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Chemistry laboratory management techniques massive open online course: Development and evaluation on students' perception

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ABSTRACT

To date, statistics in OpenLearning have demonstrated that the number of Massive Open Online Courses developed by Malaysia higher education institution is not achieving the target of DePAN 2.0. Hence, this study is aimed at developing a Massive Open Online Course (MOOC) on Chemistry Laboratory Management Techniques (CLMT) course and investigating the students' perception of the MOOC. The CLMT MOOC is developed by applying the ADDIE model as the instructional design model. In this regard, analysis, design, development, implementation, and evaluation are the phases involved. Three experts were appointed to evaluate the content validity of the e-content module and e-assessment module in the MOOC by filling the content validity evaluation form. According to the results, both e-content and e-assessment modules obtained validity index of 1.00. A group of 27 students was involved in the pilot study to answer the reliability questionnaire and the Cronbach's alpha for the two modules was found to be 0.99 and 0.97, respectively. Another group of 152 students were randomly selected as the respondents of the perception survey. Results from perception questionnaire showed the highest mean score in acceptance construct (M = 4.05, SD = 0.54), followed by instructional design construct (M = 3.96, SD = 0.59) and lastly usage barrier construct (M = 3.03, SD = 0.84). In conclusion, both the e-content and e-assessment modules used in the CLMT MOOC are valid and reliable. Meanwhile, the mean score of undergraduate students on the perception toward the CLMT MOOC was found to be moderately higher. Therefore, it can be inferred that this MOOC will be a useful self-learning and flipped classroom platform for the chemistry degree students, especially amidst the outbreak of COVID-19.

Keywords: Acceptance, Instructional design, Massive Open Online Course, Perception, Usage barrier

INTRODUCTION

A Massive Open Online Course refers to an instructional content delivered via the platform on the Internet in order to make it accessible to a large number of learners from different locations at different times. Dave Cormier had introduced this term in 2008 for a 12-week online course developed by Siemens and Downes, named Connectivism and Connective Knowledge [1]. There are two major types of MOOCs: cMOOCs and xMOOCs, with the "c" representing "connectivism", while the "x" denotes "exponential" [1].

cMOOCs are very flexible, whereas the course materials are unspecified and keep on evolving. There are no instructors and learners in the cMOOCs as all the participants contribute to building and sharing knowledge, ideas and understanding together. Learning is seen as the process of generating and connecting networks in ways that deepen knowledge [2]. In particular, cMOOCs provide participants with greater autonomy by enabling them to undertake less structured learning activities [2, 3]. However, excessive unstructured materials in the cMOOCs could make some students feel lost [4].

In contrast, xMOOCs are following a traditional university pedagogical model. Normally, a lecturer or a tutor is in charge of an xMOOC based on predetermined learning objectives of a particular course. Materials shared in the xMOOCs essentially include informative videos, assessments, and forum discussions. xMOOCs are developed in a closed platform that provides several types of structures for existing learning resources. Siemens [2] noted that this learning process focuses on duplicating the knowledge structure among both teachers and students. Given that the knowledge structure was initially determined by course designers and instructors, the instructors primarily act as experts, with learners playing the role of knowledge consumers. Hence, xMOOC was viewed as hindering the learning process of learners [2].

MOOC is in line with the goal of Malaysia's National e-Learning Policy (*Dasar e-Pembelajaran Negara*, DePAN): to transform and propel higher education in the country to a level of excellence. DePAN 2.0 comprises of six major domains (1) infrastructure and infostructure, (2) governance, (3) online pedagogy, (4) e-content, (5) professional development, and (6) acculturation [5]. In Phase 2 (2016-2020) of DePAN 2.0, 50% of courses offered in each Higher Education Institution (HEI) need to be implemented in the form of blended learning. Furthermore, at least 10% e-assessment should be practiced via blended learning, with each HEI requiring at least 15 MOOCs. In addition, 25% of all courses offered must have original e-content and 10% Open Course Ware (OCW) under the target of Phase 2. OpenLearning is the official platform for developing MOOC in Malaysia [6]. To date, statistics in OpenLearning have demonstrated that the number of Massive Open Online Courses developed by Malaysia higher education institution is not achieving the target of DePAN 2.0. Hence, this study aims to develop a MOOC in order to increase the number of MOOC in OpenLearning platform.

Chemistry Laboratory Management Techniques is a basic chemistry course related to the management of apparatus, chemical and storage in the laboratory. Typically, this course is offered to semester one undergraduate chemistry program students. Students who minor chemistry program will take this course during their fourth semester. This course does not include any lecture session; the three hours face to face contact hour is the laboratory session. Students are then provided with a laboratory manual to prepare themselves before their entry into the laboratory. This course is normally assessed by quiz, test and laboratory reports. Hence, students solely rely on the information provided in the laboratory manual to answer the quiz or test and complete their laboratory report. As a result, their conceptual understanding of the management of chemistry laboratory is quite weak (especially minor chemistry students) as evidenced in the quiz and test results. Hence, it is essential to create a self-learning platform needs to assist the students with helpful information on chemistry laboratory management techniques whilst gauging their perception on the developed MOOC.

