

ESTABLISHING AN LIFELONG LEARNING ENVIRONMENT USING IOT AND LEARNING ANALYTICS

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Abstract—With the trend of the development of global knowledge economy and lifelong learning society, the competition of lifelong learning market becomes increasingly keen. Lifelong learning units need to understand whether the courses they provide are appropriate and their students' learning effectiveness just as advertisers need to understand the market and customers. In this context, learning analytics is extremely important. Traditionally, it used the data of questionnaire after the courses to perform analysis and evaluation, however, the questionnaire survey usually was conducted at the end of the semester, and therefore the immediateness is lower and teachers couldn't adjust the content of the course and learning strategies based on their students' needs immediately. Some researchers used the data collected by LMS to conduct real-time learning analytics, nevertheless, students perform learning not just in classes, they do it when they go to libraries to borrow books, use classrooms to discuss the courses, and utilize Mobile Devices to download data and join in seminar...etc. Therefore, this study tried to combine internet of things (IOT) and the techniques of learning analytics to record and conduct the analysis of students' learning process and further enable them and schools to obtain feedbacks that they need and establish an effective lifelong learning environment.

Keywords—Internet of Things, IOT, Learning Analytics, Lifelong Learning

I. INTRODUCTION

With the trend of the development of global knowledge economy and lifelong learning society, the competition of lifelong learning market becomes increasingly keen. Lifelong learning units need to understand whether the courses they provide are appropriate and their students' learning effectiveness just as advertisers need to understand the market and customers. For instance, they can understand whether the units attract students or not or which units can't attract them through the attract degree analysis of curriculum and further adjust them. In addition, they can understand their interests or need and further know their learning status so that they can use different learning strategies to improve their learning effectiveness. In this context, it shows that learning analytics is very important.

Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which occurs [1]. Some researches including Academic Analytics, Action Analytics, Educational Data Mining, Networked Learning, etc. trying to achieve the same purpose with that of learning analytics through different directions. Learning Analytics is a field of tool and process development in the area of teaching and learning that:

1. The enables students and instructors to make decisions based on real-time or near-real-time data (individual, class, and other data).
2. Personalizes content and learner support.
3. Continuously refines student and instructor behavior models in order to inform practice [2].

Currently many schools have used learning analytics to improve their curriculum and learning effectiveness [3][4]. Researchers at the University of Florida aggregated all student activity in a graduate course with 67 students as expressed in the data logs of learning management system to see if this activity was predictive of a student's sense of community [5]. Researchers at Cordoba University in Spain, for instance, have developed some experimental data mining tools that are integrated directly into Moodle learning management system [6]. Researchers at the University of British Columbia utilized Blackboard and their self-developed internet tools to conduct learning analytics [7]. At RWTH Aachen University, researchers used Learning Portal, LMS and free survey software to conduct learning analytics and obtained good results [8]. Most researches used LMS data to conduct analysis and researchers of some studies also monitored students' actions on WEB and tracked what functions they used besides using LOG data of LMS. In addition to the above studies, plenty of schools conducted learner analysis. However, the technology to deliver that potential is still very young and research on understanding the pedagogical usefulness of Learning Analytics is still in its' infancy [9].

Currently most of learning analytics are applied in the education of universities and most of them use Log Data of LMS to conduct analysis, and some of them also add web monitoring and tracking what functions students use to do it.

However, when it is applied in lifelong learning, the following problems will emerge:

1. The course is short, and there is few and even no LMS Log Data, so it's hard to perform learning analytics on students' learning effectiveness [9].
2. Most teachers are part-time ones, and students come from every walk of life, besides, the course is short, so it's hard to know whether the curriculum is suitable only by tracking LMS Log Data [9].
3. Lifelong learning curriculum is diverse, and some skill courses emphasize attendance, practice and discussion so there is no LMS Log Data and learning analytics can't be conducted [9].

Based on the above problems, this study plan to use the concept of Internet of Things (IOT) and combine the technique of learning analytics to establish an environment for lifelong learning using learning analytics (ELLLA). The term IOT has first been used by Kevin (1999) [10]. The IOT refers to uniquely identifiable objects (Things) and their virtual representations in an Internet-like structure. Radio-frequency identification (RFID) is often seen as a prerequisite for the IOT. If all objects of daily life were equipped with radio tags, they could be identified and inventoried by computers [11].

