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A Software Design Model for Integrating LMS and MOOCs

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ABSTRACT

Instructors often experience difficulties in selecting and sequencing relevant content for deployment into learning management systems. Human error and subjectivity are apparent. This study focuses on integrating learning management systems and massive open online courses with the goal of eliminating the human element in uploading content. As far as data sharing is concerned, learning management systems and massive open online courses have known weaknesses. The proposed integration aims to reach a tradeoff between the two systems. A requirements elicitation exercise was conducted towards identification of the component units of a hybrid system. The study utilized a mixed method approach to realize the foundation of the integrated design model. The findings, based on evaluation, showed that experts established completeness of the software design model. They, however, expressed the need for the designs to be extended towards accommodating artificial intelligence features. The proposed designs, thus, present a baseline framework upon which implementation considerations may be built.

KEYWORDS

Automated Uploading, Integration, LMS, Logical Designs, MOOC, Physical Designs, Requirements Elicitation, Software Design

INTRODUCTION

Educational technologies enhance teaching and learning (Ryneveld, 2017). Learning management systems (LMS), in particular, are an example of educational technologies which allows instructors and students to share content collaboratively (Yang, Guo, & Yu, 2016). In this context, LMS are interoperable information systems used for planning, storing, assessing and accessing course materials (Szabo & Flesher, 2002). They are web-based information systems with a variety of features for effective human – computer interactions (Williams et al., 2016). They support diverse teaching and learning strategies, at the same time, providing central repositories for teaching and learning material. Although LMS help instructors to organize courses (Dube & Scott, 2014; Gautam, 2010), the choice of which content to upload subjectively remains with the instructors. Precisely, instructors select, create, sequence, and upload what they perceive as relevant content (Limongelli, Lombardi, Marani, Sciarrone, & Temperini, 2016). Therefore, time to scrutinize this content by instructors is, often, limited (Favario, Meo, & Masala, 2015). The quality of selected content is, therefore, subjectively dependent on the idiosyncrasies of the instructor (Bhalalusesa, Lukwaro & Clemence, 2013).

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Available opportunities when using LMS will, potentially, expand with the coming of massive open online courses (MOOCs) (Barclay & Logan, 2013). These are educational technologies designed for distance education (Dos Santos, Punie & Castaño-Muñoz, 2016). They are free and up to date resources available to anyone connected on the internet (McAuley, Stewart, Siemens & Cormier, 2010). MOOCs emphasize on interactivity, strengthening communication in learning environments (Iniesto & Rodrigo, 2016). Content in MOOCs is updated through open-source interventions. What is compelling is that MOOCs can, potentially, be integrated with other educational technologies (Mor, Kalz, Khalil, & Ebner, 2017) because them alone lack features to augment students' learning experiences (Pilli, Admiraal, & Salli, 2018). They lack sufficient human-computer interaction features for user-friendly engagements. Innovative ways of bringing MOOCs' benefits closer to students' familiar educational technologies environments, specifically LMS, are apparently required. Creative approaches of taking away subjectivity in the selection, sequencing, and uploading of content on LMS are also sought. This paper proposes a software design model for integrating LMS and MOOCs towards a more interactive hybrid educational technology.

Statement of the Problem

Most institutions of higher learning make use of LMS. We indicated that instructors select, sequence, update, and upload content on LMS manually. MOOCs connote more auto-driven processes regarding content selection, sequencing, and updating (Mor, Kalz & Castano-Munoz, 2016). Operational features of information systems envisioned in the 4th industrial revolution purport auto-processes. Can integration of the interactiveness of LMS and the automatedness of content management in MOOCs bring tradeoff benefits to the hybrid educational technology thereof?

