The effects of a newly established online learning management system: the perspectives of Thai medical students in a public medical school

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ABSTRACT

Background: There are obstacles for medical schools in low- and middle-income countries (LMIC) to implement an online learning management system (LMS) during the pandemic of coronavirus disease 2019. Our medical school has developed and implemented tailored LMS for medical students and examine the acceptance and effects of this LMS on the medical students’ learning outcomes and identify factors influencing their adoption of online learning.

Methods: This was a mixed-methods study using an online questionnaire and online semi-structured interviews with first-year medical students at one medical school in Thailand. The platform’s monitoring system and questionnaire data were analysed using descriptive statistics and binary logistic regression.

Results: The response rate was 55.5% (157/283). Most of the respondents agreed on the advantages and were very satisfied with their learning experience. The logistic regression showed that content quality (adjusted odds ratio (AOR) = 2.43; 95% CI = 1.11–5.31) and perceived usefulness (AOR = 2.75; 95% CI = 1.02–7.39) were significantly associated with the acceptance of online learning among medical students. There was no association between the test scores and time spent in the course.

Conclusion: Despite limited evidence of LMS effectiveness in medical schools in LMIC, learning on a customised LMS appeared to be accepted, useful, user-friendly, and effective among medical students. The perceived usefulness and the content quality are associated with the acceptance of online learning. Medical schools in LMIC can develop their own LMS to ensure that it meets their learners’ and faculties’ needs. This study is a single-institution study, further large-scale studies are needed to ensure generalisability.

1. Introduction

During the past decade, there has been the rapid development and adoption of online learning in medical education [1]. Since the coronavirus disease 2019 (COVID-19) pandemic, the online educational method has become the main available learning and teaching mode for undergraduate medical study. The COVID-19 pandemic not only affects the health of medical students but also disrupts medical education [2]. Many medical schools, therefore, have developed or adopted tailored online learning management systems (LMS) for medical students to ensure that they can have effective learning during the pandemic [2].

Many studies have examined the effectiveness of online educational method [3, 4, 5, 6, 7]. The effects of the online education were described originally based on the four levels of effectiveness by Kirkpatrick [8], or modified forms for the medical education literature [6, 9], namely, satisfaction, learning, performance, and patient/health outcomes. Despite the advantages of online education in enhancing the medical students’ knowledge and skills [7], the previous meta-analysis studies demonstrated that the effectiveness of online learning was similar to that of traditional learning methods [5, 7].

Despite the evidence of the low effectiveness of the online learning mode, this educational method offers several benefits, including convenience, flexibility [3, 6], and particularly during the COVID-19 pandemic. However, poor uptake of online learning is evident [10]. Many studies have examined the barriers to online learning, which were identified into four main groups, including infrastructure, learners, facilitators, and the instructional designs of the online program related difficulties [11] For example, the lack of computer skills [12, 13] and social interaction [14], personal discipline [13], the personal touch of traditional learning [15], the complexity of technology [13], and lack of...
sufficient feedback [13]. To increase the adoption of online learning among health professions, data from several studies suggest that ease of use [16], perceived usefulness [17], compatibility with learning preference [16], learning community interaction [16, 18], user support [19], technological infrastructure [19], and implementation in a curriculum were associated with the adoption of online learning [16].

In order to develop an effective online learning program and increase the uptake of online learning, there is a need to consider these barriers to online learning. One of the solutions to these barriers was to adopt the online LMS that match the students’ learning objectives and needs. Although there has been an increase in the implementation of online learning globally [1], there are still some obstacles for medical schools in low- and middle-income countries (LMIC) to implement online learning [20]. The difficulties in adopting the LMS include financial and technology limitations [20], insufficient support and lots of time spent for medical teachers to build the online modules [21], the learner monitoring report that cannot be completely and promptly obtained, the instructional designs that may not match the learners and teachers’ needs, and the available LMS yet cannot be customised. In addition, the systematic review regarding LIMC showed that data about the effectiveness and evaluation of online learning in medical education were limited in the LMIC countries [20]. Furthermore, online learning interventions were mostly developed as temporary, small-scale projects [20].