In this study, CLMT MOOC is developed following xMOOC format because this course is implemented in the university and has specific learning outcomes that are to be achieved. Researchers need to follow the principles of instructional design when developing CLMT MOOC. In this context, Instructional Design (ID) is an iterative process of planning performance objectives, selecting instructional strategies, choosing media and selecting or creating materials, and evaluation [7]. The instruction designed should be learner-centered, goal oriented and focusing on measurable outcomes. There are various types of ID models, such as Dick and Carey model, ADDIE model, ASSURE model, Kemp model, Gerlach and Ely model, Hannafin and Peck design model, among several others. ADDIE, an acronym for Analysis, Design, Development, Implementation, and Evaluation, is a product development concept. The ADDIE concept is being applied to develop educational products and learning resources focusing on performance-based, student centered, innovative, authentic and inspirational learning [7]. It is noteworthy that ADDIE model

has been extensively used in designing learning resources in different subject matters worldwide [8-12]. Hence, the ADDIE model is chosen as the instructional design model in this study.

Objectives of the Study

The objectives of the study are as following:

a) Development of e-content and e-assessment modules in the CLMT MOOC,
b) validation of e-content and e-assessment modules in the CLMT MOOC,
c) evaluation of students' perceptions on developed CLMT MOOC in the aspects of acceptance, usage barriers and instructional design element.

METHODOLOGY

Research Design

There are two categories of development research, referred to as Type I and Type II [13]. The emphasis of Type I is on the study of specific product or program design, development and/or evaluation projects. On the other hand, Type II focuses on the study of design, development, or evaluation processes, tools or models. With regard to methodology, Type I studies may have analysis, design, development, a try-out and evaluation phase. In contrast, Type II studies may have a model construction, model implementation and model validation phase. This study utilises a Type I development research [13] which aimed to design and develop a CLMT MOOC. The design and development procedures were carried out by following the five phases under the ADDIE model: analysis, design, development, implementation and evaluation.

Sample

Different groups of samples were involved in this study due to the different objectives. Three content experts were appointed to check the content validity of the e-content and e-assessment modules in the CLMT MOOC. During the implementation phase a group of 27 undergraduate students was randomly chosen as the respondents for pilot study to study the reliability of both modules in the MOOC. Finally, a total of 152 undergraduate students was selected randomly to answer the perception questionnaire, during the evaluation phase. The demographic information of the respondents is shown in Table 1. Students from Biology, Science and Mathematics Program, who took Chemistry as their minor course, also participated in this study.

Table 1 Demographic Information for Respondents

No.	Evaluation category	Demographic information	Categories	Frequency (n)	Percentage (%)
1.	Validity	Expertise	Chemistry education	1	33.33
			Organic chemistry	1	33.33
			Analytical chemistry	1	33.33
2.	Reliability	Gender	Male	8	29.63
			Female	19	70.37
3.	Perception	Gender	Male	37	24.34
			Female	115	75.66
		Program	Chemistry	122	80.26
			Biology	2	1.32
			Science	10	6.58
			Mathematics	18	11.84

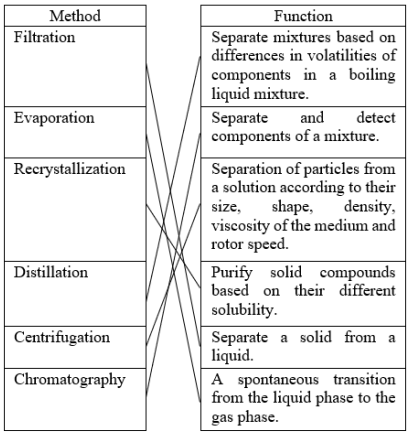
Instrument

Three instruments have been used in this study to obtain data for the three different objectives. Module content validity evaluation form is divided into two: e-content module content validity evaluation form and

e-assessment module content validity evaluation form. These forms were answered by three chemistry lecturers who had taught CLMT in the previous semesters. They needed to access to CLMT MOOC and explore both e-content and e-assessment modules. Subsequently, they evaluated the relevance of these contents in both modules to the CLMT course. A 4-point Likert scale adapted from Davis [14] was used in the content validity evaluation form: 1 - totally irrelevant, 2 - irrelevant, 3 - relevant, 4 - highly relevant. Sample items in the content validity evaluation form for both e-content and e-assessment modules are presented in Table 2. A Glass Blowing topic does not include any questions or exercises, since it is not assessed in the test or quiz.