The aim of the proposed software design model is to eliminate the human element in the selection, sequencing, updating and uploading of content in LMS by bringing in compelling automated processes supported in MOOCs. The deliverable sought from this work are explicit requirements specifications for the proposed software design model, as well as the logical and physical designs depicting the component units of the proposed information system. The precise question we answer is; what are the computational functional requirements of an information system which integrates a particular LMS and MOOCs towards a more interactive hybrid educational technology? Attempts to answer this question are an ambitious task. The outcomes thereto have direct implications to quality of online teaching and learning, user goodwill, and the educational technologies body of knowledge.

Overview

A literature review is presented in the next section, emphasizing on attempts made, so far, in enhancing the performances of LMS and MOOCs. The research methodology we follow is then explained, before desired requirements specifications, logical and the physical designs thereto, are presented. Discussion of our findings follow. We then conclude the paper, highlighting the main observations, the contributions emanating, as well as future plans and the limitations thereto.

LITERATURE REVIEW

The three main goals of LMS are (a) efficient content management (Moses, Ali, & Krauss, 2014; Mihci & Donmez, 2017), (b) effective instructors and students interactions (Dobre, 2015), and (c) better coordinated assessment (Association of American Medical Colleges (AAMC), 2008). In some cases, LMS provide accountability and transparency to teaching and learning (Cavus & Alhih, 2014; Govender & Govender, 2014). Most important are LMS prospects for educational innovations by instructors (Govender & Govender, 2014; García-Peñalvo, Fidalgo-Blanco, & Sein-Echaluce, 2018). However, are institutions of higher learning, students, and stakeholders seeing the value for their money and getting satisfactory returns on their investments when they install LMS? Is the content selected appropriate, correctly sequenced, and up to date? Is content presented in the manner students understand? A desire to find answers to these questions motivates the undertaking of this work.

Some authors have negatively responded to some of the questions posed (Jordan & Duckett, 2018), with Liu and Geertshuis (2016) citing limited use of key functionalities in LMS by both instructors and students. Other authors pointed to disregarded use of important sub-systems of LMS such as assessments and students grading (Mtebe, 2015), as well as overlooked discussion forums (Sclater, 2008). Most instructors who use LMS flout when it comes to catering for individual students' needs (Imran, Chang, & Graf, 2016). Other views point to instructors having limited time to filter the content added on LMS platforms (Favario, Meo, & Masala, 2015). Generally, these shortcomings are attributed to the involvement of the human factor and, hence, potentially genuine unawareness of the functionalities offered by these LMS (Wilcox, Thall, & Griffin, 2017). Not all instructors wittingly "dump" content on LMS (Swart, 2016). Efforts are put to filter relevant content (Ilukwe & Biletsky, 2014). However, creative interventions are apparently required towards eliminating the human factor in any ill-use of LMS functionalities.

Although MOOCs are a promising resource regarding the quality of content offered, Milheim (2013) in (López & Hernández, 2017) argues about their pitiable interaction features. More benefits would emanate from creative combination of LMS and MOOCs. Similar attempts to integrate the two information systems have been tried in the past, where students collaboratively worked on multiple projects simultaneously through MOOCs integration with LMS (Hernández, Morales, & Guetl, 2016). Reports, also, pinpoint that MOOCs alone would face passive resistance by instructors (Dos Santos et al., 2016). Effective use of MOOCs would require technical integration with other information systems (Aleven et al., 2017). In addition, MOOCs alone would face the challenge of irrepressible overload (Bollweg, Kurzke, Shahriar, & Weber, 2018) emanating from students' permissions to, also, deploy content. Consequently, Brusilovsky et al. (2014) proposed an architecture that facilitates the integration of smart learning content. Alternative perspectives are abundant (Bhalalusesa et al., 2014). Instructors, at times, even share learning content under limited bandwidth environments (Kautsar, Kubota, Musashi, & Sugitani, 2016). With the persistent need for content to be accessed in real-time (Merriman, Coppeto, Santanach, Shaw, & Díaz, 2016), this paper envisages more benefits unfolding from placing LMS as the front-end component, and MOOCs as the back-end system to the proposed hybrid information system.

