“The Impacts of Virtual Learning on American and Taiwanese Medical Students’ Learning Perceptions and Clinical Outcomes”

Scholarly Pursuit and Thesis Project

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Abstract

Research question: How did COVID-19-induced distance/virtual learning impact American and Taiwanese medical students' learning perceptions, engagement, and future willingness to participate in virtual learning opportunities compared to their experiences with traditional in-person learning?

Background, Significance, and Rationale: The COVID-19 pandemic forced swift, unanticipated, and significant changes in every facet of daily life around the globe. Our personal social lives, work, education, daily chores, and perception of personal safety were turned on their head nearly overnight. As the world adapted to these changes, medical education was not spared. Coursework was moved online, and classrooms became isolated rooms connected via virtual conferencing software so that curricula could continue, and new generations of physicians could be trained. Though diligent effort was taken to maintain normalcy, the learning experience was undoubtedly altered compared to the traditional classroom style. However, amid these changes, little research has been done to try to quantify its effects on students. Essentially, we do not know how learners have perceived and been impacted by these changes, so we decided to try to quantify their opinions to better inform the medical education system moving forward.

Materials and Methods: We created a robust survey and distributed it to two cohorts of medical students, one from Taiwan and one from the United States. It encompassed criteria such as prior experience with virtual learning, online learning engagement, perceived difficulty of online learning, and future interest/willingness to participate in online learning. Then, with their responses, we conducted an array of statistical analyses to better understand each cohort's opinions as well as how they agreed or disagreed with one another.

Results: It was clear both cohorts had good familiarity with virtual learning, but the students in Taiwan appeared to be more adaptable and overall positive about their experiences. Intriguingly though, U.S. students reported stronger efforts in curriculum engagement and effort to succeed.

Discussion/conclusions: Though some of the differences are undoubtedly linked to differences in culture between the two countries, we believe the prolonged use of online learning in the U.S. allowed those students to experience more of its challenges and therefore have a more negative overall opinion. In a free response section, both groups agreed online learning was beneficial for

review of material and creating a more personalized learning experience, but also recognized the practice of medicine as a nuanced art and felt success in clinical mastery required face-to-face learning. Moving forward, we hope this research provides educators with insight into the student experience and aids in the creation of programming to help better support the needs of students engaged in primarily virtual learning environments.

Research Question

How did COVID-19-induced distance/virtual learning impact American and Taiwanese medical students' learning perceptions, engagement, and future willingness to participate in virtual learning opportunities compared to their experiences with traditional in-person learning?

Hypothesis

We hypothesize that COVID-19-induced distance/virtual learning will have an overall negative impact on American and Taiwanese medical students' learning perceptions, engagement, and future willingness to participate in virtual learning opportunities.

Introduction

COVID-19 has had a major impact on the ways we interact one another, and medical education has not been spared[1-3]. The rapid evolution of the pandemic has posed challenges to nearly all aspects of our daily lives, including the education and training of medical students [4,5]. Social distancing guidelines have disrupted traditional course planning and clinical placements for students, forced medical schools and medical students to move to remote learning platforms, and made in-person courses difficult due to frequent and variable quarantine guidelines [6]. Currently, the most popular method for education delivery is distance learning, including asynchronous observation of pre-recorded lectures, online synchronous or asynchronous courses, video conferencing, and independent observation of handouts or other learning materials, etc.[7]. However, the efficacy of distance online learning may be considerably affected by individual students' attitude towards, and participation in, online/distance coursework [8].

Individual students' attitudes toward online learning, their participation in coursework, and their engagement during live classes/discussions represent whether they are likely to benefit from their coursework. In general, students who are more engaged tend to have better learning outcomes than their less engaged peers [9]. Traditionally, the degree of student engagement and peer to peer interaction could be observed firsthand by the teacher in the classroom, but in the era of long-distance online learning, it can be difficult for instructors to gauge participation and identify topics with which students are struggling. As a result, students' participation, interaction, and overall attitude toward online coursework is an important issue that medical educators need to analyze and discuss. In this study, we will use the Online Course Engagement and Participation Scale to investigate various dimensions of both American and Taiwanese students' course engagement [10].

When examining the history of medical education in Taiwan, it becomes clear that the system has been deeply influenced by the American medical education system. However, the vast majority of medical education literature is based on Western ethnic groups, and relatively little research has examined medical education efficacy in Taiwanese student populations. Direct comparison of differences in student attitudes and learning behaviors between Taiwanese and

American students is also relatively lacking. Undoubtedly, students in Taiwan and the United States are affected by the cultural differences between the two countries, therefore it is quite possible that the value of and attitude towards online learning may also be different [11].

Distance learning is not a new or American concept, but when the same learning model is applied to students with different cultural backgrounds, differences in learning attitudes, peer to peer interactions, and individual student engagement are expected. This study intends to use online learning attitude, engagement, and participation questionnaires of medical students in Taiwan and the United States to better elucidate the differences between the two cohorts of medical students in the face of new forms of learning. Furthermore, we intend to attempt to understand whether any differences we find can be explained by contextual frameworks such as culture or learning environment.

