User experience (UX) and usability in completing a MOOC on emergency medicine core content course (iEM/Lecturio): A case study

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Abstract

This study evaluates a Massive Open Online Course (MOOC) on Emergency Medicine designed by iEM Education Project and Lecturio, using a validated checklist to assess its usability and user experience. The MOOC received a high score for cognitive connection (>4/5), in four components including interactivity, content and resources, media use, and instructional assessment. However, for learner guidance and support, the score was 2.75/5, indicating that the course did not provide clear instructions on how learners can get support or feedback from teachers when encountering problems in the course. For affective and functional connections, all components received a high overall mean score of more than 4/5. The course was impactful to the users who were in their early clinical years, as they were actively engaged and were motivated to complete the course. However, improvements should be made to better stimulate learning by improving learner feedback and providing space for collaborative learning online.

Evaluation of MOOC applying the heuristics of usability and user experience identifies specific components of online learning course apart from rating the severity of acceptance or violation of instructional design principles. The information derived from usability and user experience studies can improve design and delivery of online courses.

Keywords: *Usability, user experience (UX), instructional technology, Emergency Medicine, e-Learning, MOOCs.*

Introduction

The digital transformation in technology-enhanced learning led to several learning strategies which includes developing e-objects of learning and use of curated online learning resources. Since 2023, hybrid learning has evolved to be incorporated in delivery of the medical curriculum.[1,2] Asynchronous online learning is widely used through MOOC to reach a larger audience today. For effective learning, such courses must engage students and evaluate their experience in relation to cognitive, affective, and technical components of the course.

Additionally, online learning will require the learner to be motivated, self-regulate, and employ higher order thinking. The MOOC should provide a safe environment for peer-learning and collaborative social intercourse with teachers and fellow learners. These factors, together with the desire to complete the MOOC, constitute the affective component of usability heuristics.[3,4]

MOOCs have emerged as a new form of technology-enhanced learning in higher education, becoming especially relevant in supporting teaching and learning processes during the recent COVID-19 pandemic.[5] Learning can take place at the convenience of the learner using MOOC,[6] apart from self-development and upskilling learners. MOOC is considered a new initiative in both public and private higher education institutions.[7] The effectiveness of MOOCs in achieving the intended objectives depends on appropriate use of instructional design principles, content development, user experience and usability in the educational process. There are some disadvantages of online courses such as poor user interfaces and disorganised learning materials, which collectively lead to a high dropout rate of learners.[8]

Usability focuses on users' performance and satisfaction between task-oriented aspects and other non-task-

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oriented aspects such as aesthetic and stimulation. Usability is closely related to user interaction,[9] while user experience (UX) takes a more holistic view. UX i.e, the functional component of a MOOC, refers to "the subjective experience of the user when interacting with technology to perform some task or function to achieve a desired outcome and end goal".[10] To ensure optimal results in both usability and UX of MOOCs, the general design should be engaging, interactive, visually appealing, and allow the user to successfully complete the tasks. A well-designed MOOC will fulfill the needs of self-directed learning. Inclusion of assessment tools and award of rewards for completion of tasks are motivating factors.

The objectives of this research are to evaluate usability and UX to provide a report of a free online course on Emergency Medicine (iEM/Lecturio)[11] to reflect on all three learning connections i.e, cognitive, affective, and functional.

Methods

The study was carried out between 1st March 2022 – 31st December 2022 in the Clinical Sciences, International Medical University, in three phases (Figure I).
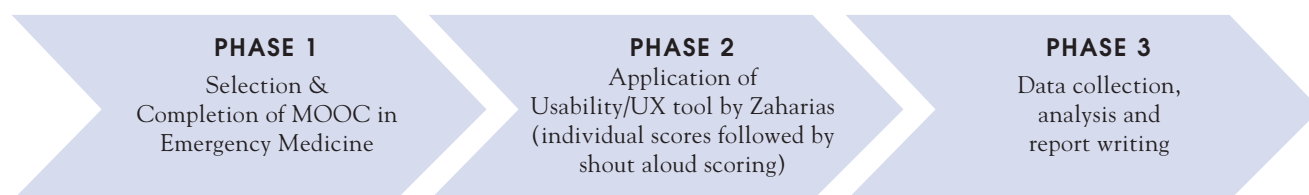

PHASE 1	PHASE 2	PHASE 3
Selection & Completion of MOOC in Emergency Medicine	Application of Usability/UX tool by Zaharias (individual scores followed by shout aloud scoring)	Data collection, analysis and report writing

Figure I: Phases of Research

1. Phase 1: Completion of MOOC on Emergency Medicine after training in UX scoring

Six medical students who were in the 4th year MBBS programme volunteered to participate in the study as both subjects and researchers. They were tasked to access the MOOC and complete the module independently. They were under the supervision of the senior author (SN). Informed consent for the study was obtained.

