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Technological Approaches for E-Content Development and Deployment

A Qualitative Analysis From Experts' Perspective

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ABSTRACT

Success of any web product and application relies upon how thoughtfully and wisely technology has been implemented for developing and deploying that product – be it e-commerce product or e-learning product. Alongside pedagogy, application of appropriate technology is the important determinant for an effective and engrossing learning experience of any e-content or e-learning system. To understand the proper utilization of IT strategies for e-content development, the qualitative method of research has been used in this study by which content analysis has been done on the interviewed data, gathered from the IT professionals, with the help of Atlas.Ti software. The findings of this study suggest how web technology can be deployed for e-content in the five identified stages, namely – programming language, web application framework, presentation/design, content creation and server-side technology including cloud storage. For this, a comprehensive technical guideline along framework for e-content development and deployment has been formulated.

KEYWORDS

E-Learning System, ICT, System Architecture, Three Tier Architecture, Web And Server Technology

1. INTRODUCTION

Due to the emergence of new media and digital devices along with their value-added fascinating applications, today's education and learning seems to be expanding beyond the walls of the classroom. This educational scenario, which is a result of combining the educational contents with information technologies or ICT (Information and Communication Technology), has come up with different forms of e-contents and e-learning applications. Online learning, web-based learning, networked learning, digital learning, technology-based learning, technology enhanced learning, technology assisted learning, technology mediated learning, ICT enabled learning, virtual learning and mobile learning are some of the different notions for e-learning. Similarly, multimedia based interactive tutorial, web based lectures, learning objects, simulation and virtual reality based learning systems, open course ware (OCW), open educational resources (OER), massive open online courses (MOOCs) are some of the major examples of different e-learning applications based on their approaches for e-content development. Due to such diversities in e-learning concept, coming up with a well-accepted single definition of e-learning is a very challenging task which is also observed by many authors e.g. Arkorful and Abaidoo (2015); Oblinger and Hawkins (2005); Sangra, Vlachopoulos, and Cabrera (2012). Therefore, in simple terms e-learning can be defined as instruction delivered on a digital

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device (such as a desktop computer, laptop computer, tablet, or smart phone) that is intended to support learning (Clark & Mayer, 2016). Basically, all the e-learning applications are meant to offer educational contents therefore they may be considered as e-content, and both the terms will be used, interchangeably, in this paper.

e-learning unites two main areas, learning and technology. Learning is a cognitive process for achieving knowledge, and technology is an enabler of the learning process (Aparicio, Bacao, & Oliveira, 2016). Therefore, technology, besides pedagogy, is also the basic prerequisite and essential part of all these e-learning applications because without it no application or e-content can be created. The role of technology becomes more critical when it is applied for shifting the learning from traditional didactic or expository learning to active and interactive learning (Means, Toyama, Murphy, Bakia, & Jones, 2009). Basically, in e-learning systems, technology is the only interface or window which facilitates interaction between instructor/content and learners therefore it can make or mar the whole e-learning experience. Thus, according to Eom, Ashill, Arbaugh, and Stapleton (2012), technological conceptualization and deployment are two important factors for the success of e-learning systems. Technology has always been with us until it is used rationally and wisely, and if not so, any attempt to develop technology-based learning application may become futile.

Before going to further sections, it would be nice to have an idea about the structure of the paper. The paper is structured as follows: having introduced the main topic, the next section is going to set the background of study i.e. role and importance of technology in education and e-learning by reviewing the recent literature which also rationalizes the undertaken study. Thereafter, methodology section explains about sample selection, tool preparation, procedure of data collection and data analysis. After this, results and findings section comes up with the description of the three stages crucial for e-content development and deployment: system architecture; web and server technologies; CMS, LMS and standards. In the next section, guidelines and technical framework are formulated and described based on the findings. In the last section, paper gets concluded by stating the scope, significance, implication, recommendation and limitation of the study along with future suggestion.

2. BACKGROUND

Technologies in developed countries are in developed stage while in developing nations they are comparatively in developing stage. Therefore, it may be deduced that the technological development and economic development are positively correlated, and the same is with knowledge economy which is also indicated by Al-Smadi (2013); Barkhordari, Fattahi, and Azimi (2018); Hadad (2017). Worldwide, the average Gross Enrollment Ratio (GER), a benchmark for educational attainment, is around 34.45% in higher education wherein developed countries seem to be contributing more than the average; on the other hand, developing countries appear to be posting less than the average (The World Bank Group, 2017).

In order to increase global GER, the efforts should be made at larger regional basis where educational indicators are compromised. In this effort, Asia, being the biggest continent of the world in terms of area and population, needs to contribute the most in educational attainment because it also has the largest youth population. Although, enrolment in higher education has experienced explosive growth across Asia over the last 20 years (Varghese et al., 2014) but the available data shows that the Asia and Pacific region has a long way to go to improve access and quality of education for all (Zhang, 2017). In this continent, India has the world's highest youth population according to Social Statistics Division of Government of India (2017) therefore much educational investment is warranted in developing and emerging knowledge economy like India. In this context, India is leaving no stone unturned by creating more educational opportunities and infrastructure with the help of various e-learning applications by exploring ICT potential. One such remarkable mission, initiated by Government of India via its Ministry of Human Resource Development in 2009, was National Mission on Education through Information and Communication Technology (NME-ICT). Under

this mission project, so many e-content projects have been initiated and the few major initiatives are NPTEL, e-pathshala, CEC's e-content, Virtual Labs, SWAYAM and so on (MHRD-GOI, n.d.).