This paper is further inspired by earlier attempts to reduce the workloads of instructors who use LMS (Limongelli et al., 2016). It is also stirred by content searching techniques used in file server repositories (Kiryakova, 2014). Furthermore, the paper is driven by our desire to curb limited use of LMS and MOOCs features (Gautam, 2010). Integration has benefits more than the sum of LMS and MOOCs' benefits individually (Payette, Blanchi, Lagoze, & Overly, 1999; Gros & García-Peñalvo, 2016), promising diverse technologies to diverse students. Potentially, integration will enable LMS to communicate with other information systems (Anistyasari, Sarno, & Rochmawati, 2018), bringing about interoperability and standardization (Abdullah, & Ali, 2016), whose benefits include allowing the services thereof to work together (Martin, Polly, Jokiaho, & May, 2017), as well as helping the integrated information systems to become even more efficient (Del Blanco et al., 2013). Some of the most commonly used standards, which this work seeks to embrace are; interoperability, content object repository, and resolution architectures (Ochoa & Ternier, 2017).

Nonetheless, although integration of LMS and MOOCs is a noble proposal, the proposed hybrid information system will likely require more computing power and resources (Bashir, Abd Latiff, Ahmed, Yousif, & Eltayeeb, 2013). The integrated environments thereof need to be robust and scalable (Dragoni et al., 2017). Apart from presenting the main deliverable of this study (the software design model for integrating LMS and MOOCs), these are some of the gaps the research undertaken in this paper seeks to address.

RESEARCH METHODOLOGY

The work is a descriptive mixed method study designed to obtain data from software engineering experts, software engineering instructors and students. The information required was about potential operational and functional matters inferred when instructors use LMS. The instructors themselves are the primary source of user needs. Software engineering experts from the industry were, then, purposively selected to contribute practitioners' views into the study. Consent was sought from all participants before the requirements elicitation process.

The research activities were divided into four phases. The first phase elicited requirements from fifteen software engineering experts via an online questionnaire. In particular, software engineering experts shared achievable goals and objectives of the software design model. The feedback gathered informed the initial understanding of the software designs thereto. The deliverable of this 'requirements' elicitation exercise were level 0 draft designs of the software model.

The second phase followed after presentation of the first draft designs of the software model. In this phase, experts were approached again, this time, to share their views regarding the completeness or incompleteness of the proposed software model designs. Their observations were noted. Generally, it was agreed that the anticipated software design model would broaden the field of shared knowledge. To add to that, an extensive range of courses supported by specific MOOCs could be taken by students simultaneously and increase response time. In light of the best practice towards integrating LMS and MOOCs, there is no point in having MOOCs stored on separate repositories from where LMS content sits since it, equally, required queries to access the right data timeously. Largely, the ideal was that integration should be continuous, dependable, effective and user friendly. In the hope of bringing about successful designs, standards provide room for appropriate design processes. Nevertheless, risks and challenges were distinguished, and the possibility of the integration process to fail on the grounds of problems that characterize integration were noted. The common opinion of software engineering experts on achievable objectives was affirmative. Precisely, automation was favored as long as selection rules matched users' needs.

Requirements Specification

Apart from the requirements obtained from software engineering experts, which formed the bulk of the basis for the proposed software design model, the views of the primary beneficiary (instructors and students) were then considered in the third phase. Precisely, a random sample of 30 instructors and 12 students from a selected institution were requested to respond to a questionnaire in which their particular user needs were solicited for tallying with the views from software engineering experts.

From the data collected, matters of timely content uploading, relevancy of the content uploaded, and lack of coherency and flow of content were highlighted by most students. Instructors emphasized on workload issues related to time demands for content filtering, pressure from students for up to date content, and the challenge of keeping oneself on track with changing educational contexts. The proposed integrated software design model is a plan to put together learning content resources that interconnect. Software engineering experts presented considerations for scalability and robustness of the proposed software design model. Views pointing to, probably, cloud based architectures with fault tolerance were connoted. Furthermore, the operating environment should allow for interoperability in view of suggested massification of content offered in institutions of higher learning. The main outcome was to get stakeholders to appreciate the possible application of the proposed software design model in the education domain and policies.

