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Online Education Improvement Using Environment-Based Design Approach

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Abstract

Online education is currently widely used to replace traditional face-face teaching and learning activities due to the recent COVID-19 epidemic. However, critical challenges exist in online education practice, such as the difficulty of teachers to learn about students' status. Aiming at identifying the key conflict and conceptual design of a solution to improve online learning and teaching. This paper analyzes and tackles these barriers in online education using the Environment-Based Design (EBD) approach. A process consisting of environment analysis, conflict identification, and solution generation is applied to generate the solution for online educa-tion improvement. This novel solution suggests monitoring students' whole bodies and facial expressions, which can be referred to by teachers for the adjustment of teaching contents. Experimental validation in the education of high school students is given to show the effectiveness of the proposed solution. The satisfaction rate is increased by around 20%.

Keywords: online education, conceptual design, environment-based design

1. Introduction

Due to the recent COVID-19 epidemic, online education has been widely adopted to replace traditional face-face teaching and learning activities (Jena 2020; Dhawan 2020). The emergence of information or communication technologies and the booming development of digital devices have facilitated online teaching and learning (Miftachul et al. 2018; Alfatmi et al. 2018), getting more students involved, including those with special needs (Haynes 2018). Real-time communication software (e.g., Zoom, QQ, Classin, etc.) is used for such online activities. However, since the software is not initially designed for online education, several drawbacks are found during the daily experience. The teacher often worries that the teaching quality cannot be guaranteed, while the students complain about the terrible learning experience.

However, Chang et al. (2018) stated that the website administrators should offer professional development resources to teachers and communicate with students about the learning expectations. Fang et al. (2018) pointed out that the quality of online learning is lower compared to face-to-face learning. They suggested that the improvement of students' external and internal learning conditions can enhance students' engagement and summarized vital influencing factors. Ni et al. (2020) identified the factors on online education, they conducted a survey on what would most improve online teaching experiences for MPA students. How to provide more communication is one of the key factors on effective online education. Gao (2020) analyzed and discussed the development of K12 online education in China. This study focused on the status, profit model and development problems. However, few researchers have proposed a concrete solution based on available software to improve the online learning experience. There is a design method called environment-based design, which includes three activities: environment analysis, conflict identification, and solution generation. EBD can help the designers better understand the requirements of customers, the structure of the organization, the process of the business models, and the inherent critical conflicts. Therefore, EBD can be a practical design methodology, which can be referred to when designing the online education system.

This paper uses the Environment Based Design (EBD) methodology (Zeng 2004, Zeng 2011, Sun et al.

2011) to investigate online education – analyze the environment of online learning, identify the significant conflicts for both teacher and student, and eventually propose the solution to improve the online learning.

2. Environment-based design approach

2.1 Overview

Zeng et al. (Zeng 2004) presented the environment-based design methodology, a step-by-step approach for understanding and performing the conceptual design process. The basic idea of EBD (Zeng 2011, Sun et al. 2011) is that a design problem is implied in a product system and is composed of three parts: the environment in which the designed product is expected to work, the requirements on product structure, and the requirements on the performance of the designed product. The start of a design process is the analysis of the environment. The design and product environment include three major environments: natural, built, and human environments. A product operates in the environment and influences and changes the environment.

The requirements on product structure and performance are related to the product environment. The EBD includes three main activities: environment analysis, conflict identification, and solution generation. These three activities work together progressively and simultaneously to generate and refine the design specifications and design solutions, as shown in Figure 1.

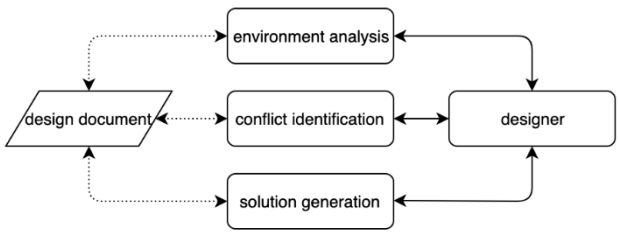


Fig. 1. Process flow of EBD.