In ELLLA, all devices related to learning in the environment would be linked by IOT including LMS, Learning Portal, mobile devices, access control system, NFC, RFID, KIOSK, libraries...etc. It would analyze all data collected from all devices and then conduct learning analytics of students and teachers. As for learners, ELLLA included the following characteristics:

1. Learners can access all physical resources they need through their student ID or NFC mobile phones in this environment.
2. It used IOT technique to store and analyze students' all records of using physical resources in schools in this environment.
3. They can use Mobile Device to obtain all sorts of resources on the internet and feedbacks and suggestions provided by ELLLA.
4. Before the classes, they can make prior preparations through preview data provided by teachers.
5. They can provide suggestions for the teachers, data and they put and learning activities they create on the internet through Mobile Device at any time.
6. They can use Mobile Device to record all learning processes (including video recording...etc.) and put them on LMS.
7. They can use Mobile Device and internet to do on-line discussion and video calling with their classmates and teachers at any time.
8. They can perform cooperative learning, discussion and experience sharing with their classmates via this environment.
9. They can exchange information and share their documents in this environment.
10. The learning process would be saved in LMS forever.

11. Their all type of learning records including attendance, discussion, practice, borrowing physical books and even data copying and the arrangement of course contents can be recorded and analyzed in detail through this environment.

As for teachers, ELLLA included the following characteristics:

4. They can access the physical resources that they need in learning by their teacher ID or NFC cell phones according to their authorities in this environment.
5. They can use Mobile Device to upload or share all sorts of learning resources.
6. They can receive students' suggestions through Mobile Device and join in their learning activities in ELLLA and offer suggestions at any time.
7. They can obtain students' real-time activities and historical records of learning process through ELLLA at any time.
8. They can perform on-line discussion and video calling with students through the internet at any time.
9. They can do cooperative learning, discussion and experience sharing with students through this environment.
10. They can exchange information and share documents with students in this environment.
11. Their teaching processes will be saved in LMS forever.
12. All of their teaching records including discussion, instruction, data copying, and the arrangement of course contents can be recorded and analyzed in detail through this environment.

This study demonstrated the practical application and effect of this environment in lifelong learning as the following.

II. ELLLA

ELLLA included three systems, and one is IOTE (Internet of Thing Environment), and its structure shows in Figure 1. IOTE manages and controls the authority of all educational resources including mobile devices, KIOSK, copy machine, RFID locker, Dom air-conditioner, school bus, VOIP, SMS service, information service, web terminal, classroom vacancy, classroom entrance, library, garage, student ID, electronic student ID, PKI...etc. IOTE manages and controls the above equipments according to the authority of students or teachers. When freshmen enter, IOTE can also issue student ID, electronic student ID and mobile device. IOTE manages and controls by RFID student ID. When students or teachers want to use any resources in IOTE, they need to use RFID student ID. In all equipments of IOTE, there are RFID readers, and when they use it they need to use student ID to do security verification, and all using records and processes will be recorded in IOTE which will be used to conduct learning analytics.