In spite of the importance of the LMS in supporting online medical education, there remains a paucity of evidence on the effectiveness of the LMS developed in LMIC and factors associated with the adoption of online learning among medical students. Responding to the COVID-19 pandemic, our school has utilised a newly developed web-based learning management system (LMS) to support online learning at the faculty. This study, thus, aimed to assess the effects of the newly developed LMS on the students’ usage, satisfaction, and learning outcomes; and identify medical students’ perceptions, and factors influencing their adoption of this LMS. The results from this present study would help to guide the medical schools, particularly in the LMIC to develop their own customised online LMS in order to provide effective online learning programs and increase the uptakes of online learning. In addition, the customised online LMS would help each medical school to provide the effective online education that serves the teachers’ and students’ needs according to their medical educational context and system.

2. Material and methods

2.1. Study design and setting

A mix-method study, comprising a cross-sectional study and semi-structured online interviews, was conducted in the Faculty of Medicine at Khon Kaen University. The undergraduate program lasts six years, divided equally into preclinical and clinical years, with a student population of approximately 1,680.

2.2. Development and organisation of KKUMEDX

The customised web-based LMS, KKUMEDX, was newly developed by our faculty to overcome the limitations of current accessible online platforms. These limitations included cost, student’s monitoring system and customisation. Although some platforms allowed their users to adjust their functions and appearances, there were still limitations in customisation and management. Thus, these commercial platforms were not able to fulfil our needs.

Our LMS aimed to support both degree and non-degree courses. In addition, the resources are available free of charge for the faculty staffs and students.

All the functions of the LMS were developed based on the frameworks created by the developing team. The team’s discussions and agreements based on literature reviews and the team’s experiences. The programmer developed the website using php, html, JavaScript, and CSS. For the databases, MySQL was used.

The instructional designs of this LMS were developed based on Sargeant’s grouping, i.e., content presentation only, interaction with content, and interpersonal interaction [22], additionally with online assessments and learners’ monitoring system. The LMS monitoring system recorded learners’ personal information, numbers and time of logins, time spent in each learning topic, total time spent in the course, statuses in the course (started, completed, and passed) and test scores. The KKUMEDX was not designed with dedicated features for specific medical education in the first place but to support all possible effective online learning formats.

2.3. Participants

This study was conducted with all 283 first-year students because online learning on KKUMEDX was first introduced to this group of students who started their first academic year in July 2020. There were no exclusion criteria in our study. Among them, 15 students were sought due to the convenience of the online semi-structured interviews. Five students from each of the following groups were recruited: regular attendance in the course; partial attendance; and rarely or never attended the online course for study. The informed consent was obtained from each of the interviewees.

2.4. Sample size

The sample size was computed using OpenEpi version 3 based on a proportion of medical students who accepted e-learning [23]. Assuming the proportion of 0.73, the population size of 283, the design effect of 1, and the significance level of 0.05, a total number of 147 were sufficient. However, we included all 283 students in the study to avoid the potential source of selection bias.

2.5. Data sources, questionnaires, and assessment

An online self-administered questionnaire was developed based on the literature on the use of online learning in health professional education [23, 24, 25, 26], and the evaluation of online learning [27] and LMS [28, 29]. The questionnaire was designed to measure the following constructs of online learning effectiveness and attitudes towards the use of LMS: individual learner, perceived satisfaction, technology infrastructure, perceived usefulness, perceived ease of use, context, pedagogy, and interactivity in the LMS. These constructs included a three-point Likert scale, ranging from disagreeing to agreeing, which was used to assess the medical students’ agreement towards each item.

During the questionnaire development, each item was assessed thoroughly regarding the intention of measurement, relativity, ambiguity, understandability, and necessity of the item by three independent experts in the field of medical education at our school to ensure the face and content validity of the questionnaire. The average content validity index of the questions was 0.98.

