A Case Study of Online STEAM Teacher Training for COVID-19 Prevention and Control

Yen-Yin Wang, Yu-Chun Cheng, and Fang-Chen Chuang

Abstract—**The COVID-19pandemic has affected education at all levels in various ways. This research using an online STEAM course for teacher training for COVID-19 prevention and control education. It integrated Taiwan's smart learning industry and schools' resources to design an online course for global teachers. We present a study that used mixed methods design to collect data form 3 instructors and 1104 attendees. The research findings indicated that it is important to consider the availability of physical learning materials for international teachers. Some international teachers may be afraid of making mistakes since their English is not very fluent, if the questions or the difficulty of the material could be ranked before the class, this might reduce learning difficulties in non-English-speaking countries. It is hoped that this research will inspire interested and willing teachers to try an online training model for epidemic-prevention education in the future.**

Keywords—**Global teachers, International program, Mixed methods design, STEAM, Teacher Training**

I. INTRODUCTION

The COVID-19 pandemic has affected education at all levels in various ways. With the temporary closure of educational institutions, institutions and teacher educators had to quickly respond to an unexpected and 'forced' transition from face-to-face teaching to remote teaching [1]. Online teacher training has also become a global trend and has already transformed the education environment.

Nowadays, teachers need strong digital competencies for teaching, but the roles of digital competency strategies in teacher training are complex [2],[3].

There are several international online learning platforms(e.g., edX, Udemy, Cousera, Harvard Business School Online, etc) that have been developed as a solution to the educational dilemma raised by the pandemic.

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However, globally, there are few online courses designed for teachers that address epidemic prevention and control. Since the start of the COVID-19 pandemic, all schools in the world have faced a challenge, and innovative solutions have been needed to optimise educational efforts [4].

Online courses become an important tool for improving the quality of teaching [5]. Online learning in teacher education can promote teachers' reflection [6]. The importance of interdisciplinary learning, such as that involved in scientific inquiry, technological creation, engineering design, aesthetic design, mathematical logic, and other approaches that can be used in designing the curriculum [7]. However, there is little research on STEAM teacher training [8], [9].

In this study, we integrated Taiwan's smart learning industry and schools' resources to design an online program for global teachers in STEAM education in COVID-19 prevention and control during this difficult time. We using an online STEAM course for teacher training sought to answer the following questions:

What was the point of view of instructors and the attendees' outcome in the Online STEAM Teacher Training for COVID-19 Prevention and Control program?

II. Theoretical Foundation

Today's children are digital natives, having grown up in the digital age, whereas most teachers are digital immigrants [10]. The challenging conditions brought on by COVID-19 can represent a pivotal moment of opportunity for reshaping education, with the implementation, development, and diffusion among educators and students of digital technologies [11].

For teaching and teacher education in such uncertain times, in regard to the role of practise within the context of a practicum (as a 'real practise' versus 'an ideal practise'), it is essential to create learning environments to meet the expectations and the requirements of contemporary education [12].

One of Finland's hundrED Global Innovation Award recipients, the Smart School Alliance, has been using an online online model to assist rural schools in gaining enterprise education resources from chemistry, biology, Chinese, English, geology, citizenship, physics, and problem solving courses [13]. The problem of teaching quality differences in remote areas. Online learning become important ways to improve the quality of education [5].

There are some pilot online teacher training courses. For example, the Taiwan Council of Indigenous Peoples [14] has taught Taiwan indigenous language through a live course since

2017. The Ministry of Education launched an online language-learning course for immigrants in 2018 and continuously promoted an English-language online learning course from 2019 [15]. In addition, the Smart School Alliance serves hundreds of schools, reaching 10,000 teachers and students [16].

In the face of the pandemic, it is urgent that an online teacher training course for epidemic prevention be initiated, based on the following principles [17]. The course should demonstrate high relevance in terms of the relationship between online instructional design and student learning; it should offer effective delivery of online instructional information, and faculty and teaching assistants should provide adequate support to students. In addition, the course should have high-quality participation to improve the breadth and depth of students' learning, and it should have a contingency plan to deal with the unexpected incidents that can occur with online education platforms.

