Learner Performance and Usability of the Medical Certification of Cause-Of-Death (MCCOD) E-Learning Intervention

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ABSTRACT

Introduction: We examined the effectiveness of a locally-developed medical certification of cause-of-death (MCCOD) e-learning intervention in improving knowledge outcomes among medical interns and clerks in the Philippines, and evaluated its usability as an alternative method for MCCOD training.

Methods: A nonequivalent control group pretest-posttest quasi-experimental study was conducted. We recruited medical interns and clerks from seven accredited medical institutions from February to April 2020. Learners were conveniently assigned to intervention and control groups. Pretest and posttest data were collected using a 25-item questionnaire while usability was assessed using a cross-sectional survey.

Results: There were 1078 learners: 869 (80.6%) received intervention and 209 (19.4%) were controls. Results revealed improvement in pretest-to-posttest mean scores and passing rates in both study groups. The intervention group gained a 16.49 ± 3.17 mean pretest score and 11 64.3% passing rate, which increased to 19.89 ± 1.88 and 99.3% in posttest respectively, while the control group received 16.20 ± 3.30 and 61.7% in pretest, which increased to 18.29 ± 3.39 and 83.7% in posttest. The intervention group obtained a significantly higher mean change in score compared to controls ($p < 0.001$) and better score distribution with around 95% of learners having posttest scores between 17 to 23 (or within 2 standard deviations from the intervention group's posttest mean). In contrast, only 68% of the control group received scores within the same range. Medical students in the intervention group gained the highest improvement in score compared to other groups. The overall mean usability score of the

MCCOD online course was 3.86 ± 0.88 with lowest dimension means noted in *Learning and Support* and *Interactivity*.

Conclusion: E-learning is an effective means of improving MCCOD knowledge outcomes among medical clerks and interns. Enhancing its usability is critical to maximize its impact on learning outcomes and improve its adoption.

Keywords: online education, vital statistics, cause of death, developing country

INTRODUCTION

Medical and public health scholarships have long been replete with literature on the importance of mortality statistics in shaping clinical and public health decision-making [1-3]. Despite considerable efforts to produce timely and accurate mortality statistics, both developed and developing countries have documented significant errors in the accuracy and completeness of cause-of-death documentations [3-9]. In the Philippines, recent studies show that 30 to 70% of medical certificates of cause of death (MCCOD) are incorrectly completed, with 25 to 40% of death certificates having major documentation errors [8-9]. One of the posited reasons behind the poor quality of MCCOD is lack of training.

Scholars have advanced the need to introduce and standardize education on the correct MCCOD documentation [11], since educational interventions have been shown to improve death certificate completion and accuracy [8,11-14]. In 2018, the Philippines' Department of Health (DOH), with support from the World Health Organization, developed the *Post Graduate Interns Practicum Guidelines on MCCOD*. From February to December 2019, the DOH coordinated with the Association of Philippine Medical Colleges (APCM) and trained clinical training coordinators across the country, with the intent to echo learnings to their medical interns, who have yet to become licensed physicians. However, these seminar-workshops were limited in scalability with only six DOH-hosted workshops conducted annually; echo sessions were not always carried out.

E-learning was a mode explored to ensure sustainability and promote wider reach. Thus, the University of the Philippines Manila - College of Medicine was deputized by the DOH to

develop, implement, and evaluate an alternative learning model for MCCOD training that utilizes digital technologies instead of the usual classroom-type of instruction.

In this article, we present the results of the pilot implementation of a locally developed MCCOD online course implemented among medical clerks and interns across the Philippines. Specifically, we examined (a) the effectiveness of the e-learning intervention in improving MCCOD knowledge among medical interns and clerks, including differences in learner performance between demographic groups, and (b) the usability of the online course as an alternative method for MCCOD training. The contributions of our article are threefold: first, we provide a summative evaluation of a locally developed MCCOD online course. Second, this paper contributes to the growing body of scholarship on the use of e-learning in MCCOD training, especially in the education of medical clerks and interns in developing countries. Lastly, our findings also aim to contribute to addressing the paucity of available evidence on the best strategies to improve adoption and sustainability of MCCOD educational programs.