The first-year medical students completed a 20-hour human behaviour course on KKUMEDX, in which this 18-topic course formed parts of the human development and behaviour module. In this course, students had twenty 1-h asynchronous online learning sessions and two 1-h sessions for class discussion with course lecturers. The total numbers of videos were 77 and the length of each video ranged from 0.22-49.01 min. The total time of the videos for each topic ranged from 8.48-70.33 min. The students would be considered as having completed the learning topic if that topic was accessed at least 50% of the total learning time for that topic. According to the definition of the learning topic completion, three clustered were grouped, i.e., regular learners were those who accessed 70-100% of the total topics; those who learned some topics were accessed 30–69% of the total topics; and those who rarely or never learned to mean they learned less than 30% of the total topics or none.
After they completed the course, they had a multiple-choice test. Although the scores were not the final grade for this module, the good score level for the course was set at 56% and above. This cut point was made based on the minimum passing level score of the module.

After the course finished, online questionnaires on Google Forms were sent to the students in August 2020. The survey was transferred from Google Sheets and the data from the LMS monitoring system were exported to Microsoft Excel version 2019. Then, the data was gathered and checked for data completion before being transferred into SPSS for Windows.

The interview questions were developed based on the literature review, findings of the survey mentioned above, and data from the LMS monitoring system. The interviews were conducted online, in January 2021, and recorded through Google Meet, together with a writing record by the interviewer (IT). Each interview took approximately 10 min. All audio recordings were transferred to a desktop computer. Each interview was listened to many times, then transcribed and saved as a Microsoft Word document. The transcripts were then sent to each interviewee to check for accuracy and to seek clarification on unclear comments. The interview data were analysed manually. The first author (IT) coded interview data directly on the printed transcripts. Each interview transcript was read many times. Data were coded by only one coder. The codes were then grouped into themes. Interrelating themes and abstracting to smaller sets of themes were performed.

2.6. Statistical analysis

Data analysis was performed using IBM SPSS for Windows version 26.0. A pairwise deletion strategy was applied to handle the missing data. Descriptive statistics were used to describe demographic data. A three-point Likert scale ranging from 1 to 3 points was dichotomised by calculating mean scores. The mean scores were considered agreed at a mean score >2.5. Chi-square tests with continuity correction and odds ratios were performed to compare dichotomous variables. Pearson’s correlation coefficient, tolerance and variance inflation factor (VIF) were conducted to detect multicollinearity among variables. Tolerance <0.1 and VIF >10 were considered as having multicollinearity, while a correlation coefficient <0.7 was considered as no multicollinearity. Significant variables were included in binary logistic regression analysis to examine their association with the adoption of online learning. Statistical significance was considered at a p-value < 0.05. The interview data were analysed manually and coded by one coder. The codes were then grouped into themes.

2.7. Ethics approval

This study was provided by the Khon Kaen University Human Research Ethics Committee (Project number HE631031).

3. Results

3.1. Demographic data

In total, 157 out of 283 (55.5%) first-year medical students participated in the questionnaires of this study. The characteristics of participants were demonstrated in Table 1.

3.2. Factors associated with the adoption of online learning

The participants reported the degree of influence that specific features of online learning had on their adoption of online learning (Table 2). Most of the respondents agreed on the advantages of online learning on KKUMEDX and were very satisfied (71.3%) with their learning experience in the LMS (Table 3). Regarding the obstacles of online learning on KKUMEDX, although about half of the medical students stated their preferences towards in-person learning (mean = 2.45, standard deviation (SD) = 0.68), there was no significant obstacle in undertaking online learning through this LMS.

| Table 1. Characteristics of the participants (N = 157). |
|--------------------------------------------------------|
| Item | Total | Having attitudes towards the adoption of online learning | Not having attitudes towards the adoption of online learning | p-value |
| Demographics; no. (%) of students | | | | |
| Age, mean (SD) years | 18.37 (0.52) | 18.33 (0.51) | 18.39 (0.53) | 0.46 |
| Gender | | | | |
| Males | 72 (45.9) | 30 (47.6) | 42 (44.7) | 0.84 |
| Females | 85 (54.1) | 33 (52.4) | 52 (55.3) | - |
| Computer literacy | | | | |
| Upper level | 141 (89.8) | 59 | 82 | 0.30 |
| Lower level | 16 (10.2) | 4 | - | - |
| Device usage | | | | |
| Computers | 18 (11.5) | 10 (15.9) | 8 (8.5) | 0.50 |
| Laptops | 55 (22.3) | 14 (22.2) | 21 (22.3) | - |
| Mobile phones | 4 (2.5) | 2 (3.2) | 2 (2.1) | - |
| Tablets | 100 (63.7) | 37 (58.7) | 63 (67) | - |
| Internet connection | | | | |
| University internet | 74 (47.1) | 28 (44.4) | 46 (48.9) | 0.64 |
| Personal internet | 53 (33.8) | 24 (38.1) | 29 (30.9) | - |
| Cellular data | 30 (19.1) | 11 (17.5) | 19 (20.2) | - |