Materials and Methods

This study will examine medical students from Taiwan and the United States as the research subjects and we will distribute a questionnaire survey on issues related to distance online courses. The questionnaire survey includes three well-structured and mature questionnaires:

1.) Engagement in the online course scale
2.) Interactions in distance education questionnaire
3.) E-learning related attitudes scale

All responses will be from medical students beginning their clinical practice years in Taiwan and the United States. Because of the different educational systems in Taiwan and the United States, the respondents in Taiwan were fifth-year medical students, while those in the United States were third-year medical students, both of whom were entering the first year of clinical training. The target number of respondents is 100 medical students from Taiwan and 100 from the United States. Inclusion and exclusion conditions are as follows:

Inclusion conditions (all of the following conditions must be met to participate in this study):

- Receive basic education locally and complete standard medical school/clinical education admission procedures
- Already participated in the blended learning course designed by this research team (Taiwanese medical students)

Exclusion conditions (if any of the following conditions are met, you cannot participate in this study):

- Individuals known to be resistant to, or unable to adapt to, online lessons

The research design of this project is divided into two parts:

1. **Curriculum arrangement and questionnaire survey**: After searching the literature, the research team obtained questionnaires on distance learning attitudes, interactions, and participation that had been verified in similar ethnic groups, and then held an expert group meeting to review the content of the questionnaires and ensure that the Chinese text and the English text were semantically consistent, and congruent with the current situation of medical students' learning. After completing the expert validity of the questionnaire, it will enter the delivery stage, and will be delivered to the target medical

student groups in Taiwan and the United States, and the students will respond according to their wishes.

2. **Data analysis stage**: The validity analysis and exploratory factor analysis of the three questionnaires put in this study were carried out to find out the specific sub-dimensions, and then the structural equation model was used to make regression comparisons with the students' learning outcomes, and it was expected to identify which variables have a greater impact on learning outcomes in distance online learning with the goal of better informing both instructors and students.

The detailed process of each stage is described below:

Curriculum arrangement and questionnaire survey

The questionnaire method is employed to conduct tests on a representative sample of the target group by using a standard set of questions with reliability and validity. The responses obtained can be used to estimate the attitudes or opinions of the group towards the research topic. This research is expected to use three questionnaires, namely 1) the participation questionnaire of distance online courses, 2) the interaction questionnaire of distance online courses, and 3) the learning attitude questionnaire of distance online courses. The three questionnaires explore different sub-facets of learners' perceptions of distance online learning.

1) Simultaneous Distance Education Interactive Assessment Tool [12]: This is a 29-item questionnaire measuring seven aspects of student experience: students' response in class, teacher's non-verbal interaction, effect of technical equipment on student interaction, teacher's language interaction, homework and its effect, after-class interactions, and student's personal interaction during class.
2) Online Course Engagement and Participation Measurement Table [10]: This is a 19-item questionnaire, and the measurement dimension includes four aspects of engagement: learning skills, emotional attitude, interactive participation, and striving for success in classroom performance.
3) Digital Learning Attitude Scale [13]: This is a 22-item questionnaire, measuring challenges of digital learning, the benefits of digital learning, attitudes towards using computer equipment, and interest in computers and digital learning innovations.

In order to estimate the efficacy of the digital learning mechanisms of the two countries, the research team intends to extract "shock and intra-hospital cardiac arrest" from the emergency medicine courses of the two places for standardization, and a team of medical educators from both countries will converge to formulate an equivalent teaching syllabus as well as learning materials for the two cohorts, and place them on the Internet for students to read before class. The teaching objectives of this demonstration course include:

1) Learning objectives:
    a. Differential diagnosis of shock
    b. Management of in-hospital cardiac arrest
2) Technical skills: Provide high-quality CPR in the event of cardiac arrest in the hospital
3) Non-technical skills: Form a team and assign roles appropriately when initiating first aid procedures

Upon completion of the digital learning phase, students will be asked to fill out the three questionnaires related to digital learning to understand their attitudes, engagement, and participation in online digital learning. Then, during the emergency medicine training period of the students, time will be arranged for a knowledge assessment written test, and simulated drills will be arranged to practice technical and non-technical skills. In addition to the above three questionnaires, we will collect background information about the trainees such as gender, digital learning experience, knowledge assessment, and self-evaluation questionnaires, including self-confidence and efficacy.

Data Analysis

1) Statistical software and basic testing

All the statistical analysis for this project will be carried out with SPSS 23.0 for Mac. If the p value is less than or equal to 0.05, it is considered statistically significant. Correlation analysis methods that can be used include: chi-squared test, Spearman's rank correlation coefficient, Pearson's correlation coefficient, bivariate linear regression analysis, bivariate logistic regression analysis, etc. The method adopted depends on the nature of the two variables. For example, if both variables are categorical variables, the chi-square test must be used; if one of the two variables is a binary variable and the other is a continuous variable, then Spearman's rank

correlation coefficient is used as the test method; if the two variables are continuous variables, the Pearson correlation analysis is used as the test method and so on.