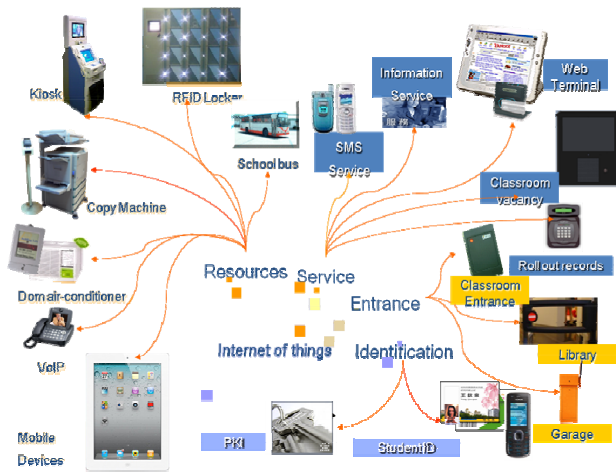


Figure 1. Structure of IOTE

Another sub-system is LMS system which includes all data of the course, and the historical records of students and teachers during the teaching process are included. LMS basically is used through mobile device, and students and teachers can download all information related to the course through mobile devices and communicate with users using other mobile devices, they can use mobile devices to communicate with each other and perform discussion related to the course. All activities conducted through mobile devices will be collected by LMS and it will use the data to conduct learning analytics. Another sub-system is Learning Analytics System (LAS) and its functions include collecting all real-time records of learning process in LMS system and all records of using resources in IOTE. The framework shows in Figure 2: After LAS system collect data, it will immediately do learning analytics and send the results to LMS by IOTE. Students and teachers can receive the feedbacks of learning analytics through mobile devices right away and the real-time information will be sent to them via various kinds of means through IOT.

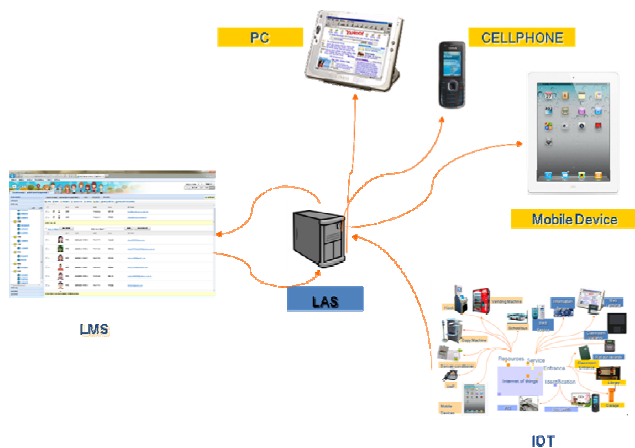


Figure 2. The Framework of LAS

In the environment of ELLLA, teachers can use mobile devices or computers to produce or upload course data. Currently the mobile device of ELLLA is MAC iPad. Through mobile devices, teachers can reserve physical resources, video-record the course, upload data, give feedbacks through LAS and discuss and interact with students in the environment of IOTE. On the other hand, students can use mobile devices to reserve physical resources, receive course data, upload assignments, video-record their practices, discuss with classmates or teachers and receive the feedback of LAS. Mobile devices are individuals' necessary objects in the course, and it uses Physical address (MAC address) to control in IOTE and does not need to use RFID. In addition to mobile devices, KIOSK, Copy Machine, RFID Locker, Library, Garage...etc. in IOTE all use RFID to control as the following figure shows:

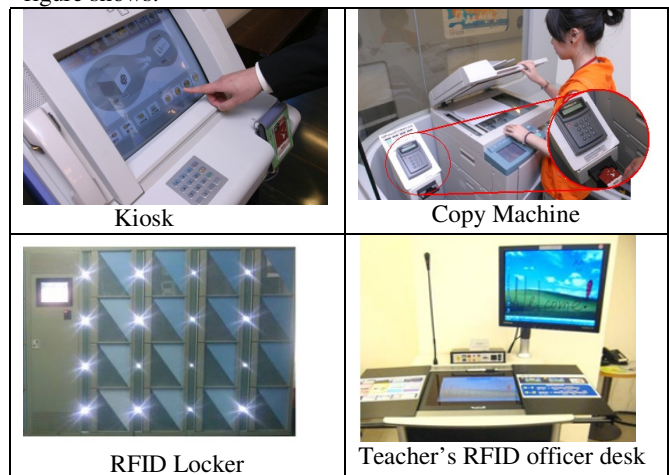


Figure 3. The physical resources control by IOTE

Besides, the services related to classrooms such as Dom air-conditioner, VOIP, SMS Service, Information Service, Web Terminal, Classroom vacancy, Classroom Entrance...etc. are controlled by RFID multi-functional controller and self-developed software.