Table 2 Sample items in the e-content and e-assessment modules content validity evaluation form

Topics	e-Content Module	e-Assessment Module
Safety Measures During Use and Preparation of Chemical Substances	PowerPoint slides titled "Safety Measures During Use and Preparation of Chemical Substances".	What should you do if chemical gets into your eyes? A. Nothing, unless the chemical causes discomfort **B. Use the eye-wash fountain; then notify the instructor** C. Notify the instructor; then use the eye-wash fountain D. Use the eye-wash fountain; then return to the experiment
Apparatus and Measurements in The Laboratory	Video titled "How to Use an Analytical Balance".	Arrange the steps to use an analytical balance. I. Place the object to be weighed on the pan. II. Open the door of the analytical balance. III. Wait until the scale stabilizes then record the weight. IV. Close the door of the analytical balance. A. I → II → IV → III B. I → IV → III → II C. II → I → III → IV **D. II → I → IV → III**
Glassware Cleaning and Chemical Storage	Video titled "How to Use an Autoclave".	There are several methods to dry the glassware after cleaning procedure. Which of the following is **NOT** a recommended way? A. Air-dry B. Rinse with ethanol C. Rinse with acetone **D. Wipe with paper towel**
Preparation of Solution and Dilution	Procedure video titled "Preparation of Solution and Dilution".	In doing dilution, the _____ of solute is remain unchanged before and after the dilution. A. mass B. volume C. concentration **D. number of mole**
Titration	Experiment manual titled "Titration".	The solution in Erlenmeyer flask will turn into colourless at the endpoint. True/**False**
Separation and Purifying Samples Using	Video titled "How to Fold a Fluted Filter Paper".	Match method of filtration and its function:

Filtration and Recrystallization		
Distillation	Video titled "Fractional Distillation".	Liquid collected at the receiver is called filtrate. True/**False**
Glass Blowing	PDF file titled "Scientific Glassblowing Class".	-

Reliability questionnaire was divided into e-content module reliability questionnaire and e-assessment module reliability questionnaire in order to investigate the reliability of both modules in accomplishing the second objective of the study. According to Russell [15], the ability of students to successfully follow each activity to achieve the module objectives is the main method used to identify the reliability of a certain module. Hence, the items in both reliability questionnaires were adapted from Ahmad's study [16] based on the activities presented in both modules in CLMT MOOC. In addition, a 4-point Likert scale was used to gauge the agreement of students on the item in terms of whether they could follow the activities presented in both modules. Table 3 shows the sample items in the e-content and e-assessment module reliability questionnaire.

Table 3 Sample items in e-content and e-assessment module reliability questionnaire

Topics	e-Content module	e-Assessment module
Safety Measures During Use and Preparation of Chemical Substances	I can understand the content in the video titled "Chemistry Safety Shower".	I can understand the instruction in this exercise.
Apparatus and Measurements in The Laboratory	I can understand the notes titled "Manipulating and Transferring sample".	I can answer the multiple-choice questions in this chapter.
Glassware Cleaning and Chemical Storage	I can follow the steps in the experiment manual titled "Glassware Cleaning and Chemical Storage".	I can match the glassware with the correct brushes.
Preparation of Solution and Dilution	I can achieve the learning outcomes in this chapter.	I can arrange the dilution steps correctly.
Titration	I can follow the steps shown in the procedure video titled "Titration".	I can label the titration diagram correctly.
Separation and Purifying Samples Using Filtration and Recrystallization	I can understand the content in the video titled "Vacuum Filtration".	I can differentiate gravity filtration and vacuum filtration correctly.
Distillation	I can understand the content in the video titled "Fractional Distillation".	I can answer all true/false questions correctly.

Glass Blowing	I can understand the content shown on the website titled "Scientific Glassblowing".	-

Perception questionnaire is used to identify undergraduate students' perception of the CLMT MOOC with regard to acceptance, usage barriers and instructional design elements. There were 44 items in the questionnaire and respondents rated their agreement on the items based on 5-point Likert scale: 1 - strongly disagree, 2 - disagree, 3 - neutral, 4 - agree and 5 - strongly agree. It is notable that the items in the acceptance and usage barrier constructs were adapted from Daud, Zulkifli, Rahman and Khalid [17], while items in the instructional design elements construct were adapted from Fesol, Salam and Shaarani [18]. After being validated by three experts, this questionnaire obtained the Item Content Validity Index (I-CVI) of 1.00. The reliability coefficient of the perception questionnaire ($\alpha = 0.80$) demonstrated that the internal consistency of the scale was acceptable. The sample items in perception questionnaire based on the constructs is presented in Table 4.

