is composed of:

- **Web and Application Servers**: The Web and Application servers serve the primary web interface for the cloud application.
- **Distributed Database**: Distributed document-based databases have recently gained wide adoption on Internet-scale applications. Distributed document-based Database does not store its information in rigidly defined tables typical of more traditional RDBMS
systems; rather, each record is stored as a “document”. Each “document” consists of multiple “fields” of data that serve a similar role to “columns” in the traditional RDBMS.

- **Cloud Middleware:** The internal plumbing layer underneath the cloud, Cloud Middleware is what makes the whole system one unified entity and transforms the e-Learning solution from cutting-edge SOA to bleeding-edge Cloud Computing Architecture. The Cloud Middleware is an essential component as it is the core layer that connects various subsystems together. The messaging bus connects various subsystems such as:
  - Central Authentication Service
  - Monitoring and Auditing Framework
  - Cloud Manager
  - Configuration Management Framework
  - Logging Framework
  - Billing System

Designing the Cloud Middleware includes the following activities:

1. Research the best technique for synchronous/asynchronous scalable message-driven bus system.
2. Design of ground-breaking logging technology that is decentralized for maximum throughput and asynchronous to ensure maximum efficiency and accuracy of the logging system.
3. Design of cloud-scale monitoring framework that allows detection of events, monitoring physical servers load, and network and I/O congestion on the storage backend.
4. Design of a cloud-scale configuration management framework that provides a decentralized configuration information inventory for every component of the system.
5. Set up a continuous integration build and testing system to ensure that there is no regression during the development time.
Figure 7 depicts some of the subsystems that will be integrated together. **Elastic Virtual Compute** comprises the cloud itself. **Cloud Manager** is what drives Elastic Virtual Compute. It configures Virtual Labs, spins VMs up and down, configures virtual networking between VMs, and so on. Cloud Manager interfaces with the Elastic Virtual Compute through various pluggable adaptor driver layers, each layer pertaining to a specific virtualization technology. As depicted in Figure 8, Cloud Manager is a central component of the solution, responsible for managing the Virtual Labs, starting and stopping VMs, taking and reverting to snapshots, and responding to user demands. Implementation of Cloud Manager includes implementation of the document-based database abstraction layer and writing code for model mapping into document-based schema-free style. Figure 9 depicts one of the data-centers that is based on VMWare virtualization technology and that adopts EMC’s storage technology to provide IaaS for the proposed Virtual Labs over a Cloud Computing solution.
Research Design and Issues
A significant question while implementing the proposed solution is; How is the Cloud-based Virtual Lab services accessed and which functionalities are provided by the Virtual Lab web interface? The following design issues must considered:

• **Social Network in every LMS**: Students must be able to track/connect with friends and communicate with learners interested in same/similar topics. The proposed solution also needs to leverage the existing social network data to collect information about friends and interests.

• **DM of learner behavior**: Such data can be used to build a personalized list of recommended courses, recommending people to follow, and guiding students when asking for help. The proposed solution needs to store every learner interaction to reflect its effect on the DM process.

• **Test different protocols for distributed task execution** and identify the information needed for accessing VMs.

• **Study industry standards** for content creation, and define standard file formats for content definition and entry.

• **Review networking, security, and performance choices** to ensure a highly secure, scalable, and high performance implementation of all solution components. Review technology choices for: Cloud Scaling, Monitoring, Orchestration and Provisioning, Continuous Integration, CDN, and Distributed DB.

• **Remote Access Protocol**: Remote desktop refers to software or an Operating System (OS) feature allowing applications, often including graphical applications, to run remotely on a server, while being displayed locally. There are various professional third party, open source, and freeware remote desktop applications, some of which are cross-platform across various versions of Windows, Mac, and UNIX / Linux / BSD. The main remote desktop protocols foreseen to be utilized in the proposed architecture is Virtual Network Computing (VNC) – a cross-platform protocol – and Remote Desktop Protocol (RDP) – a Windows specific protocol. VNC is the Remote Access Protocol to choose. It is fast and easy to implement in the web browser using pure HTML5 and JavaScript technologies. This kind of component interface is intended for human interaction allowing remote administration, observation, debugging, and configuration of components in a comfortable manner.
Massive Open Online Courses

Introduction

A Massive Open Online Course (MOOC) is an online course aimed at unlimited participation and open access via the web. In addition to traditional course materials such as filmed lectures, readings, and problem sets, many MOOCs provide interactive user forums to support community interactions between students, professors, and teaching assistants. MOOCs are a recent development in distance education, first introduced in 2008 and subsequently emerging as a popular mode of learning in 2012. MOOCs are among the latest e-Learning initiative to attain widespread popularity among many universities and have become a prominent feature of higher education discourse in recent years [70]. [41] presents important findings about MOOC, suggesting four reasons why students sign up for MOOC:

- the desire to learn about a new topic or to extend current knowledge
- curious about MOOC
- personal challenge
- desire to collect as many completion certificates as possible

Up to 90% of MOOC enrollees drop out due to reasons including a lack of incentive, failure to understand the content material and having no one to turn to for help, and having other priorities to fulfill. Findings suggest three main reasons why instructors wish to teach MOOC: being motivated by a sense of intrigue, the desire to gain personal (egoistic) rewards, or a sense of altruism.

