

# Crisis Resilience Pedagogy (CRP) for Teaching and Learning

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**Abstract**—Schools and universities face unprecedented challenges in times of crisis. Traditional teaching and learning approaches become inadequate in knowledge transmission when face-to-face teaching is unavailable. In this paper, we explore the use of resilience pedagogy in times of crisis. First, we propose Crisis Resilience Pedagogy (CRP) by analyzing key attributes of resilience and how they can be incorporated into education. Second, we discuss how CRP can be widely adopted with reference to the diffusion theory of innovation. Third, we explore how CRP can be applied and incorporated as part of the education system. CRP brings flexibility to the current education system and ensures students learn effectively in times of crisis.

**Keywords**—COVID-19, crises, Crisis Resilience Pedagogy, education system, innovation, pedagogy, resilience, teaching and learning

## I. INTRODUCTION

Crises provide an opportunity for schools and universities to re-evaluate the current education system and for educators to be ready, resilient, and creative at all times to reinvent their methods of teaching. The recent global wave of coronavirus outbreak has forced educational institutions to shut down for months and switch from in-class face-to-face teaching to implement an online learning system in order to minimize the impact of crises [1]. This online implementation has helped schools and universities keep the learning activities going and allows teachers to continue maintaining interaction with students through education technology platforms.

In the surge of the COVID-19 pandemic, a high number of schools in the U.S. have moved their learning activities to online learning. However, many schools also still lack in resources and struggle to progress from offline instruction to distance learning. A survey conducted in May 2020 from Educator for Excellence (E4E) on 600 U.S. public school teachers shows only 24% of teachers stated that their students have access to a digital computer or a tablet to be used for remote learning and school-related work [2]. Apart from the instructors, administrators as part of the resilience learning key elements also need to adapt and contribute through an adequate support system in order to nurture the resilience approach for their local institutions.

In the past year, the Chinese University of Hong Kong (CUHK) has experienced two kinds of crises: the social unrest and the COVID-19 outbreak. Since then, the university teaching and learning team has been actively implementing the use of online learning and innovative pedagogies (e.g., blended, flipped, role-playing gamification, micro-modules, MOOCs, and hybrid learning or a combination of both face-

to-face and online class) as part of the university's strategies in managing the crisis [3]. Following the university-wide strategies, the engineering faculty also actively administers online learning and advocates our teachers to disseminate online and other relevant pedagogy in respective engineering courses.

This paper aims to examine resilience as a novel teaching approach in times of crisis, e.g., social unrest, pandemic outbreak, civil war, fire, natural disasters, etc., to illustrate the elements or key attributes that form resilience, and to discuss how resilience is useful to address various education-related crises that affect teaching and learning activities. Furthermore, from the implementation aspect, this paper also aims to explore how resilience can be applied by educators across different subjects and how it can be combined with other innovative learning pedagogies, e.g., online learning, role-playing, storytelling, and gamification in order to enhance teaching and learning.

Resilience learning can be achieved by combining multiple learning pedagogies together at the same time. Teaching and learning practice that integrates both offline and online (hybrid) approach in order to accommodate various circumstances and students' learning needs also can be supported through following activities, e.g., pre-recording lectures, developing micro-module videos for particular topics, audio podcast, virtual lab, and video conferencing to promote discussions with students remotely. For students, this combination approach also enables opportunities for them to learn in a more flexible way, to actively practice personalized independent-learning, and to learn from diverse and online resources available. We will discuss in the following sections how educators can apply resilience approaches while also accommodating other learning methods.

Developing a teaching and learning method that can be executed rapidly by teachers without concern of space availability, more adaptive and responsive, more creative and diverse, and more flexible and resilient toward crises could provide an ideal alternative for education institutions. We call this approach as crisis resilience pedagogy. Our team define Crisis Resilience Pedagogy (CRP) as a teaching and learning approach that enables teachers to act rapidly and to adapt creatively in navigating through any critical situations or emergency circumstances. The resilience approach also equips educators on how to respond effectively to provide for different students' learning needs particularly in times of crisis.

