Short Communication

Fully digital problem-based learning for undergraduate medical students during the COVID-19 period: Practical considerations

Chia-Ter Chao [a,b], Chiao-Lin Tsai [b,c], Mong-Wei Lin [b,d], Chih-Wei Yang [e,f,g], Chao-Chi Ho [b,h], Huey-Ling Chen [e,i], Chiun Hsu [b,j], Bor-Ching Sheu [b,k,*]

[a] Nephrology Division, Department of Internal Medicine, National Taiwan University Hospital, Taipei, Taiwan
[b] Center of Faculty Development and Curriculum Integration, National Taiwan University College of Medicine, Taipei, Taiwan
[c] Department of Radiation Oncology, National Taiwan University Hospital, Taipei, Taiwan
[d] Department of Surgery, National Taiwan University Hospital, Taipei, Taiwan
[e] Graduate Institute of Medical Education and Bioethics, National Taiwan University College of Medicine, Taipei, Taiwan
[f] Department of Medical Education, National Taiwan University Hospital, Taipei, Taiwan
[g] Department of Emergency Medicine, National Taiwan University Hospital, Taipei, Taiwan
[h] Chest Medicine Division, Department of Internal Medicine, National Taiwan University Hospital, Taipei, Taiwan
[i] Department of Pediatrics, National Taiwan University Hospital, Taipei, Taiwan
[j] Department of Education and Research and Department of Medical Oncology, National Taiwan University Cancer Center, Taipei, Taiwan
[k] Department of Obstetrics and Gynecology, National Taiwan University Hospital, Taipei, Taiwan

Digital problem-based learning (PBL) was originally introduced as a means to improve student engagement and increase flexibility. However, its use becomes mandatory during the coronavirus disease 2019 (COVID-19) period, accelerating changes in medical education. Few elaborated on the implementation details of digital PBL curricula. Technical guidance can be important but under-recognized prerequisite of a successful digital PBL session. In National Taiwan University College of Medicine, we established a digital PBL curriculum and previously validated a confidence questionnaire for surveying undergraduate students receiving digital

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PBL sessions. In this opinion piece, we gleaned multiple procedural details from our experiences based on students'/tutors' feedback, which we summarized in a 5″W″ recommendations (Who), timing/duration (When), location (Where), software/hardware/topics (What), and evaluation aspects (Why). Suggestions on how to optimally prepare for digital PBL session are also provided. We believe that these tips can further facilitate the wide adoption of digital PBL.

Effective learning for health professionals is an important task in this era of information explosion. Technology-assisted education provides recipients with a better subjective efficacy compared to traditional pedagogy. Students prefer this education strategy due to its flexibility, high accessibility, and ease for tool usage.[1] A literature review summarized that the context and themes involved in internet-based learning and the learning theories should be tailored individually.[2] Among the spectrum of internet-based curricula, digital problem-based learning (PBL) gains popularity recently. Traditional learning process among medical students hinges on one-way knowledge transmission, but interactive modules such as PBL are better suited to enhance engagement and potentially increase learning effectiveness.[3] Three core components of PBL have been proposed; an initial problem-presentation and analytic phase, a second self-oriented learning phase, and the final result synthesis/reporting phase.[4] However, the coronavirus disease 2019 (COVID-19) pandemic, accompanied by social distancing and city lockdown, cripples medical students' opportunity to receive in-person lectures and to participate in face-to-face meetings/discussions. In turn, COVID-19 creates unprecedented opportunity for innovations in medical education. Digital PBL, especially fully online ones, have never been more important until the COVID-19 period. Nonetheless, questions emerge regarding the efficacy and effectiveness of digital PBL during this pandemic, and there are concerns stating that online courses are in essence "emergency remote teaching" instead of "online reaching".[5] These thoughts are reflective of the heterogeneity in course quality, which we believe stems from the meager evidence focusing on the practical details about digital PBL curricula. Technical guidance is therefore an under-recognized issue for a successful digital PBL.[6]

