Chemistry Massive Open Online Course: Validity, reliability and undergraduate students' perception

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Abstract

Massive Open Online Course (MOOC) is a new trend in flexible education due to its flexibility to study anything, anywhere and anytime. It has the potential to attract a huge number of learners to study courses unlimitedly via the online platform. This is a design and development study where a Chemistry MOOC was developed in an OpenLearning platform using ADDIE Instructional Design Model. The purpose of this study is to (1) identify the validity of the e-content module and e-assessment module in the Chemistry MOOC, (2) identify the reliability of the e-content module and e-assessment module in the Chemistry MOOC and (3) gauge undergraduate students' perceptions on the MOOC, especially the instructional design elements, the acceptance and usage barrier. Instruments involved in the study are content validity evaluation form, module reliability questionnaire and perception questionnaire. Four content experts and 23 undergraduate students were involved in evaluating the validity and reliability of the modules during the pilot study. A total of 129 undergraduate students participated in the real study as the respondents for the perception questionnaire. The content validity index for both the e-content and e-assessment module is 1.00, meanwhile, the reliability index for the e-content module and e-assessment module is 0.94 and 0.97, respectively. The overall mean score on the perception, instructional design elements, acceptance and usage barrier is 3.87 (SD = 0.53), 3.91 (SD = 0.62), 3.83 (SD = 0.52) and 2.80 (SD = 0.92) respectively. In conclusion, the results show that Chemistry MOOC is valid and reliable for self-learning online material for chemistry concepts. Students' perception mean scores on the Chemistry MOOC are moderately high, indicating that they positively perceive the MOOC developed. Improvement can be made to ensure a better quality of MOOC before carrying out the summative evaluation on the effectiveness of the Chemistry MOOC.

Keywords: Chemistry, Massive Open Online Course, Validity, Reliability, Instructional design, Acceptance, Usage barrier

Introduction

Massive Open Online Course (MOOC) is an online course offered for unlimited participation and open access through the Internet (Hervatta, 2016). It was introduced in 2008 by Dave Cormier to describe the 12-weeks online course titled Connectivism and Connective Knowledge developed by Siemens and Downes from the University of Manitoba, Canada (Holland & Tirthali, 2014). The MOOC aims to increase the level of networking between students and their communities, where students receive the same skills and knowledge at the end of the program (Mackness, Mak & Williams, 2010). This is in line with the lifelong learning needs, which are also continuous and voluntary learning in the pursuit of knowledge (Hamidon, 2014). Lifelong learning enhances social involvement and human development and is more resilient in competition and pursuit of employment.

MOOC can be divided into two types, namely cMOOC and xMOOC, with "c" representing connectivism and "x" representing exponential (Holland & Tirthali, 2014). cMOOC is based on the connectivist pedagogical model. The course materials in cMOOC are flexible, unspecified and are constantly evolving. Participants in cMOOC act as instructors and learners as they build and share practices, knowledge, and understanding. Learning is seen as generating and connecting networks that connect knowledge (Siemens, 2013). The advantages of cMOOCs are open, where students can continue their learning with less structured learning activities and thus provide more autonomy to students (Kop, Founier & Mak, 2011, Siemens, 2013). However, due to the openness of these cMOOCs, it also has a negative impact on students as cMOOC has caused some students to feel "lost" in the learning environment (Kop, 2011). Besides that, it has also caused students to become confused with the overwhelming learning resources available to them.

On the other hand, xMOOCs are based on the traditional university pedagogical model. A lecturer or tutor handles this xMOOC with predetermined learning objectives. The implementation of xMOOC is based on instructional video, assessment and discussion in the forum. xMOOC can block the learning process because instructors act as experts while learners are considered knowledge consumers (Siemens, 2013). xMOOC is developed in a closed platform that provides several structures for students' existing learning resources. Siemens (2013) noted that the learning process focuses on teachers while students duplicate the knowledge structure that was initially determined by course designers and instructors.