All these projects were conceived to cater the curricula of different subjects and disciplines, therefore under each e-content project, 100 to 10000 e-learning modules have been created and deployed on the Internet. Altogether this ICT based project is having a database of more than 50000 e-learning modules and this number keeps on increasing as it is ongoing. Because of which, India as of 2015 has become the second largest market for e-learning after the United States (Docebo, 2016). However, in terms of revenue India ranked fifth in the top seventeen e-learning buying countries in 2016 (Adkins, 2016). But in global ICT development index, India has ranked 138th out of 175 countries, according to Measuring the Information Society Report 2016 issued by the International Telecommunications Union (ITU, 2016). When India seems to be lagging behind in this ICT development index, then it would be relevant to understand ICT deployment approaches, adopted in India, in the process of e-content development particularly from a technical perspective. Sometimes it is observed that policy-makers and even technocrats get so fascinated with technological offerings that they may use it less wisely without exploring its fullest potential. Maybe for this reason, Bates (1999) has stated long back that wise use of technology can simultaneously widen access, improve the quality of teaching and improve the cost-effectiveness of education. But using technology for technology's sake may not be the best strategy supporting good teaching practices (Amirian, 2003). While new technologies offer considerable opportunities for improved learning, their use however has remained as a plug-on to traditional teaching methods (Narayan, Davis & Gee, 2012).

The role of Pedagogical Content Knowledge (PCK) in teaching and instruction given by Shulman (1986), and Shulman (1987) remains incomplete without technology therefore Mishra and Koehler (2006) have extended this PCK notion to Technological Pedagogical Content Knowledge (TPACK) framework by integrating technology into teachers' pedagogy with content knowledge. The TPACK framework has been a remarkable milestone in the journey of learning because it explains the influence of technology in the present era of technology mediated teaching-learning process. The relevancy of this TPACK framework in different technology based learning modes is still significant which is evident in the work of many authors such as Malik, Rohendi, and Widiaty (2019); Maor (2017); Setuju et al. (2018), and so on.

As appropriate technological implementation has come out as important determinant of an effective e-content system, therefore so many authors have suggested different technological options for the development of e-learning applications. A supportive literature review, in this regard, has been briefly summarized in Table 1 by covering only last two years research work i.e. from 2017 to 2018 because technology is changing very fast.

Based on above literature review it is concluded that all the technological options and frameworks were proposed to address particular learning need and context but no comprehensive framework, covering a wide range of suitable technological options, has been found on the basis of which a full-fledged e-content system may be rolled out and developed. Therefore, the researchers have taken this work for further study. As maximum work has been devoted to e-learning framework formulation, therefore authors have also tried to formulate an IT based technical framework as result of this study.

So, what kind of technology may be used while designing the e-learning system and developing e-content to cater today's smart learners better known as millennials and digital natives who have optimum exposure of different technological options – is one monster question which constantly needs to be fed and answered. To answer this question, the view and opinion of IT professionals is warranted. The purpose behind exploring the technical perspectives of IT professionals is to come up with comprehensive guidelines and framework for e-content development and deployment, which could give optimal learning outcome while keeping pace with new technological development and changing paradigm. Meeting the educational expectancies alone, of today's learners, cannot assure the success of the e-learning system until their technological expectancies are also taken into due consideration.

Table 1. Recent studies about technological implementation for e-learning application development

Proposed Technological Implementation Options	Author
Theoretical framework and architecture for designing Smart Learning Environment	Karoudis and Magoulas (2017)
Framework and architecture for developing e-learning contents based on collaborative design & concept maps	El Mhouti, Nasseh, Erradi, and Vasquèz (2017)
Personalized e-learning framework	Alhawiti and Abdelhamid (2017)
Three tier architecture based dynamic mobile ad hoc e-learning system design and development framework	Aruna and George (2017)
Architecture for implementing cloud computing in e-learning	El Mhouti, Erradi, and Nasseh (2018)
Framework for creating augmented reality based mobile application as learning tools	Mota, Ruiz-Rube, Dodero, and Arnedillo-Sánchez (2018)
Big data-based framework for e-learning systems to handle learning related massive data and respond accordingly using learning analytics	Huda, Haron, Ripin, Hehsan, and Yaacob (2017); Elhoseny, Elhoseny, Riad, and Hassanien (2018); Huda, Maseleno, Atmotiyoso, Siregar, Ahmad, Jasmi, and Muhamad (2018)
Application of Machine Learning techniques and approaches for online learning and e-learning systems	Maina, Oboko, and Waiganjo (2017); Al-Shabandar, Hussain, Laws, Keight, Lunn, and Radi (2017)
J2EE architecture-based e-learning system to address the problems existing in traditional teaching.	Zhang, Wang, and Zhang (2018)

3. METHODOLOGY

Keeping in view the objective of this study i.e. to explore different suitable technological approaches along with developing a guiding framework for e-content system, a qualitative approach to the research has been adopted. Because the study is intended to know the views, opinion and perspective of the experts which could not be measured in quantity, rather it is going to be a qualitative data coming from the experts with detailing and descriptions about different technological implementation options. As the intended result about theorizing the technical framework is supposed to be embedded or grounded in interviewed data therefore grounded theory approach of qualitative research has further been followed. Grounded theory is a general methodology for developing theory that is grounded in data systematically gathered and analyzed (Strauss & Corbin, 1994). It is designed to generate or capture an explanation (theory) of a process, action, or interaction (Olson, 2017). Participants in the study would all have experienced the process, and the development of the theory might help explain practice or provide a framework for further research. A key idea of this grounded theory is that the development does not come "off-the-shelf," but rather is generated or "grounded" in data from participants who have experienced the process (Strauss & Corbin, 1998). The same approach has been followed in this study i.e. to develop theory (in the form of guidelines) and framework by extracting it from the gathered interview data of the IT experts.

3.1 Sample

The purposive type criterion sampling has been used to form a sample of IT Professionals to know their technical perception towards e-content. For this, experienced and expert insights from the IT professionals for e-content development and deployment was needed and that is why criterion sampling was selected by which only those cases were selected who met the predefined criterion of significance for gathering in-depth information with reference to the objectives of the study (Patton, 2002). The prerequisites or criteria for selecting the sample of IT professionals were:

- The IT professionals should have minimum 10 years of experience in IT Industries.
- Some of the IT experts should be senior System Architects so that they can give insights about architecture aspects of e-content.
- Some of the IT experts should be Chief Technical Officers who can comment and guide web technologies for e-content.
- Some of the IT experts should be at Director level who can visualize the whole execution process for e-content development.
- Some of the IT experts should be from IT Faculties so that they can give their academically balanced IT perspective.
- Rest of the IT experts should be Software Engineers, Technical Leaders and Programmers.

