



Future directions of online learning environment design at medical schools: a transition towards a post-pandemic context

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Coronavirus disease 2019 (COVID-19) has had an extremely large impact on methods of teaching and learning, and the need for online learning has grown enormously during the COVID-19 pandemic. Because most professors and students adjusted their mode of teaching and learning to this new context, online learning seemed to be going well. The problem is that distance learning was abruptly adopted as an alternative method of classroom instruction. To increase the effectiveness of online learning, more consideration is needed to explore future directions of creating learning environments. Therefore, this study suggests seven design guidelines for designing learning environments at medical schools based on a theoretical background and experiences from the pandemic. Constructivism and situated learning theory are introduced as the theoretical background for learning environment design, and the basic principles of learning environment design with the paradigm shift to learner-centered classrooms and experiences using EdTech, including HyFlex learning, flipped learning, learning management systems, and interactive learning tools, were used to develop the design guidelines. Each design guideline is strategically matched with the basic principles: learner-centeredness, real-world tasks and contexts, problem-solving, new roles of professors as facilitators or tutors, collaboration, and new perspectives of evaluation and assessment.

Keywords: Constructivism; EdTech; Learning environment design; Online learning; Situated learning theory

Introduction

Coronavirus disease 2019 (COVID-19) has extremely impacted current education systems all around the world, in particular, the method we teach and the way we learn. With the limitation of physical interactions, most schools temporarily closed their doors, and online learning has become the main means of teaching and learning. Although this kind of distance learning was already prepared theoretically through various research, it was difficult to

use practically in the field except for online-only classes [1]. However, the need for an online learning method has grown enormously through the COVID-19 pandemic situation. Most schools, including universities and colleges, were forced to change the way of teaching and learning, and educators and learners had to adjust their mode of teaching and learning to the recent phenomenon.

Medical schools were the same as other schools. Most curricula were delivered to students through pre-recorded lectures or real-time online classrooms with video confer-

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encing tools. Clinical clerkships and other clinical practices were postponed or suspended. The problem is that this remote learning was abruptly adapted as an alternative way of classroom instruction. There was no preparation for online learning, no discussion of the effectiveness of learning, and/or no agreement between professors and students. Distance learning was used not because it can be an effective way of learning activities but because it was urgent [2]. Numerous research on online learning in terms of the media used in online classes, the type of classes, and preferred online class methods to identify current experiences were also followed immediately after the change [3-6]. However, little attention has been given to research on the effectiveness of online learning and its future directions for learning environment design. The efforts for developing a better learning environment not only for online learning conditions but also for traditional learning situations based on the theoretical background to prepare after the COVID-19 or another pandemic situation are needed more at this point.

From the contemporary perspective on learning, building a digital learning environment where knowledge and information can be explored and acquired anytime and anywhere, and creating and utilizing integrated knowledge for real-world problem-solving are becoming normal. It goes beyond simply memorizing and utilizing a large amount of knowledge, and developing creative problem-solving skills and convergence thinking skills are becoming more important. With these perspectives on learning, the purpose of this study is to suggest how to design learning environments at medical schools after the COVID-19 situation based on the theoretical backgrounds and experiences from the past.

Theoretical backgrounds: constructivism and situated learning theory for basic principles of learning environment design

The constructivists' view of learning assumes that knowledge exists in the human mind that has its contents, and the knowledge can only be interpreted through personal and social experiences [7]. It provides more meaning to how knowledge is constructed than the knowledge itself, and learning is defined as a process in which the learner

constructs the inner meaning of knowledge anew in his or her own space. It is a personal interpretation uniquely developed by experiences [8]. Therefore, in order for this process to be transferred from the contents learned in school or classrooms to true knowledge, it is argued that learning must take place in complex and diverse situations that reflect real-world context [9,10]. Because this context is already integrated into the learned knowledge itself, it is impossible to learn knowledge in isolation from its actual context. Learning can be placed by situating cognitive experience in real situations [11].

According to the situated learning theory, students are failing to apply the knowledge they have learned in school because the experiences they are learning at school are very different from the experiences they face in real situations [12,13]. In particular, in the case of medical schools, students need to learn again and practice new things through internships and residency courses after graduation. The learning culture in Korea is characterized by students doing their best to follow teachers who organize the contents well during the class and passively acquiring knowledge [14]. As a result, the acquired knowledge does not transfer well into long-term memory, or the method of newly constructing and utilizing knowledge is inexperienced or focuses only on improving test-taking strategies to do well in tests by focusing only on test scores [15]. Although the clinical practice period at medical schools for third and fourth-year students provides opportunities to directly face actual clinical situations, mostly traditional lectures are provided in other learning periods. In order to prepare for situated learning, it is necessary to organize and provide a learning environment where students who go through the premedical period, basic medicine, and clinical medicine period can learn not only content knowledge but also situational and strategic knowledge in an integrated manner [16].