Although the three questionnaires administered to Taiwanese and American medical students have been verified in similar ethnic groups, they may not be able to achieve the original reliability and validity when applied to the target populations of this study, so it is necessary to use statistical methods for analysis. In terms of internal consistency reliability, we use the reliability coefficient [12] to measure the correlation between each evaluation item and the average value of all items in the pre-test and post-test respectively. When the value of the reliability coefficient is greater than or equal to 0.70, it is acceptable to represent the internal consistency reliability of the assessment tool, that is, to point to a specific concept in common.

Multivariate regression analysis is used for multivariate analysis where the dependent variable is continuous. The linear relationship between all independent variables and dependent variables will be tested by Pearson correlation analysis or Spearman rank correlation coefficient, and independent variables with a p-value less than or equal to 0.30 will be considered in the final regression model for regression analysis 64. All collinearity among independent variables will also be tested by Pearson correlation analysis, Spearman rank correlation coefficient or Chi-square test. Several independent variables with p-value less than or equal to 0.05, due to the problem of collinearity among each other, put into the model together will make the final model unstable, so only one independent variable can enter the regression analysis. We will adopt stepwise multivariate linear regression analysis to construct the final multivariate linear regression model to estimate the correlation between independent variables and dependent variables after controlling for interference factors. After the multivariate linear regression model is established, the influence of the relevant independent variables on the dependent variables can be answered. The predictive power of the model will be judged by adjusted R square. The adjusted R square indicates how many relationships between independent variables and dependent variables can be predicted by the regression model. If the adjusted R square is higher, it means that the regression model we constructed is better, and the displayed results will have more application value.

For multivariate analysis where the dependent variable is a binary variable, logistic regression analysis will be used. All linear relationships between independent variables and dependent variables will be tested by bivariate logistic regression analysis. Those with p-value less than or equal to 0.30 will be considered in the final regression model for regression analysis. All collinearity between independent variables will also be tested by bivariate logistic regression analysis. For variables with a p-value less than or equal to 0.05, only one independent variable can enter the regression analysis. Stepwise multivariate logistic regression analysis will be adopted to analyze and construct the final multivariate logistic regression model to understand the correlation between independent variables and dependent variables after controlling interference factors. After the multivariate logistic regression model is established, the influence of the relevant independent variables on the dependent variables can be answered. Finally, we will use the area under the ROC (Receiver Operating Characteristic) curve (above 0.8 is a good logistic regression model) to understand whether the discrimination of this regression model is good enough. We will also use the Hosmer-Lameshow Goodness-of-fit test to judge this logic calibration of the regression model.

2) Path analysis

Structural Equation Modeling

Before the 1980s, the structural equation was called "path analysis." The purpose of the structural equation was to construct a set of "multivariate causal models," which included: dependent variables, independent variables, mediator variables, moderator variables, etc., that have a "causal relationship." In this project, we will also use the statistical method of structural equations to explore the causal relationship between the degree of medical knowledge and the degree of medical problem solving. And the causal relationship between each item is presented in the form of pictures through software, so that the results are easier for readers to understand. Through the above data analysis, we hope to find out the moderating variables between engagement, interaction and attitude, the correlation between these sub-factors and learning outcomes. A model of this is shown below (Figure 1).

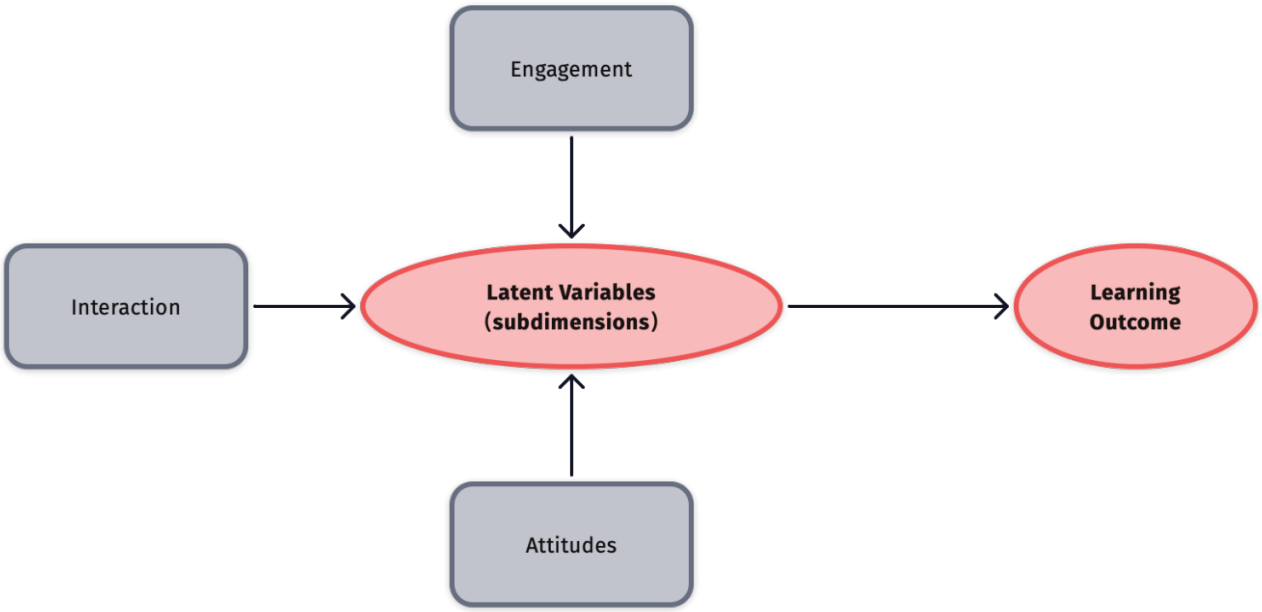

Figure 1: Visual representation of each measured variable and how these variables come together to influence learning outcomes. In this case, Engagement, Interaction, and Attitudes are all variables that contribute to the end point of Learning Outcomes.

