Does the Choice of Teaching Approach and ICT affect Teaching Quality During the Global COVID-19 Pandemic? A Case Study from Suranaree University of Technology

Somjin Phiakoksong[1,*], Sudarat Noimano[1] and Prapat Pentamwa[2]

[1]Faculty Development Academy, Suranaree University of Technology, Nakhon Ratchasima 30000, Thailand
[2]School of Environmental Health, Institute of Public Health, Suranaree University of Technology, Nakhon Ratchasima 30000, Thailand

[*]Corresponding author's e-mail: somjin@sut.ac.th

Received: *September 19, 2021* ***Revised:*** *December 27, 2021* ***Accepted:*** *September 7, 2021*

Abstract

The global pandemic has disrupted conventional higher education that relies on in-person instruction. Online instruction has largely replaced in-person instruction in regions where COVID-19 restrictions are firm. This study investigates teaching pattern effectiveness and ICT use support at Suranaree University of Technology (SUT). The data were collected from 377 students and 217 teachers via online questionnaires. The Multivariate Analysis of Covariance (MANCOVA) and the Tukey-HSD method were able to identify significant trends in teaching approaches and ICT usage affecting both teaching and learning achievements. The results showed that effective teaching techniques included (1) Pre-recorded teaching videos as the main process at medium usage (average at 51.92% of teaching time) combined with (2) F2F live teaching and/or (3) Homework and assignments at low usage (average at 28.14% and 26.28% of teaching time, respectively). The ICT with significant impacts on teaching achievement were (1) ICT for communication i.e., Zoom Meeting and (2) ICT for classroom participation specifically Google forms. These teaching approaches and ICT usages patterns may support student were achievement and thus their learning during the global COVID-19 pandemic.

Keywords: ICT for teaching, Online teaching, Teaching support, Internet platforms, Pedagogy

Introduction

Many international organizations like The United Nations Educational, Scientific and Cultural Organization (UNESCO), The Organization for Economic Co-operation and Development (OCED), The United Nations Children's Fund (UNICEF) put forth education as a fundamental tenet for quality of life. Conventional education management operates in

classrooms with the instructor playing a central role in learning (Lathan, 2021). Globally, instructors and pedagogical practitioners have developed numerous techniques to aid in class learning and engagement: Think-pair-share, Improvisational games, Brain writing, and Peer review (Gogus, 2012). These more active learning approaches enhance higher order cognitive skills among the student community., Students participate more in their learning by thinking, creating, discussing and investigating (Madhuri et al., 2012), leading to improved learning.

The "CoronaVirus (COVID-19)" has led to a current global pandemic resulting in a slew of unexpected challenges for educators at the global scale (Schleicher, 2020). Governments and educational institutions have launched prevention policies and many have promoted online learning as the main teaching activity (The United Nations Educational, Scientific and Cultural Organization, 2021; Harris et al., 2020). Suranaree University of Technology (SUT) is a university that promotes online teaching and supporting technological innovation for instructors. However, rapid changes in teaching processes may have resulted in reduced teaching quality (Appendix A).

This study aims to investigate the effectiveness of online teaching and ICT (In the case of applications that integrateonline teaching) materials on the teaching and learning process.

Teaching approach and model in digital age

Teaching approaches

The prime teaching process, "Face-to-Face" (F2F) is effective because the student and instructor meet at a set place for a set time providing structure to the learning environment (Elson, 2014). Despite mounting evidence for comparable learning quality with online teaching (Hoffman & Elmi, 2021; Race et al., 2021; Harris et al., 2020), in person teaching provides a wealth of learning benefits beyond online education (Gacs et al., 2020). Teaching and learning strategies and context have changed over the last decade. Educators have developed more effective teaching approaches within a variety of learning environments (Gogus, 2021; Lathan, 2021; Hoidn & Klemenčič, 2020; Dziuban et al., 2018). Two main approaches dominate pedagogy in higher learning: "Teacher-centered" and "Student-centered" learning.

The Teacher-centered approach is where the teacher presents information to the students and acts in a classical lecturer role; students typically remain passive with regards to the learning environment here (Murphy et al., 2021). Direct Instruction, Flipped Classrooms, and Kinesthetic Learning (Hand-on learning), are examples of this approach. While this approach has merits such as greater structure and often less preparation time, it has a number of drawbacks given students tend to have less engagement in the material (Lathan, 2021; Garrett, 2008).

Student-centered approaches aim to foster a sense of ownership and agency in the student's learning and by definition result in a more active student environment (Murphy et al., 2021). Student centered approaches allow students to be the masters of their own learning. Differentiated Instruction, Problem-Based Learning, Inquiry-Based Learning and others are examples (Ireri et al., 2017). Activities to support student engagement and a more open learning

environment typically take the form of student-centered approaches. Brainstorming, Classroom discussion, Role playing, etc. (Lathan, 2021) are common in student-centered classrooms.