This paper is structured as follows. In Section II, we propose a model of resilience pedagogy based on the resilience attributes and stakeholders involved. In Section III, we outline the stages of diffusion of resilience learning for higher education using the diffusion of innovation framework as the methodology. In Section IV, we will discuss the learning outcomes from several engineering teachers who

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successfully implement resilience pedagogy in combination with other teaching pedagogy during campus closure. The final section of this paper will outline the summary of the resilience teaching approach along with the suggestions for future studies.

## II. CRISIS RESILIENCE PEDAGOGY

We propose CRP as the adoption of resilience in teaching and learning when crises come. This novel teaching and learning approach is a continuous progress approach to accommodate different types of crises. It enables teachers and students to adapt to changes effectively so that the impact of crises on teaching and learning can be minimized. It is a rejection of fixed and static pedagogy that cannot cope with changes brought by crises. If a school sticks with traditional classroom teaching and chooses to simply stop teaching and learning in times of crisis, the school is said to be using a fixed and static pedagogy. On the contrary, if a school uses teaching and learning approaches that can adapt to changes, then it is considered to be using CRP. To establish the CRP model, we first review some literature on resilience and pedagogy.

### A. Literature Review

1) *Resilience*: Resilience is usually linked with adaptations to unexpected changes. According to American Psychological Association (APA), resilience is the process of how we adapt to changes when we face adversity or other sources of stress, such as financial difficulties, family issues, and relationship problems [4]. Adaptability leads to transformation and improves performance [5]. This helps minimize the negative impact of crises.

To be resilient to unexpected changes, we need to formulate suitable solutions to problems. Creativity plays an important role here as it enables us to come up with new ideas in adversity [6]. It is also essential to utilize connectivity to cope with changes as it allows us to give a more flexible response by facilitating the sharing and exchange of information and resources [7]. Besides, the diversity of resources and methods can confer resilience in times of crisis [8]. When more resources and methods are available, it is more likely that suitable ways can be found in response to changes. Moreover, psychological endurance is also important in fostering resilience [9]. We need to possess the mental strength to continue and not to give up in adversity.

2) *Pedagogy*: Pedagogy is generally interpreted as a method of delivering teaching and learning activities. Various pedagogies propose different approaches to implementing teaching and learning activities. The objectivist learning model suggests the transfer of knowledge is best delivered directly by instructors through traditional lectures because knowledge is objective rather than subjective [10]. In this model, the instructor acts as an expert on the topics learned. On the other hand, the constructivist model emphasizes on building new knowledge on top of the preceding knowledge. Interaction between students and the reasoning process to solve problems is encouraged. Moreover, the instructor operates as the facilitator in the learning process [11]. While these models have significant implications on how to help students acquire knowledge, they may be inadequate in addressing challenges in times of crisis. Since the objectivist learning model mainly relies on direct



Fig. 1. Features of Crisis Resilience Pedagogy

instructions from teachers to students, the unavailability of physical space means that it is infeasible to solely adopt this model. The constructivist model is also challenged because student interaction is less effective when they cannot have face-to-face communications.

We recognize that even though traditional face to face lectures are still the most commonly used pedagogy in higher education, other innovative pedagogy such as resilience approach and online learning should be incorporated. The blended learning model, which refers to the integration of offline and online teaching, might be adopted to enhance resilience of the current educational system and sustain effective learning in adversity [12].

### B. Crisis Resilience Pedagogy Model

In proposing the CRP model, we consider the educational challenges brought by crises, objectives of the pedagogy, attributes of resilience as well as the stakeholders involved (shown in Fig. 1). In adversity, the main challenges we face are the physical barrier and the decrease in learning incentives. Disasters such as earthquake, flood, and pandemic often lead to campus closure, which means teachers and students are no longer physically connected. Moreover, students' learning incentives may also decrease because the traditional ways of learning are infeasible and they need to adapt to the new ones.

In view of these challenges, we aim to develop CRP that can achieve flexibility, sustainability, and recoverability. The pedagogy is flexible so that it can accommodate different situations during crises. It should also enable educators to sustain high teaching quality even when new delivery modes are implemented. Furthermore, it needs to restore and recover teaching and learning effectively both during crises and after the crises subside.

Based on the literature review in Part A, we identify five key attributes of resilience that can be applied to CRP to achieve the above objectives (shown in Table I).