Results

1. Subject recruitment:

Since this research is cross-border and cross-institutional, much time was spent on the participation acceptance mechanism and ethics committee review between Taiwan and the United States. In the end, this study recruited 55 fifth-year medical students in Taiwan and 28 second-to-fourth-year medical students in the United States. Students from both places completed the digital learning attitude, engagement, and interaction questionnaires, while only the students from Taiwan were able to complete online course portion of the study.

A total of 83 medical students from Taiwan and the United States completed the pre-test questionnaires. Among them, a total of 42 Taiwanese students also completed the online portion successfully.

2. Narrative statistics

Among the 28 American medical students who have answered, 14 are male and 14 are female, and the grade distribution is from the second year to the fourth year of medicine students, approximately equivalent to the third to sixth grades of the Taiwan Medical Department. Among the 55 students in Taiwan, there are 41 males and 14 females, all of whom are fifth grade students in the Department of Medicine. A table depicting the distribution of responding students can be found below (Table 1).

	Taiwanese medical students	American medical student
Number (n)	55	28
Gender (Male %)	74.5%	50%
Grade	Grade 5 of the Department of Medicine	Second to fourth year of the Department of Medicine

Table 1: Total number (n), gender (presented as % male), and grade level of medical students included in this study. Table also specifies students' country of medical education.

In the part of digital learning familiarity, 96% (27/28) of American students answered

familiar/very familiar, while about 81.8% (45/55) of Taiwanese students answered familiar/very familiar, slightly lower than the proportion of American students. In terms of digital learning experience, 71.4% (20/28) of American students answered frequently and very frequently, and about 67% (56/83) of Taiwanese students answered the above frequency of use. If the above distribution percentage is tested by chi-square test, the results are as follows:

(1) If the chi-square test is performed with the response distribution (strongly disagree to strongly agree, five-point scale) of B4: "I am familiar with the use of digital learning", $p = 0.006 < 0.05$, indicating American medical students are more familiar with digital learning than Taiwanese medical students. Results are presented below (Table 2).

Responses for B4: Familiarity

			2	3	4	5	Total
Ethnicity	U.S.	count	1	0	9	18	28
		expected count	.3	3.4	12.1	12.1	28.0
	TAIWAN	count	0	10	27	18	55
		expected count	.7	6.6	23.9	23.9	55.0
Total		count	1	10	36	36	83
		expected count	1.0	10.0	36.0	36.0	83.0

Table 2: Table depicting students' self-reported levels of familiarity with online learning. Table is split by country of medical education and includes both the expected and actual counts of each response score. Score of 1="strongly disagree" and score of 5="strongly agree", in response to "I am familiar with the use of digital learning.".

(2) Using the response distribution (from always use to never use, a six-point scale with six representing always use) of B5: "My experience of utilizing digital learning" to conduct a Chi-square test, $p=0.455$, which means that Taiwanese medical students are roughly equivalent to American medical students. In other words, medical students in Taiwan have also conducted digital learning for a considerable period of time during the pandemic. Compared with American medical students, Taiwanese students may not be more familiar with digital learning, but they also have considerable experience with

various digital learning platforms. Results are presented below (Table 3).

Responses for B5: Digital learning experience

			3	4	5	6	Total
Ethnicity	U.S.	count	1	7	17	3	28
		expected count	.3	8.8	16.2	2.7	28.0
	TAIWAN	count	0	19	31	5	55
		expected count	.7	17.2	31.8	5.3	55.0
Total		count	1	26	48	8	83
		expected count	1.0	26.0	48.0	8.0	83.0

Table 3: Table depicting students' self-reported levels of experience with digital learning. Table is split by country of medical education and includes both the expected and actual counts of each response score. Score of 1="never use" and score of 6="always use", in response to "My experience of utilizing digital learning."