Based on fulfilling these criteria, a sample of 20 IT experts or professionals ($N = 20$) was finally constituted though it was targeted to 50 respondents. Appropriate sample size in qualitative studies may be determined by the concept of saturation as recommended by Glaser and Strauss (1967). Saturation occurs when adding more participants to the study does not result in additional perspectives or information. In such scenario, Creswell (1998) suggested to take a sample of 20 – 30 for the interview. Therefore, the sample of 20 valid responses/submissions (40% response rate) may be considered to be good enough. The sample constitution is tabulated in Table 2:

This pool of IT professionals was selected from various parts of the world i.e. 75% (15) from Indian IT domain and 25% (5) from International IT domain.

3.2 Tools: Interview Guide for IT Professionals

In order to understand appropriate technological approaches for e-content, the IT professionals have been contacted and interviewed by using an interview guide which was finalized after incorporating feedback and suggestions of expert panel followed by pretesting with no further suggestions in the third draft. The final guide has three major open-ended questions:

1. What kind of system architecture would you suggest for developing and hosting the e-content system?
2. What kind of web technology and server technology would you suggest for e-content development?
3. Can e-content be developed based on certain LMS, CMS or standards such as SCORM and other programming models? If yes what kind of LMS, CMS may be recommended.

3.3 Procedure of Data Collection

Interview of the IT professionals was carried out by using an interview guide, having three open ended detailed questions, either through e-mail for their written responses or through telephonic interviews, as per their convenience. Since the nature of the open-ended questions was very detailed

Table 2. Sample constitution

Expertise Domain/Designation of Participants in Sample Constitution	Number of Participants
Software Engineers. Technical Leaders, Programmers	9 (45%)
System Architects	4 (20%)
Director-IT program	4 (20%)
IT Faculties	2 (10%)
Chief Technical Officer (CTO)	1 (05%)
Total	20 (100%)

and comprehensive thus experts preferred to give their well thought written responses in comparison to interview. The Interview guide included the purpose of the research along with the hyperlink of Indian e-content projects for reference (http://mhrd.gov.in/e-contents).

3.4 Data Analysis

Qualitative analysis has been done using content analysis method. In this regard, Atlas.ti 7.0 qualitative data analysis software was used so that repeated ideas, concepts in the collected data become apparent, and are tagged with codes which further can be grouped into concepts, and then into categories for searching the themes, relationships, frequency and patterns. These categories may become the basis for new formulations. The ultimate objective of this analysis was to formulate comprehensive guidelines along with framework for e-content development from the technical perspective.

4. RESULTS AND FINDINGS

4.1 System Architecture for e-Content

The result in response to first open ended question, in regard to what system architecture can be suggested for e-content development and deployment, has been summarized in Table 3. Just as a hint to read this table and subsequent tables, frequency may be referred to understand the weightage given to particular key concept as well as to some sub-category/grouped concept also, in some cases. All the concepts and subcategories/grouped concepts then get grouped into relevant category, and for that group frequency may be referred. It may also be noted that group frequency, as a collection of various frequencies, may go above the sample size (n=20) because one concept was sometimes given more than one time by a respondent in different contexts.

From the frequency analysis of suggested system architectures for e-content development and deployment, the three-tier architecture was the most frequently suggested architecture followed by some similar architecture suggestions such as layered component based architecture and n-tier architecture.

Different technologies and frameworks have been recommended for three tier architecture which consists of presentation layer; middle layer; backend/storage; and communication layer.

For presentation layer or web tier, which mainly consists of web servers, IT professionals suggested AngularJS, HTML5, CSS3, Bootstrap, JavaScript, Play Framework. For the backend support, RDBMS Server kind of database technology has been suggested for content storage & fast retrieval. It was also suggested to use Content Delivery Network (CDN) such as Amazon S3, Akamai for very large-scale data and content deployment with efficient and fast delivery. For improved caching mechanism, Redis and Memcache kind of technological concepts can also be applied in backend of the system. Hybrid Model was also suggested for implementation in backend tiers database technology.

Layered component-based architecture was the second choice of the IT professionals after three tier architecture. Further, if large scale content deployment is a need, the IT professionals suggested the usage of n-tier architecture which is an extension or advancement of three tier architecture and layered component-based architecture.

IT professionals also suggested cloud and REST architecture in order to reap maximum advantages of advancing technologies for an efficient e-content system so that it can easily handle increasing data (big data), users and hits. In cloud architecture Amazon Web Services (AWS) was the first choice followed by Google App Engine and Azure. The result may also be interpreted through Figure 1, created with the help of codes networking feature of the Atlas.ti software.

4.2 Web and Server Technologies for e-Content

The result in response to second open ended question, with regard to what web technology including server-side technology can be suggested for e-content development and deployment, has been summarized in Table 4.

Table 3. Frequency analysis for system architecture for e-content development and deployment

S. N.	Category	Key Concept	Frequency	Group Frequency
1	Three Tier Architecture			35
1.1	Presentation Layer/ Web Tier		14	
		Web Server	3	
		AngularJS	2	
		HTML5, CSS3	2	
		Bootstrap	2	
		Javascript	2	
		Play Framework	1	
		Edge Servers	1	
		Apache Technologies based	1	
1.2	Middle Layer/Business Layer/Application Tier		8	
		Application Server/Web Application Framework for content management	8	
1.3	Backend/Data Layer/ Storage		10	
		Database Technology for content storage & fast retrieval such as SQL Servers	4	
		Content Delivery Network (CDN) such as Amazon S3, Akamai	3	
		Caching Mechanism such as Redis & Memcache	2	
		Hybrid Model	1	
1.4	Communication Layer		3	
		HTTP(s), EDI, offline	3	
2	Layered Component-based Architecture			6
		Web Portal (User Interface)	2	
		Content Management Layer (Delivery)	2	
		Database Content Layer	2	
3	n-tier Architecture			5
		Interface Layer	1	
		Content Management Layer	1	
		Application Integration Module	1	
		Peripheral Services Layer	1	
		Content Repository Layer	1	
4	Cloud based Architecture			4
		Amazon Web Services (AWS)	2	
		Google App Engine	1	
		Azure	1	
5	REST Architecture			4

Five stages of web technology are important for any system development, which have also been recommended by experts for e-content system, namely – programming language, web application framework, presentation/design, content creation and server-side technology including cloud storage.