Community in MOOC communicates in either synchronous or asynchronous way (Hervatta, 2016). Synchronous communication occurs when all MOOC participants interact at the same time regardless of location. In contrast, asynchronous communication occurs when MOOC participants interact freely at different time and location. Synchronous communication occurs using live video conferencing and text chats in real-time. In contrast, asynchronous communication occurs in the forums through discussions, comments, votes, and peer evaluation.

Background of Study

Malaysia's Higher Education Institutions (HEIs) are encouraged to globalize online learning as written in the ninth shift of the Malaysia Education Blueprint 2015-2025 (Higher Education). This shift aims to widen access to good quality content, enhance the quality of teaching and learning, lower the cost of delivery, and bring Malaysian expertise to the global community (Ministry of Education Malaysia, 2015) and foster lifelong learning, especially among Malaysians. The proposed approach is through the offering of MOOC at each HEI in Malaysia.

MOOC is in line with the direction and goal of the Malaysia National e-Learning Policy (Dasar e-Pembelajaran Negara, DePAN), which was launched on 16 April

2011. DePAN is a policy developed specifically to support the National Higher Education Strategic Plan (Pelan Strategik Pengajian Tinggi Negara, PSPTN) to enhance and strengthen the quality of higher education in Malaysia so that higher education can be transformed and propelled to a level of excellence. Now, this policy has been updated as DePAN 2.0. The new policy focuses on promoting innovation in education, branding Malaysian education, bringing Malaysia's expertise and skills globally, reducing the cost of delivering and cultivating lifelong learning. DePAN 2.0 outlines six major domains (1) infrastructure and infostructure, (2) governance, (3) online pedagogy, (4) e-content, (5) professional development, and (6) acculturation (Ministry of Education Malaysia, 2015). There are three phases in DePAN 2.0, namely, Phase 1 (2015), Phase 2 (2016-2020), and Phase 3 (2021-2025). In Phase 2, 50% of all courses offered in each HEI should be implemented in the form of blended learning. In addition, 10% e-assessment needs to be practised via blended learning, and each HEI needs to offer at least 15 courses in the form of MOOC. Phase 2 also targets 25% of all courses offered to have original e-content and 10% Open Course Ware (OCW).

OpenLearning is the platform for developing MOOC in Malaysia. To date, statistics in OpenLearning show that the number of MOOC registered by HEIs in Malaysia still does not hit the target of DePAN 2.0.

Objectives of Study

In order to help the university respond to the ninth shift of the Malaysia Education Blueprint 2015-2025 (Higher Education), a Chemistry MOOC has been developed in the OpenLearning platform. Besides achieving the ninth shift, this Chemistry MOOC also contributes to the vision, mission and objective of the DePAN 2.0 through the online pedagogy domain and e-content domain. This Chemistry MOOC can reach all focus areas in the online pedagogy domain, namely (a) blended learning, (b) Open Course Ware, and (c) e-assessment. Two of the focus areas in the e-Content domain can also be achieved through this study, namely (a) original e-content and (b) open e-content. Besides, the development of Chemistry MOOC contributed to the design and development studies, especially in online chemistry learning. This MOOC will spark the idea of educators, program developers and instructional designers to develop more similar MOOCs in various learning platforms. This paper highlights the validity and reliability of e-content and e-assessment module and students' perceptions of the Chemistry MOOC in different constructs. The objectives of the study are to:

a. Evaluate the validity of e-content and e-assessment modules in the Chemistry MOOC.

b Identify the reliability of e-content and e-assessment modules in the Chemistry MOOC.
c Gauge the undergraduate students' perceptions of the MOOC in the aspects of instructional design elements, the acceptance and usage barrier.