The key factors of courses included: real-world-focused activities, the promotion of collaboration and interaction with peers and outside experts, development and refinement of plans for classroom implementation, and observation of student interest and progress [18]. The teaching of technology education should not only focus on design but also include problem solving, systematic methods, invention, and manufacturing [19]. Technology is in an era of evolution [20]. It also includes large-scale projects, models, prototypes, environments, graphics, systems, and services. The goal of implementing learning should be to provide an environment where it is possible for learners to become excited and curious and to take control of their own learning experience, thus fostering more active learning [21].

These needs should be considered using a combination of interdisciplinary learning theory and a paedagogical model of teaching. When addressing problems, it is important to include paedagogical theory, cooperative learning, framework theory, behavioural theory, cognitive theory, social theory and psychological theory[22], [23]. Education is a process of continuous interweaving and restructuring of knowledge and experience; it is also a process of learning, understanding, and reflecting based on practice[24].

The goal of this research was to share knowledge from a position as educational practitioner. Dewey, an important representative of Pragmatism, proposed the concept of problem-based learning [24]. Based on this research paradigm, this researcher is eager to solve the pandemic problem. Another question is how to help teachers to become resilient to changes in teaching.

It is important adopt STEAM interdisciplinary learning and one of the possible innovations in the preparation of teachers for STEAM education in the content of training future teachers [7], [25]. It is crucial to prepare teachers to implement practice-oriented educational activities based on the lesson design.

The learning network in higher education is important to development. It could increased the extent to which participants feel empowered to reform and increased collaboration across disciplines and institutions [26].

We used the above information as the plan background and design foundation and then gathered resources from education, industries, and transnational systems to launch the international courses of Online STEAM Teacher Training for COVID-19 Prevention and Control course for global teachers.

III. Methods

A. Design of the course

We present a study that used mixed methods design to collect data about the Online STEAM Teacher Training for COVID-19 Prevention and Control course. The three instructors for the course were recruited through Taiwanese smart learning industries. The course attendees were teachers from around the world.

Coronavirus poses unprecedented challenges to schools around the world. How can we fight against and simultaneously learn from this outbreak using STEAM education? In this course, teachers learned from industry experts how to bring STEAM education into the classroom. The special features of this course are shown in Fig. 1. The course included a 2-in-1 mechanism; each course was taught by a team comprising an instructor and a facilitator. This international courses featured instant, real-time Q and A. Furthermore, it incorporated an edutainment element, a rundown design, an online teaching assistant, and a variety of topics. The discussion and assessment were conducted using real cases and hands-on practise.

Fig. 1. The course's special features

The instructional design of this course is shown in Table I. This course including IoT, AI, robots, drones, Arduino, 3D modelling and aesthetic design. All the course is refining several times by domain experts and instructional design experts. As an incentive strategy, teachers received an international e-certificate when they finished the course.

TABLE I. Instructional design

Lesson outline	Title	Objective
Course orientation	Global STEAM Course Launch Ceremony	Introduce STEAM concepts throughout the course and explain their importance in the 21st century.
Stay home for aesthetic education	1–1 Finding Inspiration in the Macro Virus World	Discover the beauty of the macro virus world and play around with your creativity in arts.
	1–2 Bubble Ninja Gives You the Power to Fight the Virus.	Express your creativity and introduce the correct way to keep your class sanitised.
Keep learning during social distancing	2–1 Cloud-based Internet of Things (IoT) Learning Part 1	Utilise "Webduino bit" to easily design your own tools.
	2–2 Cloud Based IoT Learning Part 2	Implement "Webduino bit" to explore artificial intelligence (AI), collect big data to design your own games and cloud controller.
Protect yourself from virus	3–1 3D Printing Your Protective Face Shield	Protect yourself from the virus by exploring the world of 3D printing.