Figure 1. System architecture for e-content development and deployment

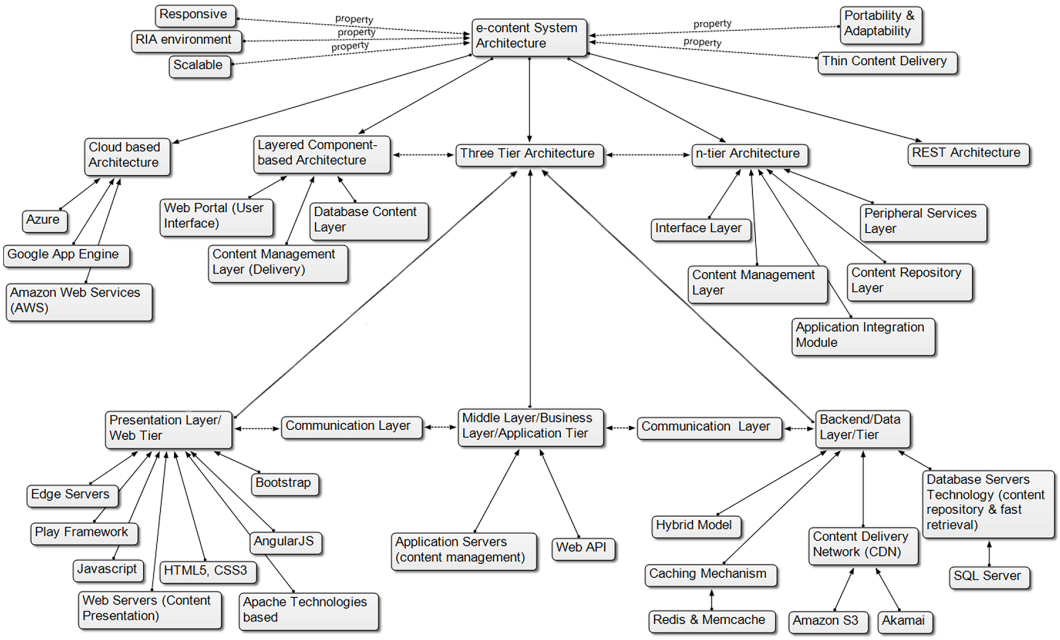


Figure - 1: System Architecture for e-Content Development and Deployment

Within each stage, different technological options were suggested and accordingly prioritized in the frequency table.

For programming language for e-content, the experts, most frequently, suggested Java followed by PHP, Python and Perl. In respect to web application framework, the most frequently suggested framework was AngularJS followed by JQuery, AJAX and then React.js.

For presentation & template design of the e-content, HTML5/CSS3, JavaScript or Bootstrap can be used. Further, for content creation, the experts have suggested four ways, by using – authoring tools, authoring API, Content Management System (CMS) and Learning Management System (LMS). In general, the maximum suggestions have gone with CMS by which small scale as well as large scale content deployment can be done and this will be dealt in detail during the analysis of 3rd question which is all about CMS & LMS.

J2EE and Rest based APIs were the most suggested server side technologies and platforms. Node.js, jBPM, DotNet, NoSQL, PHP5/MySQL and LDAP can also be used for database management of the e-content system. When it comes to cloud based storage and computing for content repository and fast retrieval, Amazon Web Services (AWS) stole the show by getting most number of recommendations. The other choices for cloud storage were Microsoft Azure, Linode and Cloudera. The result may also be interpreted through Figure 2, created with the help of codes networking feature of the Atlas.ti software.

4.3 CMS, LMS and Standards for e-Content

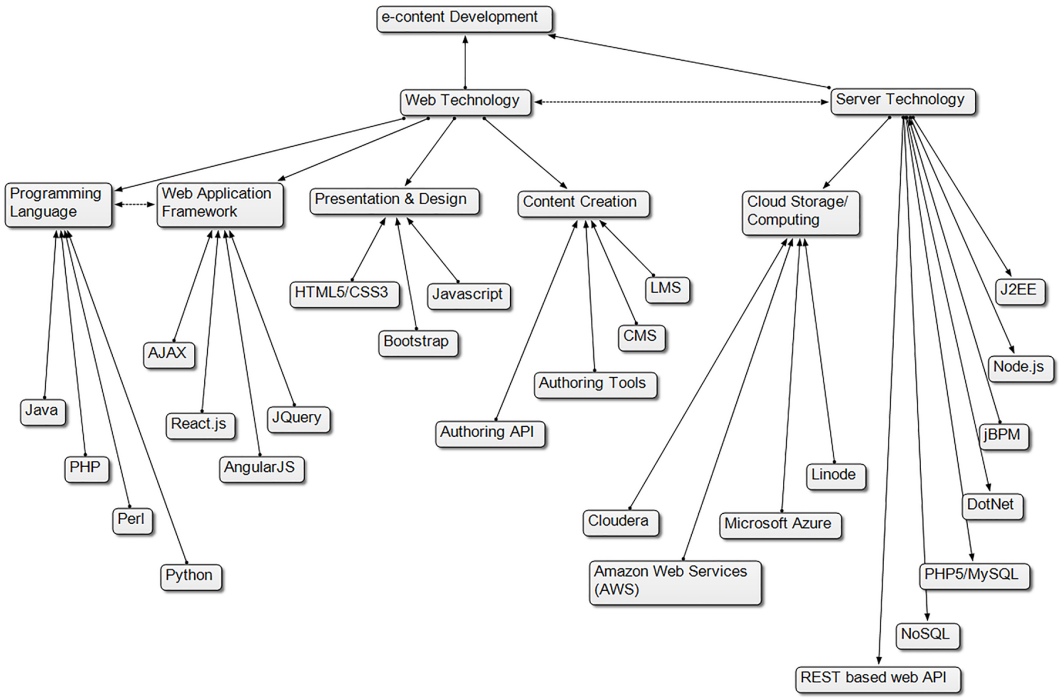
The result, in response to the third open ended question regarding if any CMS, LMS or standard can be used to develop e-content and its packaging, has been summarized in Table 5.