Another key consideration made by both the experts and potential beneficiaries was that users should access content from anywhere and anytime, preferably from their devices without requiring additional software installation. Since hopes are that LMS interfaces with MOOCs repositories, there are cross repository connections which are formed to attain automation of the content uploading process. Typically, the designs should be marked by identification and selection of appropriate

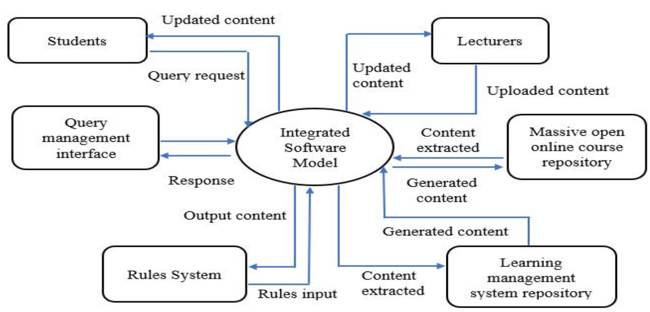
MOOCs. As a result, the software design model should enable the sharing and extraction of learning content between the LMS and appropriate MOOCs. However, inferred queries should access the required data in real- time.

To improve on query turnaround time, software engineering experts proposed the use of an empty MOOC repository. This could be more of a buffer repository where resources are not stored as such but, referenced for channeling to additional sources, thus reducing the response time. The proposed empty MOOC would serve as a lookup MOOC for relevant MOOCs. Overall, observations drawn from the requirements elicitation process point to participants valuing integration of LMS and MOOCs. The proposed software design model may guarantee the emergence of more appealing learning environments with enhanced content access processes. This software design model should, therefore, be based on standards which permit compatibility with existing platforms and operating systems, while enabling upgrading, maintenance and repair. The same software design model should, primarily, automate the part where instructors are involved in the use of LMS, and if possible, allowing processes to be completed on light weight devices. Such features are envisioned to support learner engagement and digital nativity at anytime and anyplace.

Software Design Model

To breakdown the functions highlighted in the problem statement, structured analyses were employed. Data flow diagramming (DFD) was applied to depict the design process, following modest rules. For example, there are rules for content sequencing, and rules for content retrieval. In the level 0 data flow diagram shown in Figure 1, students input data request queries. The system responds by giving relevant, updated content as per student's request. Information is accessed based on the presented query which passes through the query management interface. The query management interface is the main show through which lightweight devices access the proposed information system.

Figure 1. Level 0 DFD Diagram version



Source: (Authors)

The student entity describes all students who relate with the content thereto. Students submit query requests, indicating the information they require from the repositories, together with the course information from their profile. The expected output from the model is updated content on the topic.

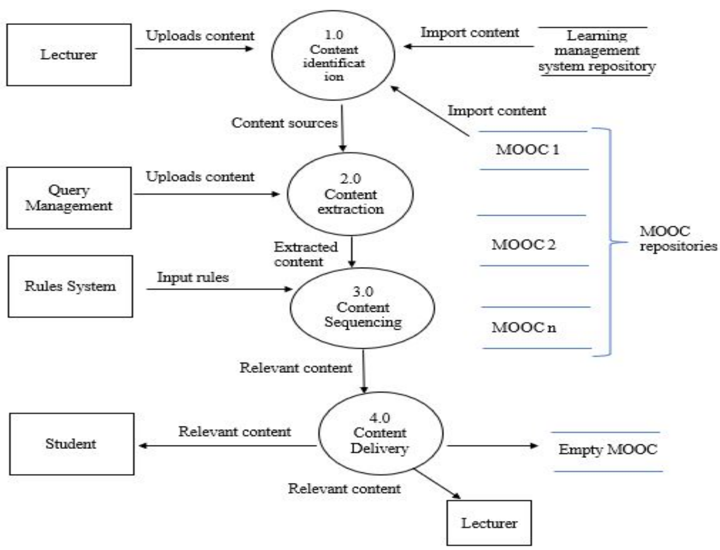
The instructor entity describes content authors who, predominantly, upload content on the LMS platform. The aim is to automate content uploading, which balances instructor generated content. Instructors in turn, benefit from the auto-updated content which includes access to content from the "empty MOOC".