According to the items of the above three questionnaires, there are the following main aspects:

1) Engagement in the online course scale

a. Engagement Skills: Engagement in learning during the online course process

- Representative item: ES: "I will listen/read carefully during online-classes"

b. Emotion engagement: Emotional engagement in online courses

- Representative item: EE: "I will find ways to make the course interesting to me"

c. Engagement of Participation: Engagement in online participation and interaction

- Representative item: EPA: "I am having fun in online chats, discussions or via email with the instructor or other students"

d. Engagement of Performance: Engagement in online course performance:

- Representative item: EPE: "I am working hard to get a good grade"

2) e-learning related attitudes scale

a. Challenges of technology e-learning: challenges of digital learning

- Representative item: TC: “Learning in an e-learning environment is very difficult”

b. e-learning Technology Benefits: the benefits of digital learning

-Representative item: TB: “I believe using e-learning technologies will improve my learning performance”

c. Attitude on using technology devices: the use of digital tools

- Representative item: TA: “It will be difficult for me to become skilled in the use of e-learning tools”

d. Leisure interest on technology: interest in digital tools

- Representative item: TL: “I like discussing new e-learning innovations”

Regarding the previously mentioned variables, the descriptive statistics (Table 4) and independent sample T-test results (Table 5) of Taiwanese students and American students are presented on the following page:

Descriptive Statistics for the Scores of each Aspect of Taiwanese and American Medical Students' Online Learning Experience

Item	Ethnicity	N	average value	standard deviation	Standard error of the mean
ES	U.S.	28	3.1786	.65723	.12420
	Taiwan	54	3.8210	.65944	.08974
EE	U.S.	28	3.8095	.60470	.11428
	Taiwan	55	3.9394	.67918	.09158
EPA	U.S.	28	2.4286	.79534	.15031
	Taiwan	55	2.9455	.84562	.11402
EPE	U.S.	28	4.6964	.39298	.07427
	Taiwan	55	4.0000	.82215	.11086
TC	U.S.	28	3.5214	.63091	.11923
	Taiwan	55	2.5564	.65737	.08864
TB	U.S.	28	2.8214	.64856	.12257
	Taiwan	55	3.8318	.63292	.08534
TA	U.S.	28	2.2619	1.01575	.19196
	Taiwan	55	2.0121	.78296	.10557
TL	U.S.	28	2.7738	.58128	.10985
	Taiwan	55	3.4848	.70803	.09547

Table 4: Table depicting the descriptive statistics for the analysis of self-reported scores for the aforementioned aspects of online leraning. See page 14 and 15 for the complete list of statements associated with each item abbreviation. Results are presented for each variable item and split by students' country of medical education. Scores were reported 1-6, with 6 indicating "strongly agree."

Independent Sample T-Test of Responses to Aspects of Online Learning:

		F	Significance	t	df	one-tailed p-value	two-tailed p-value	mean difference
ES	with equal variance	.129	.720	-4.188	80	<.001	<.001	-.64242
	without equal variance			-4.192	54.921	<.001	<.001	-.64242
EE	with equal variance	.057	.812	-.854	81	.198	.396	-.12987
	without equal variance			-.887	60.366	.189	.379	-.12987
EPA	with equal variance	.016	.899	-2.685	81	.004	.009	-.51688
	without equal variance			-2.740	57.497	.004	.008	-.51688
EPE	with equal variance	5.500	.021	4.234	81	<.001	<.001	.69643
	without equal variance			5.219	80.798	<.001	<.001	.69643
TC	with equal variance	.013	.908	6.408	81	<.001	<.001	.96506
	without equal variance			6.496	56.468	<.001	<.001	.96506
TB	with equal variance	.004	.948	-6.820	81	<.001	<.001	-1.01039
	without equal variance			-6.765	53.267	<.001	<.001	-1.01039
TA	with equal variance	.976	.326	1.240	81	.109	.218	.24978
	without equal variance			1.140	43.801	.130	.260	.24978
TL	with equal variance	.708	.403	-4.582	81	<.001	<.001	-.71104
	without equal variance			-4.885	64.727	<.001	<.001	-.71104

Table 5: Table depicting results of independent sample T-test of self-reported scores for the aforementioned variables of interest. See page 14 and 15 for list of statements associated with each item abbreviation. Results are presented for each variable item and split by students' country of medical education.

Note that there are significant differences in ES, EPE, TC, TB, TL and other variables (Table 5), which are described below:

1) The scores of Engagement Skills (ES), e-learning Technology Benefits (TB), and Leisure interest in Technology (TL) are significantly higher for Taiwanese medical students than for American medical students. For the above three aspects, the possibility of a low percentage of positive responses by American medical students includes the fact that the pandemic occurred earlier in the United States, therefore American students have more practical experience in online courses, including the challenges it presents.
2) Engagement of Performance (EPE): In the measure of engagement with online coursework, American students scored higher. The performance engagement items included EPE: “I am working hard to get a good grade.”
3) Challenges of Technology e-learning (TC): TC is an inverted score question, and a relatively high proportion of American students answered that they agree with the challenges of digital learning, which may also indicate that American students have a deeper understanding of the challenges digital learning presents.

The questionnaire also included several dependent variables that were originally intended for use in statistical analyses, and still may appear in future publications from this research, but ultimately proved more insightful due to the text responses they generated:

a) D1: “Are you willing to utilize digital learning for your future course?”
b) D2: “Digital Learning platforms are suitable for medical curricula.”
c) D3: “Following the above question (D2), why?”