disease	**3–2** Non-programmable Robotic Hand Sanitiser	Assemble your own robotic hand sanitiser using sensors and motors.
Making connections to the world	**4–1** DIY an Autonomous Vehicle to Deliver Food	Learn about the different ways an autonomous vehicle can protect you during this social distancing period.
	4–2 Keep Learning While You Are Quarantined at Home	Explore important tools for designing and developing STEAM courses right at your fingertips.
Support Frontier By Creative Thinking	**5–1** SCRATCH Your Creativity!	Learn to think creatively, reason systematically, and work collaboratively using SCRATCH.
	5–2 Motivational LED Display Board for COVID-19 Fighters!	Build an LED display board to cheer up the COVID-19 front line workers.
Graduation	Showcase What You Have Learned	Showcase what you have learned and let us all celebrate in the STEAM graduation ceremony

B. *Implementation of the Course*

A snowball method and intentional sampling were used to select three representative instructors from different smart education companies.

Teacher training can be delivered through Facebook (FB) groups, and FB appears to be a promising tool to tackle the attrition issue in online training [27]. Using FB discussion aligned with selected paedagogies, the learning community becomes more interactive and cohesive [28]. A total of 1104 international teachers from 26 countries were randomly registered by email marketing through the Innovative Education Alliance (https://www.metaedu.org.tw/), with post-marketing through the International Community of Teachers' FB page and post-distribution with the support of Industrial Development Bureau, Ministry of Economy Affairs, Taiwan.

The attendees were in Vietnam (32.6%, n=360), Indonesia (27.1%, n=299), Taiwan (14.0%, n=115), or Malaysia (6.3%, n=69). Others were from Guatemala, Ukraine, the United States, South Africa, Singapore, Austria, Russia, Bengal, Australia, the Netherlands, Myanmar, Brunei, India, China, Thailand, Algeria, Spain, Slovenia, and Turkey (20.0%, n=221).

The attendees' background including teachers (72.6%, n=801), education managers and administrators (21.0%, n=232), and people who aspired to be teachers in the future (6.4%, n=71).

C. *Data collection*

We conducted a literature review and case study. The Online STEAM Teacher Training for COVID-19 Prevention and Control course was conducted from 17:00 to 18:00 Taiwan time every Monday and Wednesday from April 22 to June 1, 2020, for a total of 12 h.

Various types of evidence were used, including documents, archives, interviews, project reports and course platform records. Semi-structured interviews were used to understand the three industry instructors' views, thoughts, experiences, and reflections. Each interview lasted about 20 min. The three instructors had 10–20 years' experience in the education industry and 2–5 years of teaching experience in the intelligent learning industry.

The attendees' outcome were available for all to access and could be shared freely through the FB group. This research provided a learning environment with scaffolding intended to encourage help-seeking and to help instructors and students using the learning management system (LMS)(https://corelab.iiiedu.org.tw/).

D. *Data analysis*

The data analysis procedures were as follows:
1) Recording the data: The interview data recorded on mobile phones were converted into transcript form.
2) Coding the data: The data were coded and classified. T1, T2, and T3 represented the first second and third instructors, respectively. Five core concepts used to code the data included Subject (S), Course Content (C), Teaching Method (M), Assessment (A), and Attendee Characteristic (D).
3) Analysing the data: The data analysis process included continuous coding, induction and comparison, cyclic construction of a theoretical framework, analysis of the conceptual construction underlying the data, and inductive establishment of the research results.
4) Enhancing the credibility, verification, and reliability: The researcher first conducted a background survey of each research subject, solicited the subject's consent in advance, recorded the interview by audio recording, and organised the transcript to provide a complete record of the data, minimising inferences, and citing interviews directly.

This research checked data accuracy by employing different forms of data, using different data collection strategies, and including data obtained at different times and from different places. Triangulation among these elements was used to ensure the reliability and validity.

IV. RESULTS

The point of view of instructors in the Online STEAM Teacher Training for COVID-19 Prevention and Control course on the subject, course content, teaching methods, assessment, and teachers' characteristics was as follows:

A. *Subject*

The instructors generally believed that other subjects could be taught in the future. Their opinions are summarised below.