Four key challenges of teaching MOOC are also surfaced:

1. difficulty evaluating students’ work
2. a sense of speaking into a vacuum due to the absence of immediate student feedback
3. being burdened by the heavy demands of time and money
4. encountering a lack of student participation in online forums

Early MOOCs often emphasized open-access features, such as open licensing of content, structure, and learning goals, to promote the reuse and remixing of resources. Some later MOOCs use closed licenses for their course materials while maintaining free access for students. The first MOOCs emerged from the Open Educational Repository (OER) movement. Early MOOCs did not rely on posted resources, LMSs, and structures that mix the LMS with more open web resources. MOOCs from private, non-profit institutions emphasized prominent
faculty members and expanded existing distance learning offerings (e.g. podcasts) into free and open online courses. Several well-financed American providers emerged, associated with top universities, including Udacity, Coursera, and edX.

In the fall of 2011, Stanford University launched three courses. The first was Introduction into AI, launched by Sebastian Thrun and Peter Norvig. Enrolment quickly reached 160,000 students. The announcement was followed within weeks by the launch of two more MOOCs, by Andrew Ng and Jennifer Widom. Following the publicity and high enrollment numbers of these courses, Thrun started a company named Udacity and Daphne Koller and Andrew Ng launched Coursera. Coursera subsequently announced university partnerships with University of Pennsylvania, Princeton University, Stanford University, and The University of Michigan. Concerned about the commercialization of online education, MIT created the not-for-profit MITx. The inaugural course, 6.002x, launched in March 2012. Harvard joined the group, renamed edX, that spring, and University of California, Berkeley joined in the summer. The initiative then added the University of Texas System, Wellesley College, and Georgetown University.

In November 2012, the University of Miami launched its first high school MOOC as part of Global Academy, its online high school. The course became available for high school students preparing for the SAT Subject Test in biology. In January 2013, Udacity launched its first MOOC-for-credit, in collaboration with San Jose State University. In May 2013 the company announced the first entirely MOOC-based Master’s Degree, a collaboration between Udacity, AT&T, and the Georgia Institute of Technology, costing $7,000, a fraction of its normal tuition. In May 2013, Coursera announced free eBooks for some courses in partnership with Chegg, an online textbook-rental company. Students would use Chegg’s e-reader, which limits copying and printing and could use the book only while enrolled in the class. In June 2013, the University of North Carolina at Chapel Hill launched Skynet University, which offers MOOCs on introductory astronomy. Participants gain access to the university’s global network of robotic telescopes, including those in the Chilean Andes and Australia. It incorporates YouTube, Facebook, and Twitter.
In September 2013, edX announced a partnership with Google to develop Open edX, an open source platform and MOOC.org, a site for non-xConsortium groups to build and host courses. Google will work on the core platform development with edX partners. In addition, Google and edX will collaborate on research into how students learn and how technology can transform learning and teaching. Some of the more well-known OER that helped shape the existence of MOOC include:

- Stanford Free Courses: [http://online.stanford.edu/courses](http://online.stanford.edu/courses)
- UC Berkeley Free Courses: [http://itunes.berkeley.edu/](http://itunes.berkeley.edu/)
  [http://webcast.berkeley.edu/series.html](http://webcast.berkeley.edu/series.html)
- MIT Free Courses: [http://ocw.mit.edu/index.htm](http://ocw.mit.edu/index.htm)
- Duke Free Courses: [https://www.coursera.org/duke](https://www.coursera.org/duke)
- Harvard Free Courses: [http://www.extension.harvard.edu/open-learning-initiative](http://www.extension.harvard.edu/open-learning-initiative)
- UCLA Free Courses: [http://www.openculture.com/freeonlinecourses](http://www.openculture.com/freeonlinecourses)
- Yale Free Courses: [http://ocy.yale.edu/](http://ocy.yale.edu/)
- Carnegie Mellon Free Courses: [http://oli.cmu.edu/](http://oli.cmu.edu/)
- MERLOT: [http://www.merlot.org](http://www.merlot.org)

**Selected MOOC’s Technology Stack**

MOOCs rely highly on third platform. The technology stack utilized by global MOOC providers like Udacity, Coursera, and edX is presented below. Please note that some of the information presented below are not derived from official sources as the first two providers are not open-source.

**Udacity**

Based on the information listed on [https://www.quora.com/What-is-Udacities-technology-stack](https://www.quora.com/What-is-Udacities-technology-stack) and from the discussions and answers of Udacity engineers, it is concluded that the main technology stack of Udacity is as follows:

- Udacity utilizes **Google App Engine (GAE)** for the back end: The scalability of GAE has been a huge benefit to the Udacity team. Udacity has a relatively small engineering team, and though GAE has certain characteristics, i.e. eventual consistency and random latency, the fact that the Udacity engineering team don’t have to sink a lot of time into server maintenance or hardware scalability and reliability is an important advantage.
• Udacity uses a **Python** variant of GAE because of the many Python advantages, including not only a widespread and fast learning curve.