When asked to expand further on questionnaire item D2, medical students in Taiwan and the United States were both able to create free text responses. Their responses to D3 are compiled below:

a. U.S. medical student responses:

i. "Some online curriculum may be acceptable, but I believe medicine is as much an art as a science so face to face learning is the gold standard. "
ii. "Less time spent in physical class."
iii. "More accessible for didactic."

iv. "Many study resources available to medical students are online flashcards, summary sheets, question banks, etc. "
v. "Makes resources more readily available. "
vi. "E-learning, although required during COVID-19, was not very effective in terms of learning medicine. We had around a month of in person learning and the difference in productivity and effectiveness of class time was evident. "
vii. "For some information in medical education, it's just eating to consume and memorize those facts, that type of information I think I'm about to be communicated via e-learning. However, I do think that there are other types of information in medical education, such as higher order, medical decision making and areas of communication that are quite difficult to learn an e-learning environment."
viii. "It is effective for some activities, but less so for others. "
ix. "Team based learning can be difficult, but lectures are equally good."
x. "Digital learning can be helpful when various barriers (limited time, geographical distance, etc) make in-person learning unavailable. However, I am more engaged during in-person learning. "

From the responses listed above, we can infer that American medical students accept the fact that some coursework can be delivered digitally, but also emphasize the nuance of medicine and recognize medical communication simply cannot be sufficiently learned through a computer screen.

b. Taiwan medical student responses:

i. "Medicine is constantly updated knowledge, and digital learning helps to present the latest knowledge."
ii. "Clinically relevant learning is less likely to be replaced by online courses."
iii. "I still think physical and online can go hand in hand. "
iv. "You can use a video or some three-dimensional pictures to make it easier for students to understand."
v. "It can be reviewed repeatedly, and there are new guidelines for quick updates and faster querying of knowledge content."

vi. "Pre-recorded videos can save time for teachers (avoid taking the same course many times), and can also increase students' learning efficiency (freely decide class time, video rate)."
vii. "If it is basic medical knowledge, it may be suitable, but many clinical contacts with patients, equipment operation, etc. still need physical courses."
viii. "Advantages: Take video learning as an example. You can study at a suitable time and place, usually in a good spirit and you can pause, listen again, and adjust the speed at places you don't understand. It is conducive to flexible learning. Disadvantages: If the video recording is not good, or the course schedule does not have enough rest time for students to take advantage of their studies, there is no way to flexibly choose the right time, and there is a lack of real-person interaction to deepen the impression."
ix. "Many operations cannot be taught by hand."
x. "I think this will be the norm in the future."
xi. "Digital learning can make good use of the pause and playback function, and learn according to your own understanding level. If you have understood the part, you can speed up, and if you don't understand the part, you can pause. It is very convenient. And for some medical content such as heart sounds, images, etc., personalized learning using digital resources is better. But if it involves discussion and asking questions, I feel that it is more interesting and rewarding to interact with teachers and classmates on the spot."
xii. "Suitable for most situations, only a small number of practical trainings are necessary for physical classes."
xiii. "Many lessons are recorded on video to allow students to play back and forth on what they don't understand, and to help with time allocation."
xiv. "Digital learning can make it easier for teachers to juggle student teaching with clinical work."
xv. "The lecture part can allow students to go back and listen to it if there is something they don't understand, and the study is more effective. But the clinical part may require practical contact and actual participation."
xvi. "There is still much to learn about the actual patient contact."
xvii. "Easy search for information."

xviii. "Intellectual learning is sometimes more efficient with online learning, but it is difficult to impress, and online learning cannot gain clinical experience. There are advantages and disadvantages."
xix. "Basic subjects agree to online courses because it is more efficient. For clinical practice, I do not want to change to online courses, because it will lose meaning."
xx. "I think that medical education often requires many different sensory stimuli, and demonstrations through many different media can help students understand better and more efficiently, while online learning will lack some real-time interactive functions. In addition, it will make everything into a sound plus a flat image, which I think will affect my learning effect."
xxi. "Online courses are suitable for medical principles courses, but physical courses are more suitable for clinical courses that sometimes require demos."
xxii. "I find it difficult to discuss."
xxiii. "Because there is always too much medical knowledge, it is impossible to learn about it in the classroom. If you can use the video to play it repeatedly, you can even check the information in the middle. I don't understand, or I don't have time to understand; in addition, the teachers in medical schools often don't teach well, the content is empty and boring, or they talk about things that are completely irrelevant to the class. If you use online classes, you can skip or fast-forward these parts."
xxiv. "Clinical practice section not fully appropriate"
xxv. "Digital learning approaches are still evolving and may not be suitable for medical education as currently used, but the flexibility of digital learning has the opportunity to provide other approaches."

The following themes can be summarized from the replies of the Taiwanese medical students:

- Recorded teaching materials can be watched repeatedly, which is helpful for understanding and content review. You can also adjust the speed of video playback to suit your needs, thereby increasing efficiency and autonomy of learning.
- Virtual discussions still have their limitations, and it is difficult to achieve the effect of face-to-face discussion.
- Clinical skills training requires physical courses, and it is difficult, if at all possible, to

replace it with digital learning.

- Medical education involves use of all 5 senses, and digital learning cannot fully recreate the face-to-face experience, which will hinder its effectiveness.
- Digital and physical courses can run side by side in a hybrid/blended model to achieve maximum efficiency.
- Online learning may be suitable for basic knowledge or introductory courses, but we still need in-person training for clinical skills and communication.
- Online learning can help mitigate socioeconomic difficulties caused by in-person courses such as transportation to class and cost of travel/food; thereby making the content more accessible and equitable.