The query management interface is a tool for execution, that allows students to express their queries, and the results are availed through the interface via lightweight devices. As users search for learning material through the query management interface, results are attained through MOOCs associated to the LMS repository. The query management interface then automatically changes the query request into the required format and forward the request to the repository interfaces.

Rules are input into the model to manipulate learning content in a useful way. The focus is on sequencing rules which control the ordering of content. The rules system defines LMS repository, open MOOCs and a hybrid repository or empty MOOC. The empty MOOC is then produced from the queries made by students. Content is also pulled out from LMS and open MOOCs for access by the students.

Learning content resources are presented as entities that define learning management system repository, open massive open online courses and a hybrid repository or empty massive open online course. The empty massive open online course is then produced from the queries made by students. Content is also extracted from learning management systems and open massive open online courses.

Figure 2. Level 1 Data flow diagram



Source: (Authors)

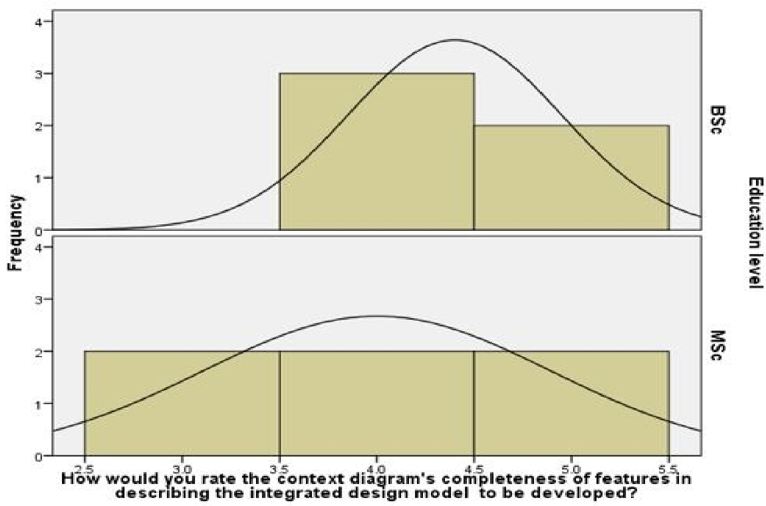
4.5.4 Decomposition of the sub-processes The diagrams below show the various decomposition levels of the processes in the data flow diagram of the proposed integrated design model. In Level 1 of the data flow diagram, Figure 4-6, further explains how the automation process is given. As students and lecturers input query for content retrieval, the content extraction process takes place, which assists in retrieval of content from massive open online course repositories.

Figure 2 is a further decomposed level of the automation process in the data flow diagram of the proposed software design model. As students and instructors input queries for content retrieval, the content extraction process takes place, which supports retrieval of content from MOOCs repositories.

Consideration for spiral experimental design is made focusing on tests for the completeness of the designs. Key variables of the designs are iteratively matched to quality attributes until the integrated model is yielded. To intensify validity and reliability of the experimental processes undertaken, triangulated use of another questionnaire was administered to further validate the designs.

Software engineering experts' views of the designs with regards to completeness, consistency, scalability and complexity were obtained in phase four, using the triangulating version of the questionnaire. In that regard, completeness refers to the extent to which functions of the designs cover specific stakeholder objectives. This is measured by identifying missing requirements, if any, as well as picking up any inconsistencies with the modeling techniques used. Scalability refers to the capability of the integrated design model, when applied, to sustain the anticipated workload (Zaharias, & Pappas, 2016).This is measured by investigating the amount of content collected when designs are implemented. Consistency talks of no contradictions (Mohagheghi & Dehlen, 2009) in the software design model. The authors measured consistency by evaluating qualitative description of the characteristics of the software model components by users. Complexity accounts for the extent of connectivity between entities in the software design model (Benbya, Nan, Tanriverdi, & Yoo, 2020). Similarly, the authors measured complexity by assessing the total analyses of the component designs.