• **MongoDB** for Analytics: Udacity collects lots of activity data into the NoSQL Document-based MongoDB. Everything from sign up events, to quiz results, to Twitter shares is collected in MongoDB. Storing and pulling data from MongoDB focuses on performance and flexibility. Collected data is used for Analytics. Examples of analytics include answering questions like: “Does encouraging students to share their progress on Facebook help them reach the end of the course?” Other useful questions might include looking for broken or unintentionally difficult quiz content. A huge benefit of MOOC is the ability to use large-scale data to improve how educational materials are delivered, and MongoDB has provided valuable time investment in database performance and maintenance.

• **Amazon Web Services (AWS)** for Code Execution: For programming assignments, students’ submitted code needs to be executed in a full environment. Udacity has a sandboxed grading system on AWS that is responsible for the code execution task. Utilizing Cloud Computing in the form AWS to address such a tough task has helped Udacity focus more on the core value; an enhanced e-Learning experience. Everything from simple Python programs, to massively CUDA code runs in this environment.

• **AngularJS** for JavaScript

• **Bootstrap** and **LESS** for styling
Coursera
From information available on http://stackshare.io/coursera/coursera and verified by http://stackshare.io/bryan-coursera, the Coursera Technology stack contains the following technologies categorized into the following layers as:

1. Applications and Data
   - jQuery: JavaScript UI Libraries
   - Node.js: Languages
   - Bootstrap: Frontend Framework
   - nginx: Web servers
   - MySQL: Databases
   - JavaScript: Languages
   - Amazon EC2: Cloud Hosting
   - Amazon S3: Cloud Storage
   - Django: Frameworks (full stack)
   - Scala: Languages
   - React: JavaScript UI Libraries
   - Backbone.js: JavaScript MVC Framework
   - Amazon RDS: SQL Database as a Service
   - Play: Frameworks (full stack)
   - Cassandra: Databases
   - Underscore: JavaScript Utilities and libraries
   - Stylus: CSS Preprocessors extensions
   - D3.js: Charting Libraries
   - Amazon Redshift: Big Data as a Service
   - Jade: Tinplating Languages and Extensions
   - kafka: Message Queue

2. Utilities
   - Amazon Cloud Front: Content Delivery Network (CDN)
   - Amazon Route 53: DNS Management
   - Amazon SES: Transactional Email
   - Braintree: Payment Services
   - Transloadit: File Uploads
   - AWS Data Pipeline: Data Transfer
3. DevOps

- **GitHub**: Code Collaboration and Version Control
- **Docker**: Virtual Machine Platforms and Containers
- **Data Dog**: Performance Monitor
- **Vagrant**: Virtual Machine Management
- **Pingdom**: Website Monitoring
- **Jenkins**: Continuous Integration
- **npm**: Front End Package Manager
- **Virtual Box**: Virtualization Platform
- **RequireJS**: Front End Package Manager
- **Phabricator**: Code Review
- **Mocha**: JavaScript Testing Framework
- **PagerDuty**: Monitoring Aggregation
- **Zookeeper**: Open Source Service Discovery
- **Apache Mesos**: Server Management

4. Business Tools

- **Slack**: Group Chat and Notifications
- **Google Apps**: Productivity Suite
- **JIRA**: Issue Tracking

Coursera presents the Coursera App Platform “currently in beta” that presents the capabilities of some integrations with enterprise systems, mainly LMS. Available integrations include:

- **OAuth 2 APIs**: Coursera powers its state-of-the-art web and mobile learning experiences with general-purpose APIs. The OAuth2 integration allows developers to build upon some of these same APIs in a secure manner.
- **Learning Tools Interoperability Standard (LTI)**: A standard that permits learning tools to integrate with LMS. Coursera is fully LTI 1.1 compliant, including accepting grade post-backs. Any LMS learning tool can plug into a Coursera course.
- **Catalog**: Coursera Catalog APIs enable third parties to easily obtain a list of all courses, sessions, instructors, and more. This API is publicly available with no authentication required. The catalog API is the API that powers the catalog feature in Coursera mobile apps.

- **Shibboleth / SAMLv2**: Partner schools can integrate with Coursera using Shibboleth or SAML2 to secure their private on-campus courses. Coursera is a registered service provider in the InCommon Federation. Additionally, Coursera metadata is available over http and https.

**Open edX**

From [http://code.edx.org](http://code.edx.org), Open edX is implemented mostly in Python for the server and JavaScript for the browser. The code is available under an AGPL license. The main repository is edx-platform which includes both the LMS and the authoring tool, Studio. Repositories include:

- **edx-platform**: edx-platform is the main repository covering both the LMS and the authoring tool, Studio. It also includes XModules (the courseware components that are being upgraded to the new XBlock architecture in the coming months) and various checkers.

- **Configuration**: Configuration provides a simple, but flexible, way for anyone to stand up an instance of the Open edX platform that is fully configured and ready-to-go. The reference platform is provisioned using an Amazon CloudFormation template. When the stack has been fully created there will be a new AWS Virtual Private Cloud with hosts for the core edX services. This template will build quite a number of AWS resources that cost money. The configuration phase is managed by Ansible. A number of playbooks that will configure each of the edX service is available on Open edx.