As a result of frequency analysis in regard to what LMS, CMS or Standards can be adopted to develop and package e-content web application, it was recommended that e-content can also be developed using some LMS or CMS or standards instead of using dedicated web technologies

Table 4. Frequency analysis for web and server-side technology for e-content development

S.N.	Category	Key Concept	Frequency	Group Frequency
1	Programming Language			14
		Java	6	
		PHP	3	
		Python	3	
		Perl	2	
2	Web Application Framework			14
		AngularJS	5	
		JQuery	4	
		AJAX	3	
		React.js	2	
3	Presentation & Template Design			14
		HTML5/CSS3	6	
		JavaScript	5	
		Bootstrap	3	
4	Content Creation			19
4.1	Authoring Tools		1	
4.2	Authoring API		3	
		Tin Can API	2	
		SCORM	1	
4.3	Content Management System (CMS)		11	
		Drupal	2	
		Joomla	2	
		IBM Content Management System	1	
		ORACLE WebCenter content	1	
		DjangoCMS	1	
		Alfresco	1	
		Adobe CQ5	1	
		Apache Sling	1	
		eXo Platform	1	
4.4	Learning Management System (LMS)		4	
		Blackboard	2	
		Moodle	2	
5	Server Technology			15
		J2EE	3	
		REST APIs	3	
		Node.js	2	
		DotNet	2	
		NoSQL	2	
		jBPM	1	
		PHP5/MySQL	1	
		LDAP	1	
6	Cloud Storage/ Computing			10
		Amazon Web Services	5	
		Microsoft Azure	3	
		Linode	1	
		Cloudera	1	

Figure 2. Web and server technologies for e-content development and deployment



consisting of programming language and web application framework. The most frequent suggestions were in favour of using LMS and CMS followed by some well tested Standards and specification for learning. Thereafter few suggestions, which were least frequent, indicate that e-content development may also follow MOOCs approach which does not follow any LMS or CMS or Standards. Instead, MOOCs follow new and advance web technologies as a developmental framework because it demands scalability, collaboration, interaction, customization and assessment. From the list of LMS and CMS which comprise small scale and large-scale content development and deployment software applications, the most frequently suggested was Moodle followed by Blackboard, Drupal, Edmodo, Sakai for small scale content. In the large-scale content, the suggested CMS and LMS platform was IBM Content Management System. It was also suggested to use Apache Sling and DjangoCMS/ MERN stack as web application frameworks for CMS and LMS development. Similarly, some of the other suggestions, which could act like CMS, LMS and thus could be used for the development of LMS or CMS kind of web learning applications, were ORACLE WebCenter content, Adobe CQ5, Exo Platform, Alfresco, CollaborativeClassroom, Sumtotal.

In regard to the standards to be followed for e-content development, the most frequently suggested standard was TinCan (Experience API) followed by SCORM and LTI (Learning Tool Interoperability) and then ePub3 (e-book format). However, TinCan has been suggested as better than SCORM by few of the IT professionals. The result may also be interpreted through Figure 3, created with the help of codes networking feature of the Atlas.ti software.

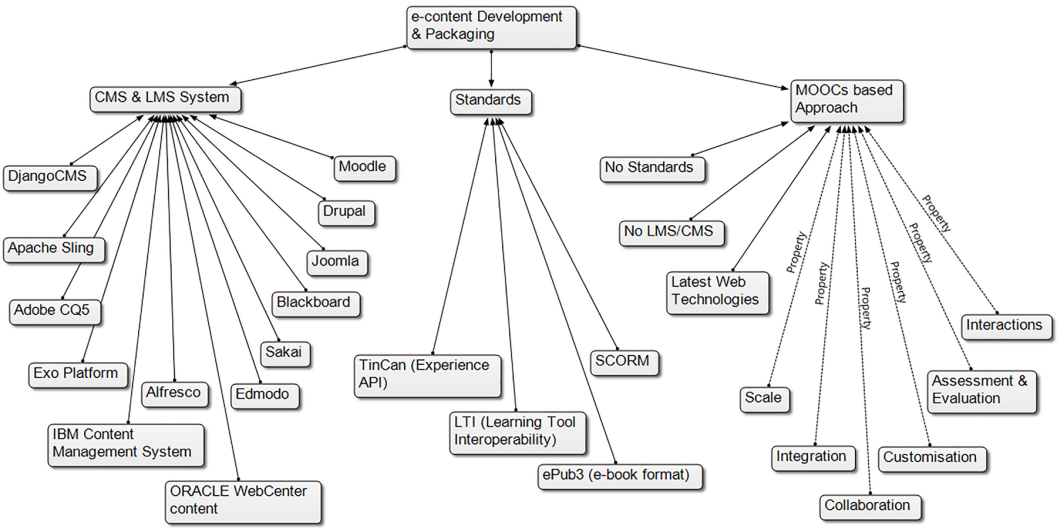
Table 5. Frequency analysis for LMS, CMS and standards for e-content development

S.N.	Category	Key Concept	Frequency	Group Frequency
1	CMS & LMS System			22
1.1	Small or moderate scale content development		15	
		Moodle	4	
		Blackboard	2	
		Drupal	2	
		Edmodo	2	
		Joomla	2	
		Sakai	1	
		Sumtotal	1	
		CollaborativeClassroom	1	
1.2	Large scale content development		7	
		IBM Content Management System	1	
		DjangoCMS / MERN Stack	1	
		Apache Sling	1	
		ORACLE WebCenter content	1	
		Adobe CQ5	1	
		Exo Platform	1	
		Alfresco	1	
2	Standards			9
		SCORM	4	
		Standard: TinCan (Experience API)	2	
		Standard: LTI (Learning Tool Interoperability)	2	
		Standard: ePub3 (e-book format)	1	
3	MOOCs based approach			4
		No LMS/CMS	2	
		No Standards	1	
		Latest Web Technologies	1	

5. TECHNICAL GUIDELINES FOR E-CONTENT DEVELOPMENT AND DEPLOYMENT

Basically, to develop and deploy an e-content system, it is of general importance for a developer to decide the scope of usage. The scope can be understood in terms of certain aspects such as: number of end users and number of requests at a time; time to go live; ownership; software development capability; resources available – financial resources and development resources. For this, following guidelines based on the findings, are discussed and recommended, keeping in view the four stages of Information Technology, namely: architecture & design; tools & technologies; content hosting; content development.