The selected MOOC on EM was developed in accordance with the International Federation of Emergency Medicine and Society of Academic Emergency Medicine's standards for undergraduate emergency medicine curriculum.[11] There are a total of 11 lessons in the module, covering 37 subjects.
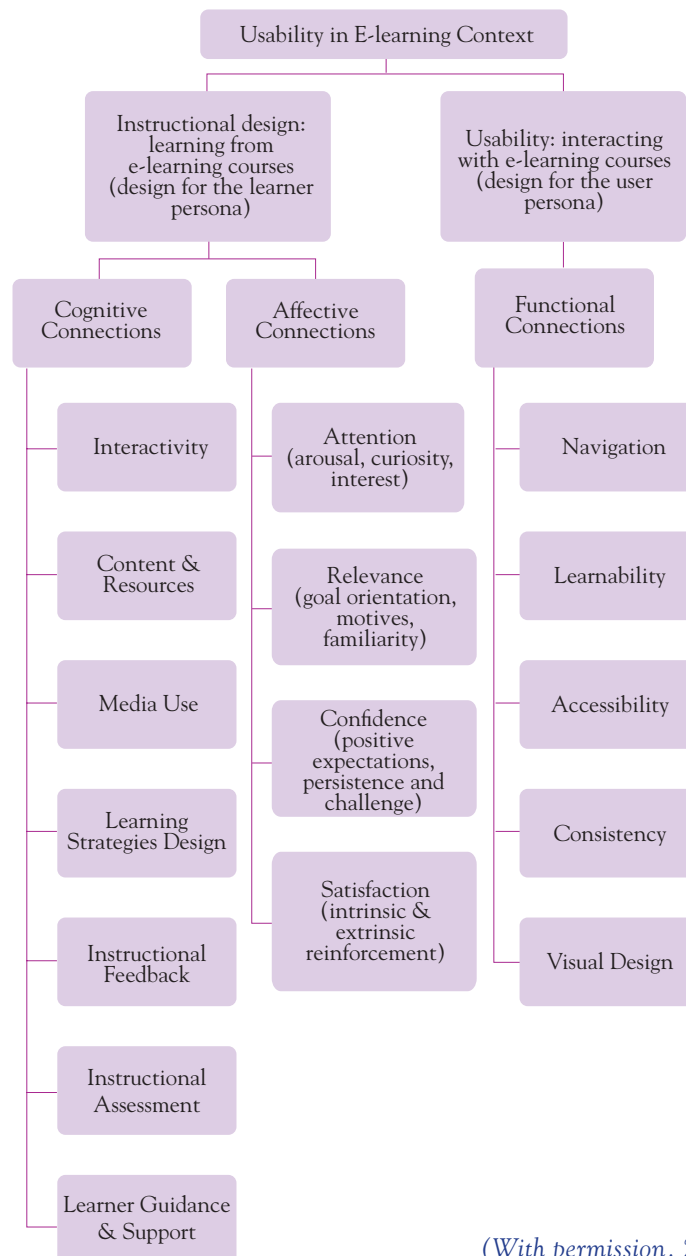
Each lesson ended with self-check formative quizzes, reading assignments, and videos. The learner will receive a certificate of completion after completing all components of the course. All the participants, being fourth year medical students in IMU, were familiar with the use of e-learning platform used in delivery of the module. They were trained by the senior author to use a validated checklist for independent evaluation of the MOOC by each participant. Informed consent for participation was obtained from all subjects.

2. Phase 2: Rating components of the MOOC on EM using a validated checklist on UX

A framework checklist developed by Panagiotis Zaharias[12] was used to evaluate the usability and user experience of this MOOC. He had developed this

tool based on Neilson's heuristic principles of user-design and studies on usability parameters to provide measurement criteria.[13] Written permission for use of this checklist was obtained from the checklist developer. The framework focuses on instructional design which has cognitive and affective learning connections; and usability which has functional connections (Figure II).[14]

(With permission, Zaharias P, 2009)

Figure II: A Framework that Integrates Usability and Instructional Design Parameters

Cognitive connections in the checklist used in the study are interactivity, content and resources, media use, learning strategies design, instructional feedback, instructional assessment, learner guidance and support. They focus on how the learner interacts with the course module, and how well the course helps the users achieve their learning goals.

Affective connections addressed are attention, relevance, confidence, and satisfaction. They focus on determining how motivated the learner is to complete the course.

Functional connections focus on navigation, learnability, accessibility, consistency, and visual design. They test the design of the course based on technological aspects to facilitate learning.

All six participants, tasked to complete the EM module online, conducted the usability study of the MOOC independently, before reaching a rating consensus for each component in the checklist.

3. Phase 3: Evaluation, consensus rating and comments

The MOOC was evaluated by each of the six participants independently. For each criterion, the researchers assigned a score that best reflects their reaction. To determine the final score, each researcher was expected to provide a justification for their response. A Likert scale (1-5, five being best), with a maximum score of 5, was used to determine the scoring. After completion of the MOOC, all participants met to develop final scores, applying the "shout-aloud" method. Justifications and comments were collated to reflect on the three main components of the evaluation tool for usability and UX. Recommendations to improve the MOOC based on its strengths and weaknesses were discussed.