Many subjects are also suitable for online teacher training, e.g., design thinking. (T3-S)

The fields suitable for online teaching are in two areas. The first is relatively simple teaching materials, such as design and word processing, where the software and materials are simple. The second focuses on areas of understanding, such as language, economics, and conceptual or theoretical understanding. (T1-S)

I enjoy the feeling of physical teaching because you can feel children's emotions, responses and feedback. I know that now we can use AI to overcome these problems, such as sensor to know the kid's facial emotion, but I think there is still a lack of humanity, the soft things in it. (T2-S)

This course is appropriate for many classes, but it is important to keep the soft elements of STEAM courses.

B. *Course Content*

Considerations raised in this area pointed to teachers' inability get teaching materials immediately and the need to adjust the content for international teachers. The following are examples of points of views from the instructors.

The course itself has a lot of English textbooks, which was very convenient. (T3-C)

The length of each session should also be considered. Interactions will be reduced due to the concentration of the session, or additional non-synchronised sessions will be required to allow participants to preview or understand the theme of the session in advance so that they can master the level of learning and interactive activity design. (T1-C)

In fact, we have significantly adjusted the content of the course because the time is limited. Therefore, we use a "simulator" manufacturer solution; at least teachers can know their own results in the operation. (T1-C)

After an outbreak, the host can send teaching materials to teachers so that teachers can be equipped for online teacher training. (T1-C)

After the pandemic, when possible, the instructors suggested that the host could send the tool kits to teachers who were highly interested in this course.

C. *Teaching Methods*

This course relied on a design that usually required teachers' reading messages or sharing screens for discussion. Instructors' points of views on the course's teaching method was as follows.

Suggest discussion groups that can have a teaching assistant in a chat room as an adjunct to courses. This would help with whole-network teaching. (T3-M)

With small groups, everyone can publish for at least 5 min. For example, before the class, teachers could design some friendly things for the earth, and students could come up with their own design before the official class. (T2-M)

I would break it down step by step. If it was a general physical course, I would finish the lecture first and then let the teachers absorb it by themselves. Each attendee's production would be different, but because it was online, I would take the teaching step by step. (T2-M)

"Why do so many children love to play board games?" "As a game player, it's like playing video games, because I'm not afraid to make mistakes." Education needs to allow teachers to make mistakes, which is also true of online or offline teachers. (T2-M)

Try to keep it to 1 to 1.5 minutes when playing video science. The teachers are easily distracted. And suggest that instructors reach a conclusion every few minutes. Besides, the slide doesn't need to include a lot of words, it's got to have a few main points. And don't expect a lot of slides for one class. (T2-M)

Support mechanism are needed. For example, good learning results could come through instructor and facilitator guidance where one instructor is good at professional fields, and another one is good at increasing class interaction. (T1-M)

In course design, it is important to consider teaching needs, so learning theory and teaching environment should be integrated, and a teaching model based on interdisciplinary paedagogy should be combined with difficult situations that include paedagogical theory [22], [23]. This course integrates current events and aims to use technology and knowledge to immediately transfer epidemic prevention knowledge to countries in need.

D. *Assessment*

The learning platform allows teachers to submit pop quizzes, review slides, and videos to extend their thinking on the topic. The following are the instructors' opinions about assessment.

It is suggested that the correctness of knowledge about a subject could be examined during after-class evaluations. Thus, the instructors could see how well the teachers understand the content and could check the teachers' backgrounds, answers, and other relevant data as some reference to give feedback for the next class. (T1-A)

Perhaps some people think they need to take photos and that is extra homework, or at least homework, so teachers just feel they don't want to do. But if it is a real homework, then teachers can do it directly in the class. On the whole, I was impressed by two teachers who even expressed abstract concepts through design. (T2-A)

During the evaluation, it is easy for teachers "like" the project in class time. They can use emojis immediately to reflect their emotions. (T3-A)

Multiple assessments are quite convenient in an online course. This course also use open a FB group (Power Your Skill–STEAM Up) to discuss and give feedback for teachers' homework every week.