One of the recent major concerns for effective learning is what kind of learning environment should be organized to satisfy students' desire for intellectual inquiry. Another concern is whether it can enhance the problem-solving ability to recognize, investigate, analyze, and explore problems from a new perspective and develop the thinking ability to accept and integrate other disciplines beyond the framework of knowledge delivery as a traditional teaching method [8]. The World Economic Forum [17] presented

15 personal skills that will be important in 2025, including analytical thinking and innovation, active learning and learning strategy, complex problem-solving, critical thinking and analysis, creativity, and originality and initiative. The abilities to recognize problems and analyze situations are vital for medical students, and innovative thinking from these abilities is also needed. The abilities to creatively restructure the acquired knowledge through active learning and solve problems critically are important as well. Memorizing fragmentary knowledge or information itself is becoming meaningless, and a digital learning system has been established in which necessary knowledge and information can be searched for and obtained anytime and anywhere through the Internet or multimedia materials. In addition, as the development of knowledge accelerates, memorizing all knowledge and information is impossible, therefore the importance of using knowledge is being emphasized more than the importance of acquiring knowledge. Moreover, the ability to establish relationships in different communities through cooperation with others, including the ability to communicate with each other, is also being emphasized, which has a significant impact on the development of communication skills of medical students, which is considered important recently.

Based on the theoretical backgrounds, including constructivism and situated learning theory, mentioned above, the basic principles of learning environment design are as follows [8]. First, a learner-centered learning environment is essential. Learning is a process of constructing meaning through individual experiences, and it is important that the environment in which a learner as the subject of learning is the center. Meaningful learning is available when the learner actively participates in the learning process and constructs meaning from learning, rather than the knowledge imparted unilaterally by the instructor. Therefore, it is necessary to design a learning environment in which learning can occur, and learners should be able to engage in learning activities by themselves through active participation and evaluation. In addition, it should emphasize a learning environment in which various perspectives can be developed by providing complex and dynamic situations and problems.

Second, it is necessary to construct a learning environment that includes real-world contexts and tasks. Rather than delivering only objective and factual information

separated from the context, the context and process in which knowledge can be used should be emphasized, and this context and process should reflect the complex and ill-structured real-world situation. Unlike traditional classes, difficulties of knowledge transfer can be solved through contextual learning, such as case-based learning or problem-based learning, because the tasks to be performed by learners should also be authentic.

Third, creating a learning environment based on problem-solving is needed. By restructuring how thoughts and information in the knowledge domain are integrated and interrelated [18] and by providing problems through learning that knowledge can be directly or indirectly applied to, understanding of situations, ability to recall information, metacognitive sensing ability for processes of problem-solving, and thinking ability can be promoted [10]. In addition, it can induce learning motivation and provide learning experiences through the process of solving problems by identifying problems and acquiring related knowledge. Through problem-based learning or project-based learning, learning experiences including knowledge application and various decision-making processes can be provided.

Fourth, a different teacher's role is required. Instead of being a knowledge provider that delivers existing simple knowledge, professors should play the role of a tutor or facilitator who can create an environment in which learners construct meaning and help its process of the learning environment. This specific role can motivate learners and induce them to reflect on various perspectives through appropriate questions. And professors can play a role in helping learners solve problems on their own through immediate and continuous feedback. However, unlike the traditional method, this requires a lot of time and effort on the part of the professors, and it is necessary to participate in learning by considering the appropriate level of intervention. For this role, various support and compensation for professors are required, and also understanding of school administration is necessary.

Fifth, creating a learning environment that emphasizes cooperative learning is important. Since students' social interaction has an important influence on learning, it is necessary to construct an environment where learners can learn through peer-to-peer networking, such as group activities or project-based learning. When ideas are shared

and discussed within a learning community, various perspectives are encountered, and sometimes contradictions and inconsistencies are experienced and learned [19]. In addition, through interactions within the community, reflective thinking to look back on oneself is possible, and alternative perspectives compared to one's own point of view are analyzed and reviewed. This can help individuals' cognitive development and learning process, and it can also help learners improve their abilities.