Results

1. Cognitive Connections

Cognitive connection measures the degree of effectiveness to achieve students' learning goals in the MOOC. The results are summarised in Figure III.
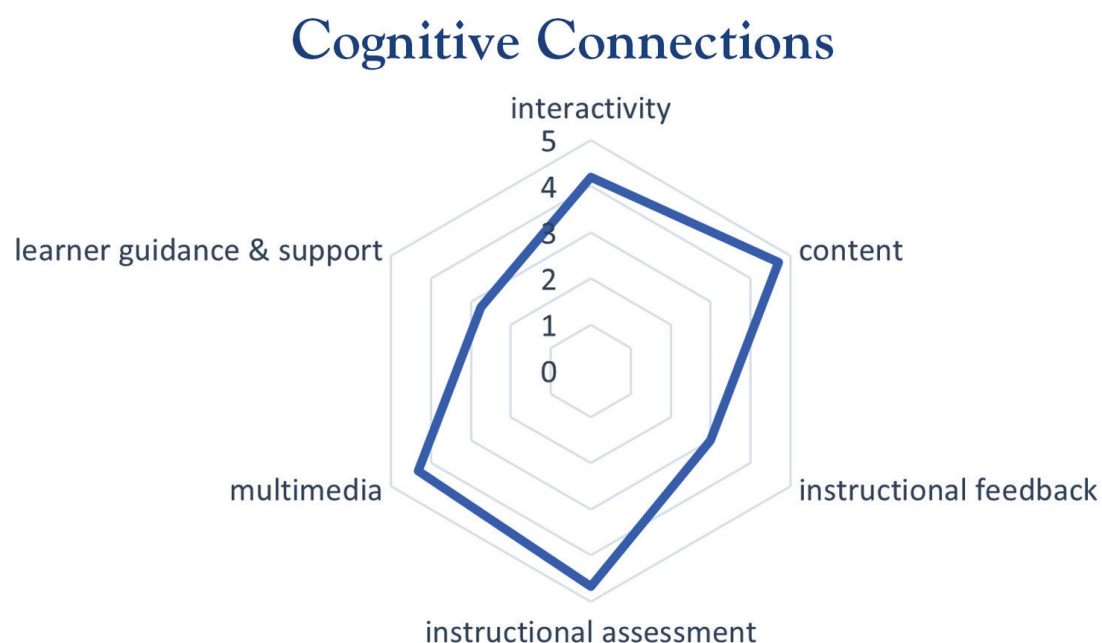

Figure III: Cognitive Connections Radar Chart

a) Interactivity/engagement

Interactivity measures how engaged and how interested the learners were in their learning experience. The results for the interactivity section are presented in Table I. The overall mean score is 4.2/5, with three out of five items given the full score of 5/5, whereas item number 2 received a score of 4/5. However, item number 1 was given a low score of 2/5 because there were little to no games, simulations, or role-playing activities which made maintaining motivation harder. Self-check was with quizzes.

Table I: Cognitive Connections in Emergency Medicine by Interactivity

NO	ITEM	SCORE (max. score: 5)
1	The courses use games, simulations, role-playing activities, and case studies to gain the attention, and maintain motivation of learners.	2
2	The courses provide meaningful interactions (for example, embedded quizzes, tests, etc.) when there are long sections of text.	4
3	The courses provide access to a range of resources (web links, case studies, simulations, problems, examples) appropriate to the learning context and for use in the real world.	5
4	The courses engage learners in tasks that are closely aligned with the learning goals and objectives.	5
5	Media are used appropriately, so as to assist in highlighting and learning critical concepts rather than merely entertaining or possibly distracting learners.	5
Mean: 4.2 **Mode: 5** **Standard Deviation 1.3**		

b) Content and Resources

This is a major part in the instructional design of the overall course. Table II shows the results from the analysis of the study, with seven out of ten items awarded the highest score of 5/5 while items 4, 8 and 9 were scored 4/5 each. The score for item number 4 was given as such because the researchers believed that the resources were accurate, albeit clinical management may be different locally, as the course is a USA based one. For items number 8 and 9, the researchers concluded that the concepts are well explained but could be better if more examples were given. With a mean score of 4.7/5 and a standard deviation of 0.48, the researchers quite strongly agreed that the MOOC contained relevant and accurate information originating from reliable sources.

Table II: Cognitive Connections in Emergency Medicine Core Content by Content & Resources

NO	ITEM	SCORE (max. score: 5)
1	Content is organised in an appropriate sequence and in small modules for flexible learning.	5
2	The material in the course is accurate and current.	5
3	The course covers the subject in sufficient breadth and depth to meet the learning objective.	5
4	Resources are provided in a manner that replicates as closely as possible their availability and use in the real world.	4
5	Text blocks are written in minimalist style: compact, yet useful.	5

6	The course provides access to a range of resources (web links, case studies, simulations, problems, examples) appropriate to the learning context.	5
7	Vocabulary and terminology used are appropriate for the learners.	5
8	Abstract concepts (principles, formulas, rules, etc.) are illustrated with concrete, specific examples.	4
9	All units/modules in the courses include an overview and a summary.	4
10	Learning objectives of each module are quite (obvious) clear to the learners.	5
Mean: 4.7 Mode: 5 Standard Deviation 0.48		

c) Instructional Feedback

This segment had an overall mean of 3/5 and standard deviation being 1.41. Item number 1 rated 2/5 because the course had no "space" where the learner could be motivated to request feedback. Figure IV shows that there was only an email mentioned briefly at the beginning of the course for feedback to the course designers. Although the feedback on questions were good, further explanation would have been better (Figure V).

Table III: Cognitive Connections in Emergency Medicine Core Content by Instructional Feedback