Independent sample t-test for age; Continuity correction for Chi-square test for gender and computer literacy; Chi-square test for device usage and internet connection.

The results of the crude odds ratios (Table 4) showed that while the content quality and perceived usefulness were associated with the acceptance of online learning, class interaction, user-friendliness, and platform infrastructure were not found significantly associated with the acceptance of online learning. The binary logistic regression model (Table 5) indicated that content quality and perceived usefulness were marginally statistically significant attitudes towards the acceptance of online learning among first-year medical students.

3.3. Data from the LMS monitoring system (N = 283)

Our data revealed that the students completed the learning topics ranging from 0-18 topics, mean 8.77 (SD 5.28). The total learning time of the students ranged from 0-6848 min, and a mean of 908.13 (SD 933.24) minutes. In terms of students’ learning behaviour, 134 (47.35%) students spent ≤10 h on the course and they often logged in to the course during the morning (2780 logins, 45.3%) and evening hours (1678 logins, 27.3%). Although most of the students had good scores for this course (N = 249, 88.6%), there was no association between the good score and the course attendance (COR = 0.84; 95% CI = 0.40–1.75), time spent in the course (COR = 1.55; 95% CI = 0.61–3.91), or frequency of the course’s logins (COR = 1.51; 95% CI = 0.73–3.13).

3.4. Semi-structured interviews (N = 15)

Among the participants, 60% were males and 26.7% had previous experience in online learning. The mean percentage of scores for the test scores after the course completion was 64.2%. The interviewees’ experiences and perceptions toward their learning through the LMS were described in Table 6. Regardless of the students’ preferences in educational methods and the course attention, they all had positive attitudes toward online learning. The reason for those who rarely or did not adopt the course was not due to the barriers in online learning but the skills in self-directed learning.
Table 2. The medical students’ ratings regarding the influence of online learning characteristics on adoption of online learning (N = 157).

| Item | Degree of influence on undertaking the online learning | Mean* SD |
|------|-------------------------------------------------------|----------|
|      | No influence (%) | Some influence (%) | Major influence (%) |
| Domain 1. Content quality | Content quality | 10 (6.4) | 36 (22.9) | 111 (70.7) | 2.64 | 0.60 |
| Domain 2. Class interaction | Interaction | 18 (11.5) | 68 (43.3) | 71 (45.2) | 2.34 | 0.68 |
|      | Case discussion | 12 (7.6) | 53 (33.8) | 92 (58.6) | 2.51 | 0.64 |
|      | Frequent interaction | 17 (10.8) | 58 (36.9) | 82 (52.2) | 2.41 | 0.66 |
| Domain 3. Perceived usefulness | Convenience | 3 (1.9) | 15 (9.6) | 139 (88.5) | 2.87 | 0.39 |
|      | Flexibility | 5 (3.2) | 23 (14.6) | 129 (82.2) | 2.79 | 0.48 |
|      | Prompt result | 7 (4.5) | 50 (31.8) | 100 (63.7) | 2.59 | 0.58 |
| Domain 4. User-friendliness | Ease of completion | 4 (2.5) | 38 (24.2) | 115 (73.2) | 2.71 | 0.51 |
|      | Ease of access | 0 | 40 (25.5) | 117 (74.5) | 2.75 | 0.44 |
|      | Ease of use | 0 | 25 (15.9) | 132 (84.1) | 2.84 | 0.37 |
| Domain 5. Platform infrastructure | Technical support | 2 (1.3) | 50 (31.8) | 105 (66.9) | 2.66 | 0.50 |
|      | Online platform quality | 0 | 35 (22.3) | 122 (77.7) | 2.78 | 0.42 |
|      | Ease of the language use of the platform | 2 (1.3) | 31 (19.7) | 124 (79) | 2.78 | 0.45 |

* Mean was calculated from a three-point Likert scale ranging from 1 (no influence), 2 (some influence) to 3 (major influence).

