Information Sciences Letters

Volume 11
Issue 6 *Nov. 2022*

Article 19

2022

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Information Sciences Letters
An International Journal

http://dx.doi.org/10.18576/isl/110619

Empirical Results on Interactive E-learning Using Knowledge Acquisition Based Learning

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Received: 21 May 2022, Revised: 22 Jun. 2022, Accepted: 5 Jul. 2022.
Published online: 1 Nov. 2022.

Abstract: This paper presents empirical results on the efficiency of e-Learning systems which deploy and use knowledge acquisition based method (KA-LMS) for enhancing the learning capabilities of students. A new e-Learning method, which was developed by the author, is used to measure the impact of the new method on the learning achievements of the students. The method utilizes learning management systems, which restricts the ability of a learning student to advance from one topic to the next one unless he/she has acquired a minimum set of learning outcomes and knowledge. The data is collected from relatively large class rooms, where students attend online classes using the knowledge acquisition based method, and then the same set of students go through physical face to face exams. The results show that on the average students were able to score in the physical exam similar or higher grades compared to the results obtained automatically using the e-Learning KA-LMS. The effectiveness of KA-LMS was shown to be effective during the Covid-19 lockdown.

Keywords: Covid-19, empirical results, interactive learning, iterative learning, knowledge acquisition, online learning.

1 Introduction

During the Covid-19 school lockdown, students' level of learning acquisition declined [1] especially in disadvantage areas, while the in-class learning was absolutely cutoff in almost all countries in the world [1]. Existing e-Learning systems proved to be inefficient for substituting the face to face education systems and difficult to maintain academic integrity [1, 2]. Many of the current e-Learning schemas have pursued their goals in conventional ways, albeit transferring the lecture hall to an online medium presentation. In essence, there had been little innovation above traditional classroom lecturing.

According to a UNESCO report [3, 4], the usage of online learning materials in e-Learning system has become the main challenge for many universities during COVID-19 pandemic. While, e-Learning systems played an important source of information, due to its availability anywhere and anytime, low cost, ease of use and interactive capability, several challenges prevented e-Learning systems from achieving the expected level of learning by students [5].

The author has addressed several challenges and dilemmas, which can be related to both conventional and e-Learning system. But since Covid-19 caused a tremendous pressure on the educational systems, the proposed method was focused on e-Learning systems as a platform to address learning challenges and dilemmas. The novel approach aimed at optimizing the learning outcomes of learning per student. Namely, the author proposed an "Iterative and Interactive e-Learning Platform", where the main focus of the education/learning paradigm is shifted towards the learner, i.e., the student. The role of the instructor is directed more towards the design, construction and presentation of interactive education material in a manner to enable the learner to acquire the minimum required knowledge and to achieve the intended outcomes in the most effective manner.

The new eLearning model constituted a knowledge-acquisition based learning management system (KA-LMS). Unlike the traditional ways of classroom or online lecturing, a student using KA-LMS is expected to achieve a quality of learning, never before achieved via standard offline or online pedagogical methodologies. The Iterative and Interactive KA-LMS is sought to enable various academic institutions to achieve quality standards in both online and on premise setup, thus avoiding the calamities of pandemics, such as the one imposed by the Corona Covid-19.

The KA-LMS model is designed to enable students to achieve the required skills and knowledge, which allow them to compete in a more vigorous and competitive marketplace at the local and global levels. KA-LMS has the inherent capability to monitor and control the progress of the learner entity based on the quantity and quality of the knowledge acquired by the learner.