2.2 Environment analysis

The objective of environment analysis is to identify the environment in which the desired product is to work. According to the EBD, the environment includes its components and the relationships between those components. One of the key methods for environment analysis is using the Recursive Object Model (ROM) (Zeng 2008). As explained in detail by Zeng (2008), the ROM includes two types of objects, i.e., object and compound object, and three kinds of relations between any two objects, i.e., connection, constraint, and predicate.

According to environment analysis, it is clear that the purpose of online education improvement is "to design a solution that improves current teaching quality and promote student's learning experience". Based on EBD analysis, the corresponding ROM and its description are shown in Figure 2 and Table 1, respectively. Based on the ROM diagram, questions can be asked to clarify every object in the ROM diagram.

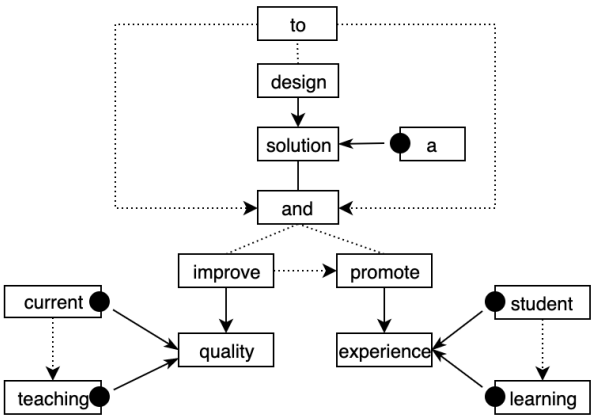


Fig. 2. Recursive object model (ROM).

Table 1 Elements in the ROM diagram

Graphic representation	Description
	object
	Constraint relation
	Connection
	Predicate relation

Apparently, "quality", and "experience" are the most constrained objects, thus constructing the key environment components. A few questions (Wang and Zeng, 2009) are generated to clarify these objects. A survey was conducted to an online English learning company with 10 classes (8 TOFEL, 2SAT), 10 teachers, and 58 students. Questions are listed as follows.

"Quality" questions are asked to the teacher,

(1) What is the definition of good teaching quality?

(2) What is the difference between classroom-based and online in terms of teaching quality?

(3) What is your expectation of online teaching quality?

(4) What are the factors impacting online teaching quality in priority sequence?

"Experience" questions are asked to the student,

(1) What is the definition of a good learning experience?

(2) What is the difference between classroom-based and online in terms of learning experiences?

(3) What is your expectation of the online learning experience?

(4) What are the factors impacting the online learning experience in priority sequence?

After finishing the environment component questions, relation objects "improve' and "promote" questions are generated,

(1) What is your proposal on improving online teaching quality/ learning experience?

(2) What are the functions you mostly wanted basing on current communication tools?

Naturally, both teachers and students will refer to the traditional classroom-based experience to share their ideas. The following are the analytics from the answers of the teachers and students.

Currently, a typical online education environment would be a meeting room opened via communication software, which the teacher hosts. The speaker is mainly a teacher, while all students listen and watch the materials (doc/slides) shared by the teacher. Both students and teachers use one display screen to share (from teachers) or view (from students). A typical environment of online education is illustrated in Figure 3.

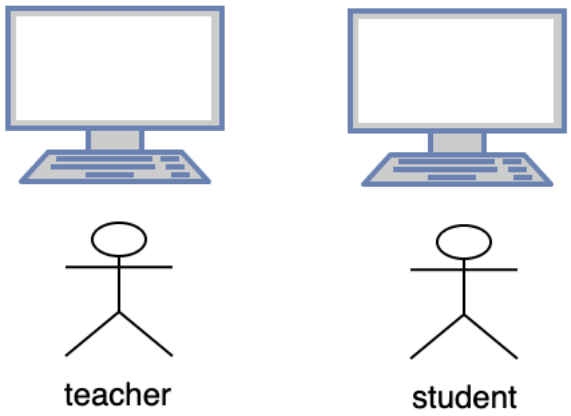


Fig. 3. A typical environment of online education.