Table 4 Sample items in perception questionnaire

No.	Construct	Sub-Construct	Sample items
1.	Acceptance	Performance Expectancy (PE)	Using CLMT MOOC allow me to accomplish the task more quickly.
		Effort Expectancy (EE)	CLMT MOOC is easy to use.
		Social Influence (SI)	People who are important to me will recommend me to use CLMT MOOC.
		Facilitating Conditions (FC)	I have the required knowledge to use CLMT MOOC.
2.	Usage barrier		I seldom use MOOC due to poor Internet / Wi-Fi coverage.
3.	Instructional design elements	Course Information (CI)	Couse objectives are clearly stated in CLMT MOOC.
		Course Resources (CR)	I engage more with lecture videos to understand CLMT better.
		Active Learning (AL)	I find that self-assessment activities in CLMT MOOC are enjoyable.
		Monitoring Learning (ML)	Quizzes given in CLMT MOOC helped me to achieve the learning objectives.
		Interaction (IR)	I find it comfortable to communicate with friends via forum in CLMT MOOC.
		Intended Perception (IP)	I intend to use MOOC platform to study other courses in the next semesters.

Procedure

The first objective of the study is to develop the e-content and the e-assessment modules in the CLMT MOOC. Therefore, the ADDIE instructional design model was used to develop the MOOC. The objectives of the module, target users and the content of the module were identified during the analysis phase. The objective of developing e-content and e-assessment module for CLMT MOOC is to develop an online learning platform for basic concepts in managing storage, chemical, waste and experiments. It is hoped that the MOOC will equip students with conceptual and procedural information before they enter the chemistry laboratory and prepare them for the quiz and test. The target users of this MOOC are lecturers and

undergraduate students who register for this CLMT course. The lecturer can use this MOOC as a flipped classroom platform, while students can utilise it as a self-learning platform. The CLMT course includes eight topics: (1) Safety Measures During Use and Preparation of Chemical Substances, (2) Apparatus and Measurement in the Laboratory, (3) Glassware Cleaning and Chemical Storage, (4) Preparation of Solution, (5) Titration, (6) Recrystallisation, (7) Distillation, and (8) Glass Blowing. Hence, both e-content and e-assessment modules are required to contain learning materials related to these eight topics (Figure 1).

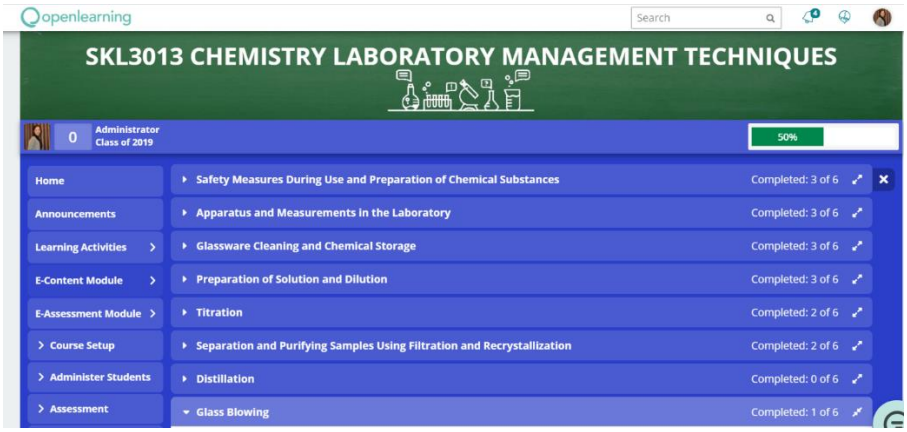


Figure 1 List of topics in CLMT MOOC

The design phase starts once the analysis phase is done. This phase focuses on designing the content of both modules. e-Content module mainly delivers the content for the eight topics in CLMT course, with each topic consisting of six components: (1) Learning Outcomes, (2) Notes, (3) Laboratory Manuals, (4) Procedure Video, (5) Laboratory Report and (6) Reflection (Figure 2). Learning Outcomes page lists all the learning outcomes that need to be achieved by the students upon concluding the topic. PowerPoint slides and YouTube videos related to the basic concepts for each topic are shown in the Notes page. Laboratory manuals are also presented to the students to prepare them before their entry into the laboratory. The laboratory manuals contain information about the objectives of the experiment, list of apparatus and material, procedures, result table and questions. Procedure video showing experiment procedures step by step is prepared to make it easier for students to carry out each experiment in the course. After each laboratory session, students are required to complete the laboratory report and then upload to the Laboratory Report page in the e-content module (Figure 3). At the end of each topic, students need to do the reflection and share their thoughts on the Reflection page.