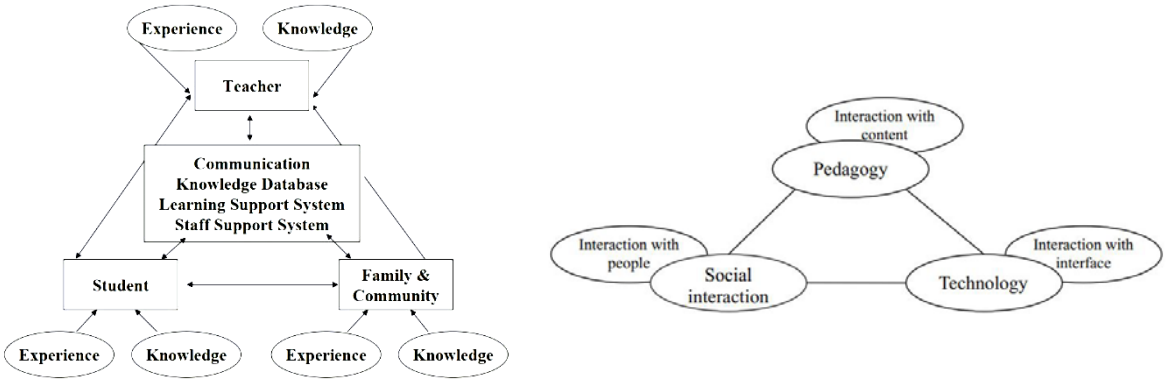
In 2013, the term "Blend-Based learning" (a.k.a "Hybrid-learning") came into widespread use (Oleksandra et al., 2015). This approach embeds readily available technology to enhance the learning process (Dziuban et al., 2018; Ossiannilsson, 2016). Both internet access and computational devices (Computer and Handheld devices) are necessary for supplying course contents to the student and engaging students outside the classroom (Ustun, 2019; Xiao et al., 2020).

Finally, when students are "master learners", they can extend beyond the course framework and follow up by developing further relevant skills (Klemenčič, 2017). The concept of "lifelong learning" is a core tenet in higher education and many educators aim to engender this quality in their learners (The United Nations Educational, Scientific and Cultural Organization, 2020; Carr et al., 2018). Lifelong learning courses should consist of activities extending beyond typical school ages, and support for longer term learning processes (Kaplan, 2015).

Teaching and learning components in digital age

Technology has been embedded in teaching and learning, since 1990. Branson proposed a diagram intended to adapt a technology-based model from traditional approaches (Branson, 2000). He presented a technology-based model consisting of 4 major components: (1) Teacher; (2) Student; (3) Family & Community; and (4) ICT systems such as the Communication, Knowledge database, Learning support systems, and Staff supporting systems (Figure 1a).

The Generic Model coined by Wang in 2008 is most similar to the proposed model of Branson in 2000. It consists of 3 key components of design to reach effective ICT support teaching and learning: (1) Pedagogy, (2) Social interactions, and (3) Technology. Proper pedagogical practice must consider using ICT resources in an effective way in order to scaffold students during their learning processes. Social Interaction for ICT should support social activities and provide students with opportunities to collaborate and flexibly share problems. Technology should be user-friendly, easy to use, and support the online learning environment by being available continuously, and being both fast and convenient to access (Wang, 2008), (Figure 1b).



(a) The Branson Learning model (b) The Generic Model for support teaching and learning

Figure 1 Integration of ICT in Teaching and Learning Process
Source: (a) Branson (2000), (b) Wang (2008)

The above models suggest that ICT is a compulsory component of teaching capable of enhancing learning during the digital age with appropriate use. For example, on site, communication between teacher and student is often conveyed via audio systems. This could easily be adapted to teleconferencing.

ICT for support teaching and learning (in SUT context)

The Information and Communication Technology (ICT) paradigm has gained recognition since the mid-1990s. Certain technologies are already abundant: Classroom Video Recordings (CVR) , Computer Assisted Instruction (CAI) , and Educational Television Channels. In the last two decades, there have been many technological advances leading to a greater presence of technology in the learning environment.

In the SUT context, after the government of Thailand announced the first COVID-19 infection on Thai soil, the government also passed policies to inhibit the spread of COVID-19. The SUT administrators responded to government mandates by: (1) Informing all students and staff of the pandemic situation and restricting of traveling aboard for foreign students from/to SUT, and requested for extra-permission if anyone whose need to travel crossing the living area, (2) Prohibiting activities consisting of large groups, (3) Providing all courses via online platforms, and (4) Enforcing a Work from Home strategy to limit contact.

Learning Management Systems (LMS) emerged long ago and have become widespread. These systems are mainly ICT used to support teaching and learning processes outside the classroom During the pandemic crisis, E-courseware use in SUT doubled (597 E-courses in 2019s and 1,099 in 2020s). The educational support unit, the Faculty Development Academy (FDA) provided many urgent training courses to develop teaching quality i.e., Hybrid learning & Active learning approaches, Designing effective assessments, and also Technology

to enhance student learning, etc. During the pandemic crisis, there were many new ICT training events (both internal/external training) organized for all SUT Instructors.