- **XBlock**: XBlock is the component architecture standard for building courseware. Open edX courses are built of XBlock learning components. XBlocks can be created by third parties to extend the functionality of Open edX and other learning platforms. There are two repos: one contains the core code for implementing XBlocks, the other is the SDK with tools for building XBlocks, including a simple workbench application for running XBlocks in a small testing environment.
• **edx-ora2 (Open Response Assessor):** The Open Response Assessor is a problem type that allows authors to ask open-ended questions that have long-form text responses, with the option to attach an image to the response. These problems include peer assessments and self-assessments, in which students grade each other and themselves, as well as example-based artificial intelligence assessments, in which an algorithm grades responses based on example responses that professors provide. Because humans grade responses in peer assessments and self-assessments, professors can ask questions that have more complex answers than other problem types. ORA also includes an optional student training section in which authors provide sample responses that help teach students how to grade responses.

• **CS Comments Service:** CS Comments Service is an independent comment system which supports voting and nested comments. It also supports features including instructor endorsement for education-aimed discussion platforms.

• **CodeJail:** CodeJail manages execution of untrusted code in secure sandboxes. It is designed primarily for Python execution, but can be used for other languages as well. Security is enforced with AppArmor.

• **XQueue:** XQueue defines an interface for the LMS to communicate with external checker services. For example, when a student submits a problem in the LMS, it gets sent to the XQueue, which then has the problem graded by an external service and sends the response back to the LMS.

• **XServer:** XServer accepts student code submissions from the LMS and runs the code using courseware checkers. This repo does not include the checker code.

• **notifier:** notifier sends daily digests of new content to subscribed forums users, with a goal of eventually supporting real-time and batched notifications of various types of content across various channels (e.g. SMS).

• **Analytics Dashboard:** edx-analytics-dashboard displays key metrics to instructors about enrollment, engagement, and performance of students in their courses.

• **Analytics Pipeline:** edx-analytics-pipeline analyzes data from tracking logs and edX databases and stores the results in a database that is exposed to consumers by the edx-analytics-data-api.
Third Platform Benefits in e-Learning Ecosystem

Introduction

Third Platform need not provide new digitization capabilities by itself. Instead, it should make strategic digitization capabilities like big data analysis, social networking, mobility, Internet of Things, and Cloud Computing more integrated and accessible by firms, their clients, and their customers [2]. As the main software for e-Learning, LMS has evolved from monolithic to services-based and is moving toward the future now. Examples include:

- More Social
- More Mobile
- Greater use of Analytics in e-Learning
- Greater use of Cloud Computing
- More Virtual Labs
- More Interactive
- Greater student involvement in the learning process
- More Collaborative
- Heightened focus on Pedagogical aspects

The developing technology landscape as seen by one major industry player is described in the IBM Global Technology Outlook 2013, which identifies the following major trends [2]:

- Mobile First
- Scalable Services Ecosystems
- Software-defined Environments
- Multimedia and Visual Analytics
- Contextual Enterprise
- Personalized Education

LMS would not have transitioned this way without the help of infrastructure and the adoption of Third Platform. The platform should enable enterprises to create, evolve, adopt, and use solutions based on current and future emerging technologies to achieve business value. It should do this in a business environment in which end users access the technologies directly and develop innovative business solutions [2]. Third Platform benefits in e-Learning can be grouped into two categories: pedagogical and technical benefits.
**Pedagogical Benefits**

**Enhanced Learning Experience**

Moving forward in Bloom’s taxonomy through an e-Learning ecosystem is an important achievement. Figure 10 presents the six phases of Bloom’s taxonomy that is widely known as “Revised Bloom’s Taxonomy”. Figure 11 introduces the deliverables from students at each phase. Students must go through phases iteratively to achieve the required learning objectives. Traditional learning methods will not achieve the required goals. Bloom’s taxonomy revised six phases are summarized as:

1. **Knowledge:** Student recalls or recognizes information.
2. **Comprehension:** Student changes information into a different symbolic form/language.
3. **Application:** Student solves a problem by using the knowledge and appropriate generalizations.
4. **Analysis:** Student separates information into component parts.
5. **Synthesis:** Student solves a problem by putting information together that requires original and creative thinking.
6. **Evaluation:** Student makes qualitative and quantitative judgments according to set standards.
Figure 10: Bloom’s Taxonomy Revised
Third Platform adoption in e-Learning ecosystem will have a direct effect on the learner. Enhanced learning experience will include new added features and values, such as:

- **Always-On:** Applications will be always-on, delivering information any time as needed.
- **Push vs. Pull:** Learner expectations of how information is accessed is changing from Pull to Push.
- **Context:** In a world of Attention Economy, relevance of services delivered is key.
- **Intuitive Interface:** Great experience need great interfaces. Tough, Gesture, and Voice interfaces are redefining how learner experience is delivered.
- **Multi-Screen:** Applications have to be available across screens (phones, PCs, Tablets, TVs, smart watches, etc.)
- **Elastic:** Applications have to scale elastically.
- **Experience:** Enterprise Applications need to match the experience of Consumer Applications.

Third Platform adoption in e-Learning, especially social networks and analytics to present what is known as Social Network Analysis (SNA), will give LMS capabilities to analyze social
networks formed by students and instructors. Such capability will help e-Learning understand students. SNA will help enhance the learning process, especially in:

- Student’s classification based on their learning performance.
- Detection of irregular learning behaviors.
- e-Learning system navigation and interaction optimization.
- Clustering according to similar e-Learning system usage.
- Group Students in Labs/Sections based on their preferences.
  - Matching Students with Students as Group in Social Network.
    - Labs/Sections.
    - Assignments.
    - Graduation Projects.
    - Study Groups.
  - Matching Students with Professors and Instructors as Group.
    - Choosing Supervisor.
  - Matching Professors with Researchers and other Professors.
    - Research Projects.