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The KA-LMS system addressed several of the most pressing and critical challenges and dilemmas facing the education/learning system both at schools and higher education [3,5]. One of the major challenges facing the learning/education field is the selection, design and presentation of the education material in a manner to enable the learners to achieve and meet the expected learning outcomes. This is attributed to wide diversity and variability of teaching materials including textbooks, power-point, audio-visual material, and augmented virtual reality. This dilemma is further complicated by the cost associated with education material, which increases the education divide between developed and under developed countries, as noted by the UNESCO report [4]. To address this dilemma, the KA-LMS system provides a methodology to create tools and templates to allow an instructor to structure and present the material in a manner to allow simple learning, and to enable iterative interactive learning process [6]. Thus, it is possible to achieve a pre-determined quality of learning, where each learner has the opportunity to acquire the expected learning outcomes of any course work [7, 8, 9]

Another dilemma and challenge addressed by the KA-LMS system is related to the variations in the learning capabilities among students population, which may restrict the rapid progress of the gifted students, while depriving the least gifted ones from acquiring the required knowledge. This dilemma becomes more severe, when we take into consideration the variations among geopolitical regions, where students in developed countries have access to more resources, attend better equipped schools, and can afford to have private tutors [4, 11, 12, 13]. Pace adjustment of learning is not readily available in classical classrooms or in current e-Learning systems, which merely transferred the education from the classroom to remote video presentations. The classical structure of semester based education limits the progress of the gifted and impede the progress of the less gifted.

This paper discusses how KA-LMS system enabling students to learn at self-pace, in a manner to allow a student to progress in an incremental manner based on his/her capabilities [14]. Thus, it is imperative to provide an environment, where students can choose and select their pace at which they can achieve their learning objectives [7].

The delivery process of education material using eLearning systems lacks the ability to provoke dynamic engagement and interaction with each and with every learner. In fact this challenge faces regular in-class learning as well. In-class learning provides limited interaction between the lecturer and students due to time constraints and quite often large class population. It is impossible for the lecturer to interact with each and every student, or even a small percentage of the population. The most popular interaction comes through assignments, quizzes, exams, reports. But these techniques in reality are used to monitor and evaluate the progress of students, rather than techniques for realtime interaction. Within the online eLearning systems, even the evaluation and monitoring techniques become less effective. Both in-class and online eLearning systems are bound to leave behind dis-involved students, who will eventually lag behind. The Covid-19 pandemic revealed that current methods of online eLearning methods suffer from serious lack of interactivity between instructor and learners [14,15]. The KA-LMS system [5,10] addresses novel methods of delivering the education material in a manner to enforce engagement and interaction, which allows controllability and observability of the learning process.

Another challenge regarding the current eLearning systems lies in the current assessment and evaluation processes, which rely on assessing the final knowledge acquired by a student, which may not provide accurate assessment. Furthermore, current systems allow students to fail a subject, to pass with a low threshold, or below an acceptable line, for example passing a subject with 50% final grade. The overwhelming fact is that a graduate with low grades or insufficient knowledge will suffer great deal securing a job in a competitive job market. Consequently, many graduates end up changing their careers, accepting low paying jobs, or remain unemployed for a long time [11]. As such the economy of the individual as well as of the state at large suffers great deal [16].

The KA-LMS system [5], which is used in this study, provides an incremental, iterative, and adaptive evaluation and assessment process in a manner to guarantee the required level of knowledge acquisition. This objective is meant to steer the learning process based on a preset education quality level. For example, it would be possible for an academic department to set a minimum level of achievement for each and every student in a particular discipline [5, 8, 9, 10, 27].

In this paper, we will provide empirical results on the performance of the KA-LMS system. We will discuss results obtained from a real case of deployment of the system.