Methodology of Research

Research Design

This is a design and development research (DDR) implementing ADDIE instructional design model. An xMOOC typed of Chemistry MOOC had been developed in the OpenLearning platform following the phases in the ADDIE model. A needs assessment was carried out during the Analysis phase to get the information from the lecturers on the chapters which are suitable to be delivered to the students in the form of MOOC. Types of content and assessment materials were collected and designed during the design phase. All the materials were then uploaded in the OpenLearning platform during the Development phase. Pilot study was done during the implementation phase to obtain the validity and reliability index of the modules in Chemistry MOOC, and finally perception questionnaires were distributed to the respondents to study their perception of the MOOC during the evaluation phase.

The main learning outcome to be achieved through this Chemistry MOOC is to enable the learners to apply fundamental chemistry concepts to solve chemistry problems. The content of this Chemistry MOOC is based on four chemistry topics, namely (1) Stoichiometry of Formulas and Equations, (2) Quantum Theory and Periodic Table, (3) Chemical Bonding and (4) Nuclear Chemistry. The e-content module compiles all the notes for the four topics in the form of PowerPoint slides, videos and animations. On the other hand, the e-assessment module provides exercises in multiple-choice questions, short answer questions, drag and drop activities, crossword puzzles, mix and match questions and true or false questions. The exercises were presented in two categories. The remedial exercise provides simple questions with difficulty level 1 and 2. While enrichment exercise consists of more challenging questions with difficulty level 3 and 4.

Sample of Research

Sample of research was chosen based on the objectives of the study: validity, reliability and perception. Four content experts were assigned to evaluate the content validity of the e-content module (three experts) and the e-assessment module (three experts). Since the Chemistry MOOC was developed for the undergraduate chemistry topics, a group of 23 undergraduate students was involved in the pilot study to answer the reliability questionnaire. A total of 129 undergraduate students from the Faculty of Science and Mathematics enrolled in Chemistry courses were randomly chosen as the respondents for perception study. The demographic information of the respondents is shown in Table I.

Table I. Demographic Information of Respondents

No.	Objectives	Demographic information	Categories	Frequency (n)	Percentage (%)
1.	Validity	Expertise	Physical chemistry	1	25.00
			Organic chemistry	1	25.00
			Inorganic chemistry	1	25.00
			Analytical chemistry	1	25.00
2.	Reliability	Gender	Male	9	39.13
			Female	14	60.87
		Program	Chemistry	19	82.61
			Biology	2	8.70
			Mathematics	2	8.70
3.	Perception	Gender	Male	28	21.70
			Female	101	78.30
		Program	Chemistry	112	86.80
			Biology	3	2.30
			Physics	6	4.70
			Mathematics	8	6.20

Instruments and Procedure

This study's three different instruments are the content validity evaluation form, reliability questionnaire, and perception questionnaire. These instruments were distributed to different groups of respondents in different phases based on the study's objectives.

Content Validity Evaluation Form

Content validity evaluation form was developed based on the content presented in both e-content and e-assessment modules in the Chemistry MOOC. For instance, the evaluation form for the e-content module listed all the videos and notes delivered in the module (Hamid, Lee, Taha, Rahim, & Sharif, 2021). On the other hand, the evaluation form for the e-assessment module listed all questions and exercises asked in the module (Kamarudin, Tien, Sharif, Taha & Rahim, 2020). The evaluation form was given to the four content experts during the Implementation phase of the ADDIE model. Experts were given the link of the Chemistry MOOC in the OpenLearning platform (Figure 1), and they were briefed on how to use both the e-content and e-assessment module in the MOOC. They need to evaluate the relevance of content in the e-content module and relevance of questions in the e-assessment module based on a 4-point scale: 1 = totally irrelevant, 2 = irrelevant, 3 = relevant, 4 = highly relevant.