**Boundary-less Information and Knowledge Flow**

Sociotechnical systems recognized many years ago that organizations functioned most effectively when their social and technological networks were compatible [26]. Knowledge flows are invisible but very essential to achieve individual or organizational success. The application of IT in the continuation of education facilitates knowledge flow and makes its contents accessible regardless of an individual’s location and time [65]. Third Platform can act as enabler of information and knowledge flow, something that is essential in e-Learning and the way we hope children will consume learning.
Technical Benefits

Future LMS

Future LMS that is empowered by Third Platform will be:

- Intelligent
  - Auto scale and elastic.
  - Self-healing.
  - Dynamic and self-configurable.
  - Defensive.
- Context Aware
  - Awareness of user context.
  - Cross-channel experience.
  - Environment Awareness.
- Client Aware
  - Adapt to device capabilities.
  - Responsive to form factors.
  - Behave native.

Sustainable IT Services

Sustainable e-Learning Ecosystem features [21]:

- Track the situation of resource configuration and utilization in real time, allocate resources on demand, and make full use of resources.
- Allow workloads to recover from unavoidable hardware/software faults.
- Promote the evolvement or extinction of learning species (including learning contents, services, and applications).

Remote Virtual Labs

A Third Platform in e-Learning Ecosystem has enabled things that seemed impossible not so long ago, like presenting the capabilities of remote Virtual Labs. Automatics and Robotics subjects are always greatly improved when classroom teaching is supported by adequate laboratory courses and experiments following the “learning by doing” paradigm, which provides students a deep understanding of theoretical lessons, and taking students skills to higher levels in the above mentioned Bloom’s taxonomy. However, expensive equipment and limited time prevent teachers having sufficient educational platforms, and several low cost and flexible solutions have been developed to permit effective teaching in Automatics and Robotics at a
reasonable cost. Virtual and remote laboratories are inside this group of solutions as Web-based experimentation tools which have demonstrated the importance and effectiveness of hand-on experiences [42].

[40] describes an Internet-based Electrical Engineering Laboratory (IEE-Lab) with virtual and physical experiments at Zhejiang University. In order to synthesize the advantages of both experiment styles, the IEE-Lab came up with a Client/Server/Application framework and combines the virtual and physical experiments. The analog electronic experiment is an example to show Flex plug-in design, data communication based on eXtensible Markup Language (XML), experiment simulation modeled by Modelica, and control terminals’ design.

[12] describes results of the Cloud e-Learning for Mechatronics (CLEM) project. CLEM is an example of a domain-specific cloud that is especially tuned to the needs of Vocational Education and Training (VET) teachers. An interesting development has been the creation of remote laboratories in the cloud. Learners can access such laboratories to support their practical learning of mechatronics without needing to set up laboratories at their own institutions. The cloud infrastructure enables multiple laboratories to come together virtually to create an ecosystem for educators and learners. From such a system, educators can pick and mix materials to create suitable courses for their students and the learners can experience different types of devices and laboratories through the cloud. A holistic e-Learning experience can be obtained through use of static, dynamic, and interactive material together with facilities for collaboration and innovation.

[42] presents an experience teaching based on a blended-learning method using as experimentation tool a virtual and remote robotic laboratory called RobUALab, in Automatics and Robotics subjects of the Computer Science degree at the University of Alicante. Students experiment with a set of hand-on exercises about Automatics and Robotics using RobUALab, first in face-to-face classes where they experiment in-situ with the real plant and, afterwards, they access the experimentation environment to finish their practical exercises remotely outside the laboratory. The results obtained in the evaluation of the educational methodology proposed attest to its efficiency in terms of learning degree and performance of the students.
[10] reports a work-in progress at the Students Online Laboratory Through Virtual Instrumentation (SOLVE) at the National Institute of Technology, Surathkal, Karnataka on the design and implementation of a remote lab utilizing emerging technologies. [10] focuses on the basic implementation of a remote laboratory using the publisher-subscriber architecture. Control system and Vibration experiments were chosen for practical implementation which could be monitored and controlled by students using Internet. This enabled remote users to gain a better understanding of the concept of vibrations and control system by performing the real experiment at a time and place of their choice. Both publisher and subscriber were developed using LabVIEW and SCCT add-on for communication. SCCT provides high performance data communication on conventional platforms like LabVIEW, Android, HTML5, Java, and JavaScript, thereby making it a multiplatform approach.

[4] describes a 3D virtual lab environment that was developed using OpenSim software integrated into Moodle, a well-known LMS. A virtualized software tool was used to provide pedagogical support to the lab by providing the capability to create online texts and deliver them to the students. The courses taught in this virtual lab are methodologically conform to theory of multiple intelligences. [23] describes the approach to the design and implementation of a Virtual Learning Laboratory (VLL) with the use of Cloud Computing technologies within the model of Application as a Service (AaaS). The relation to learning objectives in accordance with the revised Bloom’s taxonomy was identified for each model.