4. Discussion

This study described the effectiveness, acceptance, adoption and obstacles of online learning during the COVID-19 pandemic on the medical students’ perspectives using the customised LMS developed in a public medical school in Thailand. This study also helped provide international evidence of developing LMS in LMIC where funding and resources were limited [20]. Furthermore, this study paid attention to the LMS infrastructure, which the data from LMIC were still insufficient [20].

Owing to the medical students’ learning experience on KKUMEDX, which is their first time in self-directed learning for an asynchronous structured online learning course in medical school, the results showed that the LMS was effective in terms of the students’ satisfaction, acceptance, and learning outcome. Regarding the effect on learning outcome, our study did not conduct pre and post-tests to compare knowledge gain but considering the effect of the LMS on learning outcome using a test score, that was the summative assessment, conducting by the course itself after the students completed the online course. The results showed most of the students had a good score after the course completion. According to the monitoring data recorded by the LMS, the student test scores were not significantly related to the time spent, frequency of login, and attendance. The possible reasons can be explained more through interviews with the students.

Firstly, although the students were satisfied and accepted this method of learning, half of them still preferred in-class study. The reason for preferring in-class study was not because of the interaction with the teachers or peers but the force or motivation for them to learn. This may be due to the fact that students may have a lack of personal discipline [13], motivation and skills in self-directed learning [30, 31, 32]. However, a previous study showed that online learning positively affected self-learning readiness [33].

Secondly, some students who had good scores but rarely or never attended the course accepted that they could not understand the contents by themselves. They, therefore, used other learning methods such as reading the summary notes from their peers or seniors. There is, thus, a need to provide educational methods that serve and suit the different learning preferences. Similar to the self-directed learning in physicians, this emphasised the importance of utilising multifaceted educational methods rather than using a single form [34, 35]. Despite the limitation of face-to-face learning activities during the COVID-19 pandemic, other
possible but effective combined educational methods with online methods need to be explored.

Thirdly, the time spent in the course did not relate to the test score may be due to the students’ learning styles. The students reported one of the features of the LMS that they most preferred was the speed-up video, its convenience, flexibility to learn at their own pace, place and time, and could speed up the videos.

Regarding the acceptance of online learning on this LMS, our study found that the medical students’ acceptance was slightly above neutral and Pakistan who were not ready to adopt online learning [25, 26]. This may be due to the students may also be due to the lack of practical aspects of learning [26]. Therefore, it would be worth maximising the benefits of online learning in medical education and find the balance between online and face-to-face learning activities. These should be

| Table 5. Adjusted odds ratios and associated 95% confidence intervals for independent predictors of the acceptance of online learning in the logistic regression model (N = 157). |
| Variables | Adjusted odds ratio | 95% CI | p-value |
| Gender (males) | 1.22 | 0.62-2.40 | 0.56 |
| Computer literacy (upper level) | 2.55 | 0.76-8.56 | 0.13 |
| Content quality | 2.43 | 1.11-5.31 | 0.03* |
| Perceived usefulness | 2.75 | 1.02-7.39 | 0.05* |

Logistic regression (Enter); N = 157(100%); Cox & Snell R² = 0.78; Nagelkerke R² = 0.11.

* Statistically significant at an alpha level of 0.05.