- **Adaptability.** In times of crisis, traditional teaching and learning methods become infeasible. Therefore, new teaching and learning should be developed to adapt to changes efficiently and effectively. During COVID-19, on-campus classes of many schools were suspended to prevent the spread of the virus. Teachers started to use the video-conferencing app ZOOM to conduct online lessons. Students can continue to learn even classroom teaching is unavailable. The use of adaptive teaching methods impart flexibility to the educational system in facing crises.

TABLE I. KEY ELEMENTS IN CRISIS RESILIENCE PEDAGOGY

Element	Application in Resilience Pedagogy
<b>Adaptability</b>	Teaching and learning methods that adapt to changes quickly and effectively
<b>Creativity</b>	Creative teaching and learning methods that can address challenges
<b>Connectivity</b>	Sharing and exchange of educational tools and resources
<b>Diversity</b>	A wide variety of teaching and learning approaches
<b>Endurance</b>	Mental strength to continue teaching and learning

- **Creativity.** Changes brought by crises are usually unexpected. To cope with these changes, creative teaching and learning methods are required. With technological advancement, many educational tools such as Kahoot! and Google classroom are available. Teachers can come up with creative ways of teaching using these tools. The use of creativity pedagogies enhances flexibility in teaching and learning.
- **Connectivity.** Traditional educational tools and resources are inadequate to address the challenges brought by crises. Therefore, sharing and exchange of educational information and resources are beneficial for educators and students. MOOC platforms can facilitate the sharing of educational resources and enable students to get access to online educational materials from different universities. Students can continue to learn in times of crisis. Besides, administrators can establish an online resource center during crises to help teachers and students stay connected with each other. The connections among teachers and students enable teaching and learning to be sustained despite the physical barrier exacerbated by campus closure.
- **Diversity.** When a wide variety of teaching and learning approaches are available, educators can choose suitable approaches to address the challenges in crises. In normal circumstances, educators can conduct both classroom and online teaching. When crises come and classroom teaching is unavailable, they can continue their teaching with online videos and online discussion forums. The diversity of teaching approaches provides educators numerous choices to restore and recover teaching during crises.
- **Endurance.** While it is difficult to use traditional teaching and learning methods in times of crisis, educators should continue to devise suitable ways to continue teaching and learning. Besides, since crises often bring stress to people, it is important for teachers and students know how to manage stress so that teaching and learning can continue. The COVID-19 pandemic has brought unprecedented challenges to teaching and learning as students cannot attend school as normal. However, educators did not give up and continue to use a wide variety of tools such as ZOOM and online platforms to continue their teaching. The

TABLE II. ROLES OF STAKEHOLDERS IN CRISIS RESILIENCE PEDAGOGY

Element	Teachers	Students	Administrators
<b>Adaptability</b>	Devise new teaching methods to adapt to changes	Use new methods to continue to learn	Implement new policies to adapt to changes
<b>Creativity</b>	Use creative pedagogy to continue their teaching	Learn through creative ways	Use creativity to devise suitable policies to address challenges
<b>Connectivity</b>	(1) Connect with other teachers to share educational ideas and resources  (2) Connect with students to deliver teaching	(1) Connect with other students to share ideas and knowledge  (2) Connect with teachers to learn from them	Connect with teachers and students to understand their needs and devise suitable policies
<b>Diversity</b>	Deploy a wide variety of teaching approaches	Learn through different channels and resources	Use different policies to address challenges
<b>Endurance</b>	Possess the mental strength to continue teaching in adversity	Possess the mental strength to continue learning in adversity	(1) Help teachers and students stay healthy physically and mentally  (2) Encourage teachers and students to continue teaching and learning

endurance teachers and students possess allow them to sustain teaching and learning in adversity.

Resilience pedagogy involves the joint efforts of different stakeholders. It is important to consider the roles of different stakeholders in education for effective strategic planning [13]. To form a dynamic system that is flexible and responsive to changes, different stakeholders need to work together (shown in Table II). The role of different stakeholders in resilience pedagogy are listed as follows:

- **Teachers.** Traditional pedagogy is insufficient for content delivery in times of crisis. Teachers need to come up with suitable pedagogy that is responsive to changes. They can use creative teaching approaches to continue their teaching. For instance, many teachers use ZOOM to conduct online teaching during COVID-19. They can also share teaching resources and ideas through online platforms. With a wide variety of teaching methods such as online lectures and real-time response activities, the impact of crises on teaching and learning is minimized.