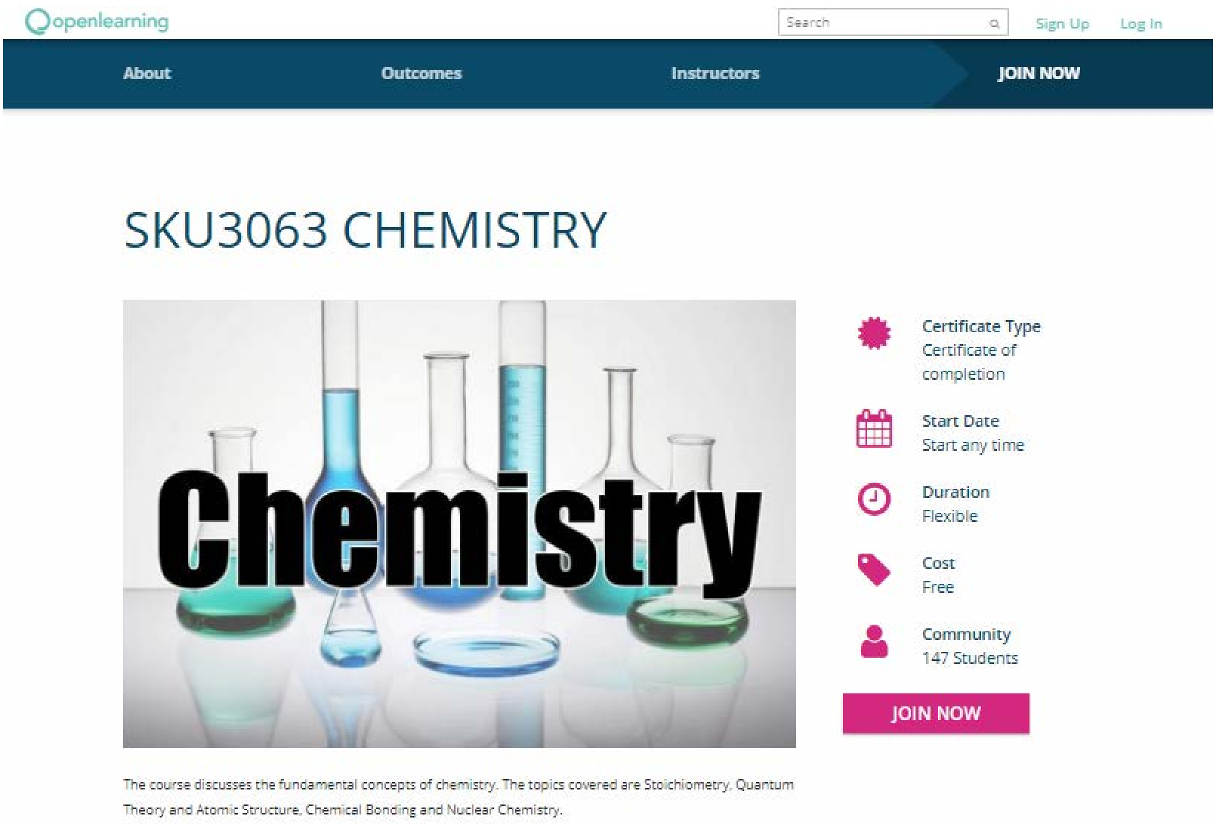

Figure 1. Promotional Page of Chemistry MOOC

Reliability Questionnaire

The reliability questionnaires used in the study were adapted from Noah and Ahmad's study (2005), which suggested two ways of identifying the reliability of a module. First is the ability of learners to achieve learning outcomes of the module, and second is the ability of learners to follow all the activities presented in the module. This study followed the second option. A group of undergraduate students were randomly chosen to answer the reliability questionnaires. The purpose of giving the reliability questionnaire to the respondents was to obtain the reliability index of the e-content and e-assessment module in the Chemistry MOOC. There are two sets of reliability questionnaire that focus on the e-content and e-assessment module activities. The items in the questionnaire are meant to check whether students can follow the content in the e-content module and answer the questions in the e-assessment module. Example of items in the reliability questionnaire is listed in Table II.