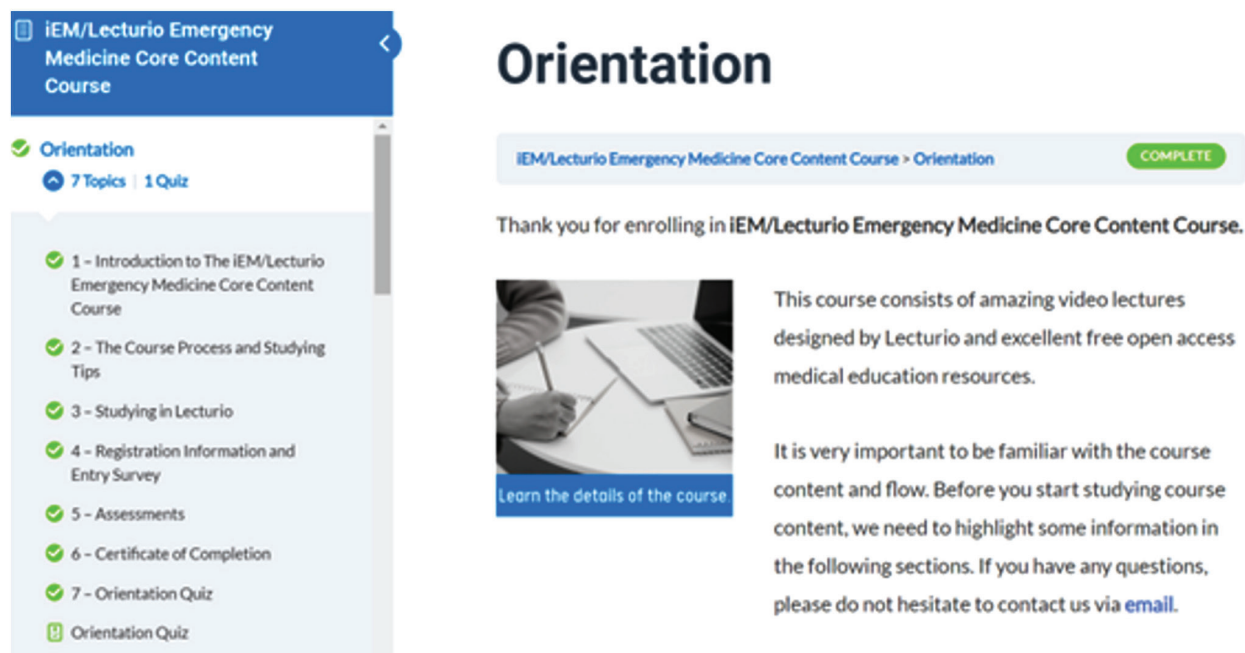| NO	ITEM	SCORE (max. score: 5)
1	The courses motivate learners to request feedback from instructors, experts and peers, through e-mail or other online communications.	2
2	Feedback given (by exercises or simulations, etc.) at any specific time, is tailored to the content being studied, problem being solved, or task being completed by the learners.	4
Mean: 3 Mode: – Standard Deviation 1.41		

Figure IV: Screen shot – Emergency Medicine Core Content Course by Instructional Feedback
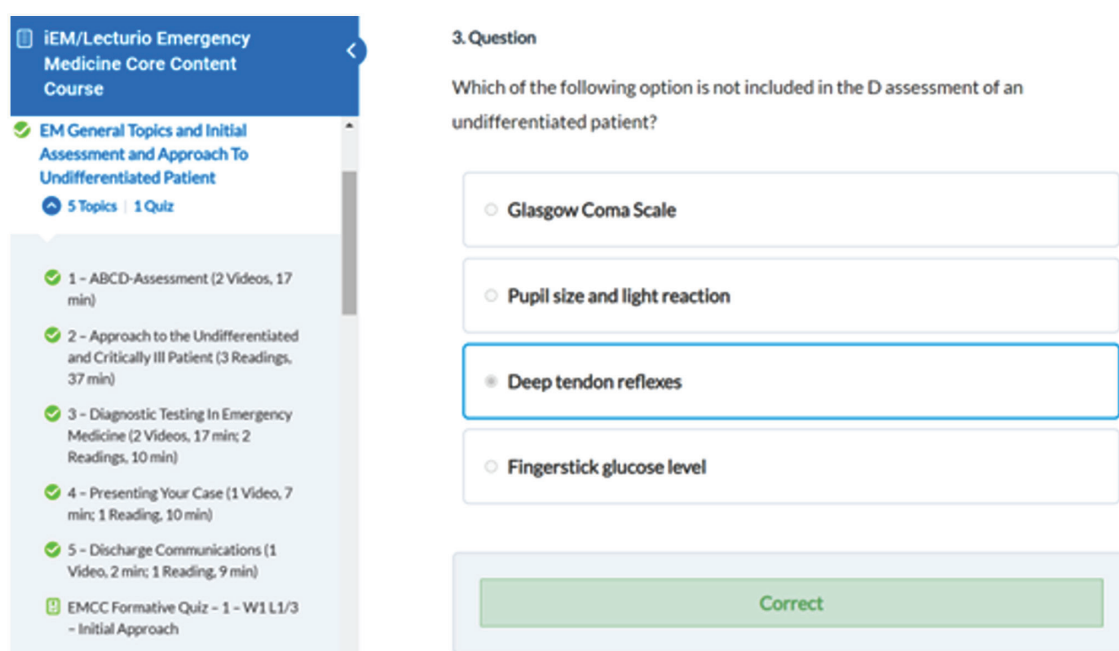

Figure V: Emergency Medicine Core Content Course by Instructional Feedback

d) Instructional Assessment

Table IV shows the descriptive results for the instructional assessment. The overall mean of 4.67/5 suggested that participants were generally satisfied with the instructional assessment component of the course. Participants also agreed that the course was able to provide excellent self-assessments and tests that would adequately measure the accomplishment of the learning objectives.