Sixth, the concept and principle of evaluation should be changed. The role of assessment in the traditional view is focused on judging individual abilities and achievements, but the student assessment in the new learning environment should be done from time to time in the course of learning. The focus should be on the ability of the learner to recognize a problem in order to solve it, to transfer to a new situation based on the acquired knowledge and information, and to evaluate the ability to solve the problem. In other words, the focus of the new assessment should move from checking the acquisition of knowledge to confirming problem-solving ability.

Paradigm shift: from educating to learning

Teaching-learning paradigm in recent years is changing from educating to learning, from instructor-led classes to learner-led classes. Traditional lecture-oriented classes are shifting to inquiry-oriented and problem-solving classes, and collaborative learning and participatory learning through project-based learning or problem-based learning are more important than individual learning conducted by each student separately [8]. This paradigm shift is a simple message to every educator, however, the current learning in classes may be still traditional, teacher-centered.

Learner-centered paradigm includes several important goals for effective learning. First, it is important to clearly set competencies for students' performances and educational goals and to achieve them. Frank et al. [20] addressed that focusing on learning outcomes to be achieved, emphasizing abilities to be acquired, de-emphasizing time-based training, and promoting greater learner-centeredness to increase learners' participation are four rationales for competency-based medical education. Students should think in an integrated manner so that they can achieve outcomes

rather than just memorizing fragmentary knowledge, and medical school should help them acquire abilities according to the learning pace of each individual by providing clear learning goals to students in advance. This has benefits for cooperative learning among students and inducing intrinsic learning motivation, and this can be linked to personalized learning, which is ultimately pursued in competency-based learning.

In evaluation, a norm-referenced assessment that indicates relative rank or position based on the learner's evaluation results should be limited, and a criterion-referenced assessment that evaluates the performance level in specific knowledge or competence by indicating the score of the learner in consideration of the criterion, which is a pre-established mastery level, should be aimed. Focusing more on what individual learners know and don't know becomes a major concern to provide an opportunity for all learners to reach the given learning goal by proceeding with the evaluation with more emphasis on the reliability and validity of the evaluation. It is also possible to consider switching to absolute evaluation which evaluates the performance level of the learner, rather than evaluation information on relative positions.

Constructive feedback for students is also required in the learner-centered paradigm [21]. By providing immediate (just-in-time) feedback on the students' learning performance, it can serve as a reinforcement for task performance. Through the feedback, it is possible to determine whether students themselves have achieved their goals, enabling reflective thinking to look back on areas in need of improvement. Utilizing formative assessment can also be a good example of a learner-centered classroom. It is necessary to check the learning gap between students, which has widened due to online classes, and to conduct formative assessments and provide feedback to improve individual learners' learning by focusing on the learning process of learners. Through formative assessment, students can find out information such as what they are lacking in and what they have not achieved in consideration of their learning goals, and by checking and reflecting on whether they have achieved their learning goals on their own, it is a new element of reinforcement in future learning. This can also be an opportunity to motivate learning. Moreover, formative evaluation provides an opportunity for professors to improve learning progress and teaching methods through

reflection. By pointing out the contents that students misunderstand, it is possible to immediately check the level of achievement at a certain point in time and apply it to the instructor's teaching-learning method.

As mentioned above, this requires more time and effort from professors than traditional lecture-based classes. Learning in a learner-centered paradigm requires not efficiency of teaching and learning but effectiveness of them. It may expect professors' ownership and service-oriented leadership to lead their students to better learning. Therefore, the paradigm shift in learning should be applied as an important concept to construct all learning environments including online classes, and in particular, the online learning environment should be configured in a way that avoids online classes as a simple digital conversion of traditional face-to-face lectures as much as possible.

Enormous possibilities of EdTech taught from experiences with COVID-19

While face-to-face classes at educational institutions were reduced, almost 100% of non-face-to-face classes were implemented through the pandemic. As such, online learning activities caused by COVID-19 were another new normal in our society [2]. After online learning was settled by professors and students, other types of online learning activities were also introduced and implemented. Hybrid or blended learning refers to classes in which face-to-face classes, online discussions, and online lectures are operated in a mixed form using flipped learning or a learning management system [22]. A model that an instructor conducts classes with students participating in face-to-face classes in the classroom and transmits the classroom activities in an online environment for other students in real-time to provide a higher quality online class experience is called a HyFlex learning [14,23]. Beatty [23] introduced four characteristics of HyFlex classes: learner choice, equivalence, reusability, and accessibility, and through this, better learning outcomes can be achieved and flexible academic management can be coped with.