Table II. Sample Items in Reliability Questionnaire (Hamid *et al.*, 2021; Kamarudin *et al.*, 2020)

No.	e-Content Module	e-Assessment Module
1.	I understand the notes titled "The Mole".	I understand all the instructions of exercise in the module.
2.	I can follow the explanation in the video titled "Stoichiometry Made Easy: Stoichiometry Tutorial".	I can choose the correct answer in the multiple choice questions.
3.	I can follow all the content delivered in "Stoichiometry" topic.	I can solve the cross word puzzle.

Perception Questionnaire

Undergraduate students were gathered in a lecture hall, and they were introduced to the Chemistry MOOC. Students were given the QR code or website address to join the Chemistry MOOC. After they signed up or signed in, the course's homepage will be shown to the respondents. The respondents were briefed about how to use the e-content module and the e-assessment module in the MOOC. All respondents were given one to two weeks to explore the Chemistry MOOC before answering the perception questionnaire.

The perception questionnaire consists of three constructs, namely instructional design elements (20 items), acceptance (12 items) and usage barriers (8 items). The sub-constructs and the relative number of items are shown in Table III. This questionnaire was adapted from Fesol, Salam and Shaarani (2017) for the instructional design elements items and Daud, Zulkifli, Rahman and Khalid (2017) for the acceptance and usage barrier items. This study uses a 5-point Likert scale questionnaire, with 1 indicating 'strongly disagree', 2 indicates 'disagree', 3 indicates 'neutral', 4 indicates 'agree', and 5 indicates 'strongly agree'. Three experts were assigned to check the content validity of the instrument. The experts gave comments to improve the items. After revision, the instrument obtained a content validity index (I-CVI) of 1.00 for all the items in the questionnaire. The reliability of the questionnaire was analyzed using internal consistency, and the Cronbach's Alpha value obtained is 0.93.

Table III. Distribution of Items based on Constructs and Sub Constructs

No.	Construct	Sub-Construct	Distribution of items	Total item
1.	Acceptance	Performance Expectancy (PE)	A1 – A3	3
		Effort Expectancy (EE)	A4 – A6	3
		Social Influence (SI)	A7 – A9	3
		Facilitating Conditions (FC)	A10 – A12	3
		Total		12
2.	Usage barrier		A13 - A20	8
3.	Instructional design elements	Course Information (CI)	B1 – B4	4
		Course Resources (CR)	B5 – B8	4
		Active Learning (AL)	B9 – B12	4
		Monitoring Learning (ML)	B13 – B16	4
		Interaction (IR)	B17 – B20	4
		Total		20
4.	Total			40

Results and Discussion

The validity of e-content and e-assessment modules were analyzed using Item Content Validity Index (I-CVI) (Polit & Beck, 2006), while the reliability of both modules was analyzed using the internal consistency method. Students' perceptions of the Chemistry MOOC were analyzed using Statistical Packages for Social Sciences (SPSS) version 20 to get the mean scores and standard deviations. The data will be presented according to the constructs and sub-constructs in the perception questionnaire.

Validity and Reliability

Four chemistry content experts checked the content validity of both e-content and e-assessment modules. Comments and suggestions from the experts were followed, and corrections were done accordingly. Hence, all the experts agreed on the relevance of all content in both modules giving the results of 1.00 for all I-CVIs in the content validity evaluation form. Lynn (1986) suggested that I-CVI should be 1.00 when less than six experts are evaluating the content validity. On the other hand, the reliability index of the e-content and e-assessment module is 0.94 (Hamid et al., 2021) and 0.97 (Kamarudin et al., 2020), respectively. These indexes indicate that both modules show high reliability (Hair, Black, Babin, Anderson & Tatham, 2006) because students can follow the content in the e-content module and answer the questions in the e-assessment module.

Perception

The perception of students on the Chemistry MOOC was analyzed based on instructional design elements, acceptance and usage barrier. Table IV shows the mean scores and standard deviations for the students' perceptions of Chemistry MOOC according to the constructs and sub-constructs.