Table IV: Cognitive Connection in Emergency Medicine by Instructional Assessment

NO	ITEM	SCORE (max. score: 5)
1	The courses provide opportunities for self-assessments that advance learners' achievements.	5
2	Wherever appropriate, higher-order assessments (for example, case studies, business simulations, discussion topics, etc.) are provided rather than lower-order assessments (for example, simple quizzes and tests).	4
3	Post-tests and other assessments adequately measure accomplishment of the learning objectives.	5
	Mean: 4.67 Mode: 5 Standard Deviation 0.58	

e) Multimedia Use

Table V below shows the results of multimedia use in the Emergency Medicine Core Content Course, with a mean score of 4.3/5, and a mode of 4. Participants agreed that the course used appropriate multimedia when trying to highlight or emphasise a certain concept to its learners. Participants also agreed that the media used was always related to the objectives of the lesson, which proved to be helpful when trying to learn a new concept.

Table V: Emergency Medicine Core Content by Multimedia Use

NO	ITEM	SCORE (max. score: 5)
1	Graphics and multimedia assist in highlighting and learning critical concepts rather than merely entertaining or possibly distracting learners.	4
2	Graphics (illustrations, photographs, graphs, diagrams, etc.) are used appropriately (for example, to communicate visual and spatial concept).	4
3	Media (text, images, animations, etc.) included have a strong connection to the objectives and design of the courses.	5
	Mean: 4.33 Mode: 4 Standard Deviation 0.58	

Figure VI below shows the use of media in emphasising the steps to stabilise sick patients in the emergency department, which shows a strong connection to the learning objectives.
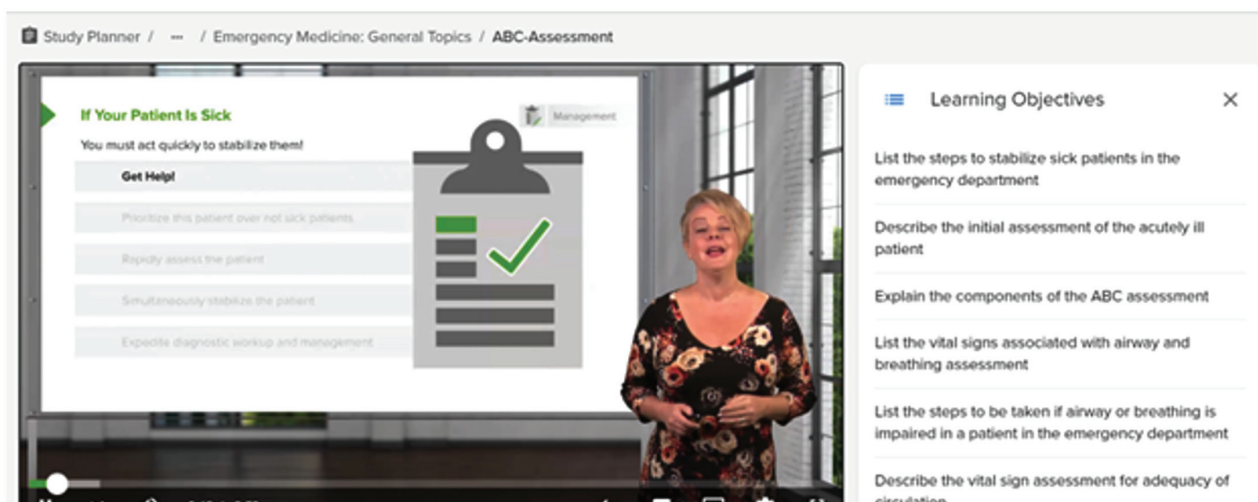

Figure VI: Emergency Medicine Core Content Course by Multimedia Use

f) Learner Guidance and Support

Table VI shows the score for the learner guidance and support component of the Emergency Medicine Core Content Course. The overall mean for this component is 2.75/5, with a mode of 2. Participants collectively agreed that if online help were offered while taking the course, it would be more convenient as participants would understand the topic better should they have any questions. However, the course did offer tools that support learning, e.g, a note taking tool.

Table VI: Emergency Medicine Core Content by Learning Guidance and Support

NO	ITEM	SCORE (max. score: 5)
1	The online help or documentation is written clearly.	2
2	The online help is screen- or context-specific.	2
3	The course offers tools (taking notes, job-aids, resources, glossary, etc.) that support learning.	3
4	The course provides support for learner activities to allow working within existing competence while encountering meaningful chunks of knowledge.	4
Mean: 2.75 Mode: 2 Standard Deviation 0.96		