RESEARCH SIGNIFICANCE AND RELATED WORK

The presented research is sought to provide several significant outcomes and results in the field of online eLearning through realtime experimental study and data collected from using an interactive knowledge acquisition based eLearning system KA-LMS. Covid-19 pandemic had exposed many of the shortcomings of current systems. As a result, many students (both school and higher education students) suffered great deal. The presented research provides realtime data on the ability of the KA-LMS model to restructure and deliver the learning material in a manner, which allows a student to increase the knowledge acquisition through incremental learning and accumulative evaluation and assessment. The progress of the student learning is based on both quantity and quality of knowledge acquired by the learner rather than based on time spent studying a certain material and the result of the final and midterm exams results. The new learning model provides a mechanism to enable a given department or instructor to adjust and adapt the learning system to each student individually based on smart adaptive algorithms. In the course of providing the material, it is possible to set and define a standard of knowledge acquisition per student, per department, or per institute. While doing so, each student should be able to learn at own pace, thus allowing to take care of natural differences in students' capabilities. In an education world moving rapidly towards interdisciplinary education, the proposed model provides a well-structured integration of knowledge acquisition within a given discipline as well as across multiple disciplines. The most important part of the proposed novel approach for learning is that it enables both online or offline learning to achieve maximum student interaction with the subject material.

The proposed model is expected to have an impact on the overall quality of education within any given organization. This includes the reduction in the overall cost of education, by shifting the center of the learning process to the learning student, and transferring the role of the instructor to preparing, modifying, and perfecting the interactive electronic material.

The model will have a direct impact on the overall education systems in developing countries. It is sought to reduce the education divide between developed and developing countries by allowing students to benefit from state of the art education material without the need of expensive class room setting. The model guarantees the acquisition of minimum level of accepted knowledge in the field of study, thus allowing graduates of different countries irrespective of their economic status to compete in the local, regional, and international market scopes.

The new model will have a direct impact on the advancement of knowledge based economy by producing graduates with proven skills rather than graduates with diplomas and low score transcripts. With this model, it is possible to provide directed education material to enable the creation of required skills in each area (country, region, global world). The presented model will have a direct impact of the education system in several segments including primary education schools, higher education institutions, training centers, continuous training and education.

Several eLearning platform systems have been developed over the past few years. Among the most commonly used platforms are:

1. Moodle [18,19]. Moodle is developed with free source code, thus making it most favorable for education organizations. The major strength of Moodle is the ability to host material in several formats and shapes including word, pdf, excel, images, audio, and video. It also provides tools for examination systems, quiz and assignment assessment. The main deficiency of Moodle in lieu of the proposed project is the lack of the ability to monitor and control the progress of the learner with the acquired knowledge. Also, Moodle does not provide a presentation platform of the material. Recently it has been augmented with video based presentation platforms such as ZOOM.
2. Blackboard [20,21]. This tool is very much similar to Moodle with the exception that is not free source platform. Similar to Moodle, Blackboard does not provide a tool to monitor and control the advancement of a student in the course with the acquired knowledge.
3. Udemy [22. 23]. This platform provides a pool of more than 20000 Subject Matter Experts. Udemy eLearning platform has many content creation tools such as PDF documents, PowerPoint, etc. text and video content. They can be utilized to create and publish courses. It is very much based on video based education. The instructor must provide a high quality video and upload it to the platform. In essence, it is more like a youtube video repository, which provides no added value to the listener or learner. Its services are mostly paid services.
4. Teachable [24,25]. This is another platform, which allows instructors to upload material in various formats for each course. It hosts more than 20000 courses created by 7500 instructors. It is a paid service
5. Other e- learning systems [26] include: Ruzuku, Educadium, LearnWorlds, Thinkific, Academy Of Mine, CourseCraft, Skillshare, Coursera and many others.

The existing e-Learning platforms provide a rich set of features. However, they all suffer several deficiencies such as:

1. The inability to monitor the exam integrity and/or to minimize the cheating and plagiarism.
2. The inability to tightly couple the student's progress with ongoing assessment
3. Do not distinguish between the assessment and the rate of knowledge acquisition.

2 Methodologies

The KA-LMS system is tested in a real education environment. Set of courses are taught in a university real environment, where the courses are taught using the KA-LMS system in parallel with simple Moodle based eLearning system, and in-class system. Also, the KA-LMS system is used in a high school environment, where one class is taught using three systems, the KA-LMS, Moodle, and in-class. The outcome of the classes is compared for the three systems. Students are subjected to the same material, the same assignments, quizzes, resources (text, videos), and time duration. All students are finally tested in one environment, where all students physically take one set of exams at the same time and same location, with the same control and monitoring system administered by the university and the school.

