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Intention to Continue Adopting Online Problem-Based Learning After the COVID-19 Pandemic: Perception Analysis Using a Structural Equation Modelling Approach

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ABSTRACT

Due to the COVID-19 pandemic, conventional face-to-face problem-based learning (PBL) had to be transitioned into online PBL. However, it was largely unknown how likely would medical students continue to adopt this form of hastily implemented remote learning solution after the pandemic ends. Using a two-stage partial least squares structural equation modelling approach, a study was conducted to develop a set of questionnaires to measure this intention and determine the influence of perceived benefits (5 items) and perceived ease of use (7 items) on the behavioural intention to continue adopting online PBL. The technology acceptance model was adopted as the conceptual framework of this study. Environment factors (11 items derived from PEST analysis, where P = policy, E = economic, S = social, and T = technology factors) were incorporated as the third independent construct in our model. A total of 149 Year 2 medical students participated in this study. Overall, the mean score for behavioural intention to continue adopting online PBL was 3.42 out of 5 (where 1 = most unlikely and 5 = most likely). Only the construct perceived ease of use had significant influence on the behavioural intention to continue adopting online PBL (path coefficient standardised β = 0.312; *t*-statistics = 2.960; p = 0.003). Perceived benefits and environment factors were not shown to have significant influence. In conclusion, as no strong intention to continue adopting online PBL was demonstrated in this study, conventional face-to-face PBL should be resumed until clear benefits of a carefully designed online PBL can be demonstrated.

Keywords: *Problem-based learning, Online platform, COVIDs-19, Technology acceptance model, PEST analysis*

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INTRODUCTION

Problem-based learning (PBL) is a pedagogy with three fundamental characteristics: (a) it uses authentic, ill-structured problems to trigger learning; (b) it is self-directed; and (c) it is student-oriented (1–2). Conventionally, PBL occurs in small groups (1). Through social interactions with peers, students learn to acquire knowledge and to apply different thinking strategies to solve different sets of problems. Underpinning this social constructivism learning philosophy is the notion that cognitive load of learning can be distributed among group members (3–4). Although traditionally associated with individual learning, the concept of cognitive load has now been expanded to collaborative learning. This is postulated to be due to the construction of a collective working memory where the complexity of a learning task can be reduced and mutual scaffolding among group members can occur (4). In PBL, students generally divide the learning tasks. By doing so, they leverage each other's distributed knowledge to solve complex problems (5–6) and through different forms of social interactions such as elaborations and verbalisations, activation of prior knowledge occurs (7–8). In this regard, it is theorised that learning of new knowledge is facilitated when students are able to connect the new knowledge with what they have already known (6–7).

Unfortunately, the COVID-19 has disrupted education in an unprecedented manner. Following the declaration by World Health Organization that COVID-19 is a worldwide pandemic, many countries (including Malaysia) implemented quarantine orders or *cordon sanitaire* as an effort to curb the spread of the infection. In Malaysia, all forms of face-to-face teaching and learning activities (including PBL) in universities had to be transitioned to emergency remote teaching and learning (9). According to Khlaif et al. (10), there is a stark difference between "emergency remote teaching and learning" and the properly designed "online teaching and learning". Emergency remote teaching and learning refers to the temporary, unplanned sudden shift of instructional delivery to a fully online solution due to a crisis. Online teaching and learning, on the other hand, is a deliberately planned instructional delivery with careful consideration of how various design decisions (e.g., modality, synchronicity of communication, pacing, etc.) influence educational effectiveness.

Given that PBL had always been conducted in the conventional face-to-face format, it is largely unknown how acceptable this form of hastily implemented online PBL was and moving forward, how likely would our medical students continue to adopt this method as the COVID-19 pandemic gradually transitions into the endemic recovery phase (11). According to Davis (12), our attitude towards any new system or technology (in this instance, online PBL) is dependent on two fundamental factors: (a) the perceived benefits – the extent to which one believes that the system (online PBL) will help them with their tasks (i.e., learning task), and (b) the perceived ease of use – the extent to which one believes that this new system (i.e., conducting online PBL) is easy enough to adopt. This framework is known as the technology acceptance model (TAM) (12).