Table 4. Associations between the participants’ characteristics and attitudes towards the adoption of online learning and the acceptance of online learning (N = 157).

| Variables | Exposed | Agree | Disagree | Total | Crude odds ratios |
| Gender (males) | Yes | 30 | 42 | 72 | 1.13 | 0.59-2.14 |
| Computer literacy (upper level) | Yes | 59 | 82 | 141 | 2.16 | 0.66-7.03 |
| Gender (males) | No | 33 | 52 | 85 | - |
| Computer literacy (upper level) | No | 4 | 12 | 16 | - |

The domains of attitudes towards the adoption of online learning.

| Characteristics | Influence | No influence | Infl  | No infl |
| Content quality | 51 | 111 | 2.41 | 1.13-5.13 |
| Class interaction | 28 | 99 | 0.74 | 0.39-1.40 |
| Perceived usefulness | 57 | 129 | 2.90 | 1.10-7.64 |
| User-friendliness | 52 | 123 | 1.53 | 0.69-3.42 |
| Platform infrastructure | 50 | 121 | 1.25 | 0.58-2.69 |

The interviewees’ experiences in and perceptions towards their learning on KKUMEDX

| Experience in online learning in the past | Comments |
| Four of the students had previous experience in structured online learning (A1, B2, C1, and C5). One did not have any difficulties in his online learning, whilst the others reported having challenging experiences. | “I posted my questions to the teacher, but it took ages to get the response” A1 |
| “The system was disconnected, and the videos stopped very often” B2 |

Perceptions about the KKUMEDX

All interviewees reported having positive attitudes to the KKUMEDX, including easy use, well-designed and organised contents, its convenience, flexibility to learn at their own pace, place and time, and could speed up the videos.

“‘The program is user-friendly; the numbers of tabs are suitable not too many but cover all the functions needed in online learning’ B4 |
| “The contents are well arranged and easy to follow” B5 |
| “I’m able to learn at any place wherever the internet is secure” B1 |
| “It is easy to access. The speed of the video can be adjusted and I can re-watch many times’ C2 |

Reasons for non-actively participation in the online learning.

The participants identified the reasons for their non-participation in the learning course (B1, B5, C1, C5), including preferences toward in-class learning and unable to understand the lesson on their own.

“I need some pushes to be able to learn, coming to the class is a push for me” C3 |
| “I want to learn with my classmates, this makes me more enthusiastic’ C1 |
| “Some topics have many new terms which I can’t understand so instead I read short notes from the seniors’” B4 |

Preferred learning methods

About half of the participants stated their preferences toward face-to-face learning for this course (A2, B3, B5, and C1–C4). Even though attending lectures was not compulsory but the reason for the preference in-person learning method was that the force for them to come and attend the class whilst the online method is self-directed learning.

Another half preferred online since they could manage their schedules and went back to the topics as often as they wished.

“I prefer face-to-face learning since it forces me to go to class and I feel more enthusiastic and more focus than learning online on my own’ C4 |
| “I prefer online since I can learn anytime and anywhere, and I can manage my study time’ C5 |
| “I can learn at my own pace, taking note and I can go back to the lesson repeatedly” B2 |
| “I like KKUMEDX more since I can go back to take notes as I wish and if I have any question, I can ask through the chat room or email, I don’t like asking face to face” A4 |

Difficulties in KKUMEDX learning.

Less than half of the students reported the difficulties they encountered during learning through the KKUMEDX. The most common difficulties were an incomplete download of the video making the sound and picture not synchronised (A3, B4, C2, and C4). However, the problem was solved by redownload the videos.

“The sounds and pictures in the video clips were not synchronized’ A3 |
| “The change of video speed is great; I can go faster and watch video on my own pace” B3 |
| “I like the colour tab indicating which topics I’ve already completed and which ones I haven’t” C4 |

Preferred characteristics of the KKUMEDX online learning.

The participants identified the most favourable characteristics of the KKUMEDX, including speed up video (A1, A4, B3–B5, and C1–C3), the progress bar (A2 and B1) and the different colour tabs indicated their completed learning activities (A3, B1, and C4). On the other hand, when asking which features that the participants did not like, the majority reported they did not like that they have to go to the lesson each in sequence and they could not skip the topics (A4, B4, B5, C1–C3, and C5).

“Having pre and post-tests or quizzes for all the topics would help us to keep track of what the key points of each topic are and they will help us like being a summary of the course” C4 |
| “Adding calendar would help to remind us for the important events or the due date of the” C4

Students’ suggestions for improvements.