2. Affective Connections

Section 2 of the checklist evaluates the affective learning dimension which relates to how participants gain motivation to learn while interacting with MOOC. Figure VII summarises the results of affective connections. In general, all of the items achieved a high score (4 and above) and the overall mean is 4.5 which is high with a very small dispersion of data (standard deviation 0.52) (Table VII). The participants agreed that the course increases their motivation level to complete it. Overall, they were satisfied with how the application incorporates activities that are enjoyable and helps the learner gain new skills at the same time.
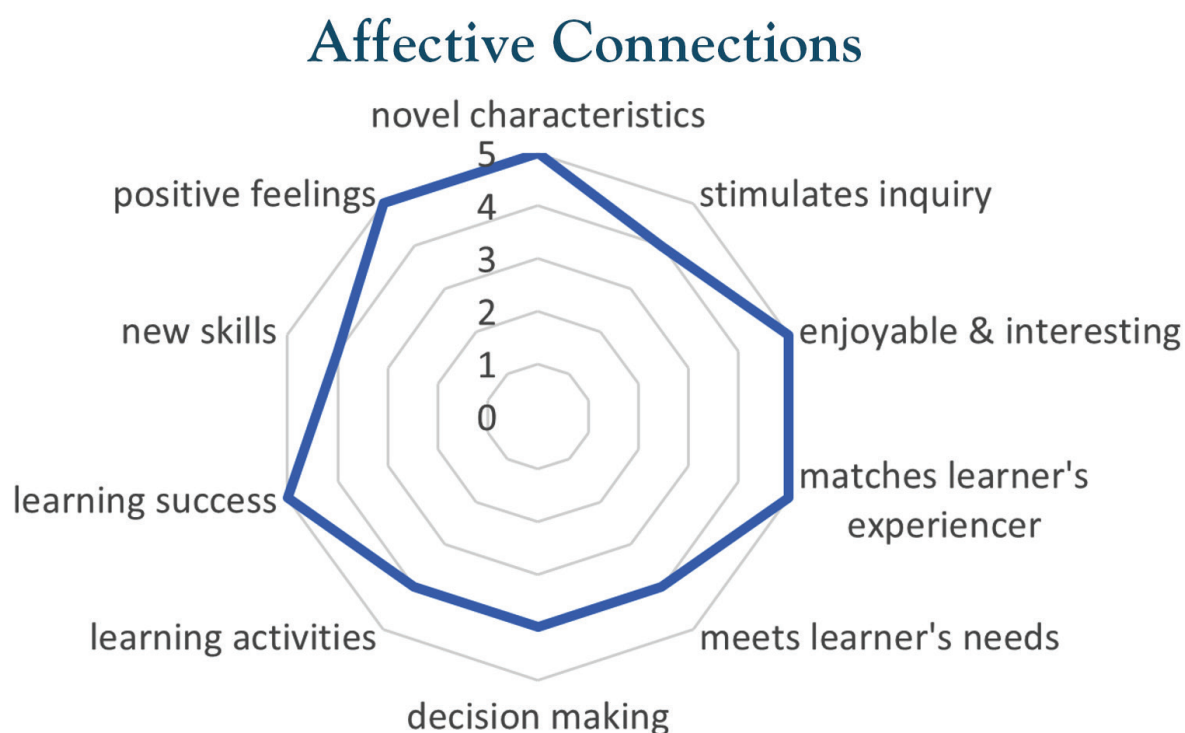
Affective Connections

Figure VII: Affective Connections Radar Chart

Tabel VII: Emergency Medicine Core Content by Affective Connections

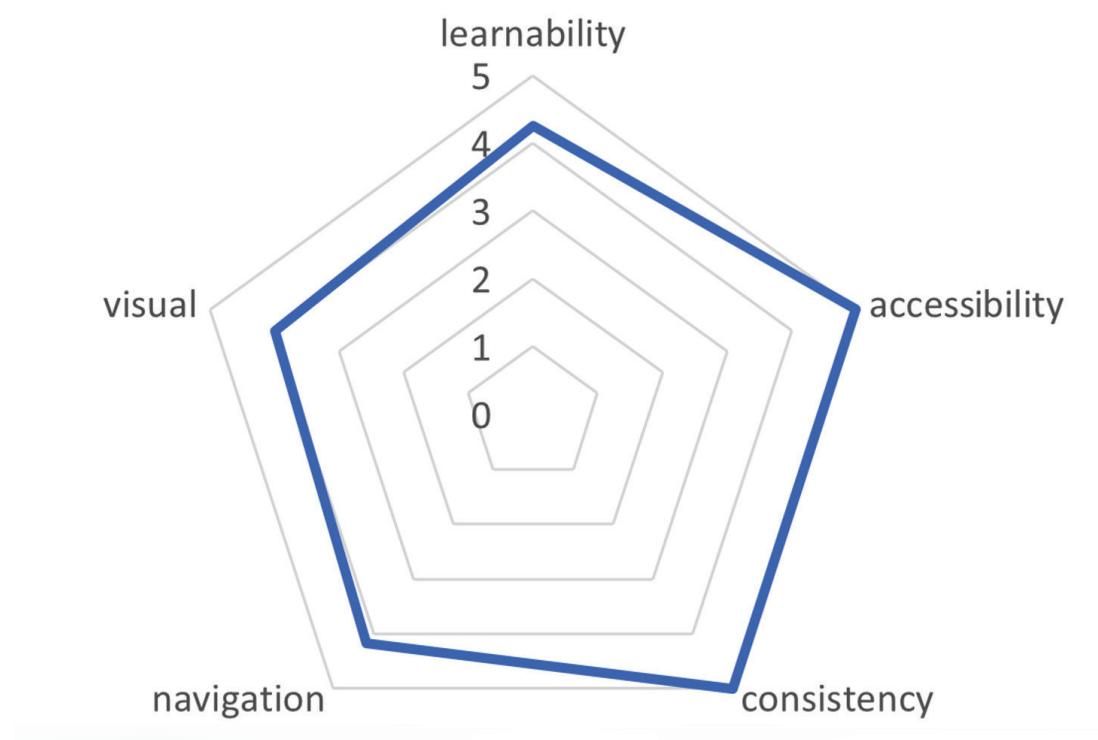| NO	ITEM	SCORE (max. score: 5)
1	The e-learning application incorporates novel characteristics.	5
2	The e-learning application stimulates further inquiry.	4
3	The e-learning application is enjoyable and interesting.	5
4	The e-learning application provides instruction/training that matches with learners' experience.	5
5	The e-learning application meets learners' needs.	4
6	The e-learning application provides learners the chances to make decisions.	4
7	The e-learning application provides learners with frequent and varied learning activities that increase learning success.	4
8	Learning requirements, criteria for learning success are clear within the e-learning application.	5
9	The e-learning application provides learners the opportunities to use new skills in authentic situations.	4
10	The e-learning application assists learners to have positive feelings about their accomplishments.	5
Mean: 4.5	**Mode: –**	**Standard Deviation 0.52**

Functional Connections

Figure VIII: Functional Connections Radar Chart

3: Functional Connections

Figure VIII summarises the details of Tables VIII-XII.

a) Learnability

Learnability can be closely tied to the effectiveness of a website. According to Table VIII, the feedback of the participants is positive with a mean score of 5, mode of 5 and standard deviation of 1.5. The only feedback is that more clear instructions should be given when the user gets stuck or unable to understand something. However, some participants suggested that clearer instructions should be provided when they get stuck or have trouble understanding something. Optimising a website's learnability is crucial for retaining visitors and achieving its intended purpose.