Using TAM as part of our conceptual framework, we embarked on a study with the overarching objectives to develop a set of questionnaires to measure this intention, and determine the influence of perceived benefits and perceived ease of use on the behavioural intention to continue adopting online platforms to conduct PBL. In addition, as the pedagogy of PBL is built upon socio-constructivism learning philosophy (13), we had also incorporated the influence of environment factors in the conceptual framework. Items in the construct environment factors were derived using a popular management tool for risk factor analysis, that is, the PEST analysis (14). PEST is an acronym for four sources

of macro-factors influencing organisational performance: P = policy or political factors, E = economic factors, S = social factors, and T = technological factors.

METHODS

This study was carried out as a two-stage project (15). In the first stage, the development and validation of the questionnaire used in this study were performed using the measurement model of partial least squares (PLS) structural equation modelling (SEM). The validated questionnaire was then distributed to the participants by authors NC, WST, AA and SCS. The authors were available to answer questions related to the comprehension of the technical terms contained in the questionnaire. In the second stage, the relationships between the independent constructs and the dependent construct of behavioural intention to continue adopting online PBL were analysed using the structural model of PLS.

Participants

For stage 1 of the study, participants were recruited from the entire 2020/2021 cohort of Year 3 medical students (a total of 300 participants). Based on the recommended ratio of five participants to one item by Costello and Osborne (16), a minimum of 125 participants were needed for a 25-item questionnaire validation process (16). All 300 participants responded in this stage of the study.

For stage 2 of the study, purposive sampling was performed to recruit participants from the entire 2020/2021 cohort of the Year 2 medical students (a total of 149 participants). Both Year 2 and Year 3 students had prior experience of learning through conventional face-to-face PBL before the pandemic hit. Prior informed consent was obtained from all participants. Participants were told that the confidentiality of their personal information would be preserved and that their responses would be anonymised and used for the purpose of this study only.

Materials

For the construct perceived benefits of online PBL, we adapted the five objectives of PBL mentioned by Barrows and Kelson (17) to develop five items in this construct. According to Barrows and Kelson (17), PBL has the following five beneficial objectives: PBL helps a student to (a) construct an extensive and flexible knowledge base; (b) develop effective problem-solving skills; (c) develop self-directed, lifelong learning skills; (d) become effective collaborators; and (e) become intrinsically motivated to learn.

For the construct perceived ease of use, we adapted the seven steps of conducting PBL by Schmidt (18) to develop the seven items in this construct. According to Schmidt (18), the seven steps of conducting PBL are (a) clarifying the terms, determining the main points and summarising the text; (b) defining the problem; (c) analysing the problem; (d) explaining and deriving tentative solutions after reviewing the previous two steps; (e) formulating learning objectives for self-directed learning; (f) searching additional information to answer the learning objectives; and (g) reporting, synthesising and evaluating the relevance of the new knowledge found in step (f).

For the environment factors construct, the items will be categorised according to four subcategories using the PEST framework (see Figure 1 for the conceptual framework of the study). The preliminary list of items in this construct was generated through focus group discussions among the authors of this article for confirmatory factor analysis. SEM analyses for testing the simultaneous multiple regression analyses between the various independent constructs and the dependent construct were performed using SmartPLS version 3.0 (19).

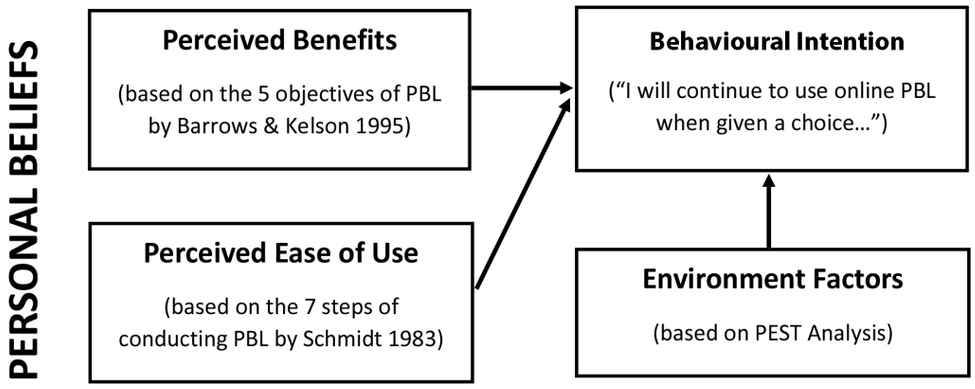

Figure 1: Conceptual framework of the study.