Figure 3. Context diagram completeness



Source: (Authors)

The dependent variables measured in the experiments are software quality metrics completeness, scalability, complexity, and consistency. On the other hand, the independent variables comprised the entities of the data flow diagrams. In all cases, the controlled variable remained the LMS thereof.

We indicated earlier on that the key material used for experimentally evaluating the completeness of the proposed model comprised DFDs. Participants were given an opportunity to express their views on the completeness of the first set of designs. Suggestions for improvements on the present designs were the most important aspect of the responses. Expert views on the general designs depicted completeness of the logical designs. Wide-ranging questions to ascertain the completeness of the designs were asked based on the metrics used to measure the key attributes of the designs. Figure 3 interprets the responses gathered on how participants rated the completeness of the context diagrams presented. The Likert scale which was measured from 1-5 strongly disagree to strongly agree is shown on the x-axis. The y-axis represents the number of software engineering experts who participated in the evaluation of the software designs. The participants mostly agreed to completeness of the designs.

Table 1. Hypothesis Test summary from Mann Whitney U Test

Null Hypothesis	p-value	Decision
The data flow diagram’s completeness of feature is the same across categories all levels of education	0.755	Retain the null hypothesis
The context diagram’s completeness of feature is the same across categories all levels of education	0.537	Retain the null hypothesis
The data flow diagram’s complexity of feature is the same across categories all levels of education	0.662	Retain the null hypothesis
The data flow diagram’s consistency of feature is the same across categories all levels of education	1.000	Retain the null hypothesis
The entity relationship diagram’s completeness of feature is the same across categories all levels of education	0.202	Retain the null hypothesis
The entity relationship diagram’s complexity of feature is the same across categories all levels of education	0.876	Retain the null hypothesis

Null Hypothesis
p-value
Decision
The data flow diagram’s completeness of feature is the same across categories all levels of education
0.755
Retain the null hypothesis
The context diagram’s completeness of feature is the same across categories all levels of education
0.537
Retain the null hypothesis
The data flow diagram’s complexity of feature is the same across categories all levels of education
0.662
Retain the null hypothesis
The data flow diagram’s consistency of feature is the same across categories all levels of education
1.000
Retain the null hypothesis
The entity relationship diagram’s completeness of feature is the same across categories all levels of education
0.202
Retain the null hypothesis
The entity relationship diagram’s complexity of feature is the same across categories all levels of education
0.876
Retain the null hypothesis

Tests for normality of the data collected shows that the data collected on the question of diagram completeness was normally distributed. Although some skewness in the distribution for undergraduate respondents is observed, the distribution curve still closely approximates the Gaussian curve. In addition, the mean of the groups of participants was used to further test the same data for similarities based on the Mann-Whitney U test. In this, the null hypothesis, drawn from the experimental design, stated that there were no significant differences brought about by the design model presented to the value of LMS. The alternative hypothesis then directionally pointed to significant difference brought about by the proposed software design model to the value of LMS. Inferential statistics administered at a 95% level of confidence, 5% level of significance, yielded the outcomes tabled in Table 1 below.

Sufficient evidence exists with which to accept, at a 95% level of confidence, the belief that the context diagrams are completeness, and that their completeness is not observed by chance. This observation is mapped to DFD complexity where strong evidence of consistency is gathered. Thus, generally, there are no significant differences between the designs' anticipated functionality and existing LMS.