METHODS

We used a nonequivalent control group pretest-posttest quasi-experimental design to evaluate the effectiveness of the e-learning intervention in improving learning outcomes. Usability of the MCCOD online course was assessed using a cross-sectional survey. The Single Joint Research Ethics Board of DOH, Philippines ascertained the ethical soundness of this multi-center quasi-experiment.

The MCCOD E-learning Intervention

The MCCOD e-learning intervention was an online course developed based on the DOH-approved MCCOD curriculum, previously implemented. It has six modules: (1) Overview of MCCOD, (2) Death Registration: Legal Mandates, Rules and Procedures, (3) Understanding Medical Certification of Death and its Principles, (4) Guidelines for Reporting Causes of Death in Specific Groups and Conditions, (5) Reviewing the Certificate of Death, and (6) Verbal Autopsy. The last part contained a review on death certificate completion and an analysis of 10 cases. The e-learning course was hosted by UP Manila's Virtual Learning Environment, a Moodle-based course management system accessible through mccod.upm.edu.ph. Two MCCOD courses were made available: one for medical clerks and interns, and another for licensed physicians. This paper only focused on the former.

Upon registration, learners were directed to the course homepage. They were required to answer a user profile form, an e-learning readiness survey and a 25-item pretest questionnaire prior to the MCCOD modules. Each module ends with a set of reinforcement questions. After the course, learners were asked to apply MCCOD cognates by completing a 78-item case analysis questionnaire. Completion was a requirement to proceed to the posttest. The last part was the e-learning usability evaluation. A certificate of completion was generated thereafter.

Instruments

We used three data collection instruments: (a) user profile form to document learner characteristics, (b) pretest-posttest questionnaire to assess knowledge on MCCOD before and after the intervention, and (c) usability evaluation form.

The 25-item pretest-posttest questionnaire was developed by MCCOD subject matter experts and included questions on *must-know* concepts based on the DOH-approved curriculum. This instrument has seven recall and comprehension items and 18 analysis and application items. The maximum score is 25 points and the minimum passing level (MPL) is 16 points based on the Angoff method [16]. The questionnaire has an average facility index of 65.5% (test difficulty is about right for the average student) and a reliability coefficient of 0.68 (fairly reliable). A second version of the test with a 0.81 reliability was developed for nationwide deployment but was not implemented during the study.

To evaluate usability, we adopted a validated 36-item questionnaire [17], which assesses eight usability dimensions of e-learning: Content, Learning & Support, Visual Design, Navigation, Accessibility, Self-Assessment & Learnability, Interactivity, and Motivation for Learning. Reliability coefficient was at 0.93 (very good reliability).

Data Collection and Analysis

We recruited medical interns (i.e., individuals who have completed their four-year undergraduate medical curriculum and are undergoing the standard 12-month clinical internship) and medical clerks (i.e., students in their fourth year of coursework in an accredited undergraduate medical program in the Philippines, and are about to go to

internship in the following school year) from seven medical universities and hospitals. Since this study draws its findings from a pilot deployment, we did not limit the number of study participants. However, we calculated a minimum sample size of 216 based on the formula for estimation of exposure. Data were collected from February to April 2020.

Participants from four pilot sites were conveniently assigned to the intervention group while participants from two sites were assigned as control. One institution had learners conveniently assigned to either intervention or control groups.

Medical clerks and interns from pilot sites were asked to register to access the course.

Learners who signified their intention to participate in the study through the digital informed consent form were included in the analysis. Both intervention and control groups answered the user profile form and pretest questionnaire on their first day of course access. The intervention group was asked to complete the course in a week while those in the control group were not given access to the learning modules. After a week, participants from both study groups answered the posttest questionnaire. The intervention group was asked to complete the usability evaluation survey. Data were analyzed using IBM® SPSS® Statistics 25, with statistical significance set at $p < 0.05$. T-test and ANOVA were used in the analysis.