The individuals’ cognitive skills, academic performance, and their relationship with programming of robots or virtual learning environment is a topic of particular interest in the area of human-robot interaction. [8] presents a pilot study performed on a group of 36 lower secondary school students involved in a 32-hours laboratory based on the combination of LEGO Mindstorm NXT and Microsoft Kodu Game Lab (KGL) and aimed at programming first a robot and further a more complete virtual world based on a narrative-designed scenario. The findings of the research highlight the effectiveness of using robotics and virtual world programming as a meaningful and playful learning environment for improving cognition in children.
Third Platform Concerns in e-Learning Ecosystem

No Clear Added Value
Not all organizations would be able to mine the true value of third platform investments. This is mainly because of the dependency factors such as type of business services/products, operating model, size, process functions, application stacks, tools integration, client geographies, user demographics, and so on. Hence, investing in these technologies without a thorough assessment and customized approach would not only miss realizing the value of those investments, but result in increased complexity and underutilized resources [39]. Moreover, e-Learning requires more responsibility and self-discipline for the learner to keep up with a more free and unconstrained learning process and schedule [9].

No Clear ROI Model
Third platform in e-Learning may cost more to develop. It requires new skills in content producers, and still has to clearly demonstrate ROI [9]. Related technology may be intimidating, confusing, or simply frustrating, lacking part of the informal social interaction and face-to-face contact of traditional classroom training. Enabling technology might also be costly, especially in cases of advanced visually-rich content. Business departments are buying systems directly, but they do so without thought for long-term needs. The systems may not be suitable for use in the long term, leading to additional purchases and higher cost. Piecemeal purchases and decisions that are micro-optimized for particular lines of business lead to sub-optimal overall architecture. There is duplication of resources, costs are unnecessarily high, and there may be security issues [2].

Ethical and Social Implications
Personalization in information systems can be considered beneficial but also ethically and socially harmful. Like many other technologies, the uptake of personalization has been rapid, with inadequate consideration given to its effects. Personalization in e-Learning systems also has potential for both harmful and beneficial outcomes, but less is known about its effects. The ethical and social hazards include privacy compromise, lack of control, reduced individual capability, and the commodification of education. Personalization is appearing in many systems already; thus, these hazards may already be occurring [5].
Third Platform Research in e-Learning
Marking Large Scale Complex Assessments

Currently, complex tasks incur significant costs to mark, becoming exorbitant for courses with a large number of students, as in MOOC. Large scale assessments are currently dependent on automated scoring systems. However, these systems tend to work best in assessments where correct responses can be explicitly defined. There is considerable scoring challenge when it comes to assessing tasks that require deeper analysis and richer responses. Structured peer-grading can be reliable, but the diversity inherent in very large classes can be a weakness for peer-grading systems because it raises objections that peer-reviewers may not have qualifications matching the level of the task being assessed. Distributed marking can offer a solution to handle both the volume and complexity of these assessments. A solution wherein peer scoring is assisted by a guidance system to improve peer-review and increase the efficiency of large scale marking of complex tasks is presented in [72]. The system involves developing an engine that automatically scaffolds the target paper based on predefined rubrics so that relevant content and indicators of higher level thinking skills are framed and drawn to the attention of the marker. However, large scale complex assessments remain a tough challenge that needs innovative solutions.

Realities of Interacting

Despite the hype and speculation about the role MOOC may play in higher education, empirical research that explores the realities of interacting and learning in MOOCs is in its infancy. MOOCs have evolved from previous incarnations of online learning but are distinguished in their global reach and semi-synchronicity. Thus, it is important to understand the ways that learners from around the world interact in these settings. In [34], three questions were asked: (1) What are the demographic characteristics of students that participate in MOOC discussion forums? (2) What are the discussion patterns that characterize their interactions? (3) How does participation in discussion forums relate to students’ final scores? Analysis of nearly 87,000 individuals from one MOOC reveals three key trends. First, forum participants tend to be young adults from the Western world. Secondly, these participants assemble and disperse as crowds, not communities, of learners. Third, those that engage explicitly in the discussion forums are often higher-performing than those that do not, although the vast majority of forum participants receive “failing” marks. These findings have implications for the design and implementation of future MOOCs and how they are conceptualized as part of higher education.
Metrics of Students’ Effectiveness

Present MOOCs do not provide teachers with precise metrics that represent the effectiveness of students with educational resources and activities. [76] propose and illustrate the application of the Precise Effectiveness Strategy (PES). PES is a generic methodology for defining precise metrics that enable calculation of the effectiveness of students when interacting with educational resources and activities in MOOCs, taking into account the particular aspects of the learning context. PES has been applied in a case study, calculating the effectiveness of students when watching video lectures and solving parametric exercises in four MOOCs deployed in the Khan Academy platform. Different visualizations within and between courses are presented combining the metrics defined following PES. Visualizations can help teachers make quick and informed decisions, enabling the whole comparison of a large number of students at a glance, and a quick comparison of the four MOOCs divided by videos and exercises. Also, the metrics can help teachers know the relationship of effectiveness with different behavioral patterns. Results from using PES in the case study revealed that the effectiveness metrics proposed had a moderate negative correlation with some behavioral patterns like recommendation listener or video avoider.