Figure 4. RFID multi-functional controller

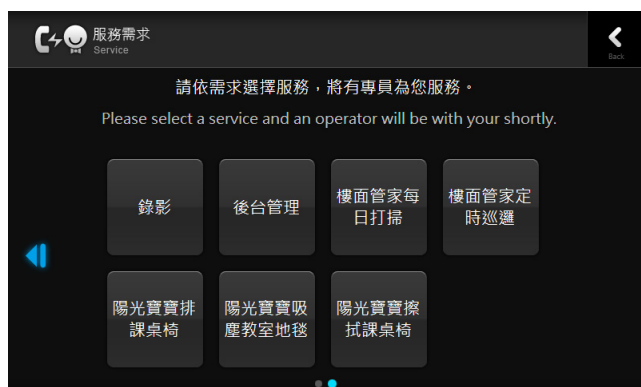


Figure 5. The Interface of RFID multi-functional controller

III.EVALUATION

This study used ELLLA to conduct the experiment on the students and teachers of lifelong learning curriculum and the results of pre-test and post-test to analyze the learning performance. Besides, a questionnaire survey was conducted on the students and teachers of the experimental group after the experiment to evaluate their satisfaction of using ELLLA.

IV.PARTICIPANTS

This study randomly selected a course of lifelong learning in School of Continuing Education of Chinese Culture University and divided the students into two classes to conduct the experiment. The subjects included a teacher and 122 students. This teacher has the experience of computer-aided instruction. There were 61 students in each class and each class was divided into 10 teams, so there were 6 to 7 students in each team.

V. EXPERIMENTAL METHOD

This study randomly selected a course of lifelong learning in School of Continuing Education of Chinese Culture University, MOCC certificate course. In order to cooperate with the teacher's teaching strategies of this course, this study used quasi-experimental design of nonequivalent pretest-posttest. The experimental group used ELLLA to learn and the control group used traditional instruction methods. MOCC teacher only has one year of teaching experience. The test that this study used was the formal simulation test of MOCC certificate. Each test had five combination questions, and the testees needed to use Microsoft's word software to do the practice according to the needs in the questions, and the simulation test software would perform computer scoring according to the practice results, so the teacher didn't need to score the results.

Nunnally (1978) proposed that Cronbach's α reliability coefficient was from 0 to 1. Usually 0.7 was considered as the lowest acceptable reliability coefficient [12]. Table 1 showed that the internal consistency reliability of the test of this study were above 0.7. The questions in the pre-test were used to test the students' prerequisites of Microsoft's word software including functions such as opening and reading file, table, drawing, layout, fonts and aligning paragraph...etc.

The post-test tested their learning performance after learning the course including their general operation and the operation of the functions of graph, table, table of content, figure, reference, indent, and formula...etc. of Microsoft's word. This study conducted the independent two-sample t-test on the pre-test scores to determine whether there was a significance difference between these two. In addition, this study conducted the analysis of covariance to determine whether there was a significant difference between these two groups' learning performance after the experiment was finished.

Besides, in order to know the influence of ELLLA on the students' learning performance this study also conducted a questionnaire survey on the students of the experimental group and an open-ended questionnaire survey on the teacher. The questionnaire for the students used five-point Likert-scale and the score from 1 to 5 represented extremely disagree, disagree, neutral, agree, and extremely agree. The questionnaire had 4 dimensions including system usability, information quality, interface quality and overall satisfaction. Table 1 showed the Cronbach's α coefficient of all dimensions, and they were all above 0.7 and this meant that this questionnaire was quite reliable.

Table 1. The Cronbach's α coefficient of all dimensions

dimension	Cronbach's α coefficient
system usability	0.725
information quality	0.761
interface quality	0.801
overall satisfaction	0.738
Total	0.807

VI.COURSE DESIGN

This study expected to apply this environment in all lifelong learning courses and therefore the researcher randomly selected one course of lifelong learning in School of Continuing Education of Chinese Culture University. The learning strategies of the course were based on the teacher's original plans, and he/she could set up the teaching strategies in Las system such as Project-Based learning, Problem-based learning, Cooperative learning, Social Learning or traditional lectures so that LAS system could give feedbacks and suggestions to the subjects according to the teaching strategies.