E. *Teachers Characteristics*

According to the background analysis of international teachers participating in the STEAM Epidemic Prevention online course and experiences after this course, the instructors' views on teachers' characteristics were as follows:

It would be better to know more about an attendee's background, why he or she is interested in the course, and what questions he or she wants to ask before the class. With a deeper survey of teachers' problems, the teacher can prepare in advance. Maybe there is some help in ranking. In fact, there is a good system that we could use. (T3-D)

The next time, if it is the same course content, it would be better to investigate more about details of learners' background and prior knowledge in advance so the lecturer can then prepare lessons more accurately. (T1-D)

Because some teachers turn off the camera or have no camera, it is important to know how to make it possible for teachers to ask more questions. I ask questions to assess how much the teachers have absorbed, and I find that most of the teachers feel embarrassed to ask questions. If there were a different platform instead of an open FB group, maybe the teachers would not be so shy. (T2-D)

If only the instructor can see the attendee's questions, then the instructor can choose the questions to answer. I think if the attendees' questions were not published, they would not feel like they asked a stupid question. (T2-D)

If all of them have the same background or if they are mixed together with no background information, a step-by-step method would be more suitable. It is not easy to teach complex concepts through an online course (T2-D)

Online teaching should consider the preparation of teachers. They may not have some of the learning materials. For example, the price of a robot may not be affordable for teachers. Therefore, I think it is necessary to consider the perspective of teachers. (T2-D)

These points of views has been received about the Online STEAM Teacher Training for COVID-19 Prevention and Control course was as follows:

All the data are open, and the teachers are willing to share their homework, as shown in Fig. 2. "Homework from one

attendee: make 800 masks to send to the hospital"; and in Fig. 3. "Anti-Covid19 Armband" countdown timer for 20-second hand washing." The following case data were selected based on the most shared "likes" and the most impressive teachers in the course.

Fig. 2. Homework from an attendee: make 800 masks to be sent to the hospital

Fig. 3. "Anti-Covid19 Armband" countdown timer for 20 seconds' hand washing

Hi, I'm from Sabah, Malaysia. When the Covid-19 pandemic first hit Malaysia, many hospitals experienced shortages of personal protective equipment (PPE) for healthcare front-liners. Together with some teachers, I utilised 3D printers in the school's MakerLab to print 3D face shields for the medical front-liners. This was also a voluntary joint effort with the local Makers Community to support the healthcare front-liners in Sabah. I used Tinkercad to make some modifications to the open-sourced face shield model to improve the clear-sheet mounting. To date, using our own resources and contributions from the local community, we have printed over 800 face shields. These face shields are being distributed to the hospitals and clinics all over Sabah. Continuous effort is being applied to support the Healthcare front-liners at this critical moment. (20200514 open FB group post-S1)

Hello or Ni Hao! I am from the Philippines!

I just made an "Anti-Covid19 Armband" using Webduino.

During this pandemic, it is very important that we always sanitise properly by washing our hands. Experts say it takes 20 seconds at least to kill the virus. I used the button of the Webduino to trigger the countdown timer for 20 seconds. Afterwards, the Webduino will flash the smiley from the matrix LEDs, and Green Monster will remind me to stay safe from Covid19. It was also recommended that we avoid touching our face. So, I use the gyroscope sensor of the Webduino to detect the orientation of the hand using the proposed armband. With this armband, I believe that I could help prevent the spread of COVID19. (20200514 open FB group post-S1)