Personalized e-Learning

An educational-oriented approach for building personalized e-Learning environments that focus on putting the learners’ needs in the center of the development process is needed. [62] proposes user-centered design methodologies involving interdisciplinary teams of software developers and domain experts. It is illustrated in an adaptive e-Learning system, where MOOC was taken by nearly 400 learners. In particular, it is reported that user-centered design methods can be applied along the e-Learning life cycle to design and evaluate personalization support through recommendations in LMS.
Third Platform Future in e-Learning Ecosystem

Smarter Universities

[15] presents a paper where the current situation of education in universities, with particular reference to the European scenario, is being analyzed. Specifically, they observe that recent evolutions, such as pervasive networking and other enabling technologies have been dramatically changing human life, knowledge acquisition, and the way works are performed and people learn. In this societal change, universities must maintain their leading role. Historically, they set trends primarily in education but now they are called to drive the change in other aspects too, such as management, safety, and environment protection. The availability of newer technology reflects on how the relevant processes should be performed in the current fast-changing digital era. This leads to the adoption of a variety of smart solutions in university environments to enhance the quality of life and to improve the performances of both teachers and students. In fact, universities should become smarter. By smarter university, [15] means a place where knowledge is seamlessly shared between employees, teachers, students, and all stakeholders. Smarter universities will be helpful and will integrate into smarter cities.

Virtual Campus and Group Awareness

It is often found that distributed learning teams are confronted by several difficulties during the process of knowledge construction. When compared to face-to-face contexts, learners and their teams are offered a higher degree of flexibility in the context of distance learning. When engaged in Computer Supported Collaborative e-Learning, students must also face Computer Mediated Communication difficulties and time flexibility challenges. Within this context, it is essential that the members of the group develop the correct level of interpersonal knowledge about one another to help them develop the feeling that they belong and are part of a team. Given that in Computer Learning Environments, the contextual cues available in Face-to-Face contexts are not available to students, certain tools such as Group Awareness widgets is needed to help compensate for the shortcomings of the e-Learning and thus enhance the Group Awareness in the distributed learning teams.

Educational Virtual World

[16] explores data retrieved from an Educational Virtual World to identify and validate behavior and usage patterns and engagement indicators. This data exploration is intended not to validate pre-defined questions or specific goals (for example, a comparison between engagement and academic scores), but to discover usage trends and obtain insights about users’ usage of the
system and their knowledge of and proficiency with the available resources and features. The engagement indicators and knowledge obtained from the analysis of these indicators regarding the users of the system, their desires, and their competencies with virtual resources will facilitate decision-making and planning by managers of the Virtual World to improve system adoption and learning effectiveness, correct usage mistakes, perform actions to enhance user exploitation of available features, and provide information to users on system usage. This knowledge and the actions based on it are capital in an e-Learning ecosystem such as an Educational Virtual World, where students are able to perform tasks in 3D at any time or location without supervision.

**Social Networks Analysis in e-Learning**

SNA will continue to play important rule in the future of third platform in e-Learning. The increasing use of Enterprise Social Network (ESN) generates vast amounts of data, giving researchers and managerial decision makers’ unprecedented opportunities for analysis. However, more transparency about the available data dimensions and how these can be combined is needed to yield accurate insights into the multi-faceted phenomenon of ESN use. To address this issue, [77] conducted a systematic literature review to identify available data dimensions and integrated them into a conceptual framework. This framework was then adopted as part of a mixed methods research approach to comprehensively analyze an empirical ESN case. With results serving as a proof of concept, [77] shows the insights that can be derived from different data dimensions and how combining these can improve the validity of the analysis. The application of the framework also allows a detailed guideline for combining different data sources in ESN analysis to support researchers and decision makers to be derived.
Conclusion

Digital Ecosystem is a digital environment populated by digital species that can be software components, applications, online services, information business models, and other components. Extending a digital ecosystem to e-Learning defines an e-Learning Ecosystem as the learning community, together with the enterprise, united by LMS. Platforms are creating an entirely new blueprint for competition, one that puts ecosystems in head-to-head competition. Third platform is a loosely-defined computing platform that includes technologies becoming commonly available early in the second decade of the twenty-first century, mainly: Social, Mobile, Analytics, and Cloud (SMAC). Third platform is a promising platform for e-Learning ecosystem. Monolithic and services-based LMS has turned into social and cloud-based Massive Open Online Courses (MOOC) that are available through mobile devices to serve hundreds of thousands of students with the help of third platform technologies. Remote and Virtual Labs has become available through third platform as well.

Proposed e-Learning ecosystem supportive software consists of different interoperable services working together to achieve the required goals. Services are grouped into layers, with each layer forming certain functionality. Services can be hosted internally in the organization or in the cloud. In both cases, services have to deal with learners’ activities on external sites. e-Learning ecosystem supportive software needs to include intelligent services. Cloud Computing can be used to provide on-demand virtual desktops for problem solving and on-demand Virtual Labs for special courses. Infrastructure as a Service (IaaS) provides Virtual Machines (VMs) on demand for students. These machines are customized for courses and laboratory exercises and provisioned to build virtual laboratories. Platform as a Service (PaaS) goes a step further and offers the students a framework to deploy their developed programming exercises on a well-defined environment. Finally, Software as a Service (SaaS) makes software services, i.e. lecturing assist tools or development tools, available for multiple users.