The KA-LMS system proceeds without direct interaction between the professor/teacher and the students. The only interaction occurs when a student requests help for understanding the procedure. The online course using Moodle is conducted in synchronous form, where the professor/teacher teachs the class using ZOOM platform, and the recorded material is uploaded to Moodle platform. Quizzes and assignments are loaded to Moodle. The physical class is carried out in the regular setup, where students and professor/teacher meet in a class room setting. The class material used to teach the class is also uploaded to Moodle.

The KA-LMS method is implemented as follows. The complete class processes are loaded to the platform. The instructor defines the flow of the material. Starting with the syllabus and the learning outcomes, the material is presented in an interactive manner, where the student is expected to answer questions in a pop-up style. The student cannot proceed to the next material subject before completing the previous part.

Each learning module is presented in three forms: text(in PDF and PPT formats), regular video segment, and interactive video. The interactive video is designed in a manner to prevent forward skipping, and with inserted pop questions generated from a question bank. The student cannot proceed to watch the video with successfully answering the pop-questions. The pop-up questions are designed to test the student ability to acquire the knowledge and the learning outcomes of the already viewed material. A student is forced to review the material iteratively in case he/she answered incorrectly. Repeated incorrect answers direct the student to material, where the student could get help and more insight into the subject. The system will not allow the student to proceed to the next subject material until and unless the student answers all embedded questions correctly. The student final grades is computed based on the time spent on the video material, the number of attempts made for each question in the video. In this model, students may complete the entire class and finish all requirements at different times. Students in principle can proceed to take the parallel in-class physical exam whenever they complete all the subject material. However, for this testing experiment, students who complete all the material must wait for the other parallel classes to take the test at the same time and settings. Figure 1 shows a sample flow of one of the KA-LMS classes.

The architecture allows an instructor to design the course flow, determine the learning material, the testing of the acquired knowledge. The testing comes in the form of quizzes and interactive pop-up questions within the visual material. A student will not reach the end of the class until he/she has acquired a pre-determine knowledge. For example the instructor may require that a student may not proceed to subsequent material without achieving minimum of X% grade, e.g. 80%. This means that no student will pass the course with less than 80% acquired knowledge.

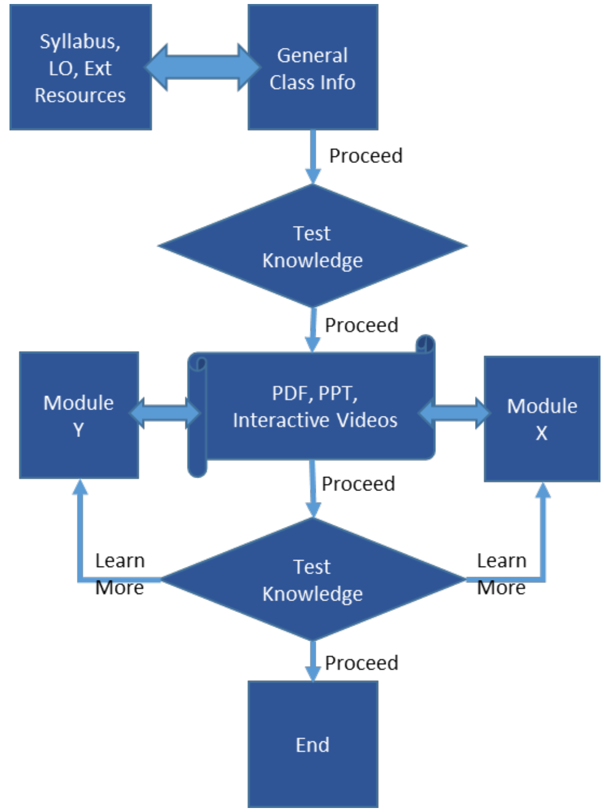

Fig. 1: KA-LMS Learning Model

This feature can be set by the university, the faculty, the department or the instructor.