Fowling Fig. show the attendees' outcome from the Online STEAM Teacher Training for COVID-19 Prevention and Control course, presented during the "Showcase What You Have Learned" segment(Fig. 4). Teachers integrate what they have learned in the course, consider current issues/funds, and combine the course and STEAM education in their own classrooms(Fig. 5).
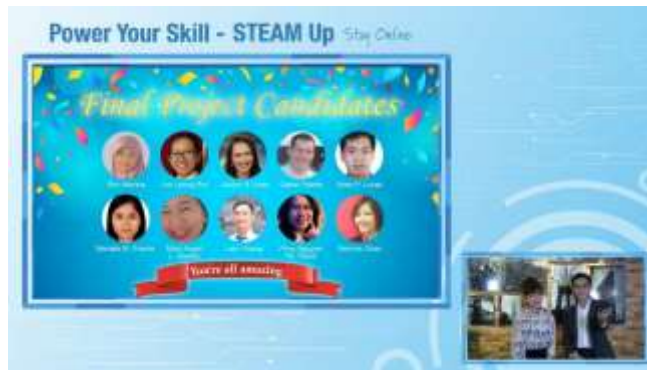

Fig. 4. The live version of Showcase What You Have Learned
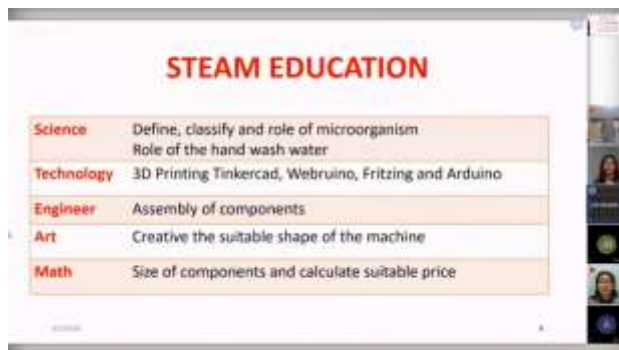

Fig. 5. combine STEAM education in their own classrooms

Another outcome is teachers design frontline robots for epidemic prevention, combined with extended applications such as courseming, modelling, and AR(Fig. 6). Teachers not only integrated Arduino, 3D modelling, and aesthetic design in the final project(Fig. 7), but also designed an automatic disinfection sprayer, a vehicle that is automatically activated to spray and disinfect the vehicle, a mask earmuff designed to reduce pressure in the ear, and a temperature sensor cap that will automatically sound a warning if the wearer has a fever(Fig. 8)

Fig. 6. design frontline robots for epidemic prevention

Fig. 7. integrated Arduino, 3D modelling, and aesthetic design in the final project.

Fig. 8. designed an automatic disinfection sprayer

The teachers came from all over the world, and considering instabilities of networks, teachers might not have been able to participate on time in every class. So, after the live class, the video was uploaded to the learning platform for those who could not synchronize to attend the class or for teachers who would like to review the class.

As Fig. 9 shows, one month after the class ended, teachers were still meeting for classes and giving feedback on the learning platform. This is an after-class video of a DIY walking car helping someone to take food to a studio. To encourage teachers to persist in learning, teachers who completed more than 80% of the course could download an e-certificate from the website.

Fig. 9. Video of a DIY walking car helping someone take food to a studio

The following data represent the attendees' records. At this point, 168 attendees (15.22% of 1104) had completed the

training and received the e-certificate. Attendees' Engagement and Performance was as Fig. 10. Engagement was based on attendees learning time, performance was based on the completion task, which was depended on whether the attendee completed viewing the video, completed the quiz, or completed the assignment.