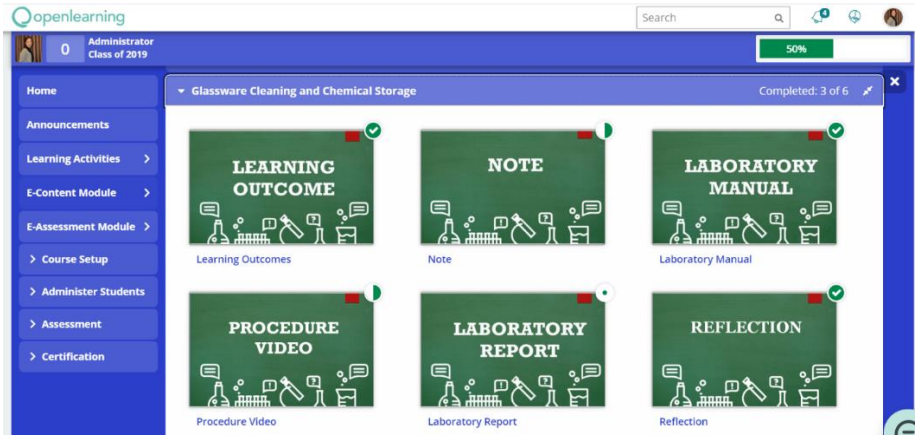


Figure 2 List of components in each topic in the e-content module

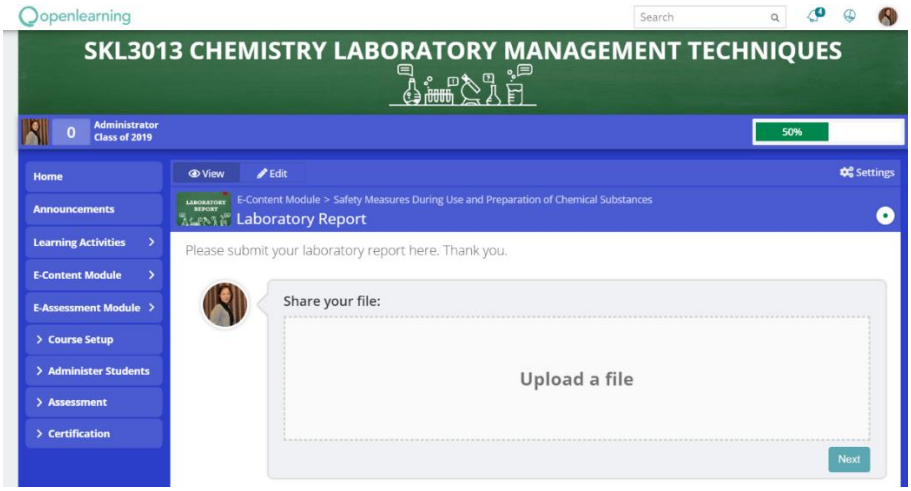


Figure 3 Students need to upload a laboratory report in e-content module

On the other hand, e-assessment module mainly focuses on providing various types of exercises related to the eight topics in CLMT course. The exercises presented to the students consist of multiple-choice questions, mix and match (Figure 4), drag and drop as well as true or false items. Students can make self-assessment because they can check their answer (Figure 4) after completing the exercise. Hence, they can evaluate themselves and prepare themselves before facing any quizzes or tests.

The third phase in the ADDIE instructional model is the development phase. The official online platform for Malaysia MOOCs is openlearning.com [6]. Therefore, this platform has been chosen to develop CLMT MOOC following the steps below:

a) register account in the OpenLearning platform,
b) register CLMT MOOC in the OpenLearning platform,
c) develop homepage (Figure 5),
d) develop announcement page,
e) develop learning activities page,
f) develop e-content module and e-assessment module page,
g) develop components in e-content module,
h) develop components in e-assessment module,
i) test all the links and navigation,
j) develop promotional page (Figure 6),
k) change course status to online (Figure 7).