Figure 3. CMS, LMS and standards for e-content development



5.1 Architecture and Design

Architecture and design, the first and foremost step, works as the blueprint for the actual development of e-content or any e-learning web application. This will help in identifying components in the system. The most commonly used approach to architect the web application is to identify layers in the system.

The system architecture for an e-content system may be composed of applications, components and services to support high level functional needs of learning process. Hence the system architecture can be envisioned as composite architecture that would include web applications, database, file storage server, back office applications, reporting applications and services that would integrate and establish communication between different modules and sub-systems. To meet this, a three-tier architecture or layered component-based architecture is recommended, keeping in view that e-content is supposedly a medium scale deployment, which has also been suggested by Kumar, Prasad, and SriPradha (2017); Leung and Li (2001). If requirement increases then three tier architecture may also get extended to n-tier architecture, which has also been adopted by Bouras, Giannaka, Kapoulas, Nani, and Tsiatsos (2003); Srai, Guerouate, Berbiche, and HilalDrissi (2017). Although cloud-based architecture may also be recommended if e-content data is expected to increase tremendously in terms of users and hits which is also suggested by Samra, Li, Soh, and AlZain (2019). Since three-tier is the most recommended system architecture to be adopted for e-content, it would be pertinent to discuss it in detail.

The three-tier architecture consists of three layers or tiers namely presentation layer or web tier for presentation, middle layer or business layer or application tier for content management, and backend or database layer for storing the content. To facilitate communication and interaction between these layers, a communication layer is also required. The Internet coupled with the backend layer brings the phenomenon of cloud computing which may also be a probable architecture for e-learning. Further the Web/REST services could also be used for integration and communication between components, applications and other building blocks of the system. The three-tier architecture provides benefits of segregation of duties and allows changes to the system without affecting the entire system. The system can grow horizontally as the scale of operations grow.

Presentation layer components are basically the software which end-user is going to use to access the content. This set of components comprise of browsers on desktops/laptops and apps on pads and smart phones. Browsers accessible learning content can be developed using tools like HTML5, CSS3,

JS, Flex, Open Laszlo and Dojo, on the other hand, apps for smart devices can be prepared using the platform-specific technology e.g. IOS for iPads/iPhones. The presentation layer should be responsive so that e-content in the form HTML content can easily be delivered on the small displays besides larger screen, and for this Bootstrap library can be used. The core system should be a web-based system, implementing proper authorization practices. Users or learners will connect to this system to get themselves authorized and have a dashboard too for actions and content access.

Middle layer or business layer or application tier component takes care of business rules and allows target segmentation, personalization and localization of content. Components in this layer contain the core application logic and it becomes the heart of the application. An example of the core logic is what content is to be displayed to a learner, based on his/her knowledge and learning styles, if learner takes a test/quiz. For this, evaluation logic goes inside the application tier in order to facilitate adaptable learning. Not only learning styles but e-content system may also be responsive towards learners' emotions by adopting such programming which is capable of 'affective computing'. Now advancement in face recognition technologies, e-content system would be able to recognize different facial expressions of the learners by using camera and other sensors, and then accordingly able to offer the suitable content and explanation as per the mood.

Middle layer depends on backend layer for data or content. Common components for the backend layer are databases, Content Delivery Networks or CDNs and file servers. Though in certain scenarios CDNs themselves have their own middle layer, in this context CDNs can be put as part of the backend. Actually, backend layer is identified separately from middle layer because of maintenance and security. For the backend support, database technology for content storage and fast retrieval such as SQL Servers is suggested.

It is suggested to use an effective caching mechanism for frequently accessed data, so that the database server is available for handling more requests. Redis and Memcache are most heavily used in-memory caching servers. Also, they have features to persist the cache in hard disk.

Similar to three tier architecture, layered component-based architecture may also consist of three layers namely web portal (user interface) for the presentation of content; content management layer for content delivery; and database content layer for content repository and its fast retrieval. For large scale content deployment, the n-tier architecture is recommended that would consist of interface layer (application modules: Web 2.0, HTML5 or applications SDK-based), content management layer (library services with publish, staging, logging, and content reporting/auditing), application integration module (web services, API), peripheral services layer (search, workflow, document manager, BPM, Collaboration) and content repository layer (web content, content archive, metadata, collaboration data, ECM content, and search index).

For making system thin, scalable, adaptive, responsive and rich Internet application based; cloud and REST architecture is suggested, which has also been recommended by Cheng, Xiong, and Zhang (2014). For hosting purposes, the cloud computing has become a good option now-a-days because it is very cost efficient and at the same time it takes care about software, hardware and licensing etc. as well as hosting the website, web services and databases on the cloud. SpringMVC framework may also serve the same objective because it takes care of core system and is scalable to become a full-fledged cloud environment. The most recommended cloud architecture is Amazon Web Services (AWS) followed by Google App Engine and Azure. All non-sensitive data can be hosted in the public cloud like AWS, Azure or Google Cloud and all sensitive data can be hosted on the owned personal servers.

5.2 Tools and Technologies

The web technology for the development and deployment of e-content can be conceptualized in the five domains, namely: programming language; web application framework; presentation/design; content creation; server-side technology along with cloud storage.

Programming languages for e-content web application should be selected as per the need and requirement of e-content system, and for this Node JS, Java, PHP, Python or Perl may be used.

There are many JavaScript frameworks like AJAX, AngularJS, jQuery, React.js, Backbone, etc., recommended to support MVC pattern of e-content development.

For presentation & template design of the e-content, it is recommended to use HTML 5.0 coupled with JavaScript/CSS and RESTful services because it offers flexibility of development and power in rendering. It also provides all the features, which a typical RIA application can provide. It has been replacing SWF for dynamic rendering also.