TABLE III. TRADITIONAL TEACHING APPROACH VS. CRISIS RESILIENCE PEDAGOGY

	Traditional Teaching Approach	Crisis Resilience Pedagogy
Location	Laboratory, Classroom	Anywhere
Time	Specific	Anytime
Delivery	Face-to-face teaching	Online
Interaction	Teacher-centered, face-to-face interactions	Student-centered, collaborative through eLearning tools
Assessment	In-class presentations, traditional examinations	Online presentations, online examinations
Learning Tools	Traditional books, journal	Online books, online journals, virtual laboratory
Learning Activities	Face-to-face in-class learning activities	Online learning activities

- **Students.** When teaching and learning methods change, students also need to adapt to new ways of learning. When the situation allows, they should continue to learn by familiarizing themselves with new learning tools. They can stay connected with teachers and other students through online platforms. For example, they can get access to a wide variety of learning resources on MOOC platforms. With these online platforms, students can continue to learn even when face-to-face teaching is unavailable.
- **Administrators.** For administrators, the first priority is to ensure the safety and health of teachers and students. They should devise suitable policies in response to crises. For instance, many institutions temporarily suspend face-to-face classes during COVID-19 to prevent the spread of the coronavirus. Administrators can also offer advice on how to improve one's mental health. They can introduce mindfulness techniques to teachers and students. This can help them stay healthy mentally and enhance learning efficiency. When the safety and health of staff and students are ensured, administrators can devise suitable educational policies. They can give directions about new teaching and learning methods to teachers. For example, our university announced that synchronous online classes and tutorials would be conducted during the spread of the coronavirus so that students' learning was unaffected. With suitable policies, students and teachers can stay connected and continue to learn in times of crisis.

### C. Significance of CRP in Times of Crisis

Traditional face-to-face teaching has been adopted globally by higher education since the early development of formal education centuries ago. However, in times of crisis, implementing traditional lectures on a daily basis can be very difficult for academic institutions. For example, in situations

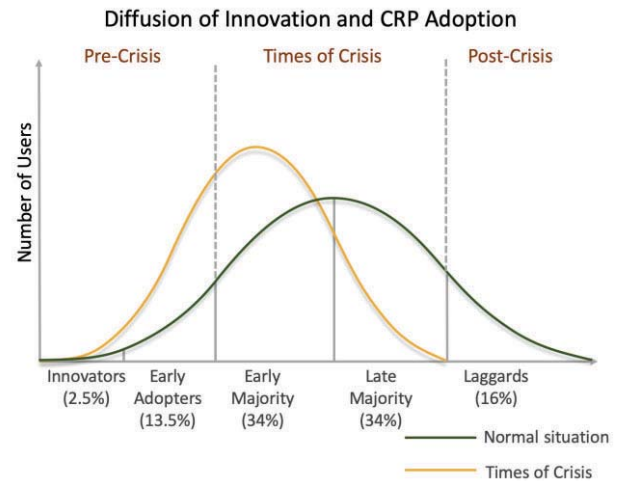


Fig. 2. Diffusion of Innovation Model for CRP Adoption

such as earthquakes, landslides, flooding, fires, etc. conducting lectures inside a laboratory or in an auditorium would be impractical for students due to health and safety issues, access to transportation, and the availability of physical space. A learning approach that can be applied without concern of space availability, more flexible time, and more resilience toward crises could provide an ideal alternative to overcome these traditional limitations. In times of crisis, an online learning approach that puts emphasis on the self-paced and personalized experience and combines together with educational technology presents an opportunity for educators to keep learning activities operating in any circumstances. The differences between traditional learning approach and CRP are summarized in Table III.

The coronavirus crisis is forcing education institutions to address urgent implementation challenges rapidly and leverage their systems in innovative ways. They need to quickly identify the most effective solutions for distance learning and implement those solutions at scale almost overnight. It is also important to consider how action can be applied as quickly as possible [14]. Massive open online course (MOOC) platforms and video-conferencing technology have enabled global educators an opportunity to deliver learning activities fully online that can be operated anywhere and anytime and the potential collaboration among institutions [15]. Besides, online learning environments can reduce the constraints of traditional teaching, improve students' overall personalized learning experience, and also enhance learning [16]. Therefore, many institutions continue their teaching with online learning. This is an example of developing resilience in teaching where online learning and technology integration could be offered as potential solutions in times of crisis.