Table VIII: Emergency Medicine Core Content by Learnability

NO	ITEM	SCORE (max. score: 5)
1	The e-learning application layout is sufficiently apparent so that learning can develop without extensive consultation of online help.	5
2	Learners can start the application (locate it, install plug-ins, register, access starting page) using only online assistance.	5
3	It is clear what learners should do if they get stuck or have questions.	2
4	Learners can predict the general result of clicking on each button or link.	5
	Mean: 4.25 Mode: 5 Standard Deviation 1.5	

b) Accessibility

Accessibility evaluates issues of accessing the MOOC. In Table IX, the mean score is 5, mode is 5 with a standard deviation of 0. Overall, participants did not face any problem launching the application and had no problem assessing the course.

Table IX: Emergency Medicine Core Content Course by Accessibility

NO	ITEM	SCORE (max. score: 5)
1	The pages and other components of the application download quickly.	5
2	The e-learning application is easy to install, uninstall and launch.	5
3	The e-learning application is free from technical problems (hyperlink errors, programming errors, etc.).	5
	Mean: 5 Mode: 5 Standard Deviation 0	

c) Consistency

Consistency ensures expected behavior and reduces user distraction. Table X shows mean score: 5, mode: 5, standard deviation: 0. All participants agree that the course layout is consistent, causing no additional mental load or distraction.

Table X: Functional Connections in Emergency Medicine Core Content by Consistency Results

NO	ITEM	SCORE (max. score: 5)
1	Terminology of the functions is used consistently throughout the e-learning application.	5
2	The fonts, colors and sizes are consistent throughout the e-learning application.	5
3	The application maintains an appropriate level of consistency in its design from one part to another.	5
	Mean: 5 Mode: 5 Standard Deviation 0	

d) Navigation

The research participants were requested to rate the ease of navigation while using the emergency medicine online course and the descriptive results are documented in Table XI. All the components under navigation were given a score of 3 and above, with the mean score being 4.17. Overall, the research participants had a positive review on the navigation which eased their learning process.

Table XI: Functional Connections in Emergency Medicine Core Content by Navigation

NO	ITEM	SCORE (max. score: 5)
1	Learners can choose (easily) what parts of the e-learning application to access, the order and pace of studying.	3
2	Learners have control of their learning activities (studying, exercising, collaborating with other peers, etc.).	4
3	Learners always know where they are in the application.	5
4	The e-learning application allows the learner to leave whenever desired, but easily return to the closest logical point in the course.	5
5	The application layout is sufficiently apparent so that learning can develop without extensive consultation of online help.	5
6	It is clear what learners should do if they get stuck or have questions.	3
Mean: 4.17 Mode: 5 Standard Deviation 0.98		

e) Visual Design

Table XII shows the score for the visual design of the Emergency Medicine Core Content Course which focuses on improving the UX of a web/app through visual elements and effects, including colors, illustrations, photography, typography, and layouts. The mean score is 4/5 while the mode is 5/5. Participants concurred on the good quality of the design.

Table XII: Functional Connections in Emergency Medicine Core Content by Visual Design

NO	ITEM	SCORE (max. score: 5)
1	The most important information on the screen is placed in areas most likely to attract the learner's attention.	4
2	Text and graphics are legible (readable).	5
3	Fonts (style, color, saturation) are easy to read in both on-screen and in printed versions.	5
4	The online help or documentation is written clearly.	2
Mean: 4 Mode: 5 Standard Deviation 1.41		

Discussion

Access to the internet and digital transformation in education has led to its widespread use of well-designed MOOCs that promote collaborative learning.[15,16] The application of heuristics to test usability and expression of user experiences improves the final product. The framework in the assessment tool in this study (Figure I) was useful in achieving the objectives of this study as it tested cognitive, affective, and functional components of the MOOC in Emergency Medicine objectively.

The participants who completed the online course asynchronously and independently were able to reflect on specific constructs and make recommendations for acceptance or improvement in certain elements. They were contented that learning objectives were carefully incorporated into the course design. Setting out the learning objectives before each lesson provides a plan for learning. These were outlined at the beginning of each module. There was congruity among the participants that the interaction and engagement with the online course was good (Figure III, VII, VIII). The participants were satisfied with the content and learning resources for its high caliber. The organisation of the contents followed established instructional design principles and the flow of the lessons were predictably arranged. (Figure III & Figure VII).[17] Additionally, information and learning objects provided were current, generally sufficient, and included additional reading resources. Although the e-contents are tailored for clinical practice in the USA, much of the learning materials applies to standard of care in Malaysia.