PROCEDURE

Stage 1: Construction and validation of the questionnaire using the measurement model

A set of questionnaires measuring the constructs derived from conceptual framework was first developed. Based on this framework, three independent constructs were outlined, namely, perceived benefits, perceived ease of use and environment factors. Perceived benefits had 5 items (based on Barrows and Kelson [17]), perceived ease of use had 7 items (based on Schmidt [18]) and environment factors had 12 items (based on focus group discussions among the authors using the PEST framework [14]). The list of constructs and items is provided in Table 1.

A measurement model was then performed to determine the internal consistency reliability, convergent validity and discriminant validity of the items in the questionnaire. For internal consistency, Cronbach's alpha, composite reliability index and the rho A (ρA) coefficient (also known as Dijkstra-Henseler's rho) were determined (20). For convergent validity, item factor loadings and the average variance extracted (AVE) values of the constructs were determined. Convergent validity is defined as the degree to which the items that are supposedly measuring the same construct are in agreement with one another. AVE refers to the grand mean value of the squared loadings of all items associated with a construct. According to Hair et al. (21), a factor loading of > 0.7 is considered acceptable, whereas if the factor loading is < 0.4, the item would be removed. For items with factor loading between 0.4 and 0.7, the AVE would then be considered. If the AVE > 0.5, the item would be included, whereas if the AVE < 0.5, that item would be deleted (21). For discriminant validity, the Fornell and Larcker (22) criterion and cross-loadings were considered. Discriminant validity refers to the degree to which the items differentiate among the constructs. In simple terms, the Fornell and Larcker criterion measures the degree to which an item loads higher on its own construct (as measured using the square root of its AVE value) compared to its correlation with other constructs (as measured using the square of correlation values).

Stage 2: Hypothesis testing using the structural model

After determining the validity and reliability of questionnaire, a structural model of SEM was conducted. The structural model's predictive accuracy was evaluated via the coefficient of determination score (R^2) and the corresponding *t*-statistics (21).

R^2 indicates the degree of the model's predictive accuracy. A substantial R^2, for example, means that a large amount of the variance in the dependent construct can be explained by the dependent constructs given in the model. According to Cohen (23), R^2 values of 0.26, 0.13 and 0.02 indicate substantial, moderate and weak levels of predictive accuracy, respectively. A bootstrapping technique with 500 re-samplings was performed to generate the *t*-statistics and path estimates. The effect sizes (f^2) of the constructs generated from the software SmartPLS version 3.0 were also analysed. The determination of f^2 is important because even though the *p*-value can inform the researchers whether an effect exists or not, the *p*-value alone does not inform the researchers the "size" of the effect (24). In other words, *p*-value is a measure of statistical significance, whereas f^2 is a measure of substantive significance. Cohen's guideline (23) was used as the reference in this study for the interpretation of the effect size, that is, 0.02, 0.15 and 0.35 represent small, medium and large effects, respectively.

Table 1: List of constructs and items in the questionnaire

Item	Code in the path model
Construct 1: Perceived benefits	
Online PBL is beneficial in helping me to:	
Construct an extensive knowledge base	B1
Develop effective problem-solving skills	B2
Develop self-directed, lifelong learning skills	B3
Become an effective collaborator	B4
Become motivated to learn more	B5
Construct 2: Perceived ease of use	
It is easy in online PBL to:	
Clarify terms and concepts in the PBL trigger that I do not understand	E1
Define the problem in the PBL trigger (step 1)	E2
Analyse the problem in the PBL trigger (step 2)	E3
Explain and derive tentative solutions after reviewing the previous two steps	E4
Formulate learning objectives	E5
Collect additional information on my own	E6
Synthesise, test and share the newly acquired information with my group members	E7
Construct 3: Environment factors	
Factors that promote a conducive environment for online PBL (based on PEST analysis)	
Policy factors	
The university policy has made it more conducive for me to conduct online PBL	EN1

(*Continued on next page*)

Table 1: (*Continued*)

Item	Code in the path model
Economic factors	
The housing condition that I am residing in has made it conducive for me to conduct online PBL	EN2
I have adequate bandwidth that enables me to conduct online PBL in a conducive manner	EN3
Social factors	
My facilitator is able to motivate me to conduct online PBL	EN4
My facilitator is able to help me and my group to summarise key concepts in online PBL	EN5
My group members and facilitator are able to give constructive feedback to me in online PBL	EN6
My group members are able to help each other to generate meaningful discussions in online PBL	EN7
Technology factors	
I have my own device (laptop, tablet or smartphone) for me to conduct online PBL	EN8
The device that I am using enables me to conduct online PBL in a conducive manner	EN9
I have a functioning webcam that enables me to conduct online PBL in a conducive manner	EN10
I have a functioning microphone that enables me to conduct online PBL in a conducive manner	EN11
The strength of internet connection from where I am conducting the online PBL is adequate	EN12
Construct 4: Intention to continue adopting	
I intend to continue adopting online PBL even after I am allowed to resume face-to-face learning in the campus	I