For server-side technologies and platform, J2EE is recommended. REST based web API is a commonly favoured framework. These REST web APIs can reach a broad range of clients, including browsers and mobile devices and even can be served in standalone backend applications. Actually, front end could be pure HTML based, and API invocation could be REST based, and further server-side middle tier can be developed using open source/JEE stack and hosted on open source application server. Also, clients would not have tight coupling with the server. Client should talk to server through well-defined interface, thus designing REST APIs would be a good idea for e-content web application development and deployment. Other recommended server-side technologies for e-content database are Node.js, jBPM (Workflow system for Approvals), DotNet (for managing users and access), NoSQL (database for fast retrieval and flexible design in document format such as JSON or XML), and LDAP (for single-sign on user authentication).

SQL Server/ MySQL/Oracle can also suffice the database management needs of the e-content system. As companion reporting and analytics tools such as SQL reporting and analysis or 3rd party reporting tool can be used for reporting sub system.

5.3 Content Hosting

For an e-content system, it becomes important to consider the fact that due to requirement of its functionality, it has to render a lot of static content. The static content comprises videos, audios, images and textual representation of learning materials. As the number of users and hosting needs (volume and traffic) increases, the server starts experiencing performance issues and bandwidth usage problems. For tackling this issue, it is recommended that the static content may be hosted on some Content Delivery Network or CDNs, which has also been advocated by Bridges, Day, Blank, and Spear (2014).

Content delivery networks (CDNs) are specially designed to render static content to request clients. The goal of a CDN is to serve content to end users with high availability and high performance. By nature, they are elastic and keep increasing the hardware when it is required. This serves three purposes for web applications: redirection of requests and reduction in load; cost effectiveness because they only pay for the space and bandwidth they use; maintenance of such content - security, backups etc.

Most commonly used CDNs are Amazon S3, Microsoft Azure, Linode and Akamai services. They provide an authorization mechanism as well as leveraging by which applications can upload their content to the CDN and get a static URL in response. For the rest of the life of the application, those URLs can be provided in the content rendered by the presentation tier - which means that the learning hosting sites and its servers need not bother about the bandwidth, scalability and load issues because it will be taken care of by the CDN. In other words, these static URLs can be provided as link in any html page or SWF file, and learners can access the uploaded content and video lectures seamlessly.

5.4 Content Development

For e-content's content format, it is recommended to use: JPEGs for static images; GIFs for dynamic images; mpeg and mp4 for lightweight audio/video. Since e-content's contents are data intensive such as images, videos etc., thus content may be created and deployed in different resolutions so that low bandwidth users can use it (content will be downloaded based on bandwidth availability).

For content preparation, it is suggested to use any text editor for text, Dreamweaver for HTML, and AviScreen, Camstudio, Camtasia for Screencasting. For simple video content creation, Adobe Presenter can be used.

Apart from using dedicated programming languages and web technologies for creating e-content, there are some other ways to create it. There are some solutions which are available off-the-shelf and ready to use such as authoring tools, authoring API, Content Management System (CMS) and Learning Management System (LMS). Amongst these four methods, the most suggested way is content management systems with subset of learning management systems by which small and medium scale as well as large scale content deployment can be done. Al-Busaidi (2013) has also given a similar suggestion, for using LMS for higher academic institutions of developing countries if they are not able to roll out full e-learning environment.

CMS like IBM Content Management System can be used for large scale web learning application development and deployment, whereas Drupal and Joomla can be used for small and medium scale e-content.

LMS like Sakai can be used for small, medium and large-scale development and deployment of learning content system as well as are capable of creating virtual classrooms based on Cloud-based environments similar to Edmodo. On the other hand, Moodle, Blackboard, Google Classroom, Google Coursebuilder can be used for the development of small and medium scale learning systems.

Some of the Web Application Frameworks such as Django/MERN stack and Apache Sling are also suggested to be used as a framework for developing the LMS and CMS based applications from small to large scale deployment as per need.

e-Content can also be developed using some authoring API. Authoring API should be standards based such as SCORM (Shareable Content Object Reference Model) or TinCan (experience API) or LTI (Learning Tool Interoperability). However, TinCan (experience API) has got preference over SCORM and LTI. But relevance and usefulness of these standards particularly SCORM is not appreciated recently and is a matter for further research (Bush, Walker & Sorensen, 2011).