KA-LMS system model is constructed as an electronic portal system, used by the students, teachers, and organization management. It enables the organization to define and set the rate and level of knowledge acquisition, grade calculating method, knowledge acquisition index, the course structure including the subjects (courses), the modules per course, and units per module and sub units. The system enables the teacher to break the subject into modules, units and/or sub units, immediate learning outcome, module learning outcome and the subject learning outcome. The instructor can set a well-defined flow for the material, while observing parallel paths, dependent paths, and independent paths. The instructor can create questions with different classifications such as difficulty index, learning outcome, proficiency skills, and others.

Students can learn at their own pace, where gifted students can complete a course in relatively short period of time without having to wait for the class end, while average and below average students can complete the course at an extended time. The final achievement score of a student is based on actual achieved score, time to achieve score, number of attempts to achieve the required score. The system will provide a final certification for the course with full authentication and verification. The experiments in this study included two classes in the software engineering department, one class has 105 students, and the other class has 45 students. The first class is completely theoretical, which does not include any programming labs. The second class is heavily programming course, where students learn how to write and build software systems

3 Discussions

Figure 2 shows an example of iterative and interactive video, which is part of one of the experiment courses taught by the instructor, and developed using the KA-LMS platform. This interactive video has 4 interactive stations.
A student must watch the video and he/she can do that only if the previous material has been completed by the student and the required knowledge has been acquired.

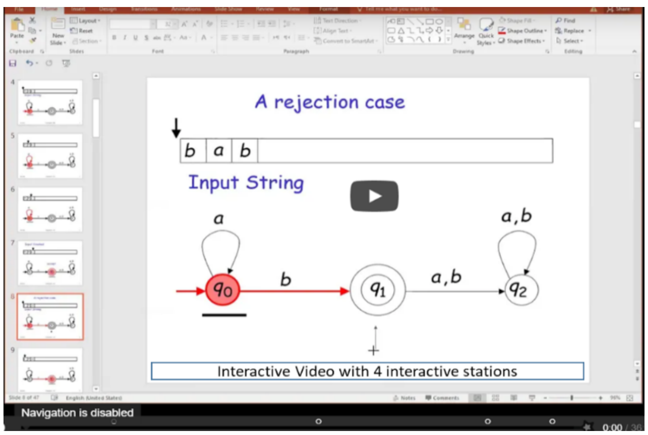

Fig. 2: Iterative and Interactive Video Lecture.

When the students reaches one of the interactive points, pop-up questions appear with random questions selected from question bank, and the student must answer the questions correctly (or with a minimum allowed score). Failing to answer or achieve minimum required score, would cause
the video to rewind back to a point where the required material can be reviewed again. If the student fails to answer the questions after several attempts, he might be redirected to other learning materials, which helps the student understand the material more efficiently. Fast navigation of the video is disabled as shown in the (left bottom corner) of the video.

Table 1: Courses Data and Performance Parameters.

Course Index	Course 1	Course 2
Number of students	105	45
Number of Units	9	8
Total Sub Units	45	40
Interactive Videos	40	35
Average Video Time (hours)	0.75	1
Interactive Videos Length (hours)	30	35
Average # Interactive Stations per video	5	5
Average time spent per video (hours)	1.75	2
Average overhead per video	1.3	1
Average # Questions per Interactive Station	4	4
Total # Pop-Questions per video	20	20
Total # Pop-Questions in all videos	800	700
Total # Quizzes	20	20
Average # questions per quiz	5	5
Average $ attempts per quiz	3	3
Minimum Acquired Knowledge Grade	80%	80%
Average grade for one 2 hours exam	90	87
Average Adjusted Grade for the exam	88.2%	85.3%
Percentage of Students who finished the course 3 weeks ahead of schedule	0.19	0.18
Average Grade of Fast Track Students	1	1
Average Adjusted Grades for Fast Track students	0.95	0.95