RESULTS

Characteristics of learners

A total of 1396 learners were recruited. Of which, 19 (1.38%) decided not to participate in the study. From the remaining 1377, we noted an attrition rate of 6.83%, with 94 learners failing to complete the course until posttest. Upon data cleaning, we further excluded 205 (15.98%) learners who were either licensed physicians who took the course intended for medical interns/clerks, or who have incomplete profile and/or usability evaluation feedback. In total, this study draws findings from 1078 learners, whose characteristics are summarized in Table 1.

Table 1. Characteristics of learners (n = 1078)

	Study Group		Total	
	Intervention	Control	f	%
Institution				
Institution 1	314	0	314	29.13%
Institution 2	117	0	117	10.85%
Institution 3	234	0	234	21.71%
Institution 4	100	0	100	9.28%
Institution 5	0	34	34	3.15%
Institution 6	104	54	158	14.66%
Institution 7	0	121	121	11.22%
Total	869	209	1078	
Age in years (Mean ± SD)				
	25.70 ± 2.01	26.63 ± 2.18	25.88 ± 2.05	
Sex				
Male	290	59	349	32.37%
Female	579	150	729	67.63%
Designation				
Medical Intern	643	192	835	77.46%
Medical Clerk	226	17	243	22.54%
Previous training on MCCOD				
Yes	385	5	390	36.09%

No	484	204	688	62.62%
Experience in completing MCCOD				
0, no experience	697	151	848	78.66%
1 to 10 death certificates	168	49	217	20.13%
> 10 death certificates	4	9	13	1.21%
Previous eLearning experience				
Yes	251	27	278	25.79%
No	618	182	800	74.21%
Attitude on Technology Use and Adoption*				
<i>Innovators</i> : I love new technologies and am among the first to experiment with them	166	35	201	18.65%
<i>Early Adopters</i> : I like new technologies and use them before most of the people I know	181	42	223	20.69%
<i>Early Majority</i> : I usually use new technologies when most people I know do	401	97	498	46.20%
<i>Late Majority</i> : I am skeptical of new technologies and only use them when I have to	88	29	117	10.85%
<i>Laggards</i> : I am usually one of the last people I know to use new technologies	33	6	39	3.62%

*adapted the categories of technology adopters of Rogers 1962, Diffusion of Innovations Theory [18]

The mean age of learners was 25.88 years old [$SD=2.05$]. Majority were female (67.63%) and were medical interns (77.46%). Most of the learners reported unfamiliarity with the MCCOD guidelines (60.11%) and no formal training on MCCOD (62.62%). More than three-quarters (78.57%) have not experienced completing a death certificate. 25.79% of the learners have tried e-learning. When it comes to using new technologies, the majority (85.53%) were early adopters while 14.47% were skeptics and laggards.

Learning Outcomes: Pretest and Posttest Performance

Mean pretest, posttest & change in score

As shown in Table 2, learners gained a mean pretest score of 16.43 [$SD=3.19$] and a mean posttest score of 19.58 [$SD=2.34$]. The resulting mean change in score of 3.15 [$SD=3.35$] was statistically significant as determined by paired t-test [$t_{1077} = -35.540, p < 0.001$].

Regardless of study group, medical interns and clerks scored higher in the posttest than in pretest with a mean difference of 3.15 points.

Table 2. Mean pretest, posttest and change in score per institution (n = 1078)

Institution	Study Group	N	Mean $\pm$ SD		
			Pretest Score	Posttest score	Change in score*
1	Intervention	314	17.33 $\pm$ 3.23	20.28 $\pm$ 1.93	2.95 $\pm$ 3.22
2	Intervention	117	15.69 $\pm$ 2.83	19.31 $\pm$ 2.06	3.62 $\pm$ 3.27
3	Intervention	234	15.76 $\pm$ 2.93	19.67 $\pm$ 1.47	3.91 $\pm$ 3.11
4	Intervention	100	16.14 $\pm$ 3.50	20.06 $\pm$ 1.94	3.92 $\pm$ 3.76
5	Control	34	13.94 $\pm$ 3.40	14.53 $\pm$ 3.76	0.59 $\pm$ 3.34
6I	Intervention	104	16.83 $\pm$ 2.90	19.72 $\pm$ 2.05	2.89 $\pm$ 3.08
6C	Control	54	16.19 $\pm$ 2.73	18.07 $\pm$ 2.87	1.89 $\pm$ 3.07
7	Control	121	16.84 $\pm$ 3.25	19.44 $\pm$ 2.65	2.60 $\pm$ 3.52
Total	Intervention	869	16.49 $\pm$ 3.17	19.89 $\pm$ 1.88	3.40 $\pm$ 3.27
Total	Control	209	16.20 $\pm$ 3.30	18.29 $\pm$ 3.39	2.09 $\pm$ 3.44
Total	Both	1078	16.43 $\pm$ 3.19	19.58 $\pm$ 2.34	3.15 $\pm$ 3.35