Recently, it has become possible to utilize various technologies that are rapidly developing to provide effective learning and to build a learning environment, called ubiquitous learning or U-learning, that allows learners and instructors to participate in classes anytime and anywhere

[24]. Medical schools are also utilizing various interactive learning tools that can help learners to focus on learning and expand mutual communication, along with support for online classes, to overcome this pandemic situation [25]. It also has been used to guarantee students' right to class and to improve effectiveness in learning. To minimize learning gaps in current pandemic situations, online classes using multimedia materials such as e-anatomy were also utilized for anatomy practices, case analyses, attending online conferences, and journal clubs online for clinical practice were employed. The important thing in configuring an online learning environment is not simply to transfer a lecture type of method from face-to-face classes to online but to enable effective learning to occur through online classes by utilizing various learning methods with theoretical backgrounds and technical methods that can be implemented online.

Despite the importance of EdTech, some medical schools have provided traditional lectures through pre-recorded classes without deep consideration of learning effectiveness in this COVID-19 situation. With current limitations, there are not that many ways that can apply various learning methods based on theoretical backgrounds. Since there is still a lack of research on the effectiveness of online classes, it is also necessary to utilize various methods and evaluate them.

Conclusions: design guidelines for HyFlex learning environment

In order to effectively provide essential learning to students, certain design guidelines are needed to implement active learning to provide opportunities for students to explore and apply knowledge on their own, away from passive learning of a simple knowledge transfer. Seven design guidelines based on the basic principles from the theoretical and practical backgrounds of the HyFlex learning environment are suggested in this section. Each design guideline is strategically matched with the basic principles and provided with the initial of the principles: learner-centeredness (L), real-world tasks and contexts (A), problem-solving (P), new roles of professors as facilitator or tutor (F), collaboration (C), and new perspectives of evaluation and assessment (E).

First, a real-time system is required for online learning (L,

C). Asynchronous learning, such as providing lecture videos to students, has been utilized for traditional e-learning systems. In the case of asynchronous learning, the focus is on learning for knowledge transfer and understanding. It will be passive learning centered on the instructor, and it is difficult to expect the effectiveness of learning through interaction between professors and students. In addition, in the case of classes using pre-recorded content, it is difficult to find a qualitatively better part compared to professionally filmed video content or education-related broadcasting, which is the expectation is too high of the current generation who has grown up with technology and video media since childhood. Even from the student's point of view, students have to take several classes online at the same time, therefore the concentration on the class may decrease differently from face-to-face lectures. For example, in the case of some students, they made lecture notes close to transcription through repeated playback several times and shared them with other students [3]. It was also found that parents or others instead of students participated in the class to help students or do assignments for them. Therefore, it is necessary to convey the image of teachers and learners creating a learning environment through interaction with students in the same way as the face-to-face class conducted in the classroom. Real-time classes should be also prioritized to ensure students' right to learn. In addition, it is necessary to prepare for a negative impact on the entire class if there is a technical problem. It is also necessary to actively operate small group activities because it is difficult to grasp the level of class participation at a glance when online learning is targeting all students. However, in the case of medical schools, there is a need to consider asynchronous learning due to the fact that the amount of knowledge medical students have to learn in the basic and clinical medicine periods is relatively heavy, and most of the classes are based on knowledge transfer. Asynchronous learning has some advantages of being able to search for knowledge from textbooks or the Internet after a pause in class [3], or to understand the contents of the class better through the opportunity to listen to the lecture repeatedly as needed on a self-directed basis.

Second, HyFlex learning can be an alternative method for online learning (L, C). In the case of some teaching methods, such as activity-based classes or clinical practice classes, excluding lectures, there are limitations in

conducting all classes online. For student assessment or evaluation, a face-to-face examination is more appropriate because taking the test online can cause fairness issues [25]. In addition, all students should be given the same opportunity for fairness of assessment, and learning outcomes should not be different due to additional information or data. In the case of an online assessment, it is impossible to prevent an environment in which students can gather together to solve problems, search for data, or directly check the contents of textbooks. It is necessary to conduct the assessment in small groups or prepare for a problem-solving type of test in which the content knowledge itself does not affect the result. Therefore, face-to-face classes or meetings can be added to achieve the learning outcomes of online classes, and the basic instructional model can be modified to choose both face-to-face and asynchronous instruction at the same time, providing equal opportunities to both professors and students. For example, online classes can be provided for all students, then small group meetings can be divided into breakout sessions through face-to-face meetings after the classes. Another example is that during lecture-style classes, 50% of students can participate in face-to-face classes, and the remaining 50% of students can participate in real-time online classes.