## III. INCORPORATING RESILIENCE TEACHING AND LEARNING AS PART OF EDUCATION SYSTEM

### A. Resilience Approach in Diffusion of Innovation Context

In the social and economic context, the adoption of a new product, service, or system does not happen concurrently to every member of the social system. According to research, the group who adopts the alteration at the earlier stage indicate a different set of characteristics than the group who adopts the change in the later stage [17]. Therefore, it is necessary to understand the characteristics in each segment that will either support or hinder the adoption of an innovation.

Similarly, in an education setting, the adoption of a new learning system, educational technology platform, curriculum design, and teaching and learning methods is a process that requires communication, time and practice.

As shown in the Diffusion of Innovation (DOI) model in Fig. 2 [18], the segments of product or change or technology adoption are categories as follows:

- **Innovators.** Innovators are the first group of people in the society to use a newly launched product or adopt an innovation. For example, a small group of teachers who started to apply flipped-classroom in their classes before the department introduced or recommended the pedagogy is considered as the innovators.
- **Early adopters.** Teachers who wait a couple of days or weeks or terms and spend some time reading reviews, journals, and listening to other teachers (innovators group) who successfully implement online learning in their teaching before going to apply it themselves are regarded as early adopters.
- **Early majority.** Teachers who implement flipped-classroom after the pedagogy has been out for some time and received good reviews from education institutions are considered as the early majority group.
- **Late majority.** Educators who embrace online learning after observing that many colleagues in the department produce online materials for their students are regarded as the late majority.
- **Laggards.** Educators that belong to the laggards category are the last group to adopt the innovation in teaching and learning. They will adopt the change in educational technology, systems, or pedagogies when they are forced by faculty or department to apply it or they do not have any alternative to maintain teaching and learning (for example in natural disaster crisis, campus closure, etc.) without applying online learning for their class.

The DOI model examines the diversification of new products or technology by incorporating communication channels, time factors, and society or social structure that affect the advance of a new concept or opinion. For decades, DOI has been used both at personal and institutional or corporation levels. Furthermore, it also provides a framework to debate adoption of innovation at a local, national and regional level [18].

In times of crisis, the DOI model can be used to illustrate the process of how educational institutions can develop policy to promote resilience teaching and learning. This model also provides information to understand how other pedagogy such as online learning and flipped classroom can be widely adopted across departments and faculties. We argue that in order to encourage effective CRP, the adoption process shall be implemented on a scale and as immediately as possible (within days) by institutions and teachers.

We observed the example of DOI and CRP implementation from the educational technology adoption of video conferencing tools for online learning such as ZOOM among schools and universities. ZOOM has been around since 2011 and a number of companies have been using the technology to support the internal communication within various departments and offices. However, they were not

widely adopted in education before the COVID-19 crisis. The crisis has leveraged and pushed the immediate adoption of video conferencing technology (particularly in education) on a global scale.

Many CUHK teachers were caught off guard by the scale and the impact of the social unrest crisis in the first semester of 2019/2020, however, in the following semester the university has better prepared for the second crisis of the pandemic outbreak. Within a short period of time (less than 14 days) the university implemented ZOOM video conferencing system to support the campus wide migration from in-class teaching to online learning. The university also provided training for teachers how to utilize video conferencing technology effectively for teaching and learning. Moreover, a variety of resources including technical support to support teachers prepare for online teaching are also provided. This effective educational technology implementation has enabled the majority of our teachers to sustain teaching and learning activities during the whole period of campus closure. Reflecting on the DOI model, during this critical situation our teachers expeditiously become the early adopters, early majority and late majority group at once. This example illustrates the adoption of resilience learning approaches in times of crisis.

In addition, Fig. 2 shows that CRP requires teachers to be early majority and late majority for adoption in a scale and rapid implementation of resilience teaching and learning activities. The pace, scale, and changing situation of the crisis also will change the shape of the curve. The faster the adoption progress from innovators to the majority, the sharper the curve will be. CUHK's rapid implementation of ZOOM video conference technology and online learning confirm the earlier illustration.