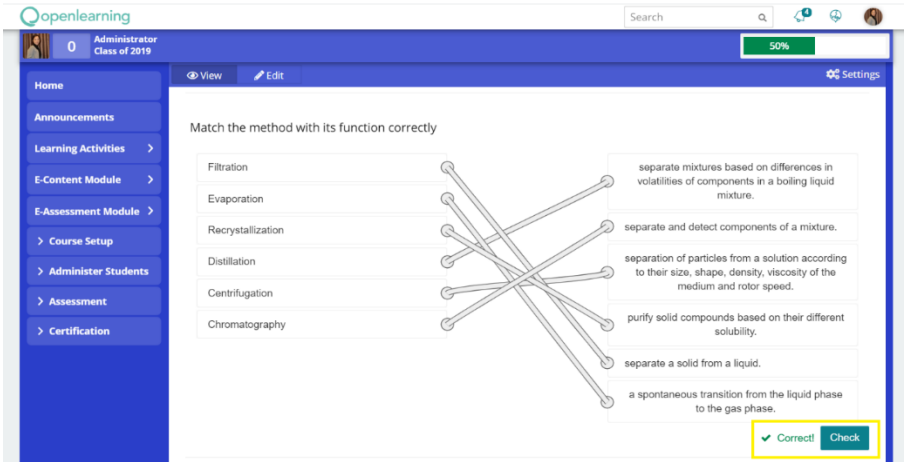


Figure 4 Mix and match exercise with answer checked

Figure 5 Homepage of CLMT MOOC

Figure 6 Promotional page of CLMT MOOC

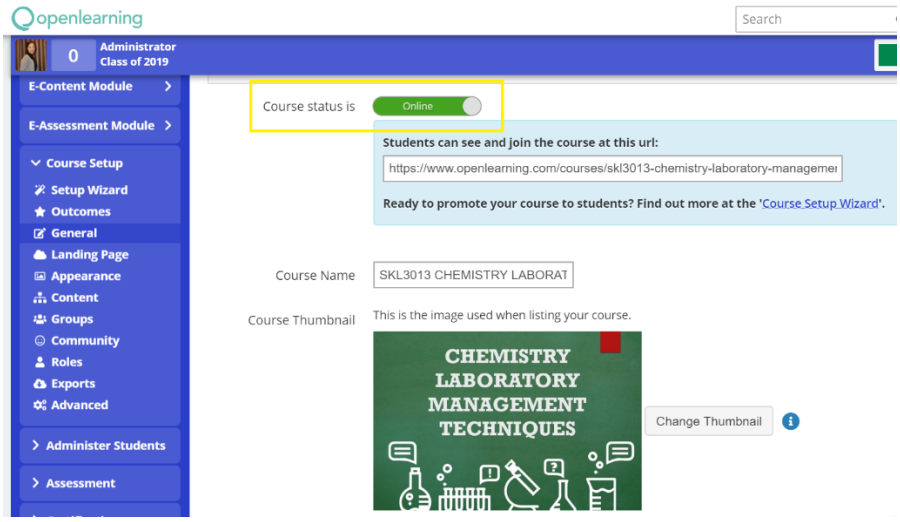


Figure 7 Change status to online

During the implementation phase, the CLMT MOOC is ready to be introduced to the users. Link of the MOOC was given to the experts, who were then briefed to use the MOOC, e-content and e-assessment module. All the experts were given a duration of two months to explore the modules and answer the module content validity evaluation form. They were introduced to a group of undergraduate students during the pilot study once the modules passed the content validity. Students were briefed about the purpose of the research and their involvement in the study. Thereafter, QR code was given to link them to CLMT MOOC. They were also given a briefing on the e-content and e-assessment module in CLMT MOOC together with the e-content and e-assessment module reliability questionnaire. Students were given a duration of one month to explore and follow the activities in both modules with a view to answering the two sets of questionnaires. The results on the validity and reliability of e-content and e-assessment modules will be reported in the Data Analysis section.

The last phase of the ADDIE instructional model is an evaluation which can be carried out through formative and summative evaluation. Concurrently, a formative evaluation was conducted with analysis, design, development and implementation phase in order to check the instructional material and identify any mistakes or weaknesses to be revised. It was done in three ways: one-to-one trial, small group trial and field trial [7]. Research assistant works together with the multimedia designer to design and develop the e-content and e-assessment modules. The supervisor checked and gave comments on the content, design and language via one-to-one trial. Review and revise cycle ended when the supervisor was satisfied with the modules. Subsequently, a formative assessment was carried out by the research team members and content validity experts via a small group trial. All the members and experts gave their views on both modules, after which corrections were made based on the comments and suggestions given. Finally, the e-content and e-assessment modules were tested in field trials during the pilot study to investigate their reliability. Thereafter, the modules were ready for the summative evaluation to be carried out on three levels: level 1: perception, level 2: learning and level 3: performance [7]. In this study, level 1 summative evaluation was carried out so as to gauge students' perception of the CLMT MOOC in the aspects of acceptance, usage barriers and instructional design element.

Data Analysis

The second objective of the study is to evaluate the validity and reliability of e-content and e-assessment modules in the CLMT MOOC. Therefore, module content validity evaluation form was given to the experts and then analysed using Item-Content Validity Index (I-CVI). As per the recommendations made by Lynn [19], three experts were appointed to evaluate the content validity of both modules. They were required to assess the relevance of the instructional materials in both modules to the content of CLMT course. Comments and suggestions from the experts were taken into consideration until they rated relevance or highly relevance for the entire content in both modules. Hence, all items in both e-content and e-assessment

module content validity evaluation form obtain I-CVI 1.00. As recommended by Lynn [19], the I-CVI should be 1.00 when there are five or fewer judges.