Table IV. Students' Perception on Chemistry MOOC by Constructs and Sub-Constructs

No.	Construct	Sub-Construct	Mean	Standard Deviation
1.	Instructional design elements	Course Information (CI)	4.05	0.63
		Course Resources (CR)	3.82	0.74
		Active Learning (AL)	3.98	0.68
		Monitoring Learning (ML)	4.01	0.70
		Interaction (IR)	3.68	0.89
		Total	3.91	0.62
2.	Acceptance	Performance Expectancy (PE)	4.05	0.65

		Effort Expectancy (EE)	3.97	0.66
		Social Influence (SI)	4.00	0.71
		Facilitating Conditions (FC)	3.30	0.92
		Total	3.83	0.52
3.	Usage barrier		2.80	0.92
4.	Overall perception		3.87	0.53

Instructional Design Elements

There are 20 items in the instructional design elements with four items in each sub-construct: course information (CI), course resources (CR), active learning (AL), monitoring learning (ML) and interaction (IR). The CI sub-construct obtained the highest mean score (M = 4.05, SD = 0.63) while IR recorded the lowest mean score (M = 3.68, SD = 0.89).

The motivation issue was reported as a challenge in enrollment or retention of MOOC learning (Henderikx et al., 2018; Siemens, 2013; Wang & Baker, 2015). The respondents in this study were briefed about the Chemistry MOOC, and their participation in this study was based on a voluntary basis. Hence, they have no intrinsic motivation (Ryan & Deci, 2000) to use the MOOC, and their registration to the Chemistry MOOC might be due to curiosity (Davis, Dickens, Leon Urrutia, Sánchez-Vera, & White, 2014; MOOC @ Edinburgh, 2013; Sukhbaatar et al., 2018; Wang & Baker, 2015) or due to the recommendation by the researchers (Sukhbaatar et al., 2018). This also explains the identification type of social influence (Kelman, 1958) because of the identity of the researchers as their lecturers.

In order to extend learners' engagement to the MOOC and ensure retention, MOOC designers need to make sure that they have quality instructional design elements (Atiaja & Proenza, 2016) in the MOOCs. Previous studies showed that course content (Atiaja & Proenza, 2016; Henderikx et al., 2018; Hone & El Said, 2016; Kop, 2011; Wang & Baker, 2015) and interaction (Atiaja & Proenza, 2016; Henderikx et al., 2018; Hervatta, 2016; Hone & El Said, 2016; Murray, 2014; Kop et al., 2011) are important features in designing MOOCs to ensure retention and decrease the dropout rate.

Course content in MOOCs enables the learners to read, watch and play, so they normally comprised supporting notes, informative videos, discussion forums, interactive quizzes and interesting games (Murray, 2014; Wang & Baker, 2015).

Content presented in MOOC must be relevant, reliable, innovative and interactive. Videos presented in the MOOC must be segmented into a short chunk (Guo, Kim & Rubin, 2014; Hone & El Said, 2016) to avoid boredom and ensure engagement. Hence, the duration of the video must not be more than six minutes (Guo et al., 2014; Schmoller.net, 2015) as it is the maximum duration for learner engagement. Besides that, MOOC designers must be creative in designing the content by selecting techno-learning tools, such as augmented reality, virtual reality, gamification, and social media use (Atiaja & Proenza, 2016).