#### B. Implication for Institutions and Education System

The advancement of digital technology in recent times and its use in many aspects of our day-to-day communication has allowed innovative learning pedagogies (such as online learning) integration with technology possible [19]. We have witnessed how the adoption of online learning in the recent pandemic crisis eventuate rapidly on a global scale. The concept of crisis resilience pedagogy introduced in this paper describes not as a static method but as a resilience-building process that continuously evolves through periods of time that involve various scenarios and critical circumstances. The first wave of the coronavirus crisis and the coming of another outbreak showed that it is time that we focus on promoting and disseminate resilience approaches as part of the local education or institutional learning ecosystem. Moreover, it is also crucial to understand that the appropriate way to address crises is to begin by working for change at personal (instructors) as well as local or institutional (schools and universities) level.

A wider scale adoption of resilience teaching and learning in higher education can be started from a small number of teachers as part of innovators and early adopters that practice the crisis resilience approach at the department or faculty level in the pre-crisis stage or before the crisis even began. The successful implementation from innovators and early adopters of crisis resilience will act as a catalyst to drive and inspire teachers from other departments or faculties (early and late majorities) to exercise resilience approaches to enhance teaching and learning. Moving forward, leadership

or schools and universities management structure resilience learning strategies and policies for campus-wide implementation that need to be followed by every instructor. Furthermore, the evaluation of resilience implications on learning should focus on the strengths and key positive attributes rather than on limitations, thus encouraging more teachers to undertake more adaptive pursuits of the new pedagogy.

#### IV. IMPLEMENTING CRISIS RESILIENCE

##### A. *Nurturing Resilience in Teaching and Learning*

Day [20] argues one of the most important resources that empower educators in times of uncertainty and challenges is resilience quality. Implementing resilience in teaching is to have the capacity and capability, to be sufficiently resilient, to have the desire and the energy as well as the knowledge and strong moral purpose to continue to teach to their best no matter how critical the situation is. Furthermore, fostering resilience is beneficial to both teachers and students. The more educators nurture resilience, the more they would be able to help do the same for their students.

One important message from this discussion is that we should not see times of crisis as the only periods for teachers to exercise resilience in teaching and learning. Instead, we need to get better at understanding what schools and universities can do to foster and nurture resilience learning environments where distress is more manageable and teaching can be continuously operating in any kind of circumstances. Fernandez and Shaw [21] point out that crises give educators opportunities to refine existing teaching practices. CRP also offers instructors insights to grasp these opportunities and equip them to form sustainable approaches that are useful for teaching and learning even after crises subside.

The effective process of teaching and learning requires those who are engaged in them to exercise resilience on an everyday basis, to have a resolute determination and commitment and most importantly positive reassurance, continuous and constructive support from the institutions. Therefore, it is important for us to nurture resilience in teaching and learning through exploring how CRP can be applied to different subjects such as engineering, science, arts, education, social science, business, and medicine. In the following section, we will discuss how instructors from the engineering faculty at our university apply CRP by modifying and combining their own unique teaching pedagogy with other innovative pedagogies.

##### B. *Resilience Approach in Practice: Adaptability*

One example of the application of CRP is how Prof. Yi-Chun Lu from CUHK Department of Mechanical and Automation Engineering (MAE) modified and continued her Role-Playing Gamification of Flipped Classroom (RPGFC) pedagogy in times of crisis. Prior to the crises, Prof. Lu had developed RPGFC based on the existing flipped classroom approach. She incorporated the role-playing and gamification elements into this pedagogy to create and maximize multi-directional interactions between students and between instructors and the students [22]. In this pedagogy, students are encouraged to understand the content and discuss with the instructors. They also act as teachers to teach selected topics to their classmates. This role-playing element aims at promoting higher order of cognitive learning. There are three main procedures and learning activities of RPGFC: Prior-

Class, In-Class, and Post-Class. Students need to watch teaching videos before class, conduct interactive presentations during class, and discuss their in-class performance after class. RPGFC has been successfully implemented in the 2017/2018 and 2018/2019 academic years.

However, the implementation of RPGFC has been affected by crises in the city recently. In response to the social unrest and COVID-19 outbreak in the city, our university has moved all undergraduate and graduate classes to online learning since November 2019. Prior to the campus closure, Prof. Lu was already ahead of other teachers in the same department in producing a series of micro-modules videos to support RPGFC pedagogy activities in the previous academic years. This micro-module series was beneficial for online class (Prior-Class) activities since students could keep track of the lessons and watch the online short videos during the campus closure period. While the Prior-Class activities remained unaffected by the campus closure, the In-Class and Post-Class activities were hindered because students could not conduct presentations and discuss with the instructor in the classroom.