In response to the COVID-19-related education crisis, the Center of Faculty Development and Curriculum Integration of National Taiwan University College of Medicine implemented a pilot digital PBL project involving undergraduate medical students during 2020—2021 (supplementary Table).[7] During course design, we involved multiple stakeholder groups including both junior and senior facilitators, course designers, medical school administrative staff, and experts from the Graduate Institute of Medical Education and Bioethics for course digitalization. The materials and themes were the same as those of face-to-face ones but the delivery platform was digitalized. We encountered challenges when implementing the pilot digitalized PBL curriculum, including two categories, potentially suboptimal

learning efficacy among medical students and technical issues. For the former category, we used to assess medical students' confidence in satisfactorily completing the digital PBL curriculum and compared results with those in completing the traditional face-to-face PBL.[7] Totally 110 medical and pharmacy students voluntarily participated, and a recalibrated confidence questionnaire was administered, followed by exploratory factor analyses and dimension reconstruction. We found that a single session of digital PBL significantly attenuated medical students' confidence in completing the curriculum, while repeated practice up to 3 consecutive sessions might partially restore it.[7] For the latter category, we synthesized technical issues and made recommendations according to a 5″W″ categorization (Supplementary Figure 1), based on feedbacks from medical students and tutors/facilitators, in Table 1.

Who? In our experiences,[7] tutors and students need to be well prepared prior to digital PBL sessions (Table 1). For tutors, we recommend pre-course workshops, aiming to elucidate values, importance and details of digital PBL and to enhance tutors' familiarity and satisfaction.[8] Junior tutors can receive briefing for digital etiquette, and live curricula observation, simulation or didactic lectures prior to sessions are helpful. Interestingly, digital PBL alters the atmosphere of traditional curricula; we implicitly find that introvert students may be more active in digitalized settings, while some become camera-shy. Atmospheric changes influence learning effectiveness of a digital PBL. For students, we recommend 3 core elements to be born in their mind: stewardship, sequence, and presentation style adaptation (Table 1). Stewardship means streamlining sessions to avoid frequent interruptions. Group members are suggested to designate chairperson(s) or auditor(s) to ensure that each session courses smoothly. It is important to address the presentation sequence for debatable points with a pre-registered or real-time updated agenda to place them in queue. The presentation style also needs to be modified using pre-course slide-sharing with in-course verbal explanation, electronic chalkboard, even social media forums, etc. Digital etiquette is another important element for a successful digital PBL, in which participants assume digital citizenship following two web manner principles, technical details and communication guidance.[9] The former refers to asking participants to turn on cameras/speakers for framing at session beginning, since the transmission of visual/auditory messages may be compromised. Participants should avoid covering their face and look at the camera but not images on the device screen. We notice that periodic checkups with audience regarding the clarity

Table 1 Our recommended practical aspects related to digital PBL according to the 5 W recommendations based on experiences from NTUCM.

Category	subcategory	Detail
Who	Facilitators	1. Experienced facilitators for leading digital PBL curricula initially
		2. Pre-course workshops and live curricula observation by junior facilitators
		3. Facilitators to follow digital etiquette during digital PBL
		4. Monitor atmospheric changes and encourage introvert members to participate
	Students	1. Three core elements to be considered: stewardship, sequence, and presentation style adaptation
		2. Students to follow digital etiquette during digital PBL
		3. Encourage students to pursue learning attitude evolution
When	Timing	1. Avoid distracting exposures during digital PBL
		2. Advise against nocturnal session (optional)
		3. Mid-session breaks to restore students' concentration (optional)
	Duration	1. The ideal duration of a digital PBL lies between 1 and 2 h
		2. Advise against a digital PBL duration shorter than 30 min or longer than 2.5 h
Where	Location	1. Secure places with adequate internet connection
		2. Locate a private room or public space with minimal to low noise interference
		3. Put a sign suggesting do-not-disturb on-site
What	Software	1. Advise prior installment and preliminary tests of online meeting applications for functionality and compatibility with hardware/other applications
		2. Ensure internet connection speed to avoid interruption
		3. Advise adjunct routes of communication in addition to the default meeting application, such as instant messaging software use
	Hardware	1. Disinfect electronic device surface during the pandemic (computer, phone, tablet, etc.)
		2. Optimize digital infrastructure and technical support office by the College of Medicine