*mean change in score is computed based on the sum of the difference in scores (posttest – pretest) divided by the total number of learners per institution / study group.

Comparison of test performance by study group

With the MPL set at 16, 64.33% of learners in the intervention group and 61.72% in the control group passed the pretest. There were no significant differences between mean pretest scores of the intervention and control groups [$F(1,1076)=1.37, p=0.24$]. The intervention group gained a mean pretest score of 16.49 [$SD=3.17$], comparable to the control's 16.20 [$SD=3.30$]. On Posttest, 99.31% of the intervention group passed while 83.73% of the control group received scores ≥ 16 . We noted a significantly higher mean posttest scores in both intervention [$\bar{x}=19.89, SD=1.88, t_{868} = -30.62, p<0.001$] and control [$\bar{x}=18.29, SD=3.39, t_{208} = -8.76, p<0.001$] groups. The intervention group received a higher mean change in score at 3.40 points [$SD=3.27$] in contrast to the control group's 2.09 points [$SD=3.44$].

To visualize the movement and spread of scores from pretest to posttest, we plotted the data in a normal distribution curve. Figure 1 shows improvement in the posttest scores in both study groups. The intervention group has a larger gain in score and a steeper bell curve, indicating a narrower score range. In the control group, the shape of the curve for both the pretest and posttest is similar, reflecting no change in the spread of scores.

Figure 1. Normal Distribution of Pretest and Posttest Scores: Intervention vs Control

We used t-test for two samples assuming equal variances to determine whether the difference in mean change in scores between the two study groups is significant. The test shows a significant difference in the mean change in scores between the intervention and control groups [$t(1076)=5.16, p<0.001$]. The intervention group obtained a higher change in score compared to the control group, with a mean difference of 1.32 points.

Comparison of the mean change in score by age group, sex, institution, designation, MCCOD training experience and attitude on technology adoption

We conducted a One-Way ANOVA to determine significant differences in the mean change in score between different cohorts, grouped based on participant characteristics. Tukey's Post-Hoc Analysis was used to identify where these differences lie. Table 3 summarizes the ANOVA results.

Table 3. One-Way ANOVA Results

Hypothesis	n	<i>F</i>	<i>p</i>	Decision
There are significant differences in the mean change in score between:				
Age groups: 25-39y (Gen. Y) vs ≤ 24y (Gen. Z)	1078	0.422	0.516	Reject
Male and female learners (regardless of study group)	1078	0.007	0.936	Reject
Interns vs Clerks	1078	5.595*	0.018	Accept
Interns (Intervention) vs Clerks (Intervention) vs Interns (Control) vs Clerks (Control)	1078	11.838*	< 0.001	Accept
Institutions 1 to 7	1078	7.777*	< 0.001	Accept
learners (regardless of study group) who reportedly received MCCOD training prior to the intervention and those who have not received any MCCOD training	1078	0.410	0.522	Reject
learners in the Intervention Group who reportedly received MCCOD training prior to the intervention and those who have not received any MCCOD training	869	1.653	0.199	Reject
learners with previous e-learning experience and those who reportedly have not tried e-learning	1078	4.450*	0.035	Accept
Attitude on Technology Adoption: Innovators-Early Adopters vs Early Majority vs Late Majority-Laggards	1078	1.007	0.366	Reject

*significant at $p < 0.05$

There is no significant variation in the mean change of scores of learners grouped based on age, sex, MCCOD training, and attitude on technology adoption and use. However, we found significant differences in the mean change in score between medical interns and clerks [$F(1,1076)=5.595, p<0.05$], between medical interns and clerks stratified by study group [$F(3,1074)=11.838, p<0.001$], between institutions [$F(7,1070)=7.777, p<0.001$], and between learners with previous e-learning experience and those without [$F(1,1076)=4.450, p<0.05$]. Medical clerks and learners with previous e-learning experience gained higher increases in score compared to their counterparts.