In a relatively short period of time, Prof. Lu quickly adjusted her teaching methodology and effectively integrated peer-to-peer learning into online learning and adopted the use of video-conferencing technology to support the online In-Class and Post-Class procedures. She divided her students into a teaching group (TG) and learning groups (LG). TG led the class discussion through weekly key reading presentations that were conducted online through the ZOOM video-conferencing application. After the presentation, LGs were given the chance to ask their pre-designed questions to TG. Similarly, in Post-Class activities, Prof. Lu provided feedback to TG's In-Class presentation and maintained learning discussion with TG and LG through video conference.

This online peer-to-peer learning modification method demonstrated the adaptability attribute of CRP. It is a flexible pedagogy that is responsive to changes. Due to campus closure, students could not do face-to-face in-class presentations. In response to this change, the teacher proposed the use of video-conferencing technology so that students could continue to participate in learning activities.

Prof. Lu compared students' learning outcomes with RPGFC in previous academic years and the online peer-to-peer learning modification in 2019/2020. The percentage of students that were able to finish the course final project in the online learning mode was similar to that in the previous years. She also noticed an increase in students' engagement during online learning as students were more active to contribute in the video conference discussion through ZOOM and also actively raised their questions. The success of implementing peer-to-peer and online learning shows how CRP helps to maintain and improve students' ability and learning performance during crises. With adaptability, students can continue to learn even when changes occur.

##### C. *Resilience Approach in Practice: Creativity*

In another case, Dr. Dongkun Han also from the MAE department during our interview explained the challenges to switch to online teaching in the first semester of 2019/2020. Originally, he favoured face-to-face in class teaching over online mode as it allows him to fully observe students activities and to have in-depth communication directly with students. Besides, in his UGEB 2303 Robots in Action course





Fig. 3. Live Robot Programming and Real-time Labs Connection

students are required to practice and spend a large amount of time inside the laboratory. However, this teaching method was not feasible during the coronavirus outbreak crisis as the campus and all lab facilities were closed.

Responding to the situation, Dr. Han decided to conduct what he called Flipped Online Class. He spent two months from December 2019 to January 2020 to develop teaching materials for a distance-learning online system, and a remote application that would allow him to integrate the existing flipped classroom approach with real-time virtual labs. This method gave students the opportunity to assemble, build, and program the wheel robots remotely through live online hands-on and engineering problem-solving exercises. Moreover, this method also provided the students with direct connections to the physical robotic labs on campus through the combined application of remote control and video-conferencing software.

In Flipped Online Class, Dr. Han and his teaching assistants utilize various ZOOM video conference functions to conduct real-time teaching, allocate students into groups, allow them to discuss the lab project in a group chat room, and hold private one-on-one consultation with students. Prior to the class session, students were provided with a series of micro-modules and eLearning materials to study and prepare for the labs and final group project. Students then attended real-time online labs through specifically developed remote control for team applications. During online labs, students controlled the wheel robot remotely by programming so that the wheel robot could draw on paper (shown in Fig. 3). Through this approach, students were able to have actual hands-on experience anywhere and anytime even during campus closure in the second semester. Furthermore, it also allowed students to have more time to practice independently and as a group as they could access the campus labs directly through the application as many times as they would like to.

Following the implementation of flipped online class, Dr. Han observed the learning outcomes and students' performance, and assessments results are comparably similar with the in-class and physical labs teaching. A number of students even achieved better scores than the previous semester results. Similar to Prof. Lu, Dr. Han also found his modifications to the original teaching approach enhanced participation and increased the level of teacher-students and students-students interactions. Learning outcomes report shows that 86.3% students appreciate the online labs experience and 92.5% students give positive feedback on the micro-module videos and eLearning materials provided.

The implementation of flipped online class demonstrates the creativity attribute of CRP. In the past, students needed to learn robotic programming in the laboratory. When face-to-face in-class teaching is unavailable, teachers started to explore the possibility of setting up real-time virtual labs. The creative use of wheel robot and remote control in the online labs enabled students to continue to learn programming.