Participants' satisfaction was measured using a five-point Likert scale. Attendees' self-assessed satisfaction was scored as 4.43, and satisfaction with the whole course as 4.51. Attendees' self-assessment and course satisfaction ratings are shown in Fig. 11.
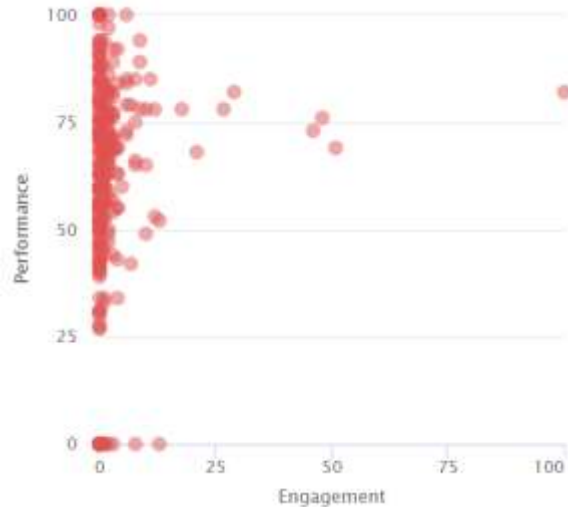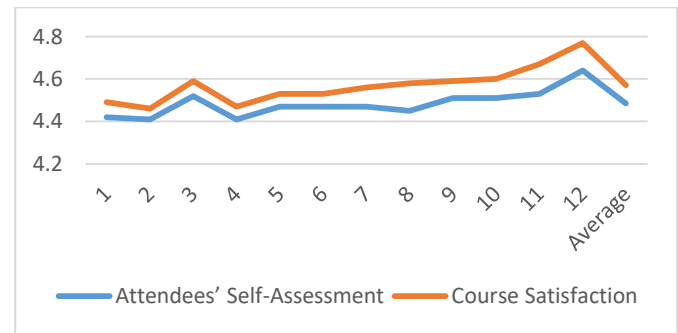

Fig. 10. Engagement and Performance

Fig. 11. Teachers' self-assessment and course satisfaction

The limitations of this study include the non-random sampling of course participants. The teachers were chosen based on the recommendations of international corporations. Teachers' backgrounds included schoolteachers of all levels, administrative staff, and other education workers.

Teachers' circumstances varied around the world. For example, in Guatemala, teachers had to attend the class in the middle of the night. Schools in Vietnam resumed classes in May, so teachers did not have enough time to attend every class. Teachers in various countries had personal reasons, such as moving their residence, requiring that they find another time to review the video on the learning platform. Overall, the score after class was over 4 points, but it was still hard to collect all of the teachers' ideas comprehensively. Therefore, this research cannot be generalized to other topics or other contexts.

V. Conclusion

The challenges and opportunities that COVID-19 poses to higher education come at a time when the field needs to redefine its teaching methods and interaction channels using digital technologies towards the improvement and sustainable development of education [11]. Under the influence of the fast pace of technological transformation, what will online STEAM learning and teacher training become in the future? How can we use technology to solve current, urgent problems such as epidemic prevention education?

This research embodies what pragmatism advocates: continuing to learn by doing, learn from experience, and learn from problem solving, as represented in the case of the international Online STEAM Teacher Training for COVID-19 Prevention and Control course.

Some researcher considered the evolution of technology and suggested that the characteristics of technology include diversity and continuous evolution [4]. The research conclusions and recommendations suggest the following, as [30] noted that in the pandemic era, all schools in the world have faced a challenge, as innovative solutions were needed to optimize educational efforts.

It is important to consider the availability of physical learning materials for international teachers. If appropriate instructional methods are used, any subject may be suitably taught using an online model. It is also important to consider how to design an appropriate STEAM course that incorporates a "human feel" in online teacher training. STEAM can contribute to teaching practices that provide learner with holistic knowledge and the ability to solve problems by combining the knowledge provided by the different areas [31].

This research found that FB community sharing was a good way for teachers to learn from one another, but some international teachers may be afraid of making mistakes and therefore do not share in public, particularly when their English is not very fluent. If the questions or the difficulty of the material could be ranked before the class, this might reduce learning difficulties in non-English-speaking countries.

It is suggested that everyone must learn to live and survive with the present crisis [32]. Developing multimodal approaches to achieve course content objectives for better learning outcomes seems to be a good way to deal with the complexity of education. This research suggests that standardization procedures are also important. If future research could recruit industry experts from various countries, this would accelerate and expand the scale of research to cultivate talent transnationally.

Finally, it is suggested that the long-term effects of online education and the engagement and performance of synchronous and asynchronous hybrid learning mode should be studied in the future. Most importantly, if future research could cooperate with local institutions, the economic and social effects of the online STEAM teacher training model could be more deeply analyzed.

Acknowledgments

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