Tukey's post hoc analysis (see Supplementary Material) showed that medical clerks in the intervention group gained the highest mean change in score compared to medical interns from the same study group, and medical clerks and interns in the control group. However, this difference is only significant between Clerks (Intervention) vs Clerks (Control), and between Clerks (Intervention) vs Interns (Control). Among controls, medical interns gained a higher mean change in score than clerks.

We also found that institutions under the intervention group (i.e., Institutions 1-4 and 6-I) consistently have a higher mean change in score than those in the control group (i.e., Institution 5, 6C and 7). The average change in score of Institution 5 is significantly lower compared to the mean scores of other institutions. Differences in the mean change in score between institutions in the intervention group are insignificant in all pairwise comparisons except between Institution 3 and Institution 1.

Usability Analysis

The overall mean usability score of the MCCOD online course is 3.86 [$SD=0.88$]. Table 4 reflects the usability dimensions, specific parameters or items per dimension and corresponding average scores per item and dimension.

Table 4. Usability evaluation*

Usability Dimension	Item	Item Mean $\pm$ SD	Dimension Mean
Content	Q1: The terminologies used are consistent and easy to understand throughout the e-learning course.	3.90 $\pm$ 1.07	3.92
	Q2: Abstract concepts (principles, formulas, rules, etc.) are illustrated with concrete, specific examples.	3.82 $\pm$ 1.08	
	Q3: The material in the course is accurate and current.	3.93 $\pm$ 1.09	
	Q4: Vocabulary and terminology used are appropriate for the learners.	3.98 $\pm$ 1.08	
	Q5: Learning objectives of each module are quite clear to the learners.	3.98 $\pm$ 1.10	
	Q6: Content is organized in an appropriate sequence and in small modules for flexible learning.	3.91 $\pm$ 1.11	
Learning and Support	Q1: The courses motivate learners to request feedback from instructors, experts and peers, through email or other online communications.	3.68 $\pm$ 1.12	3.74**
	Q2: Feedback given at any specific time is tailored to the content being studied, problem being solved, or task being completed by the learner.	3.73 $\pm$ 1.08	
	Q3: The courses offer tools that support learning.	3.67 $\pm$ 1.15	
	Q4: Wherever appropriate, higher-order assessments (for example case studies) are provided rather than lower-order assessments (simple quiz).	3.80 $\pm$ 1.08	
	Q5: The course provides support for learner activities to allow working within existing competence while encountering meaningful chunks of knowledge.	3.80 $\pm$ 1.09	
Visual Design	Q1: The most important information on the screen is placed in areas most likely to attract the learner's attention.	3.88 $\pm$ 1.07	3.99
	Q2: Text and graphics are legible (readable).	4.05 $\pm$ 1.06	
	Q3: Fonts are easy to read in both on-screen and in printed versions.	4.04 $\pm$ 1.06	
	Q4: The online help or documentation is written clearly.	4.00 $\pm$ 1.06	
Navigation	Q1: Learners can choose (easily) what parts of the course to access, the order and pace of studying.	3.95 $\pm$ 1.08	3.99
	Q2: Learners always know where they are in the course.	4.01 $\pm$ 1.04	
	Q3: The courses allow the learner to leave whenever desired, but easily return to the closest logical point in the course.	4.01 $\pm$ 1.09	
Accessibility	Q1: The pages and other components of the course download quickly.	3.84 $\pm$ 1.08	3.80**
	Q2: The course is free from technical problems.	3.76 $\pm$ 1.14	
Interactivity	Q1: The course uses games, simulations, role-playing activities, and case studies to gain the attention, and maintain motivation of learners.	3.63 $\pm$ 1.15	3.75**
	Q2: The course provides access to a range of resources appropriate to the learning context and for use in the real world.	3.65 $\pm$ 1.16	