#### D. Resilience Approach in Practice: Connectivity

Prof. Megan Ho from CUHK Department of Biomedical Engineering (BME) shared with our team how the social unrest crisis has personally changed her perception towards online learning and her way of teaching that helps her to better prepare for the critical situation. Prior to the social crisis, Prof. Ho conducted in class face-to-face teaching for her biotechnology and biomedical sciences course. However, teaching and learning were changed to online in the middle of the first semester of 2019/2020 academic year due to the safety concern from the social unrest. In view of this, Prof. Ho started to produce and disseminate several teaching videos for students to watch and learn at home. Her teaching videos received highly positive feedback from the students as it enabled flexibility in learning.

Following this encouraging feedback, Prof. Ho decided to produce more micro-module videos. She actively sought information from CUHK Centre for Learning Enhancement and Research (CLEAR) and attended online and educational technology training provided by the university IT department team. In the second semester of 2019/2020 teachers and students experienced another campus closure due to the pandemic outbreak. Adopting the CRP approach, Prof. Ho swiftly moved her class to online learning and successfully integrated flipped classroom elements with online technology through ready-made micro-modules videos and renewed online teaching materials. Students now can watch micro-modules video and reflect on the online materials prior to the class sessions. In-class sessions and group discussion were delivered through video-conferencing tool ZOOM, Blackboard learning management system, and uReply mobile classroom communication system.

Prof. Ho discovered that the level of teacher-students engagement in her class was better than the traditional face-to-face teaching in the previous semesters. There was also an increase in the positive feedback received from students for the teaching videos provided and the flexible mode of the class. The increase in students' engagement is also similar to the results from Prof. Lu and Dr. Han's courses. In terms of learning outcome, Prof. Ho observed that the results are not significantly different from the face-to-face teaching with 10-15% of students achieved over than 70% final score.

The process and activities where Prof. Ho acquired valuable resources from CLEAR of how to produce effective micro-module videos illustrate the importance of connectivity in CRP. Through this connection, she obtained useful suggestions and practical ideas on how to produce online learning materials.

#### E. Resilience Approach in Practice: Diversity

Prior to the crises, CUHK Faculty of Engineering has been actively promoting a blended and flipped learning approach to engineering teachers. The faculty provides access to resources and support tools, including but not limited to, eLearning authoring software, media equipment, video and

audio editing suite, recording studio, visual effects application, training and production consultation for teachers to produce micro-modules, short animations and various multimedia contents in order to implement innovative pedagogies for their courses. These diverse resources and opportunities are important means to sustain teaching and learning effectiveness during crises. This shows the significance of diversity in CRP implementation.

These case studies of resilience implementation show the benefits of CRP. With it, teaching and learning activities can be carried out effectively in times of crisis. The rapid spread of COVID-19 has signified the importance of building resilience to face various threats of crises, from natural disasters, social unrest and pandemic outbreak. The coronavirus pandemic is also an opportunity to remind educators of the fundamental skills needed to thrive in this unpredictable world such as creative problem solving, informed decision making, and perhaps above all, adaptability. To ensure those skills remain a priority for our teachers, resilience teaching and learning shall be developed into our educational systems as well [23].

#### CONCLUSION AND FUTURE WORK

In this paper, we propose CRP as a flexible pedagogy that incorporates the key attributes of resilience in teaching and learning. This approach is useful in addressing educational challenges brought by crises, especially when traditional teaching and learning methods are not available. Resilience is more than just an individual quality or character. It is a capacity that arises through communications, engagements, practice, and interactions among the members of society. Students, teachers, and administrators should be resilient in times of crisis to continue teaching and learning activities. It should be noted that although most of the discussion in this paper centered around the use of online tools in crises, online education only serves as a starting point for us to reflect on our education systems. It is not the only way to implement CRP. Educators should also be prepared for situations where internet connections are not available. The key is to utilize the resilience attributes to adapt to any changes that may arise during crises. Given the importance of resilience pedagogy in times of crisis, more research could be conducted on it. Directions for future studies include: (1) the combination of CRP with other innovative pedagogy to support effective teaching and learning, (2) the key factors in establishing a resilience ecosystem, and (3) the significance of CRP in normal circumstances.

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