According to Noah and Ahmad [20], the way to determine the reliability of the module is similar to the means of determining the reliability of the instrument. Hence, the reliability of both e-content and e-assessment module was investigated via module reliability questionnaire distributed to the students during the pilot study. After the students finished exploring both modules in CLMT MOOC, they answered the questionnaire. Items in both sets of questionnaires requested response from the students regarding their agreement on whether they can follow all the steps and activities in the modules. Reliability indexes analysed by Cronbach's alpha for all the topics in both e-content and e-assessment modules are presented in Table 5. The Cronbach's alpha indexes for all topics ranged from 0.71 to 0.96 in both modules, which indicated acceptable and good internal consistency of the scales, also showing their inter-item consistency reliability [21-22]. The Cronbach's alpha values of the e-content module were higher as compared to the e-assessment module, indicating that almost all the students can understand the materials delivered in the module. On the other hand, not all the students are able to answer the questions or exercises in the e-assessment module. However, overall Cronbach's alpha for both modules showing indexes that are approaching 1.

Table 5 Cronbach's alpha for all topics in e-content and e-assessment modules

No.	Topics	Cronbach's alpha	
		e-Content module	e-Assessment module
1.	Safety Measures During Use and Preparation of Chemical Substances	0.96	0.79
2.	Apparatus and Measurements in The Laboratory	0.89	0.81
3.	Glassware Cleaning and Chemical Storage	0.94	0.79
4.	Preparation of Solution and Dilution	0.92	0.71
5.	Titration	0.89	0.80
6.	Separation and Purifying Samples Using Filtration and Recrystallization	0.92	0.84
7.	Distillation	0.94	0.86
8.	Glass Blowing	0.94	-
9.	Overall	0.99	0.97

RESULTS AND DISCUSSION

The final objective of the study is to identify undergraduate students' perception of the CLMT MOOC developed in the study. During field study, perception questionnaire was distributed to 152 undergraduate students. They were given a month to explore and respond to their agreement to the items asked in perception questionnaire on the aspects of acceptance, usage barriers and instructional design elements of CLMT MOOC. Students' perception on CLMT MOOC by constructs and sub-constructs are presented in Table 6.

Table 6 Mean and standard deviation on constructs and sub-constructs for students' perception on CLMT MOOC

No.	Construct	Sub-Construct	Mean (M)	Standard Deviation (SD)
1.	Acceptance	Performance Expectancy (PE)	4.16	0.62
		Effort Expectancy (EE)	4.18	0.63
		Social Influence (SI)	3.84	0.73
		Facilitating Conditions (FC)	4.03	0.60
		Total	4.05	0.54
2.	Usage barrier		3.03	0.84
3.		Course Information (CI)	4.09	0.65

Instructional design element	Course Resources (CR)	3.88	0.72
	Active Learning (AL)	3.96	0.67
	Monitoring Learning (ML)	4.05	0.68
	Interaction (IR)	3.76	0.81
	Intended Perception (IP)	4.01	0.66
	Total	3.96	0.59

There are four sub-constructs in acceptance construct: Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI) and Facilitating Conditions (FC). Items in the acceptance constructs were based on The Unified Theory of Use and Acceptance of Technology (UTAUT) [23]. The mean values for the sub-constructs ranged from 3.84 – 4.18, and the overall mean of the acceptance construct was found to be 4.05 (SD = 0.54). The highest mean value for acceptance construct was EE (M = 4.18, SD = 0.63). EE denotes the ease of use of the new technology [23]. This sub-construct has similarities with the Perceived Ease of Use in Davis [24] and convenient to use in the study conducted by Sukhbaatar, Choimaa and Usagawa [25]. Items in EE construct are related to whether it is easy or difficult to use CLMT MOOC. The high mean score in EE sub-construct shows that CLMT MOOC is easy to use, understand and learn by using this MOOC. Moreover, CLMT MOOC provides a user-friendly learning environment by means of good navigation, the ease to find specific content as well as the ease to use the environment [26]. MOOC developers should ensure all the learning materials in the MOOC can be loaded quickly, the links can be easily navigated and the platform functions well at all times [27].

SI refers to the degree to which an individual perceives that important others (teachers, lecturers, parents and friends) believe they should use the new technology [23]. This sub-construct has the lowest mean score (M = 3.84, SD = 0.73) when compared to other sub-constructs in the acceptance construct. This low mean score may be attributed to the less exposure of MOOC among teachers, lecturers, parents and friends around the respondents. Respondents for other local studies [17, 28] also have the low mean scores for SI sub-construct, which shows that the community in Malaysia is not familiar with the use of MOOC in education. Hence, social influence does not happen among the respondents to influence and encourage them to use the MOOC.