After the random selection, this study selected MOCC course. As the abbreviation of Master of Computer Certificate, and it is a local certificate of computer professional skills and promoted by Microsoft Taiwan and Chinese Computer Education Association in Taiwan in 1994. MOCC certificate adopted the test tools provided by PreMOUS as the standard and it is an encouraging measure which promoted Taiwan to obtain the international MOS certificate after it joined in WTO. The course is a standard lifelong learning one. Besides traditional lectures, MOCC also provides long hours of practice class and homework that students can practice at home. The teachers of this course used project-based learning. The core idea of project-based learning is that real-world

problems capture students' interest and provoke serious thinking as the students acquire and apply new knowledge in a problem-solving context. The teacher plays the role of facilitator, working with students to frame worthwhile questions, structuring meaningful tasks, coaching both knowledge development and social skills, and carefully assessing what students have learned from the experience. Advocates assert that project-based learning helps prepare students for the thinking and collaboration skills required in the workplace. The goals of the course included: (1) Understanding Microsoft's word software. (2) Enabling students to understand how to operate word software and further allowing them to apply word software well in their workplaces. (3) Enabling them to understand the relationship and application of word software and other Microsoft Office software. (4) Obtaining MOCC professional certificate issued by Chinese Computer Education Association. This course mainly expects that students can finish each project that the teacher assign just as they can finish the tasks their bosses assign to them. This context allows them to learn the operation of Microsoft's word software in a short time. There were 3 phases in learning this course:

(1) Phase 1. Preparation phase

The students were divided into the experimental group and control group. The teacher conducted a pre-test on these two groups. The question was a simple project which was combined by 3 practice questions. In this phase, the teacher introduced the syllabus and learning objectives of this course and how to use the learning tools.

(2) Phase 2. Project-base learning phase

The teacher performed the project-based instruction lasting 8 weeks. In the 1st week, the teacher lectured in the instruction and after the 2nd week he/she performed the project-based learning. Each group was divided into 10 teams. The 10 teams of the experimental group used ELLLA to learning and the control group used the traditional instruction method of computer classroom to learn.

The two groups were assigned a project every week. After receiving the project, the experimental group would first do the following learning activities such as having discussion in the classroom and in the discussion room, searching information on the internet, having discussion on the internet, borrowing books from the library, using mobile devices to have long-distance discussion, and reading LMS the teacher's supplementary data...etc. After their activities were finished, LAS would collect and analyze these data immediately. The analysis results would be sent to the teacher, and some analysis results such as discussion key points and key word searching etc. would be directly sent to the students.

Data sent by LAS enabled the students to have feedbacks right away and clarify some facts. The teacher could use the data to analyze his/her teaching, improve teaching quality, answer students' questions and improve teaching effectiveness.

The control group used the traditional instruction method of computer classroom, the teacher lectured first and after the

class was over, the students did the practice and they could search data on the internet. Then the teacher evaluated and analyzed the students' practices.

(3) Phase 3. Evaluation phase

In this phase, the post-test was conducted on the students, and the questionnaire survey and satisfaction survey was conducted on the teacher and students of the experimental group after the experiment was finished

VII. RESULT AND DISCUSSION

In phase 1, this study conducted independent two-sample t-test on the two groups' pre-test scores and there was no significant difference ($t=1.161$, $p=0.718>0.05$) in the result. Before the experiment was conducted, there was no significant difference between the scores of the students in the control group and experimental group. The students of the two groups were homogenous because their pre-test scores were not significantly different.

In phase 2, the teaching was conducted and finally in phase 3 the post-test was conducted on the two groups. This study used the total score of "post-test" as the dependent variable and conducted the independent samples t-test. Their "post-test" total scores were significantly different ($t=-2.018$, $p=0.036<0.05$). It was obvious that the averages of these two groups were significantly different after the experiment. This proved that ELLLA had highly improved learning performance.