The communication software is designed for video talk between two people, and therefore on the display screen, one can see another one's face clearly. Also, each party can get feedback from another quickly and easily. However, considering the online education environment, one teacher could face 20-30 students (or even more). The teacher will generally mute everyone to avoid noise so that students' voices cannot be heard during the course.

Interviewing several teachers and students helped us identified the following major problems within the current online teaching system.

(1) Lack of monitoring.
(2) Harm for eyes.
(3) Not enough interaction.
(4) No immediate feedback.
(5) Teachers being poor at computer skills.

For the five problems, we identify the two major issues that impact the "quality" and "experience" of online education are "monitoring" and "interaction."

- ***Monitoring***

Monitoring is mainly from the teacher's viewpoint. A teacher wants to see every student's behavior, which is extremely important as he/she can adjust the language speed and facial expression to call students attention, or ask someone to answer the question based on the observation of students' body language, facial expression, etc. Also, when doing an online quiz or test, monitoring is essential to guarantee the effectiveness and fairness of measuring a student's capability. Hence, monitoring is one of the critical components of online education. In this study, the generation of a better monitoring function will be paid sufficient attention.

- ***Interaction***

As shown in Figure 5, interaction is from both teacher and student's viewpoints. The teacher likes to get feedback from students, and the students want to call the teacher's attention if they have any questions. This is not an issue in a real classroom, and every student can raise a hand and get a chance to speak out when needed. However, this is difficult in the online environment as the teacher will generally mute every student to avoid noise. The students can only get a chance to speak by using the "raise hand" function provided by the communication software. Following signs illustrated the Zoom and Tencent meeting function, the teacher can easily ignore such a small button when talking/presenting some materials.

(a) "Raise hand" in Zoom/Tencent

(b) "Raise hand" in Tencent Meeting

Fig. 5. "Raise hand" in a different online meeting room

Some students also propose "anonymous" feedback as they may not want the teacher to know who raises such questions. This is a significant advantage over traditional classroom-based teaching as the communication software can easily hide the name of the feedback provider, and it somehow encourages the student to raise questions.

It should be noted that even for the onsite education scenario, when a teacher asks whether his students have any questions, few will raise their hand and ask a question. Due to many students are too shy to ask questions. Therefore, the function of "anonymous" feedback can assist the interaction between teachers and students.

We continue the process of asking the questions, collecting the answers, and then updating the environment components until we figure out all the relevant components to the design problem. Comparing with Figure 2, a detailed and updated ROM is shown in Figure 6. As shown in Figure 6, solutions are also generated to enhance monitoring and integration during online education. Essentially, the formulation of a better communication mechanism is the key both to online and onsite education.