RESULTS

Demographics

A total of 149 (109 or 73.2% were female and 40 or 26.8% were male) Year 2 medical students participated in stage 2 of the study. The mean age of participants was 21.05 years old. Overall, when asked about their intention to continue adopting online PBL (on a Likert scale of 5 where 1 = most unlikely and 5 = most likely), the mean score was 3.42 with standard deviation = 1.27 suggesting that generally, their intention to continue adopting online PBL was only borderline.

Stage 1: Construction and Validation of the Questionnaire Using the Measurement Model

Specifically, from the measurement model analysis, all items had factor loadings of > 0.7 except for EN1, EN4 and EN12 but as the AVE values of all constructs were > 0.5, no item was considered for deletion.

Both the Cronbach's alpha and composite reliability values for all constructs were > 0.7, indicative of good internal consistency reliability (refer to Table 2 for details). The discriminant validity, as determined using the Fornell and Larcker criterion, was also good for all constructs indicating that the constructs are discriminant enough (refer to Table 3 for details). No significant cross-loading of items in one construct on other loadings was noted.

Stage 2: Hypothesis Testing Using the Structural Model

From the structural model analysis, it was determined that only the relationship between the independent construct perceived ease of use and the dependent construct intention to continue adopting online PBL was significant (with path coefficient standardised $\beta = 0.312$; *t*-statistics = 2.960; $f^2 = 0.053$; and $p = 0.003$). The overall R^2 value of our model was 0.208, indicating a substantial predictive accuracy of our model. The results of the structural path analyses are shown in Table 4 and Figure 2.

A post-hoc analysis on the potential moderating effect of environment factors on perceived ease of use was also performed. The R^2 values before and after inclusion of this moderating effect were 0.208 and 0.212, respectively with negligible effect size, indicating that environment factors do not have a significant moderating effect on the influence of perceived ease of use on the dependent construct intention to continue adopting online PBL.

Table 2: Internal consistency reliability and convergent validity

Construct	Internal consistency reliability			Convergent validity		
	Cronbach's alpha	Composite reliability	ρ	Items	Factor loadings	AVE
Perceived benefits	0.93	0.94	0.94	B1	0.916	0.77
				B2	0.870	
				B3	0.893	
				B4	0.871	
				B5	0.847	
Perceived ease of use	0.93	0.93	0.94	E1	0.797	0.70
				E2	0.887	
				E3	0.851	
				E4	0.862	
				E5	0.812	
				E6	0.827	
				E7	0.804	
Environment factors	0.92	0.93	0.93	EN1	0.583	0.54
				EN2	0.710	
				EN3	0.740	
				EN4	0.613	
				EN5	0.764	
				EN6	0.745	

(*Continued on next page*)

Table 2: (*Continued*)

Construct	Internal consistency reliability			Convergent validity		
	Cronbach's alpha	Composite reliability	ρ	Items	Factor loadings	AVE
				EN7	0.782	
				EN8	0.783	
				EN9	0.715	
				EN10	0.824	
				EN11	0.827	
				EN12	0.677	
Behavioural intention to continue adopting				I	1.00	

Notes: ρ = Dijkstra–Henseler's rho; AVE = Average variance extracted

Table 3: Discriminant validity using the Fornell and Larcker criterion

Construct	Environment factors	Perceived benefits	Perceived ease of use
Environment factors	***0.734***		
Perceived benefits	0.290	***0.880***	
Perceived ease of use	0.725	0.570	***0.835***

Note: The bold, italic numbers are the square root of the AVE values. The Fornell and Lacker criterion is satisfied if the square root of AVE is higher than all the square of correlation values.