Most of the students suggested additional functions for the KKUMEDX, including question-answer box (A1, A3, B1, and C2), having low quality of the video so then they would be able to download if the internet connection was not secure (B4 and C3) and locked video function meaning when they

(continued on next page)
considered to ensure that when designing the educational programs, students' needs and preferred learning methods have also been considered as well as the educational techniques also match the learning objectives.

Our LMS not only allowed online educational content to be delivered smoothly but also supported students' learning experiences. The results of this study found that the usefulness, infrastructure, and user-friendliness of the LMS played important roles in medical students' online learning experience (as shown in Table 3). These results are consistent with previous studies [16, 18, 19] and the technology acceptance model in physician contexts [17], which suggested that perceived usefulness [17], user-friendliness [16], and technological infrastructure are related to the acceptance of technology use [17, 19]. Besides, our results accord with the findings of the previous systematic review which found that technological infrastructure is one of the critical factors for adopting e-learning interventions [19].

In addition to the primary objective, this study explored the medical students' attitudes to understand factors associated with the adoption of online learning. The results of our analysis indicated that the quality of educational contents and perceived usefulness were found to be marginally statistically significantly associated with the acceptance of online learning on this LMS (as shown in Table 4). This finding is in agreement with the technology acceptance model in the physician context which showed that perceived usefulness significantly affected a physician's attitude towards using technology [17]. On the other hand, our analysis revealed that ease of use of the technology was not significantly associated with the acceptance of online learning among medical students. It can thus be suggested medical students, similarly to physicians, would rather focus on the usefulness than ease of use of the technology [17].

During the use of the LMS, the majority of medical students did not recognise the barriers in online learning identified by previous studies [13, 14]. The possible explanation may be because many of these barriers had already been addressed and removed while developing the LMS.

The findings of our study suggest several courses of action for medical schools in a developing country to develop their own LMS. This finding, while preliminary, suggests that the LMS for medical students needs to focus on the content quality and usefulness to enhance the adoption of online learning. Although some of the medical students did not accept online learning on KKUMEDX, they rated positive attitudes towards the online learning experience on this LMS.

This study has several limitations. Firstly, despite efforts to ensure generalisability regarding the study population, this LMS had just been launched for the first-year students which is the pre-clinical year and the curriculum focused more on the basic medical sciences. Therefore, their satisfaction and acceptance of the LMS may be different to the clinical year students. Secondly, this study was a single-institution study. Considerably more work will need to be done across medical schools to determine the effectiveness of this LMS on medical students in both pre-clinical and clinical years to ensure generalisability. Thirdly, in observational studies, there is a potential for selection bias due to the borderline participation rate of the study, the lack of randomisation. Fourthly, as a result of using online questionnaires, the participants in this study may be more familiar with online technology and have a different characteristic background to the general population. Therefore, it is important to bear in mind the possible bias in these responses.

Although this study suggests that the content quality and perceived usefulness of LMS were statistically associated with the adoption of online learning, the confidence intervals showed great closeness to the null value. These results may be due to the relatively small sample size. There is, therefore, a need for further large-scale studies to ensure generalisability.

In conclusion, despite the disruption in medical education due to COVID-19, the shift to online learning on the newly developed LMS appeared to be useful and user-friendly for medical students. Not only the students were satisfied with their learning experience but also accepted online learning. The possible barrier in adopting online learning is the medical students' preference towards in-class learning. This study also demonstrates the perceived usefulness and content quality are associated with the acceptance of online learning. However, this present study has several limitations, therefore the study findings need to be interpreted cautiously. In addition, this is a single-institution study, further large-scale studies are needed to ensure generalisability.

**Declarations**

**Author contribution statement**

Isaporn Thepwongsa, Poompong Siripa and Radhakrishnan Muthukumar: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Kamonwan Jenwitheesuk: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Surapol Virasiri: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Pat Nonjui: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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**Data availability statement**

Data will be made available on request.

**Declaration of interests statement**

The authors declare no conflict of interest.

**Additional information**

No additional information is available for this paper.

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