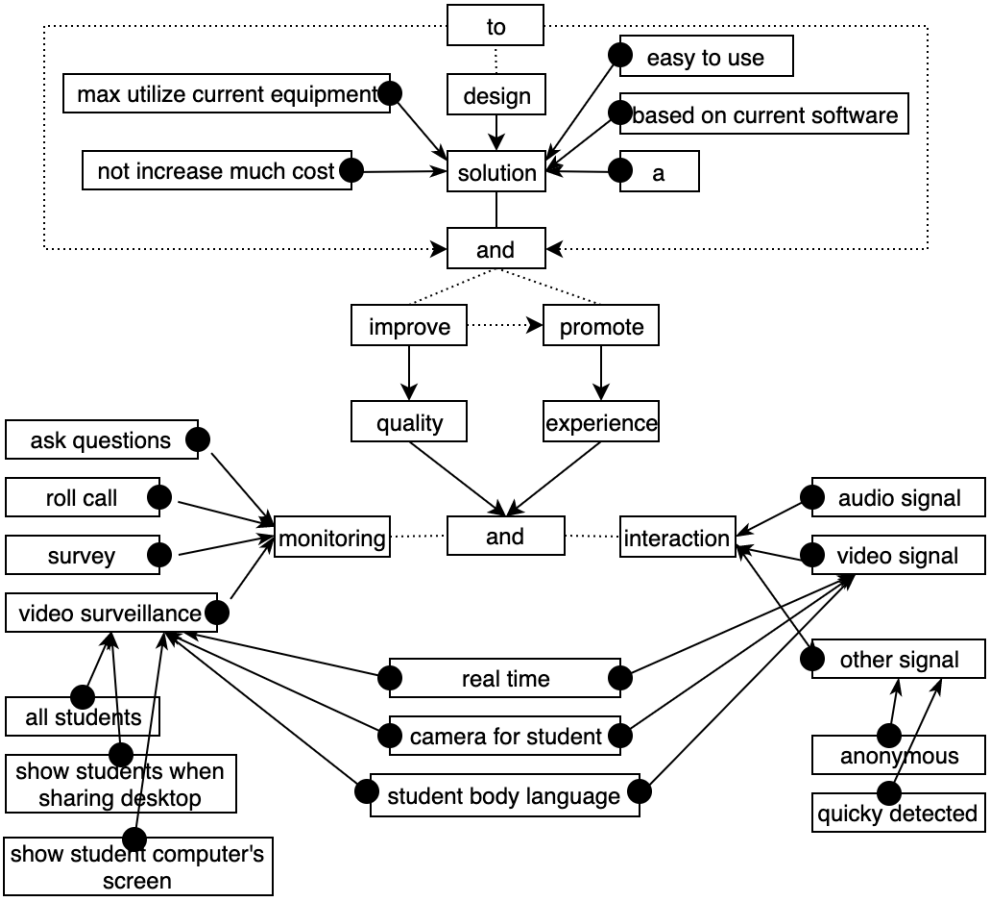


Fig. 6. Updated ROM

3. Conflict identification

According to EBD methodology, conflict refers to the insufficient resources required for an object to produce the required actions in its environment or to accommodate the actions of an object in its environment. There are three kinds of conflicts, i.e., active conflict, passive conflict, and key conflict. The active conflict refers to the shortage of resources to generate a response from the object. A passive conflict will occur when resources are insufficient to accommodate an object or its response. Among all conflicts, the key conflict is the conflict that has the most substantial impact on other conflicts. As shown in Figure 7, A, B1, B2, R1 and R2 represent different objects, C represents possible

conflicts, A represents the original objects, B1 and B2, and R1 and R2 are parallel.

Based on the environment analysis and the updated ROM (see Figure 6) as mentioned above, and following the rules introduced by Yan and Zeng (2011), and Tan et al. (2012), we can identify five key conflicts as shown in Table 1.

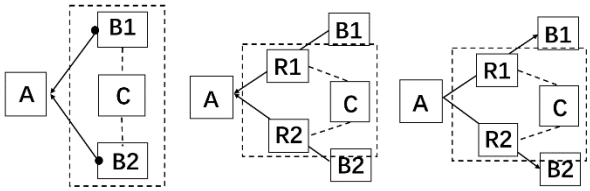


Fig. 7. Three possible conflicts in ROM (adapted from Tan et al. 2012)

Conflict 1: Current communication software cannot show the student's video when the teacher's desktop is sharing.

Conflict 2: Current communication software cannot video a student's body due to the camera's position. The camera typically sits on top of the laptop. When students look at the laptop's screen, the camera can only take the students' faces. As described above, the face is not good enough for the teacher's monitoring.

Conflict 3: The video monitoring wants to take all the students on one screen, which may introduce two issues:

(1) The network bandwidth for the teacher is limited; therefore, it is hard to get real-time video monitoring while keeping all students on the screen. Assume there are 50 students in an online course, and the video stream will typically take no less than 256kbps, which in sum is 50*256k = 12.8Mbps

(2) The display screen of the teacher is not big enough to hold all the students.

Conflict 4: As stated before, current communication software cannot support "anonymous" feedback from the student, like "I cannot understand this section," "the teacher talks too fast," "can the teacher repeat the problem A's solution?" etc. The student may be reluctant to share his/her name among the class. The "anonymous" mechanism help resolve this situation. Also, it requires such timely feedback and is shown on the teacher's screen to respond to improve learning experiences quickly.