In addition, this study conducted a questionnaire survey after the experimental group's learning activities was finished, there were totally 122 copies, and there were 115 valid copies after removing 7 invalid ones, and the valid response rate was around 97%. From the average of the questions in the questionnaire it was obtained that item 3 (Overall, I feel that it is easy to use this environment), item 6 (I feel that it is easy to learn to use this environment) and item 9 (I believe that I can learn to use this system easily). The lowest average in the questionnaire was 4.12 and this showed that 90% of the testees felt that this system is simple and it is easy to learn to use it. However, the average of item 14 (When ELLLA has errors, I can find out someone to fix them easily) was 2.94 and only 56% of them knew how to fix them when there were errors. Finally the scale was divided into 4 dimensions, and it was obtained from the analysis that the averages of system usability, information quality, interface quality and overall satisfaction were 3.90, 4.62, 4.49 and 4.87. It was found out from the results that their satisfaction about ELLLA was 82.7% and the average of overall satisfaction was 4.86. This indicated that they were willing to accept this environment and considered the environment usability was up to 84.7%. Additionally, their satisfaction about the suggestions and feedbacks provided by LAS was 82%. It showed that the suggestions provided by LAS were helpful to them.

In addition, it was found out from the open-ended questionnaire that ELLLA was highly effective on learning because:

1. ELLLA made learning convenient and flexible and offered diverse educational application.

2. ELLLA offered abundant learning resources which allowed students to learn flexibly and independently anytime and everywhere.
3. ELLLA provided interesting learning activities and enhanced students' learning motivation.
4. ELLLA helped students to solve problems, stimulate their creativity and supported the activities of Project-Base Learning.
5. The learning analytics of ELLLA offered a great help, and compared to the traditional teaching, it could help students and teachers a lot because it could provide real-time feedbacks and suggestions.
6. ELLLA could improve the effectiveness of normal courses and it particularly did a great help on the effectiveness of lifelong learning courses. In a short time of continuing courses, ELLLA recorded all the learning process and performed learning analytics, and it not only helped the students who really wanted to learn but also provided an effective learning environment.

It was obtained from the interview with the teacher that

1. The function of learning analytics of ELLLA allowed the teacher to obtain plenty of suggestions and assisted him/her to improve the teaching strategy.
2. ELLLA offered a diverse IOT environment and made learning interesting and stimulated the students' learning motivation.
3. The students of lifelong learning needed to spend a lot of money and they also wanted to have good learning effectiveness, and therefore most of them wouldn't cheat in ELLLA for the sake of scores. Hence, the learning processes recorded by ELLLA were all correct and could provide correct feedbacks and suggestions.

VIII. SUGGESTIONS

This study used IOT and learning analytics techniques to provide an ELLLA environment which combined the devices such as mobile devices, KIOSK, copy machine, RFID locker, Dom air-conditioner, school bus, VOIP, SMS service, information service, web terminal, classroom vacancy, classroom entrance, library, garage, student ID, electronic student ID, PKI...etc. The teacher used these devices to teach the students and could choose the teaching strategies, and learning analytics system would give different information and instruction contents according to the learning strategies. The learning analytics system would collect data from IOTE and provided the teacher with the students' learning performance and result analysis. The suggestions given by the learning analytics system could allow the teacher to adjust the teaching strategies and teaching activities and improve the learning effectiveness. Besides, the students could obtain different helps in learning from the learning analytics system and improve their learning efficiency and effectiveness.

This study proved that ELLLA could help learning effectiveness and the students' questionnaire survey also showed their positive feedbacks. However, they also provided

some suggestions: (1) ELLLA is too advanced, and it will be hard for seniors to operate this system because most learners of lifelong learning are seniors. One of the future goals of this system is to build up an easy-to-operate environment for seniors or youngsters. (2) It is harder to compile the contents of ELLLA, and almost all teaching materials of ELLLA are electronic, and therefore it is not only time-consuming but also expensive to create these materials. Hence, it is also one of the future goals of this study to enable teachers to produce the electronic teaching materials in a short time. (3) The cost of ELLLA is too high, and integrating this environment by IOT techniques takes much money and students' tuition will also increase. Besides, when things break down in IOT environment it is very hard to fix them due to technical problems. (4) It is hard to define teaching strategies: There are always more than one teaching strategy, and therefore making the learning analytics software to do a precise analysis is also one future goal of this study.

Currently ELLLA has been practically applied in lifelong learning units in Taiwan, it suits the current state of lifelong learning industry, and it has been already proved that it can effectively improve the students' learning effectiveness of lifelong learning. In the future, this system will move on to formal education and improve the learning efficiency and effectiveness by using IOT and learning analytics techniques.

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