The second construct in the perception questionnaire is the usage barrier defined as the obstacles faced by students that will negatively impact them when using the MOOC platform [17]. Based on Table 7, this construct was found to gain the lowest mean score among the three constructs in the perception questionnaire (M = 3.03, SD = 0.84). Low mean score in this construct shows positive usage and good implementation of MOOC among the students. Barriers listed in the questionnaire are related to internet connectivity, equipment, knowledge and skill to use MOOC, self-motivation and the content of MOOC. Among all the items in the usage barrier construct, internet connectivity obtained the highest mean (M = 3.78, SD = 1.16) as compared to other items. Students agreed that the poor internet connectivity or the absence of Wi-Fi coverage is the main obstacle for them to use CLMT MOOC. Students had problems when they want to view the videos in the e-content module. Internet obstacle was also reported in other local [28] and oversea [29] studies. In addition, respondents also have limited knowledge (M = 3.22, SD = 1.10) and skill (M = 3.10, SD = 1.12) to learn using MOOC. This barrier is relevant to the SI construct in the acceptance construct, given that the exposure of MOOC among community in Malaysia continues to be very low. Hence, respondents are less mastered and less skillful in handling learning using MOOC. Besides, results showed that item A18 gained the lowest mean score (M = 2.54, SD = 1.12), thus revealing that the materials in the MOOC are very interesting. Various information applying different multimedia elements are provided in CLMT MOOC, such as text, graphic, audio, visual, animation and interactivity. Virtual and blended learning environment is more interactive and interesting compared to the conventional learning environment [30].

Table 7 Mean and standard deviation for items in usage barrier construct

No.	Item	Mean (M)	Standard deviation (SD)
A13	Poor Internet / Wi-Fi coverage	3.78	1.16
A14	Lack of knowledge in the use of MOOC	3.22	1.10
A15	Lack of skills to use MOOC	3.10	1.12
A16	Equipment for using MOOC is incomplete	2.86	1.04
A17	No motivation to learn using MOOC	2.95	1.20
A18	The material in the MOOC is not interesting	2.54	1.12
A19	No standard allocation of scores in the MOOC	2.81	1.06
A20	The course wishes to attend is not offered in MOOC	3.01	1.07

There are five sub-constructs in instructional design element construct: course information (CI), course resources (CR), active learning (AL), monitoring learning (ML), interaction (IR) and intended perception (IP) [10]. The overall mean for this construct is 3.96 (SD = 0.59). The CI sub-construct obtained the highest mean score (M = 4.09, SD = 0.65), while IR recorded the lowest mean score (M = 3.76, SD = 0.81). CI lists all the information regarding CLMT MOOC, for instance, the objectives, the topics and assessment method of the course. Respondents found all the course information to be clearly listed and easily understood. A mind map summarising all the contents in CLMT MOOC was presented in the Learning Activities page in CLMT MOOC. This Advanced organiser [31] acts as the cognitive instructional tool to assist learners organise the information that will be delivered to them.

IR gains the lowest mean score among the sub-constructs in instructional design element construct (M = 3.76, SD = 0.81). The items in this sub-construct asked about the ease and convenience of interaction between the students with their lecturers and course mates. The mode of interactions in the CLMT MOOC included the following: student-teacher, student-student, student-content, teacher-content, teacher-teacher and content-content. These interactions are described by Interaction Equivalency Theorem [32]. Relatively low mean score in this sub-construct revealed that students find it more convenient to interact and collaborate with their peers in a face-to-face manner However, asynchronous communication technologies, for instance, discussion forums, blogs, and a variety of social media, are extensively used by MOOC platforms to support learners' interaction and communication [33], especially amidst the COVID-19 pandemic.

Educational institutions were closed due to the global outbreak of COVID-19. This phenomenon forces the educational institutions to convert traditional face-to-face learning to online learning ensuring continuity of learning. MOOC is the best alternative platform for the educators to transform their classroom into a virtual learning environment. Learners and educators can communicate in either a synchronous or asynchronous manner [34]. The virtual community of practice in MOOC entails learning together by collaborative learning [35]. They share knowledge, evaluating other's ideas and monitoring their peers' progress. Collaborative learning enables learners to assist each other and achieve intellectual, social and problem-solving learning objectives in the classroom [36]. Students registering CLMT course have no problems to continue their learning by using this CLMT MOOC, since all the teaching/learning materials and communication with their lecturer is maintained. It is hoped that more MOOCs will be developed in order to help university achieve the goal of DePAN 2.0 and globalised online learning of our university.

CONCLUSION

All the objectives of the study were achieved by developing the e-content and e-assessment modules in the CLMT MOOC by means of the following: identifying the validity and reliability of both modules, investigating undergraduate students' perception of the MOOC in terms of acceptance, usage barriers and instructional design element. However, more online learning materials need to be created in order to ease online and remote teaching due to the outbreak of COVID-19 as well as to adapt to the new norm for the post COVID-19 situation. Online teaching pedagogies related to remote teaching need to be focused in order

to ensure that teaching and learning process meet the entire learning outcomes as face-to-face delivery method.

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