Conflict 5: Current communication software cannot monitor the student computer's screen. This is important as the student may watch movies or other entertainment videos during the class. At the same time, the standard monitoring mechanism can only show how concentrated the student is focusing on the screen but cannot tell what content the student is focusing on. Also, when doing a quiz or test, student screen monitoring is essential as the student may refer to other materials to find out the answers. The screen monitoring mechanism can prevent such cheating.

Table 1. Identified conflicts

Number of conflicts	Illustration of conflicts
Conflict 1	show students when sharing desktop → video surveillance ← based on current software
Conflict 2	camera for student, student body language → video surveillance ← based on current software
Conflict 3	real time → video surveillance ← all students
Conflict 4	quickly detected, anonymous → other signal ← based on current software
Conflict 5	show student computer's screen → video surveillance ← based on current software

4. Solution generation

The environment-based design approach provides a rule for solution generation. Based on the EBD approach, the order of conflict to be solved is Natural conflict > Artificial conflict > human factor conflict. For solving the conflicts listed in Table 1, the conceptual design process is carried out in sequence according to the EBD approach.

4.1 Solution to conflicts 1&2

It is challenging to ask current communication software to support the second screen (conflict 1) or change the video camera's physical position (conflict 2). Therefore, this section proposes a method using two accounts to resolve conflicts 1 and 2. Each teacher and student have two accounts – a "monitor" account and an "education" account; a "monitor" account is used to set up the video monitoring system, "education" account is for regular online education.

As shown in Figure 8, the teacher has two screens in front of her, one to construct the virtual classroom using the "monitor" account, which shows the students' body behaviors. Another one is for sharing the desktop or materials/slides using an "education" account.

Similarly, the student will have two accounts to log in to, and the "monitor" account is typically using a cell phone. The cell phone's camera will take videos of students – the face and the body. These figures will automatically fit in the virtual classroom in front of the teacher. "Education" account is used on laptops for online education.

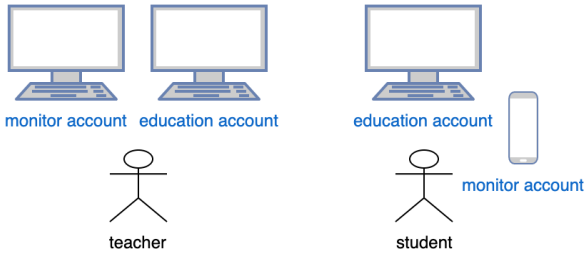


Fig. 8. A new environment for online education

4.2 Solution to conflicts 3

To resolve conflict 3, we propose a method like "filming" in the monitor area1 (see Figure 9), the virtual classroom will only show at most nine students figures at one time, lasting 2-5 seconds, then moving to the following nine students, and the next … The "filming" rotates between all the students. This effectively resolves the bandwidth limitations (only nine videos need to be transmitted at one time, approximately 9*256Kbps=2.3Mbps) and the video size issue (only nine videos need to be shown on one screen).

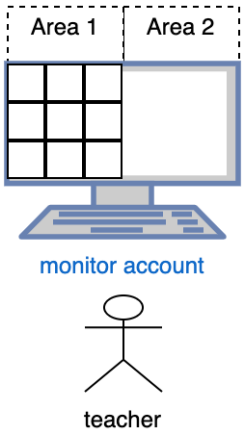


Fig. 9 "Filming" in monitor area 1.

4.3 Solution to conflict 4

On the teacher's monitor screen, we leave one area (area2 in Figure 9) for quickly catching the teacher's timely status. During the class, the message will prompt as,

Alarm: student A raises the question, "can you please repeat the process?"

Alarm: Anonymous, "speak too fast."

Alarm: student B raises his/her hand.

A student's education account will have the button "raise hand" like most communication software does today and have the option of anonymous feedback. An illustrative case was presented in Figure 10.