	Q3: The course engages learners in tasks that are closely aligned with the learning goals and objectives.	3.89 ± 1.01	
	Q4: Media are used appropriately so as to assist in highlighting and learning critical concepts rather than merely entertaining or possibly distracting learners.	3.84 ± 1.08	
Self-Assessment & Learnability	Q1: Learners can predict the general result of clicking on each button/link.	3.84 ± 1.03	3.92
	Q2: Learners can start the course (locate it, install plug-ins, register, access starting page) using only online assistance.	3.92 ± 1.03	
	Q3: It is clear to learners what is to be accomplished and what will be gained from its use.	3.92 ± 1.00	
	Q4: The course provides opportunities for self-assessments (post tests and other assessments) that advance learners' achievements according to the learning objectives.	3.99 ± 0.97	
Motivation to Learn	Q1: The course incorporates novel characteristics.	3.78 ± 1.06	3.82**
	Q2: The course stimulates further inquiry.	3.85 ± 1.05	
	Q3: The course is enjoyable and interesting.	3.76 ± 1.08	
	Q4: The course provides instruction/training that matches with the learners' experience.	3.81 ± 1.05	
	Q5: The course meets learners' needs.	3.84 ± 1.03	
	Q6: The course provides the learner with frequent and varied learning activities that increase learning success.	3.84 ± 1.03	
	Q7: The course provides learners opportunities to use new skills in authentic situations.	3.87 ± 1.04	
	Q8: The course assists learners to have positive feelings about their accomplishments.	3.80 ± 1.09	

*Only includes responses from the intervention group (n = 869)

**Dimension mean value is lower than the overall usability mean score of 3.86

Of the eight usability dimensions, *Visual Design* and *Navigation* got the highest dimension average at 3.99. Both *Content* and *Self-Assessment & Learnability* achieved a mean score of 3.92. The remaining usability dimensions were noted to have mean values lower than the overall usability mean score of 3.86. *Learning and Support* received the lowest average score among all usability dimensions. Item-wise, *Interactivity* Q1 scored the lowest at 3.63.

DISCUSSION

The e-learning intervention was developed to provide a more standardized, sustainable and scalable way of MCCOD education. Results of this study show that the MCCOD online course is an effective and usable method for educating medical interns and clerks.

Learners who completed the course achieved significantly higher posttest scores and mean change in score compared to controls. Although gains in score were noted in both study groups, we noted better score distribution in the intervention group, with around 95% of learners having posttest scores between 17 and 23 (or within 2 standard deviations from the intervention group's posttest mean). In contrast, only 68% of the control group received scores within the same range. 95% of learners in the control group have posttest scores between 10 and 23. Marked improvement in the proportion of passers from pretest to posttest was also noted. Prior to the course, around two-thirds of learners from both intervention (64.3%) and control (61.7%) received a passing mark. In the posttest, 99.3% of learners in the intervention group passed in contrast to 83.7% in the control group. These results indicate that the e-learning intervention can improve knowledge outcomes in the target population. Although these findings are consistent with current evidence proving the effectiveness of e-learning in training medical students [13-14,17] and other health professionals [8,19], they must still be inferred with prudence. As a field-based study involving human subjects, it is not possible to control all extraneous variables. While improvements in learning outcomes may be attributed to e-learning, several factors may also explain gains in posttest, especially in the control group. A *practice* effect, or a test-retest learning effect, may have occurred in both groups but might have profoundly affected the control group. Practice effects are

improvements in succeeding tests attributed to prior exposure to testing materials [20-21].

Both pretest and posttest used the same questionnaire, although items were reshuffled. The tool has also included contents covered in the course. The test has a difficulty level of about average but, questions may have become more easily answerable in the retest, since the same items are evaluated anew. Since interns and clerks are constantly exposed to different learning environments, these gains in score may also be attributed to the retention of previous or new learning contents [20-21].