Table 4: Structural path analysis

Hypothesis	Path coefficient	*t*-statistics	95% Confidence interval		*P*-value	Decision	f^2
			5.0%	95.0%			
Environment factors → Intention to continue adopting	0.231	1.212	–0.330	0.417	0.226	Not supported	0.044
Perceived benefits → Intention to continue adopting	–0.041	0.416	–0.176	0.144	0.677	Not supported	0.001
Perceived ease of use → Intention to continue adopting	0.312	2.960	0.134	0.478	0.003	Supported	0.053

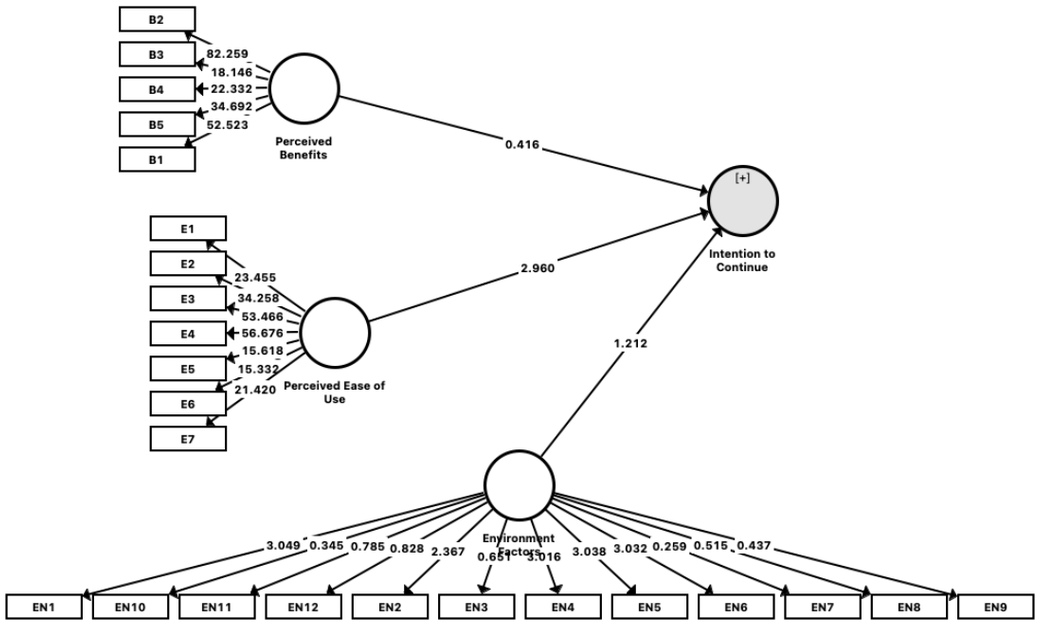

Figure 2: Final path model analysis.

DISCUSSION

Overall, this study suggests that medical students do not have a strong intention to continue adopting this form of hastily implemented online PBL. Perceived ease of using an online platform appeared to be the only factor to have a significant positive influence on students' intention to continue adopting this method. Unsurprisingly, this is probably due to the ease of using digital tools such as file and screen sharing as well as other built-in features (e.g., digital whiteboard and cloud recording) (25) in online platforms such as Zoom, Webex or Microsoft Teams. Some online platforms such as Microsoft Teams even allow for direct access to a cloud computing system (in this case, OneDrive) to facilitate data and file sharing.

Perceived benefits of online PBL, on the other hand, were not shown to have a significant positive influence on the intention to continue adopting this online method. This suggests that these online platforms may not be perceived to be beneficial enough for knowledge construction, problem solving and learning collaboration in PBL. Similarly, in a qualitative study, Riaz et al. (26) found that although online PBL can be an effective strategic alternative to face-to-face PBL, a number of challenges exist in online PBL that can compromise students' learning processes including the lack of teamwork, difficulties to foster peer interaction and passivity of student contributions.

In their community of inquiry model, Garrison et al. (27) described how optimal learning should take place at the intersection of social, cognitive and teaching presence. In an online environment, social presence is defined as the feeling of connectedness with others in the virtual space (28). Unfortunately, while cognitive and teaching presence can be easily maintained in an online platform, maintaining a virtual social presence can often be very challenging (29). The fact is that social presence is a crucial component to foster open communication, promote group cohesiveness, improve students' satisfaction and increase motivation to drive learning (29–30).

Furthermore, in most online teaching and learning activities, the student would sit passively at the same spot for a long period of time with limited physical movements. This is unnatural as people would usually move their limbs (e.g., moving their hands when they are trying to emphasise a point in their conversations), or even pace up and down in the classroom during brainstorming sessions. Interestingly, Oppezzo and Schwartz (31) found that people who walk around can generally come up with more creative ideas for problem solving than people who are passively sitting down.