Table 1 (*continued*)

Category	subcategory	Detail
		3. Prepare backup device in case of unexpected interruptions (optional)
	Topic	1. Advise shorter length of case presentations during the initial digital PBL sessions
		2. Advise against excessive details to permit more space for encouraging discussion during the initial digital PBL sessions
		3. Advise varying the levels of uncertainty within each case or theme to facilitate students' fixation
Why	Evaluation	1. Assess and monitor the progress of each digital PBL session

NTU-CM, National Taiwan University College of Medicine; PBL, problem-based learning.

of words/images is helpful. Slower movements and wider gestures increase message clarity. The latter refers to the content and message organization. Presenters are expected to speak slower with terminology explained in details. A brief but concise summary at the end of presentation places the audience at a better position to absorb content. Both digital PBL tutors and students are expected to be more patient than they would be in face-to-face PBL sessions. There are students being "digital natives" (better adapted to the technology-assisted communication), while others are "physical natives" (used to face-to-face interactions).[10] We can enhance students' engagement if communication route, schedule flexibility, device accessibility and ease of usage, etc. are taken into consideration. In our experiences, students of Asian origin may be self-effacing and tend to wait for others to express themselves. Autonomy in learning behavior assumes importance during digital PBL curricula. We encourage students' proactiveness and appraise them for such attitude.

When? Timing and duration should be carefully adjudicated for digital PBL (Table 1). We think that maintaining high concentration on visual/verbal information assumes importance. In our experiences, students reported intermittent inattentiveness owing to the monotonous background, while distracting exposures are not uncommon including environmental noise, side-chat, or connection interruption. Studies from United Kingdom identified that one-fourth medical students complained of family distraction during digital curricula.[11] We recommend that the duration of a digital PBL session ideally ranges from 1 to 2 h. A shorter duration is not recommended, as time-consuming technical issues frequently emerge during online sessions, and shorter sessions than

30 min preclude effective interactions. In contrast, prolonged digital PBL sessions impair students' concentrating capacity, since sessions longer than 2.5 h decrease students' satisfaction, leading to negative perceptions.[12] Finally, we believe that mid-session breaks similar to those in didactic lectures may sometimes be helpful for restoring students' concentration.

Where? A good location favorably influences learning effectiveness in digital PBL. Prior reports indicated that one-tenth medical students attending digital courses had difficulty searching for suitable places.[11] Internet speed frequently deranges session flow and sometimes worsens atmosphere if involving information-crowding topics. We advise students and tutors to secure places with an adequate internet connection speed and bandwidth prior to commencement. The presence of a noise-proof room/space in which individuals can talk and hear others' voice, in our experience, is a prerequisite. A good practice can be putting on a sign on one's door or behind one's chair, stating phrases such as "Do not disturb" or "In lecture", etc.[5]

What? We think 3 types of apparatuses need to be prepared beforehand for a digital PBL session. First, connecting software counts. Virtual meeting/communication software such as Google Hangout Meet, Skype, Cisco WebEx, Cyberlink U-meeting, Zoom, each carries advantages/disadvantages. We recommend participants to preliminarily run the applications and acquaint themselves with procedures/functions. Adjunct communication routes incrementally benefit students during digital PBL. Digital natives often have alternative routes for real-time opinion exchanges, and students may interact privately with others to avoid disturbing discussion. Electronic devices for joining digital PBL are also important. We recommend disinfection of user surface during the COVID-19 period but recommend against sharing devices to permit social distancing. The order and topics in digital PBL sessions require careful adjudication; those of the initial 2—3 sessions should be shorter, containing less details but allowing greater room for discussion. We can imbue different levels of uncertainty to the topics across the curricula of digital PBL to fixate students on the discussion. In addition, we should design topics to encourage team work and be of supportive nature.[13]