Demographic characteristics, such as age groups and sex, do not influence knowledge outcomes. Previous training on MCCOD and attitude on new technology use also do not have a significant impact on the change in score of learners. However, knowledge outcomes were found to be influenced by the learners' institution and designation. Medical clerks who have completed the MCCOD online course showed the greatest gains in MCCOD knowledge compared to medical interns in the intervention group, and clerks and interns from the control group. This is perhaps attributed to the more structured time for coursework available to these senior medical students compared to interns, who are otherwise more busy with clinical work. While improvements in score were noted in both intervention and control groups, there were instances when the overall performance of learners from an institution is significantly lower than those from the same study group. This finding may be a result of differences in the motivation of learners to complete or answer the evaluation. It can also be an effect of circumstances during the Covid-19 pandemic. Learners in some institutions, including Institution 5, completed the course in early February and March, before face-to-face classes and training were cancelled, and the country was put on quarantine. Clerks and interns, who have completed the course during the quarantine, may have had a more

conducive disposition to the elearning intervention since they were just at home. They may have more time, are less stressed, and have a more fit disposition to learning since they are not on clinical duties at the time of intervention.

Our study also assessed user experience and potential for technology adoption by evaluating the online course's usability. The MCCOD e-learning intervention received an overall mean usability score of 3.86 [$SD=0.88$], which indicates good usability. Of the eight usability dimensions, the online course received the highest rating in *Visual Design and Navigation*. Both *Content* and *Self-Assessment & Learnability* also achieved an above average value of 3.92. While the learners positively rated the course in *Motivation to Learn* [$\bar{x}=3.82$], *Accessibility* [$\bar{x}=3.80$], *Interactivity* [$\bar{x}=3.75$], and *Learning and Support* [$\bar{x}=3.75$], their average scores were lower than the overall usability mean. This may indicate the need for further improvements in these four dimensions. Lowest ratings were noted in *Interactivity* items Q1 and Q2 (i.e., Q1: The course uses games, simulations, role-playing activities, and case studies to gain the attention, and maintain motivation of learners; Q2: The course provides access to a range of resources appropriate to the learning context and for use in the real world), and *Learning and Support* items Q1 and Q3 (i.e., Q1: The course motivates learners to request feedback from instructors, experts and peers, through email or other online communications.; Q3: The course offers tools that support learning). These four lowest-scoring items point to a need for interactive activities and additional MCCOD learning resources/tools.

A major critique against remote learning is the limited interaction between the learner and the instructor, and between fellow learners. This gap was especially observed by our learners,

who mostly experienced classroom and peer learning in their medical education. Face-to-face learning allows learners to ask questions in real time and discuss with their instructor or peers to further understand the subject matter. This is limited in the MCCOD online course, where learning and assessments are done individually. Thus, to maximize the potential of e-learning, we recommend the adoption of strategies that enhance interactivity, such as the use of games [22], question-and-answer sessions [23], virtual discussion rooms [24], or immediate feedback mechanisms [25]. Moving towards a blended learning approach by adding face-to-face discussions with the instructor [26-27] can also be considered. Ensuring means to provide and receive feedback remains an important component of remote education in refining students' competencies [28-29]. In elearning, feedback can be automated, such as in assessments or evaluation, where explanations or references can be provided as pop-ups when a correct or wrong answer is selected. Feedback, which would inform students of best and erroneous practices alike, are well received by students, even if delivered online. The latter can also address another identified gap, which is the need for additional tools that support learning.

In developing countries, Internet access is often a challenge. Although the MCCOD online course has received a very good rating in *Accessibility*, asynchronous e-learning should be considered to improve access and sustainability of the training program. Our study sites were institutions with existing resources and infrastructure to support e-learning. And thus, ease of access may be different in remote areas where Internet connection is unavailable or intermittent. The Philippines ranks 57th and 82nd among 100 countries studied, in terms of availability and affordability [30]. For nationwide deployment, using asynchronous e-learning

that allows students to access the modules even offline, at their own convenient time, in the comforts of spaces conducive to study, will be of great value.