Social interaction in MOOCs involves three main components: content, learner and instructor. The three components can interact in multi ways such as content-learner, content-instructor, content-content, learner-instructor, learner-learner and instructor-instructor to promote deep and meaningful learning (Anderson & Garrison, 1998). According to the equivalence theorem (Anderson, 2003), deep and meaningful formal learning is supported as one of the three forms of interaction (student-teacher; student-student; student-content) is at a high level (p.4). The teacher's presence supports cognitive presence. Facilitator-learner and learner-learner interaction are important to enhance learning (Kop et al., 2011). The virtual community of practice (Hervatta, 2016) in MOOC is learning together by collaborative learning. They share thoughts and knowledge, evaluating other's ideas and monitoring their peers' progress. However, a large number of forum discussion participants make the instructors or facilitators unable to respond immediately (Hervatta, 2016), causing poor retention or dropout among the learners. Hence, MOOC designers must improve the quality of interaction through high levels of automation, allowing the optimization of instructors' time with tools that promote scalability of a need of a huge number of learners (Atiaja & Proenza, 2016).

Acceptance

The acceptance construct includes four sub-constructs: performance expectancy (PE), effort expectancy (EE), social influence (SI) and facilitating conditions (FC). The overall mean score for acceptance construct is 3.83 (SD = 0.52). The sub-construct with the highest mean score in the acceptance construct is PE (M = 4.05, SD = 0.65) while the sub-construct with the lowest mean score is FC (M = 3.30, SD = 0.92).

The acceptance constructs aimed to examine undergraduate students' acceptance of the new technology, specifically Chemistry MOOC, in this study. Acceptance constructs in the perception questionnaire are based on The Unified Theory of Use and Acceptance of Technology (UTAUT) (Venkatesh, Morris, Davis & Davis, 2003). PE is defined as the degree to which an individual believes that using the new technology will help them attain gains in job performance (Venkatesh et al., 2003). The high mean score in this study is in line with Daud and colleagues' study (2017), where each of their items in the PE constructs gained a high mean score value. The highest mean score in PE sub-construct supports Venkatesh et al. (2003) output where PE is the strongest predictor to the behaviour intention of technology acceptance. Students believed that they could study Chemistry course more effectively by using this MOOC. By reading the notes in the PowerPoint slides and watching the informative videos, students can enhance their learning about the related chemistry concepts. Hence, it can help them achieve better understanding and gain better result in the test.

EE is the degree of ease associated with the use of new technology (Venkatesh et al., 2003). This sub-construct is similar to the Perceived Ease of Use (Davis, 1989) and convenient to use (Sukhbaatar, Choimaa & Usagawa, 2018). Items in this sub construct asked about whether it is easy or difficult to use Chemistry MOOC. Students' responses showed that the MOOC is quite easy to use, as reflected by the moderately high mean score. All the content in the MOOC were arranged systematically in the e-content module and e-assessment module. Learners were shown the advanced organizer (Ausubel, Novak & Hanesian, 1978), which acts as the cognitive instructional tool to help learners organize the information presented to them. Mental scaffolding provided by the advance organizer eases the process of learning (Lee, Rohadi, Alfana, 2016; Mohammadi, Moenikia & Zahed-Babelan, 2010).

SI is related to the degree to which an individual perceives that it is important for others to believe they should use the new technology (Venkatesh et al., 2003). Important others in this study refer to teachers, lecturers, parents and friends. According to Social Influence Theory, important others influence an individual's beliefs, attitudes, and behaviours via three processes: compliance, identification, and internalization (Kelman, 1958). In this study, undergraduate students' behaviour on using Chemistry MOOC is through the identification process. They adopt the behaviour because it is associated with the desired relationship, not because of avoiding punishment (compliance) or intrinsically rewarding (internalization) (Kelman, 1958). The mean score for SI in this study is the second-highest in the acceptance construct compared to other studies in Malaysia (Azmi & Rasalli, 2018; Daud et al., 2017).

FC refers to the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the new technology (Venkatesh et al., 2003). This sub-construct gained the lowest mean score, in line with Daud and colleagues' study (2017). However, Azmi and Razalli (2018) reported the second-highest mean score for this sub-construct. FC in this study refers to the equipment needed, knowledge of students and assistance from others when students were using Chemistry MOOC. Learning via MOOC in the OpenLearning platform is considered a new experience among undergraduate students in the related university. Students were only briefed once before they started to explore the Chemistry MOOC. Hence, they may face difficulty asking for help if they need an explanation to clear their doubt in using MOOC. This supports the finding for the usage barrier about knowledge to use MOOC in the next construct.