Text blocks were well-constructed, easy to read, and full of resources, that helped learners grasp essentials with ease. In designing MOOC, developers will take cognizance of the objectives of the course. They will apply the ADDIE principles of instructional design, apart from ensuring the on-line course fulfils the three domains i.e. (i) cognitive connections (ii) affective connections and (iii) functional connections. The initial prototype would undergo usability testing and evaluation of user experience before the final product is made accessible to learners. The learnable contents in the course was appropriate for medical students studying in the clinical phase of the MBBS programme; the concepts were clearly explained. Including clinical examples would enhance learning in specific areas. Overviews and summaries again help reinforce learning and retention; these were included after each module in the Lecturio videos, but not in the iEM website.

Applying the predetermined heuristics mentioned above to evaluate usability indicates satisfactory cognitive linkages. Self-check, with the inclusion of numerous tests and quizzes enhanced learning of concepts in EM and engaged the learner more effectively. Moreover, each session also included a wide range of learning resources like web links, articles, and videos.[18] Motivating the learner is an essential component; this could be achieved with inclusion of gamification, simulations, and role-playing activities, apart from MCQs used in self-check.

Providing a forum for discussion promotes collaborative learning and provides a space for clarification and interaction with all stakeholders. Student-student interaction has numerous benefits;

group activities and chat forums avoid boredom and promote community learning.[4,19,20] Feedback that is timely, specific, and focused, is integral to formative assessment. Engaging with the instructor through discussion forums, prevents the feeling of isolation and helps in formative assessment. These were shortfalls of the course, as learners could not relate to the instructors when queries arose. The course did not provide an option for feedback requests; instead, there was only an email, briefly mentioned at the beginning of the course.

Learner-support had the least favorable effects on cognitive links. The main course website also did not contain any note-taking tools whereas the Lecturio website did. The need for teacher support in MOOCs is essential in online courses.[21] To aid in the learning process, numerous reading and video options were offered. However, the course was not able to offer help when it comes to working within current competence at undergraduate level.

The marking schemes provided were good; including explanatory notes that would be valuable for learners. Instructional assessment of the course was also notable as the course provided excellent self-assessments for learners to test their knowledge, contributing immensely to the understanding of each lesson. Most of the assessments were of low difficulty, although a number of higher-order tests were also included along case studies to increase engagement. The success of the learning objectives could be accurately measured by post-tests and other assessments. The evaluation component of MOOCs is critical to its success. The assessment tools provided in this course were appropriate and relevant to enhance learning.[22]

Multimedia used in the online courses should appeal to learners; this was commendable in this MOOC, despite being simple and repetitive. The media used in the course also aided in sustaining interest and did not interfere with the learning process. The graphics in each lesson were helpful in reinforcing several of the important concepts. Appropriate images, such as diagrams and graphs, were utilised to illustrate a particular topic. The learning objectives of the lesson were relevant and tied to the material used in each course, which was beneficial to the learners.

Accordingly, the components of the affective connections garnered positive feedback from the participants. The online emergency medicine core content course exceeded expectations and provided sufficient knowledge to encourage learning. Because of the available media, the subject matter was interesting and engaged the learner. The participants concurred using quizzes with case scenarios, prompted them to make better decisions in managing patients, and made learning about the principles of emergency medicine easier. Upon completing the course successfully there was a sense of pride and accomplishment among the participants (users).

Functional connections (summarised in Figure VIII) relate to usability; the learnability of the course was deemed adequate, except there were no clear instructions given when the users got "stuck". The e-learning application layout is sufficiently apparent for learning to take place. Accessibility of the course was exceptionally good as there were no problems encountered during application download, initiation of e-learning applications was smooth without any hassle, and little to no technical problems were encountered throughout the course. The online

emergency medicine course was also exemplary for its consistency. For instance, the designs and terminology of the functions were used consistently throughout the e-learning application without any discrepancy. On the other hand, learners have control over their learning progress, but were unable to collaborate with their peers throughout the course.

Although the course is free for undergraduates, access is restricted to the first 45 days; there are certain restrictions in the frequency of re-visit by the learner for revision. Navigation was commendable, the titles and directions allowed learners to retrace their progress. Learners could exit and return easily to the course at any given time and resume from where they had previously left off. Lastly, visual design of the course was mostly satisfactory with the learners able to identify the important information on the screen as the text, fonts and graphics are easy to read.[23]

This usability and UX study used validated heuristics[12] (Figure I) to evaluate a MOOC on EM. The whole course in EM is clearly set out; it was both satisfying and enlightening to all the six participants, generally. The course was conducted asynchronously and functioned well, achieving learning outcomes in nearly all aspects. The study provides sufficient evidence to provide an unbiased, yet comprehensive report on both the content, construct, and delivery modes.

Limitations

This study using heuristic evaluation employing a validated checklist took over 4-6 weeks. This differs from other heuristic evaluations, which are done over 2-3 days. Nevertheless, we find the evaluation tool (Figure I) sufficient to address the study objectives.[12,24]

Conclusion

Applying specific heuristics enabled the participants of this study to evaluate the usability and UX of the iEM/Lecturio Emergency Medicine Core Content online course. Except for learner guidance and support and instructional feedback, all other elements of the e-learning construct, under cognitive and functional components were ranked good to above average. This study shows the value of using a validated heuristic tool in reflecting on UX and usability of the module on EM available online as a MOOC. Given the limitations and some shortfalls in space for feedback and support from teachers, the course appears to be suitable as a complementary teaching tool for undergraduates employing a "flipped classroom" approach.[25]

The results from this research may make positive changes to the Emergency Medicine online course based on constructional feedback when presented to the constructors of the course. Additional research may be conducted to determine its alignment to the current syllabus of IMU MBBS students.

Ethics approval and acknowledgement

Conflict of Interest
All authors declare there is no conflict of interest.

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