Table 1 shows a summary of the performance and data for both courses. Students spent on the average 1.3 and 1 hours more time than the video actual time in order to finish the video with the required score for class 1 and class 2 respectively. The time overhead occurs when a student goes back to an earlier time in the video when he/she fails to achieve the required score for a given set of questions at an interactive station.
For all the videos, the required score was set at 80% of the total grade. The average grade of the students before adjusting the grades is 90% and 87% for course 1 and 2 respectively. The achieved scores is adjusted to reflect the overhead time spent on the interactive video material and the number of attempts made to achieve the required level of knowledge acquisition for the quizzes. For these courses, the student's grades are adjusted using the following formula: GADJ = G-T*G, where G is the achieved score and "T" is the rate of overhead time spent by a student to complete the videos and quizzes. For example, the adjusted grade of a student with grade G= 95 with 25% overhead to complete the videos and quizzes, is given by GADJ = 95-0.25*95 = 72.00. Note that the instructor or the department

can set the grading scale for one or more classes.
19% and 18% of the students in class 1 and finished the

course 3 weeks earlier than the scheduled class end calendar, and all achieved a 100% grade in both courses. The average adjusted grade of the fast track students is 95% for both courses.
The acquired knowledge is indicated by the average grade (G) before adjusting the grade, which is 90% for a 2-hour online exam. The overhead for this exam was calculated based on the number of attempts allowed (3 attempts for this exam). The average number of attempts for all students was 1.02, and the adjusted average grade is 90-0.02*90 = 88.2.
Another test was made for this system by comparing the achievement of the students in one exam taken by the student using the interactive approach and the physical face-to-face approach for the same exam. Figure 3 shoes the grade distribution for both exams. As shown in Figure 3, students achieved similar score distribution for the physical exam and the online exam taken with the KA-LMS method. Note that the KA-LMS grades are the adjusted grades based on the time overhead spent during the class. However, the actual learned material is much higher than the reported adjusted grades. In other words, the students were able to achieve the minimum required knowledge at a certain cost reflected through the adjusted grades.

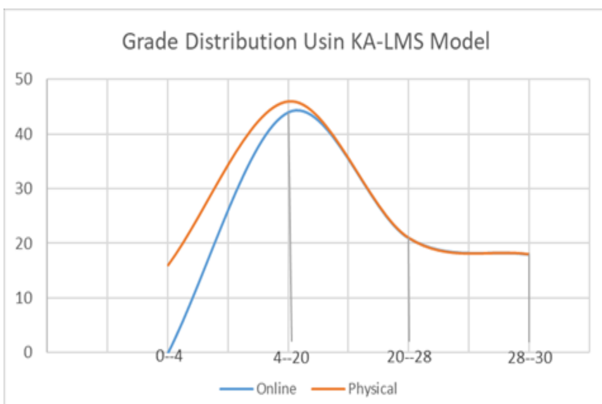

Fig.3: Distribution of grades for Online and Physical Exams.

This paper presented a novel method for enhancing and harvesting the online education platforms, with emphasis on knowledge acquired by the students. The proposed method allows students to learn at their own pace, while making sure that they achieve a minimum level of learning. A pilot project was created and tested in a real education environment, at Jordan University of Science and Technology. The obtained results show that the proposed method achieves good performance for a controlled environment, where students in two classes achieved more than 80% of the required knowledge. The adjusted performance of the students using the KA-LMS method closely matches the physical acquired knowledge of the students, which reveal the skills variations between students.
Given the environment created by pandemics and crisis, the KA-LMS model provides a proper solution for many of the challenges, which have faced the learning system throughout the pandemic and even before.

Conflict of interest : The authors declare that there is no conflict regarding the publication of this paper.

Acknowledgements or Notes

The author would like to acknowledge Shoman Research Foundation, Jordan and the faculty of scientific research at JUST for funding this project.

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