Overall, learners agree that the MCCOD online course has good usability. This is further supported by the high completion rate of the course, with only around 6-7% attrition rate. However, the latter may also be attributed to the sudden shift to online learning during the study period due to COVID-19. The disruptive consequences of the pandemic to medical education have caused e-learning to rapidly receive attention as a viable alternative to traditional models of person-to-person didactics, lectures, and chalk talks [31-34].

Participating medical clerks and interns may have found themselves with more time to complete this online learning while educators may have become more open and interested in promoting e-learning to their students.

In conclusion, our study shows that e-learning is an effective means of improving knowledge outcomes on MCCOD among medical clerks and interns. E-learning is an acceptable alternative to face-to-face training on MCCOD. It has the potential to provide remote education, as well as complement, augment, and transform a traditional classroom pedagogy. Enhancing the usability of the MCCOD e-learning intervention is critical to maximize its impact on learning outcomes and improve its adoption.

The limitations of this study are generic to most social science research associated with quasi-experiments. Although control groups were used to measure the effect of extraneous factors in the pretest, the study does not allow for random sampling and random assignment of subjects to study groups. Furthermore, the study duration of four months limited the

number and type of post-intervention evaluations that can be done. Thus, we advise modest generalization of our findings. Follow-up studies can be conducted using true experimental designs to produce highly generalizable results.

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SUPPLEMENTARY MATERIALS

Supplementary Table 1. Tukey's Post Hoc Analysis: Comparisons of mean change in score by designation & study group

(I) Designation (Study Group)	(J) Designation (Study Group)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intern (Int.)	Clerk (Int.)	-.56	.255	.121	-1.22	.09
	Intern (Ctrl)	1.04*	.271	<.001	.34	1.73
	Clerk (Ctrl)	2.67*	.810	.006	.58	4.75
Clerk (Int.)	Intern (Ctrl)	1.60*	.324	<.001	.77	2.43
	Clerk (Ctrl)	3.23*	.829	<.001	1.10	5.36
Intern (Ctrl)	Clerk (Ctrl)	1.63	.834	.206	-.52	3.78

*significant at $p < 0.05$

Supplementary Table 2. Tukey's Post Hoc Analysis: Comparisons of mean change in score by institution

(I) Institution	(J) Institution	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Institution 1	Institution 2	-.67	.355	.566	-1.74	.41
	Institution 3	-.96*	.283	.017	-1.82	-.10
	Institution 4	-.97	.376	.164	-2.11	.17
	Institution 5	2.36*	.591	.002	.56	4.16
	Institution 6-I	.05	.371	1.000	-1.07	1.18
	Institution 6-C	1.06	.483	.354	-.41	2.53
	Institution 7	0.35	.350	.973	-.71	1.42

Institution 2	Institution 3	-.29	.371	.994	-1.42	.84
	Institution 4	-.30	.446	.997	-1.66	1.05
	Institution 5	3.03*	.638	<.001	1.09	4.97
	Institution 6-I	0.72	.441	.730	-.62	2.06
	Institution 6-C	1.73*	.539	.030	.09	3.36
	Institution 7	1.02	.425	.241	-.27	2.31
Institution 3	Institution 4	-0.01	.391	1.000	-1.20	1.17
	Institution 5	3.32*	.601	<.001	1.49	5.14
	Institution 6-I	1.01	.386	.149	-.16	2.18
	Institution 6-C	2.02*	.495	.001	.52	3.52
	Institution 7	1.31*	.367	.009	.20	2.42
Institution 4	Institution 5	3.33*	.650	<.001	1.36	5.31
	Institution 6-I	1.03	.459	.331	-.37	2.42
	Institution 6-C	2.03*	.553	.006	.35	3.71
	Institution 7	1.32*	.443	.057	-.02	2.67
Institution 5	Institution 6-I	-2.31*	.647	0.009	-4.27	-.34
	Institution 6-C	-1.30	.717	.611	-3.48	.88
	Institution 7	-2.01*	.636	.035	-3.94	-.08
Institution 6I	Institution 6-C	1.01	.549	.600	-.66	2.67
	Institution 7	0.30	.438	.997	-1.03	1.63
Institution 6-C	Institution 7	-.71	.536	.892	-2.33	.92

*significant at $p < 0.05$