Usage Barrier

The overall mean score for the usage barrier is quite low, with a mean score of 2.80 (SD = 0.92). The item related to the barrier factor on Internet coverage (item A13) gained the highest mean score (M = 3.98, SD = 1.13). The usage barrier factor on the content of Chemistry MOOC (item A18) recorded the lowest mean score (M = 2.52, SD = 1.15). The detailed information on the usage barrier items with their related mean scores and standard deviations are displayed in Table V.

Table V. Mean Score and Standard Deviation for Usage Barrier Construct

No.	Item	Mean	Standard Deviation
	I am less involved in MOOC learning because		
A13.	poor Internet / Wifi coverage.	3.98	1.13
A14.	lack of knowledge in the use of MOOC.	3.20	1.16
A15.	lack of skill to use MOOC.	3.04	1.14
A16.	equipment to use MOOC is incomplete.	2.99	1.18
A17.	no self motivation to learn to use MOOC.	3.04	1.07
A18.	material in MOOC is not attractive.	2.52	1.15
A19.	no standard allocation marks in MOOC.	2.82	1.09
A20.	courses to be followed are not offered by MOOC.	2.81	1.12

Self-paced learning, self-directed learning, independent learning, life-long learning and collaborative learning are inter-correlated when a student learns a certain course in the MOOC platform. MOOC designers and instructors should provide sufficient content to ensure that learners can have a quality learning experience in the MOOC. However, statistics showed that only a small portion of learners completed the MOOC due to some retention barriers (Atiaja & Proenza, 2016; Hone & El Said, 2016; Siemens, 2013; Wang & Baker, 2015).

Major problems faced by the respondents in this study when using Chemistry MOOC are poor Internet/wifi coverage problem, lack of knowledge or skill in using MOOC (Henderikx, Kreijns & Kalz, 2018; Kop et al., 2011; Sukhbaatar et al., 2018) and no self-motivation to learn to use MOOC. These results support previous research in Malaysia where Internet problems and self-motivation are the main barriers in using MOOC (Azmi & Rasalli, 2018). The location of the study causes Internet problem because Internet quality is not so good in the town area compared to the city. Students need to connect to the university's wifi to access the MOOC. A huge number of wifi users reduces the quality and speed of the connection. This problem does not apply to Daud and colleagues' study (2017) because their respondents were from a city with good quality Internet and wifi coverage. Besides, the respondents in Hone and El Said's study (2016) stated that they had difficulty loading the long video due to connectivity issues, especially from mobile devices. Hence, learning with MOOC will be more convenient when computers or laptops with strong Internet/wifi connections are used instead of mobile devices.

Conclusions

A Chemistry MOOC was developed in the OpenLearning platform as an effort to assist the related universities in achieving the government's desire in globalizing online learning. Many factors need to be considered in designing a MOOC. It is a series of instructional content delivered over the Internet and access to a huge number of learners from different locations connected at different times. The Chemistry MOOC developed in this study showed good validity and reliability for both the e-content and e-assessment modules. Furthermore, perceptions from the undergraduate students revealed that they have strong performance expectancy in using this MOOC as they believed that it helps them have a better performance in the future. Students rated Internet connection as their main usage barrier in using MOOC, but they have the least problems with the material presented. To improve the instructional design of this MOOC, researchers need to overcome the interaction issue, which gained the lowest mean score among the instructional design elements. Further investigation on the effectiveness of Chemistry MOOC on students' cognitive performance and social development needs to be done as a summative evaluation of the ADDIE instructional design model. Besides, it is expected that the Chemistry MOOC can positively influence chemistry learning and teaching from a global perspective. Hence, a research collaboration between different countries could be done to compare the different perspectives among the learners from the countries.

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