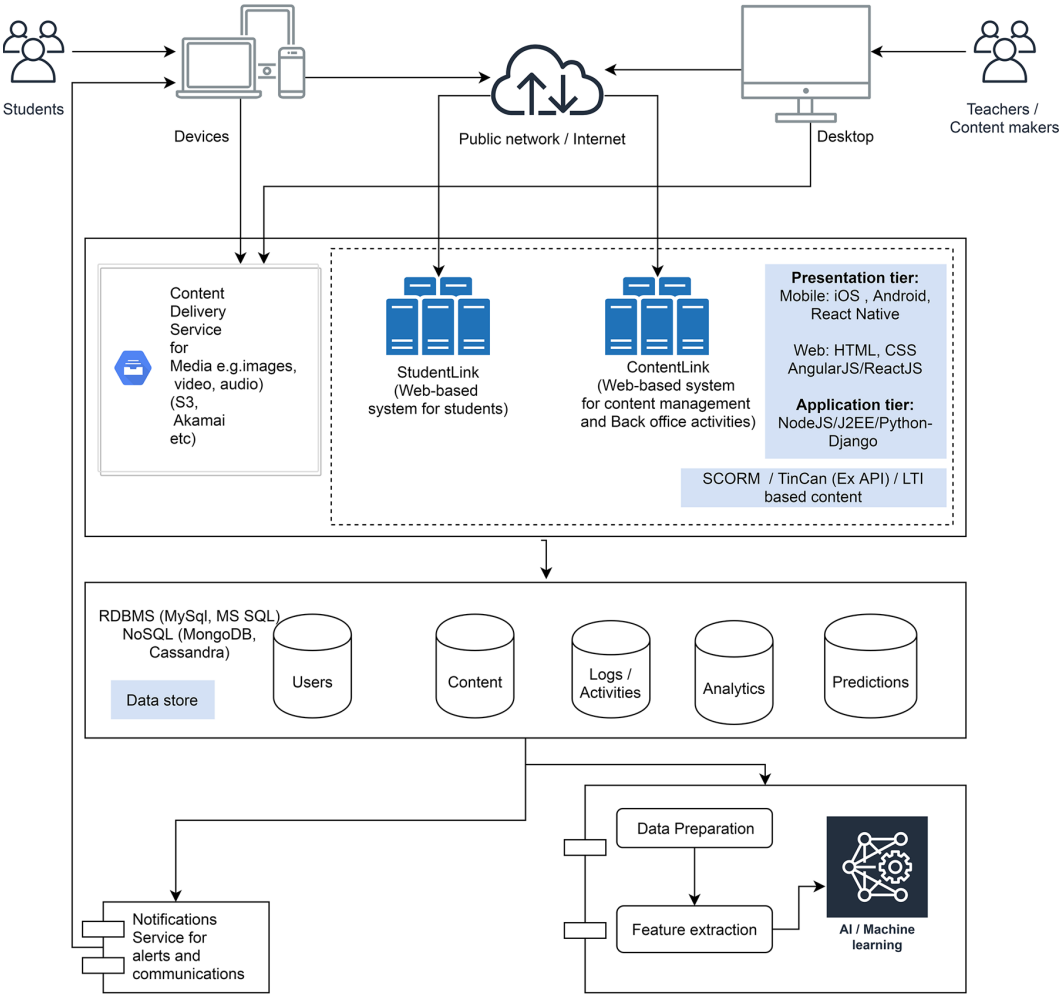
6. TECHNICAL FRAMEWORK

Frameworks are important because the speed and quality of the work depends on them as they facilitate web programming in many ways (Prokofyeva & Boltunova, 2017). Therefore, by summarizing above findings and recommended guidelines, a technical framework (Figure 4) is formulated which can be implemented, per se, to develop and deploy a full-fledged e-content system - capable to serve as MOOC platform. As we can see in the Figure 4, it starts with very simple three-tier system architecture – extendable to a very flexible n-tier system by using microservices approach. Therefore, the proposed framework aims to suggest an implementation which can scale to cater any numbers of the users and at the same time offers some key architectural benefits.

Although the framework is self-explanatory, even then it is described as follows within the shown system components for more clarity:

- **End user applications (Presentation tier)** - Looking at current trends it is important to see how the end users will interact with the applications. Students will mostly use Mobile devices, tabs or desktop applications. However, the content makers or teachers will use desktop computers. Hence the end user applications shall be developed to be able to render the content on the following platforms with corresponding technologies:
  - iOS (using iOS or React Native)
    ○. Android (with Android or React Native)
    ○. Web UI (HTML/CSS/JS/Angular JS/React JS/Bootstrap)
- **Application layer:** In order to be able to serve all types of end user applications, it is important to have an application layer with which all types of the end user applications can interact. Typically, this layer needs to be a collection of HTTP Rest APIs. These APIs can be developed using any one or with a combination of the following:
  ○. NodeJS/ExpressJS

Figure 4. Technical framework for e-content system development and deployment



○. J2EE/ Spring
○. Python/Django

- **Content storage -** e-content by definition, can have files with different Media e.g Text, audio and video and hence it is important that the storage used for the system can scale with time and number of users. With latest trends it is recommended to use cloud platforms like S3, Akamai etc for the same. This will prevent the system maintainers from maintenance overhead.
- **Data store:** Since the system is going to see a variety of data with volume, it is important that it is segregated thoughtfully and hence the data store becomes a very important component of the system. Some popular choices are listed below:
  ○. Content related data (not the actual content) is something which may be slightly more than being simple to define. And in this case, NoSQL DB's like MongoDB will help.
  ○. The nature of the system will require a proper search engine implemented within the system and hence ElasticSearch or Solr can be used.
  ○. For normal data store activities - RDBMS e.g. MSSql Server, Oracle, MySQL or other leading products can be used.

- **Notifications Service:** Nature of the application requires a lot of back and forth communication with the users. New courses, reminders for classes, reminders for tests and other functional requirements of the system require an independent service which just sends notifications. This service can be developed again in NodeJS or J2EE. It should be callable from the main applications but needs to be hosted separately.
- **AI and Machine learning:** Since the system is going to collect a lot of data for human behavior, it can leverage that to come up with good predictions. Therefore, in order to make e-content system smart and interactive at human level, it is recommended to consider affective computing and learning analytics using Python/TensorFlow and/or with leading AI and ML technologies.

7. IMPLICATION, RECOMMENDATION AND CONCLUSION

The findings of this study, in the form of technical guidelines and framework, would be helpful for higher educational setups, open universities as well as IT professionals who are engaged in the development of e-content. By considering the fact that the policy makers and educationists may not be well aware with the core computer technologies so by referring these guidelines they would be in better position to conceptualize, guide, monitor and supervise the whole e-content system development process. By employing the proposed technical framework, IT professionals would be able to develop their e-learning system which is efficient and cost effective. The outcome of this study is a kind of new piece of knowledge, in a sense that no such kind of comprehensive guidelines seem to be available which cover a wide range of suitable technological options, web technologies, programming languages along with IT based technical framework.

Therefore, the study would not only offer a roadmap for developing a full-fledged e-content system but also assist in improving the technical aspects of various existing e-content projects, which is not limited to Indian higher educational context but may also be extended to the other developing nations who are in the process of developing and deploying similar e-learning web applications. Since the study is of qualitative nature with comparatively small sample size, therefore the findings and recommendations could not be generalized. In future, these limitations can be addressed by administering the interventions on a larger sample size. Future research may also validate the proposed guidelines and framework by developing and deploying an e-content system based on the guidelines and framework, followed by the testing of the developed system.

Thus, it may be concluded that technological aspect of any e-learning system, apart from pedagogy, has emerged as an important determinant for perceived effectiveness of any e-learning system or e-content. So, this aspect should not be left unattended as it would be responsible for making e-content – interactive, adaptable, scalable, responsive, customizable, flexible, intuitive and fast.

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