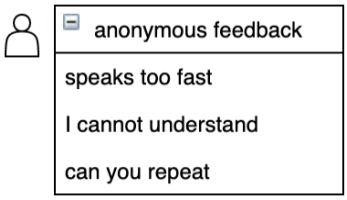


Fig. 10. Anonymous feedback

4.4 Solution to conflict 5

Apparently, current communication software does not show meeting participants' screens due to privacy reasons. While used for online education purposes, we propose the software to enable the option "monitor student's screen." These screen copies are not sent to the teacher, and they are sent to a backend analysis server instead. During the teaching activity, when the teacher

shares the materials/docs to the students, the analysis server will automatically compare the screen copies with the contents shared by the teacher and raised alarms to the teacher if finding some student's screen copy is not expected (using the monitoring area 2 in Figure 8). The teacher can then alarm the student on concentrating back on the class contents. Again, during the quiz or test, the analysis server will automatically compare the screen copies with the quiz contents; an alarm will be raised if finding students change the quiz contents to other pages (like searching the answers via Baidu/Google).

4.5 Solution validation and discussion

Since the solution to conflict 3/4/5 requires modification on current communication software, we have initialized the discussion with several video communication software providers, and the solution has not yet been validated. Therefore, we developed a solution to conflicts 1 & 2.

The solution to conflicts 1&2 – i.e., two accounts solution is tried on online education of one TOFEL/SAT training company. We select the online courses with less than 9 students as samples, and the satisfaction rate is shown.

Samples: 10 classes (8 TOFEL, 2 SAT), average 6 students/1 teachers per class. Totally 10 teachers, 58 students.

Communication Software: Zoom

Satisfaction survey on teachers: 3.5 (5 – very satisfied, 1 – not satisfied at all)

Satisfaction survey on students: 3 (5 – very satisfied, 1 – not satisfied at all)

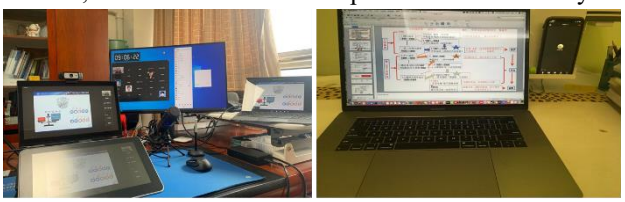
After we applied the two accounts solution, the satisfaction rate is increased by approx. 20% for the teacher, 10% increase for the student. This result is not surprising, as the two accounts solution is more helpful to the teacher than the students.

Satisfaction survey on teacher: 4.1 (5 – very satisfied, 1 – not satisfied at all)

Satisfaction survey on students: 3.4 (5 – very satisfied, 1 – not satisfied at all)

The possible solution to conflicts 1&2 has the potential to improve the satisfaction of online education. Both teachers' and students' environments are improved by using this solution. As shown in Figure 11a, for teacher's environment, two laptops are used as education account and monitor the account, respectively. For the education account, a handwriting board, a camera, and a microphone enhance the communication between teacher and students. For the education account, all the slides can be annotated by a teacher using a handwriting board. A teacher can use the monitor account to log in to the online education platform. On this hand, a teacher can observe the state of the education account (e.g., see the state of the slides and body language of a teacher), and on the other hand, can help a teacher to see the state of all the students via video and get to know what the students' real-time communication is and in time for user feed. As shown in Figure 11b, a student also has an education account to see the slides or other contents of a course. A monitor account is usually a cell phone. The cell phone's camera will take videos of students – the face and the body. These figures will automatically fit in the virtual classroom in front of the teacher.

Although solutions were developed to improve the satisfaction of online education, only conflicts 1&2 are solved. Because the solution to conflicts 1&2 depends less on software. However, some solutions depend on the development of new software functions, e.g., Zoom, Classin, which are out of the scope of the current study.



(a) Improved teacher's environment (b) Improved student's environment

Fig. 11. Solution for online education

5. Conclusion and outlook

This paper analyzes and tackles the barriers in online education using the Environment-Based Design (EBD) approach. Five key conflicts are identified by using the EBD approach, and the solution is generated to solving the five key conflicts. Surveys on both teachers and students revealed that the solution could promote the satisfaction of online education.

Our future work is to continue working with communication Software Companies to combine the two accounts into two roles of one account so that teachers and students do not need to log in using a different account and integrate the solution to conflict 3/4/5. Also, we will expand the trial to more audiences, recursively develop the system, and hopefully improve the experience of online education like traditional classroom-based.

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