5. Online learning effectiveness:

A total of 42 Taiwanese medical students were able complete the online course and pre/post-test assessment portion of the survey (Immediate Life Support Course). Among them, the paired sample T-test of the pre-test and post-test results shows that the average post-test score was 78.69 points (Table 6), which is higher than the pre-test average score of 69.05 points (Table 6), and that a statistically significant difference exists (Table 7).

Pre vs Post Test Score Descriptive Statistics

		mean	N	standard deviation	Standard error of the mean
pair 1	Post test Score	78.69	42	8.342	1.287
	Pre test Score	69.05	42	10.075	1.555

Table 6: Table depicting the descriptive statistics for the medical students in Taiwan who were able to complete the online course as well as the associated pre and post tests for the survey. Notable result is the higher mean post-test score.

Paired Sample T-Test Results of Difference in Post vs Pre Test Scores

		Paired difference test			95% Confidence Interval			
		mean	standard deviation	standard error of the mean	lower limit	upper limit	t	one-tailed p-value
pair 1	Post test Score – Pre test Score	9.643	8.930	1.378	6.860	12.426	6.998	<.001

Table 7: Table depicting the mean difference in post-test and pre-test score results, as well as the results of a paired sample T-test. Notable result is the p-value (<0.05) indicating a statistically significant difference in test score after completing the online learning portion.

Discussion

Several inferences can be made about the differences between students in the U.S. and Taiwan from the data we have collected and analyzed.

When examining the results of the survey on digital learning familiarity and experience, it was found that U.S. students were more familiar with digital learning platforms than Taiwanese students, but with regard to user experience, the responses of both cohorts did not present a statistically significant difference. This may be explained by the fact that medical schools in the United States employed more digital learning coursework prior to the pandemic than their Taiwanese counterparts and therefore students in the U.S. had more exposure to these avenues of learning. However, though they had been in use, many of these online services were merely supplemental to the classroom experience rather than serving as the primary mode of education delivery. Furthermore, with regard to overall negative student learning experience in both countries, this may be explained by several factors. Namely, the students represented in this data set were in the beginnings of their medical education when the pandemic began and therefore were likely stripped of the social/camaraderie aspects in-person learning provides [14]. For example, students likely were not as able to form social groups, exchange information/study habits, and generally felt more “alone” in their medical education experience.

We found that the scores of American medical students in Engagement of Performance (EPE) and Challenges of Technology e-learning (TC) are significantly higher than those of Taiwanese medical students. The former may be because the learning mentality of American students and overarching culture in America tends to pursue more grade-based “success” rather than true topic mastery. The latter is an inverse score question, so American students' higher scores may reflect that they have more experience with the challenges and negative experiences presented by online learning platforms.

Taiwanese medical students responded significantly more positively than American medical students in Engagement Skills (ES), e-learning Technology Benefits (TB), and Leisure interest on Technology (TL). There are many potential factors that may be explored to make sense of

these differences. For example, pandemic restrictions in the United States drug on for many months, and were largely unanticipated when they first began, so online learning was forced to be both implemented and continued with for well over a year. However, because Taiwan has a more global group of educators and learners, as well as sufficient online learning infrastructure, it may have indirectly narrowed the digital gap, and thereby increased the acceptance of digital learning by Taiwanese students. Undoubtedly, cultural differences and differences in each country's handling of COVID-19 social distancing guidelines also influence this data set[15]. American culture is far more freedom-based, and being forced to adapt to online learning was likely met with more inter and intra-personal resistance than it was in Taiwan.

In the Taiwanese medical school, online learning platforms include NTU MOOC, TMS and other platforms, as well as various online conference software that could be used for real-time synchronous teaching. Therefore, the infrastructure provided by the school for its students is believed to have been quite sufficient. In the U.S. school, equivalent or better resources existed, so differences in responses are not believed to be due to the presence or lack of sufficient online learning and/or synchronous video conferencing services.

Finally, when comparing the pre- and post-test results of 42 Taiwanese medical students who completed the online course portion, there is a significant difference. However, in the multivariate regression, we were not able to use the various aspects measured to find sufficient predictive learning outcomes. We speculate that success in the learning activities themselves involves multiple variables that can be difficult to quantify and cannot be discussed simply in terms of the students' attitudes and process of digital learning. For example, in addition to individual attitudes towards digital learning tools, factors that affect learning outcomes in distance courses include prior knowledge, learning motivation, learning management skills, etc [16].

Future Research Direction

There are several opportunities for future research based on the data collected in this study, as well as some its limitations.

First and foremost, it would have been ideal to have had larger sample sizes for both cohorts. Future research should seek to expand the sample size and even include students from a variety of phases in their training. Since this study focused on students at the beginning of their clinical training, future endeavors could seek to examine the opinions of students who were pre-medical school and/or medical residents who were fully immersed in their clinical training at the time the pandemic began. With these new data sets, we could gain insight into how virtual or semi-virtual/hybrid clinical training may have supplemented, or hindered, the clinical learning experience. Additionally, we may learn more about how an online pre-medical curriculum has affected now-matriculated medical students' performance, attitudes, and future willingness to participate in virtual classroom scenarios.