MOOC is an online course aimed at unlimited participation and open access via the web. In addition to traditional course materials such as filmed lectures, readings, and problem sets, many MOOCs provide interactive user forums to support community interactions between students, professors, and teaching assistants. MOOCs adopt third platform in e-Learning ecosystem in different ways. MOOCs highly rely on third platform. Technology stack utilized by global MOOC providers like Udacity, Coursera, and edx was presented, highlighting their integration of social media into the learning experience, capabilities to present learning through
mobile devices, utilization of big data analytics to answer advanced questions, and their reliance on Cloud Computing to present scalable services.

Adopting third platform in e-Learning had already presented tremendous benefits. Pedagogical benefits include the enhanced learning experience, as students right now can apply what they learn in Virtual Labs, and can discuss and share ideas and knowledge collaboratively. Such capabilities move the learning curve into newer areas that were not available before. Social Networks and Big Data Analytics present what is known as Social Network Analysis (SNA) that gives LMS capabilities to analyze social networks formed by students and instructors. SNA will help enhance the learning process. Boundary-less information and knowledge flow is another pedagogical benefit. Knowledge flows are invisible but very essential to achieve individual or organizational success. The application of third platform in e-Learning ecosystem facilitates knowledge flow and makes its contents accessible regardless of an individual's location and time. Technical benefits of adopting third platform in e-Learning ecosystem are many. Future LMS that is intelligent enough to present personalized e-Learning experience will become applicable. Sustainable IT services capable of tracking resource configuration and utilization, and automatically present services like load balancing will be available. Remote virtual labs is one of the main gains of third platform in e-Learning ecosystem, especially when it comes to advanced learning topics like robotics. Several case studies and research topics related to remote and virtual labs were presented.

Adopting third platform in e-Learning ecosystem does introduce concerns. Not all organizations would be able to mine the true value of third platform investments. Investing in third platform technologies without a thorough assessment and customized approach would not only miss realizing the value of those investments, but result in increased complexity and underutilized resources. Third platform in e-Learning may cost more to develop. It requires new skills in content producers, and still has to clearly demonstrate a return on investment. Related technology may be intimidating, confusing, or simply frustrating, lacking part of the informal social interaction and face-to-face contact of traditional classroom training. Personalization in information systems can be considered beneficial but also ethically and socially harmful. Like many other technologies, the uptake of personalization has been rapid, with inadequate consideration given to its effects.

Third platform adoption in e-Learning ecosystem presents different research topics. Marking large scale complex assessments is an important one. Currently, complex tasks incur significant
costs to mark, becoming exorbitant for courses with a large number of students, as in MOOC. Large scale assessments are currently dependent on automated scoring systems. However, these systems tend to work best in assessments where correct responses can be explicitly defined. There is considerable scoring challenge when it comes to assessing tasks that require deeper analysis and richer responses. Realities of Interacting is another topic. Despite the hype and speculation about the role MOOC may play in higher education, empirical research that explores the realities of interacting and learning in MOOCs is in its infancy. MOOCs have evolved from previous incarnations of online learning but are distinguished in their global reach and semi-synchronicity. Thus, it is important to understand the ways that learners from around the world interact in these settings. Metrics of Students' Effectiveness need to be identified, detected, and measured. Present MOOCs do not provide teachers with precise metrics that represent the effectiveness of students with educational resources and activities.

The future of Third Platform in e-Learning ecosystem include Smarter Universities, Virtual Campus and Group Awareness, Educational Virtual World, and SNA. Universities should become smarter. Smarter University is a place where knowledge is shared seamlessly between employees, teachers, students, and all stakeholders. Smarter universities will be helpful and will integrate into smarter cities. Tools such as Group Awareness widgets are needed to help compensate for the shortcomings of the e-Learning and thus enhance the Group Awareness in the distributed learning teams. Educational Virtual World, where students are able to perform tasks in 3D at any time or location without supervision will be the future of e-Learning. SNA will continue to play an important role in the future of Third Platform in e-Learning.
Acronyms

- **AI**: Artificial Intelligence.
- **AWS**: Amazon Web Services.
- **BIM**: Business Impact Management.
- **BPM**: Business Process Management.
- **BPMN**: Business Process Modeling Notation.
- **CDS**: Content Delivery System.
- **CRM**: Customer Relationship Management.
- **CS**: Computer Science.
- **DM**: Data Mining.
- **DSS**: Decision Support System.
- **EDM**: Educational Data Mining.
- **ERP**: Enterprise Resource Planning.
- **ESN**: Enterprise Social Network.
- **GAE**: Google App Engine.
- **ICT**: Information and Communication Technology.
- **IoT**: Internet of Things.
- **ISM**: Information Storage and Management.
- **IT**: Information Technology.
- **ITU**: International Telecommunication Union.
- **LMS**: Learning Management System.
- **LO**: Learning Object.
- **LTI**: Learning Tools Interoperability Standard.
- **M-Learning**: Mobile Learning.
- **MOOC**: Massive Open Online Courses.
- **NGO**: Non-Governmental Organizations.
- **OER**: Open Educational Repository.
- **PES**: Precise Effectiveness Strategy.
- **SMAC**: Social, Mobile, Analytics, and Cloud.
- **SNA**: Social Network Analysis.
- **SOA**: Service Oriented Architecture.
- **XML**: eXtensible Markup Language.
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