Why? Evaluating the best format of the entire landscape of digital PBL is difficult. We can extrapolate experiences from other forms of online learning,[14] with 3 domains identified including organizational capacity, effectiveness learning and assessment, and human resources. For organizational capacity, there should be an accountable organization/course leader that is supportive and willing to lead the designer process, allocate resources, and implement relevant regulations.[14] For learning effectiveness, components need to be inspected including digital course design, delivery, and student evaluation.[14] For human resources, stakeholders including faculty, students, and administrative staff, should all be considered.[14]

We next provide period-dependent recommendations for implementing digital PBL, divided according to the timings, before, during, and after digital PBL (Table 2). From the 5″W″ categories, students mostly reported difficulties related to the "Where" and "What" categories; that is, their comments frequently involved how to secure

Period	Actions recommended
Before	1. Be sure to assign a moderator to streamline each course 2. Be sure to allocate themes/questions to avoid speaker crowding 3. Be sure to ask students to adapt their presentation style 4. Be sure to introduce and train digital etiquette 5. Be sure to arrange a preliminary check-up of software/hardware/location/connection
During	1. Try to encourage students' participation; for example, designate a dedicated questioner(s) 2. Try to rotate speaker orders to encourage interactions 3. Try to and encourage the provision of feedback, preferably instantaneously 4. Try to turn off curricula-irrelevant applications, except adjunct communication modules 5. Consider adopting role playing to encourage participation (optional) 6. Consider adopting intermittent real-time polling (optional) 7. Consider monitoring the speed of feedback of the entire group (optional)
After	1. Be sure to provide content summarization after each digital PBL session 2. Be sure to address any unfinished issues following each session

Table 2 Preparations recommended prior to, during, and after the implementation of digital PBL curricula.

PBL, problem-based learning.

places with adequate internet connection, the selection of a suitable conference software, the style of presentation, etc. Feedbacks from the facilitators, on the contrary, spanned from "Who", "When", "Where", "What" to "Why". Prior to the first session, we can ask each group to assign a moderator to lead, organize, and streamline the preparation, avoiding blank period, awkward silence, speaker jamming, or crowding messages. Studies indicate that moderators can guide others to perform better if their ties to the moderators are strong.[15] We recommend allocating questions to participants on a mutual agreement basis to increase course smoothness. The moderator needs to be careful in leading the course and monitoring the atmosphere of discussion. We suggest introduce details of digital etiquette prior to digital PBL commencement, with all utilities and supporting measures tested for functional integrity. During session, we can consider offering multiple communication strategies and encourage interactions. Tutors can ask participants to serve as questioners. Feedback from tutors should be instantaneous and avoid losing catch of messages. All should turn off/silent other applications such as emails or recreational ones. We identify several options to ensure students' concentration ability (Table 2), including role playing, real-time polling, and monitoring the timeliness of student feedback. After completion, one or more of the participants make a succinct summary of the index case and respond to remaining questions. A good practice would be to devote additional time to the

management of these questions, to further enhance post-course learning.

In conclusion, digital PBL becomes mandatory during the COVID-19 period. There are pilot experiences regarding the performance and learning theory of digital PBL prior to the pandemic, but they may not completely fit the requirement of the post-COVID-19 era. Based on our experiences, we believe that process-related details for optimizing digital PBL curricula offer an important guidance missing from the current literature. A summary of our 5 W approach using a strategy activity map is shown in Supplementary Figure 2. Sharing of our experiences are expected to further enrich the knowledge base of digital PBL.

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Declaration of competing interest

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Appendix A. Supplementary data

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