Additionally, we would like to have been able to have both cohorts complete the online course as well as the associated pre and post-tests. Since only the group from Taiwan was able to complete the portion, we are undoubtedly missing out on opportunities to glean valuable information on how students in the U.S. do or do not improve their performance after engaging with an online learning assessment.

Conclusion

In short, this project recruited two cohorts of medical students, one from the United States and one from Taiwan, and asked them to complete a comprehensive survey regarding their experiences with distance/virtual learning during the COVID-19 pandemic. Collection of this data was deemed meaningful due to several factors: the unprecedented nature of global lifestyle change during the pandemic, the lack of data examining the effects of COVID-induced virtual medical education, the fact that educators should have a way to quantify or approximate the degree to which online learning affected their students, and our own research curiosity regarding how these experiences may effect students' future willingness to participate in online curricula.

After collecting and analyzing the data, we were able to make several informative conclusions. First, both cohorts reported relatively strong familiarity and experience with online learning platforms. This means that neither group had significantly more or less familiarity/experience with digital learning going into the pandemic, and therefore we can assume they started from roughly level playing fields with regard to adjusting to a primarily digital medical school curriculum. Next, we collected data regarding each cohort's self-reported engagement with online learning, perceived benefit of these platforms, and leisure interest in technology. This is where the data became a bit more interesting. Across these measures, the Taiwanese students responded significantly more positively than their American counterparts. Several factors may explain these disparities, including the fact that American students continued to use online platforms for longer than their counterparts in Taiwan and therefore had more opportunities to see its shortcomings, as well as the undeniable but difficult to pin down cultural/social differences that exist in the two countries. Interestingly though, students in the U.S. responded more strongly to questions regarding their engagement, including items like, "I am working hard to get a good grade." We found this particularly interesting, especially when considering that most of the relatively more positive responses about online learning came from the Taiwan cohort. Though this difference is open to further interpretation, we believe it again harkens back to cultural and social differences between the two groups. American education focuses on grades, numbers, rankings, etc. while true subject mastery and functional knowledge is valued more in Taiwan. Finally, students in the U.S. also reported feeling more strongly about

the challenges imposed by online learning. This may be explained by some of the aspects discussed previously, but still provides valuable insight to the opinions and wellness of learners in both countries. All in all, Taiwanese students seem to be more willing and able to adapt to online learning and had less hesitancies about continuing to engage with it, whereas American students seemed to have more difficulty and hesitancy adapting to an online-only curriculum.

In addition to quantitative survey responses, we also provided a section for learners to create their own free-text statements. This was done to allow survey respondents to summarize their opinions in their own words, as well as to help us contextualize the quantitative data they provided. Though there were too many responses to thoroughly discuss them all here, several themes became evident. In general, both cohorts acknowledged that medicine is an inherently social practice filled with nuance, therefore online learning can only go so far in teaching the true art of medical practice and patient care. However, both cohorts agreed that digital platforms make educational material more accessible and equitable, while also allowing the learner to move at their own pace and more easily review topics that prove challenging. There were no opposing thoughts or opinions strongly held by one cohort and not the other, indicating that even through differing cultural and social lenses, medical students' learning experiences and desire for in-person interactions are constants.

Much discussion can be had about the nuances of these responses, but we believe the main takeaways are quite straightforward. First, learners who are engaging in a primarily online curriculum may require more frequent check-ins with faculty as well as more peer-to-peer support. Coursework can prove difficult and become daunting even in traditional classrooms, therefore the increased social isolation induced by online coursework undoubtedly leads to increased challenges for learners. Second, the cultures of individual students influence their willingness and ability to engage with, and excel, in online coursework. In particular, our data indicates students in the United States have a particular affinity for the traditional classroom and being in-person confers benefits beyond merely being face to face with instructors. There is undoubtedly an aspect of comradery students feel when learning amongst their peers that eases the difficulties of advancing through a medical school curriculum. Third, caution should be taken by educators when employing online-based coursework or meeting platforms. Though virtual

classroom settings increase accessibility, ineffable changes seem to occur within the student-to-student and instructor-to-student dynamic that most students appear to agree is not for the better. Finally, and most importantly, virtual curricula simply cannot fully teach the "art" of medicine. Instructors, students, and patients lose the ability to employ all five of their senses as well as the ability to communicate conversationally. Subtle changes in body language cannot be perceived, certain smells and/or textures cannot be noticed, and the critical human connection between patient and provider cannot be fully formed.

Virtual learning was a necessary adaptation to COVID-19-induced social restrictions and allowed students to continue their education, but it was not without its own consequences. In the future, especially in medical education, we believe efforts should be made to maximize the amount of in-person learning that occurs. These efforts will benefit students, as well as their future patients, in innumerable ways. Medicine is an art, embodying a delicate dance of communication and trust that cannot be sufficiently recreated in a virtual environment.

Compliance

We have no required regulatory compliance issues to describe or discuss.

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