DISCUSSIONS

Reliability is an important aspect to assess utility in educational technology development (ref). To achieve reliability in a software design model, experts emphasized on seamless, efficient and user friendliness in the integrated version of LMS with MOOCs. The functional needs of the integrated system extended from specific to general requirements, in order for the outcome to improve teaching and learning experience. In addition, database capacity was pointed out as a critical aspect requiring scalability. It is envisaged that increase in content would, apparently, be coupled with potential increase in students' enrolment. Robustness of the system in the face of failures is also a key functional requirement. Instructors and students would likely interact with content anytime, anywhere, 24/7. These observations informed the logical and physical designs yielded.

We pointed out the components of the logical designs as comprising students, instructors, content location, content deliver, query management interface rules system, learning content resources, and standardization. In this context, content location functionality is included in order to provide a base for the structure of queries submitted. Eventually, the success of the model is hinged on the content location feature which supports automated access to relevant content. The content delivery feature comprises that which would be done to present content that engage students. This is where the system interfaces and the search facilities are defined.

We also indicated that the Query Management Interface connects lightweight devices, the LMS and MOOCs repositories. This feature simplifies systems administration. Although automated, some software engineering experts still insinuated the need for instructor intervention in content selection here and there, hence the need for a connector built into the model structure. Precisely, special attention was paid on inferential rules fired into the model with an emphasis on sequencing for appropriate content, and timing of content. This would bring in the aspect of system learning from history, a feature in line with Instructional Management Systems (IMS) Global specification (Zlatkovic, Denic, Petrovic, & Ilic, 2019) regarding digital technology systems having to learn in a persistent way.

There is need for content knowledge to evolve. This requirement called for database capacity planning, where LMS and related MOOC data is stored. Due to massification in university education, it is inevitable that data requirements will grow (Selyutin, Kalashnikova, Danilova, & Frolova, 2017). Interfacing database feature, learning resources, and integrated systems need standardization. Earlier studies (Fleischmann, 2007) informed us of the criticality of standards in educational technologies, without which it would be difficult for LMS, MOOCs and other digital learning platforms to interface.

With the proposed integrated LMS with MOOCs' designs, content management can only get better, which is the intended contribution of this work. Even though there was confirmation of the completeness of the proposed designs, improvements could be done on the experimental model in preparation for a full comprehensive system at a larger scale.

CONCLUSIONS

Institutions of higher learning have a choice of applying content repository-based technologies to enable effective teaching and learning. Even so, a crucial but least utilized feature is the integration facility between LMS and other application systems. The main objective of this paper was to find out whether the component units of LMS had complete features with which to tap into content offered in MOOCs or whether they required further improvement. A requirements elicitation process was administered with software engineering experts, students, and instructors in institutions of higher learning. Findings showed that additional considerations were required. New designs were proposed. Most experts were satisfied with these newly proposed designs. Empirically, there was no statistical differences among the groups of experts on their opinions of the designs as evidenced by the inferential statistics extracted at 0.05 significance level. Precisely, software engineering experts saw no differences between the functionalities offered in current LMS and those anticipated when LMS are integrated with MOOCs.

Integrating LMS with other platforms is important, particularly with respect to stretching diverse technologies to various students. Institutions may consider evaluating the cost consequences of scaling up present infrastructure to these proposed views. That way, students may acquire pertinent learning content timeously. Instructors, also, would have some of their work automated. These, and other implicit benefits, aid goodwill, giving an extra competitive advantage to institutions and their stakeholders.

FUTURE WORK

The future of integrated siblings of LMS and MOOCs seems poised for greater height. Even new agents such as integration of LMS, MOOCs, and IoT may make a mark. Education spaces would benefit from switching from monolithic systems (Luo & Lin, 2013) to more adaptable service-oriented applications. This will break views related to scholars in other circles arguing that LMS are monolithic in nature and restrain technology advances, supporting integrated designs in the direction of micro services-based platforms.

LIMITATIONS

A limitation to this study is that the evaluations focused on one LMS. Although working with every LMS is not feasible, more accurate outcomes would ensue towards generalizable views.

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