Additionally, we also found that environment factors (particularly social factors) did not seem to positively influence one's intention to continue adopting online PBL. Neither did our study demonstrate any moderating effect of environment factors (e.g., making it more conducive) on the perceived ease of adopting online PBL. As stated earlier, the effectiveness of PBL in developing problem-solving and collaboration skills is built upon the concepts of socio-constructivism learning (13). In this regard, the dialogic or Socratic method among group members is pivotal (32). The dialogic method is defined as the insights and understanding gained from the processes of asking and answering questions (33). Unfortunately, while back-and-forth dialogue can flourish organically in a face-to-face environment, this form of iterative elaborations and verbalisations among group members may prove to be too disruptive in an online environment. Online platforms are designed in such a way that only one person can speak at a time while the other participants should mute their microphones and passively listen until the speaker has finished talking. Occasionally, when someone must interject to ask a question, he or she may even have to resort to activating emoji buttons. This form of monologue with a tendency of students to give "mini-lecture" (32) defeats the very purpose of PBL, namely, solving problems through leveraging each other's distributed knowledge in an organic and collaborative manner. Indeed, one of the major unintended consequences reported by students in online PBL is the experience that the quality of the discussion transpired was not as rich as in face-to-face sessions (32).

In addition, the sum of our communicated messages is often more than what our words can say. For example, according to Mehrabian's communication model (34), only approximately 7% of messages are transmitted through spoken words. Nonverbal cues such as body language and the tone of voice are equally, if not more, important in the encoding and decoding processes of communication loop. In an online platform, these nonverbal cues are lost. Inadvertently, this would have induced a higher extraneous cognitive load as the students would need to look hard for nonverbal signals projecting through the computer webcam and audio speakers (35). This would likely reduce the germane capacity for learning, thus making it fewer effective means to develop problem-solving and collaborative skills.

This study has several limitations that should be mentioned. First, the overall coefficient of determination, R^2, was only 0.208, which indicates that a large proportion of the variation in the dependent variable (i.e., behavioural intention to continue adopting online PBL) remained unexplained. Second, this study was conducted among medical students from a single institution in Malaysia. As PBL has been implemented for a very long time in various medical schools in Malaysia, a multicentre study should be conducted to determine the extent of generalisability of our findings. Third, although the participants in this study had the PBL experience in both the conventional face-to-face and the online format, a direct comparison between these two formats (face-to-face vs. online PBL) was not performed. As such, we could

not conclusively say that our students still prefer conventional face-to-face PBL when compared to online PBL. Fourth, although the conceptual model was built upon TAM (12) and other pre-existing theories (14, 17–18), content validity and face validity had not been performed. This may threaten the relevance and comprehensibility of the items in our model. Fifth, having more than 2.5 times the number of female participants compared with male participants in our cohort of Year 2 medical students could have introduced gender bias in the responses. Finally, some of the terms used in the questionnaire can be rather technical and may impair the comprehensibility of the terms by some novice learners. Although the authors were available to clarify these terminologies, the technicality of these terms may still have an impact on the responses given by the participants.

This study mainly addressed students' perception and acceptance of online PBL due to extrinsic factors including policy, economic, social and technological factors influencing their intention to adopting online PBL. However, there may be other intrinsic factors such as individual learning behaviour that may influence their perception and acceptance of online PBL that should be addressed in future studies. In particular, elements in individual learning behaviour such as the degree of intrinsic empowerment (i.e., their internal strength to positively engage in the learning process), entrustment (i.e., their ability to identify learning gaps, engage in self-assessment and help peers to learn) and their functional skills (i.e., their discipline to set and stick to deadlines, digital literacy skills, etc.) may play important roles in influencing their intention to adopt online PBL (36).

CONCLUSION

Nevertheless, this study infers that our medical students did not have a strong intention to continue adopting this form of hastily implemented online PBL. The only factor that appeared to have a positive influence on the intention to continue adopting online PBL was the ease of using the online platforms. Neither the perceived benefits of online PBL nor the environment factors appeared to have a significant influence. These findings imply that, as countries gradually transition to a recovery phase of the COVID-19 pandemic, conventional face-to-face PBL should be resumed as the de facto method for PBL until clear advantages of a carefully planned online PBL could be demonstrated.

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ETHICAL APPROVAL

Ethical approval was obtained from the institutional medical research ethics board of UNIMAS (reference no. UNIMAS/NC-21.02/03-02 Jld.5 [50]).

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