Third, Small group learning activities should be emphasized (L, C). In the case of general classroom classes, students must adjust their progress to the structured curriculum, and their learning proceeds according to the schedule without considering individual abilities and circumstances. Because the lecture method is mainly used to promote knowledge or information acquisition, many students lose their interest in learning or experience "learned helplessness" that is normalized to monotonous [26]. To this end, it is necessary to restructure learning activities that allow students to construct and develop knowledge by themselves, and to help them interact with the learning environment and construct meaning on their own. It is also necessary to change the composition of the online class environment so that learners who passively accept knowledge become learners who actively accept knowledge, learners who use acquired knowledge as creative producers, and learners who learn through cooperative thinking. In addition, some problems, including communication breakdowns with students, lack of student response, and difficulty in providing feedback, which is common in large-scale lectures, are dis-

advantages that can appear more easily in online classes. Therefore, the learning environment should be structured so that students can increase interaction between students, share and adjust various perspectives, experience contradictions and inconsistencies of multiple opinions, and experience reflective thinking that can be seen from the perspective of others through small group activities during online classes.

Fourth, authentic learning experiences should be embedded in learning environments (A, P, C). The knowledge provided by schools is abstracted, decontextualized, and highly structured, separate from the context or situations in which the knowledge is used [27,28]. Because of this, incomplete knowledge or immature knowledge that does not support complete understanding is transmitted to students, and they experience inert knowledge that is not applicable to solving real-world problems. Therefore, it is necessary to provide authentic learning experiences that require problem-solving logic similar to real-world problem-solving, have real-world complexity, and have problem types that can be faced in real life. Learning that can be easily transferred to real-world situations should occur with problem-oriented characteristics that require problem-solving rather than learning through simple knowledge acquisition so that teaching and learning methods, including problem-based learning, project-based learning, or case-based learning can be utilized. Through ill-structured authentic experience, students can indirectly learn to solve real-world problems, grow cognitively, reinterpret and transform their point of view, and make efforts to have a shared meaning.

Fifth, interactive learning tools can be utilized for better learning (L, F, E). It is necessary to actively utilize online interactive learning tools to expand communication and interaction between professors and students. For better classes, creating appropriate interactions between teachers and learners is essential. In particular, due to the nature of medical schools, communication between professors and students is more important because the relationship starts with the professor and continues as a senior doctor or fellow medical staff after graduation [3]. By using online interactive tools, such as Mentimeter, Kahoot, Socrative, and Padlet, which enable real-time student participation during classes, quizzes, opinion listening, and formative evaluation can be provided [25,29]. Because these tools

mainly use mobile devices, they can also bring a better class atmosphere and increase students' learning motivation.

Sixth, utilizing a learning management system is required (L, F, C). It improves learners' self-directed learning ability and provides class-related information and materials, feedback on assignments, the interaction between students, formative assessment, case-based learning, project-based learning, and student opinion exchanges through bulletin boards or forums to enhance two-way communication. In particular, in the case of medical schools, team teaching is being conducted in most of the courses, and since many instructors are in charge of different classes, it is difficult to provide a big picture of the entire learning courses to students. Because students are requesting a roadmap or systematic composition for the entire course, a large direction for the entire course should be presented through a learning management system to solve this problem. In addition, text-oriented communication is possible without exposing individual student's opinions during class, and it is possible to easily share multimedia learning materials or other materials by creating another online virtual classroom. For example, when cases need to be presented step-by-step, the individual problem-solving process or group problem-solving process corresponding to each stage can be recorded through a learning management system, and all information can be exchanged and viewed later again. Through the use of this learning management system, HyFlex learning, including real-time online classes, students' opinions and information exchanges, and learning assignments, can be conducted. For this system to be available, administrative support is also essential. In terms of administrative and technical issues, it is not easy for individual instructors to manage the system.

Seventh, qualitative improvement of multimedia learning materials is required (L, A, F). Current medical students are generation Z, who have been exposed to the digital environment and are familiar with the Internet and information communication, and are more accustomed to learning through visualized or imaged content than acquiring information through text. It is important to develop authentic learning materials to draw educational interest from students who are accustomed to well-organized online lectures or high-quality videos. It is also necessary to provide opportunities to develop and share multimedia learning

materials through learning assignments or project-based learning to students who are not afraid to actively share their interests and produce content. To this end, it is necessary to support multimedia equipment to develop learning materials or provide faculty development workshops, and discuss on which each college of medicine shares developed materials.

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