Recently, there are many products that consisting of different designs and functions implemented in the teaching and learning process. The administration of SUT has given instructors the freedom to select and used both commercial and freeware products to support their learning mission during COVID-19 pandemic. These educational softwares could roughly categorize into 4 groups based on their main function including; (1) Communication; (2) Video and screen recorders; (3) Content management; and (4) Classroom participation (Figure 2).

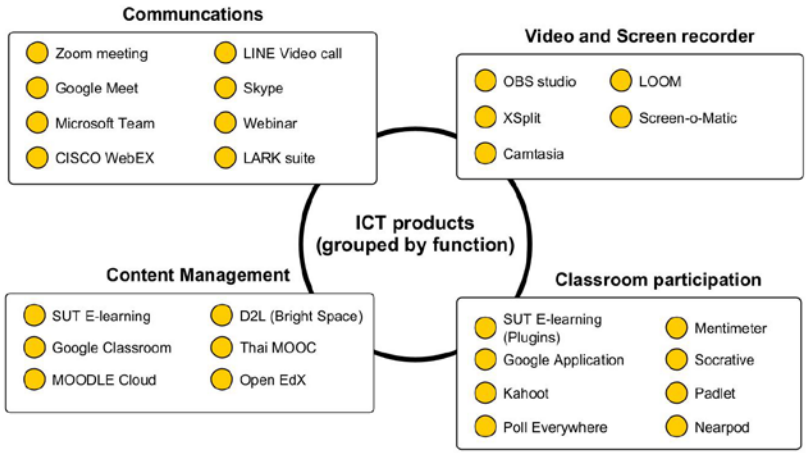


Figure 2 Categorization of various ICT to support teaching and learning in SUT

Methodology

Population and samples

This research investigation began during the first wave of the COVID-19 pandemic equating to the SUT 3rd trimester of the academic year 2019 (March 21 - July 10, 2020). The populations of interest for this study were full time lecturers and the current undergraduate SUT students. There were 15,343 students and 487 lecturers at SUT during the study. The Krejcie and Morgan table was used to determine the optimal sample size at the 95% confidence level (Krejcie & Morgan, 1970). The total number of samples were 594 which consisted of the 377 students and 217 teachers. Sample units were drawn with proportional stratified random sampling throughout the 8 institutes at SUT. After the sample size was determined the data were collected via an online questionnaire (the questionnaire; https://bit.ly/3p8k2Ly). Figure 3 shows that most responders were students and teachers from the Institute of Engineering (65.52% and 35.19%, respectively).

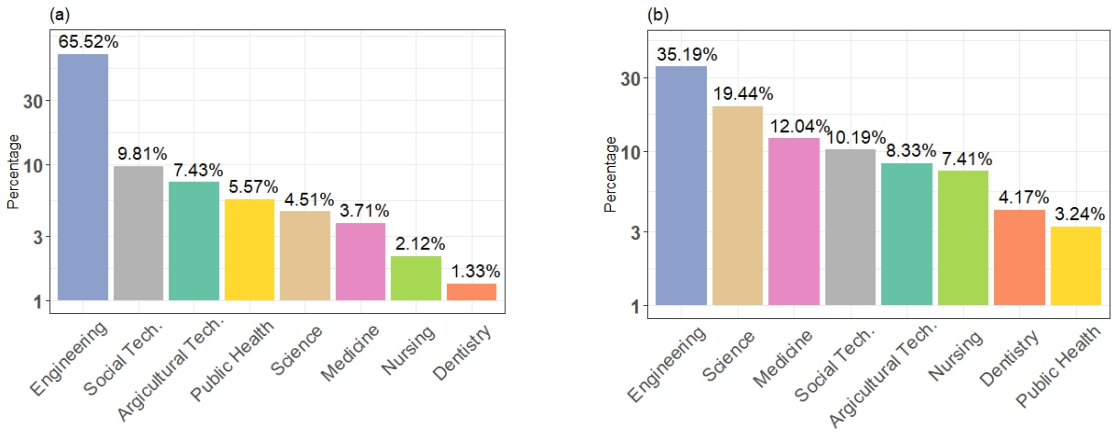


Figure 3 (a) Percent of students, and (b) Percent of teachers who responded the questionnaire organized by institute ratios

Instruments and data collecting

The authors developed a questionnaire (the usage of 14 different teaching approaches and 4 categories of ICT) as the main investigative instrument to survey the context of teaching process. It had sufficient research instrument quality based on the reliability coefficient (Cronbach's α at 0.83) and validity score (Average of IOC at 0.85). The data were collected after the 3rd trimester was finished. It was collected via an online platform (which all responses received between 1st August to 30th November 2020). Other compulsory data were compiled including; (1) the SUT teaching effectiveness survey forms (TEF). The TEF score was collected by the Unit of Teaching Effectiveness Evaluation of Faculty Development Academy of SUT, and (2) SUT Class Grade Point Average (CGPA). The CGPA is the grade average score of a subject which is reported by the Center of Educational Service of SUT (the data source; https://bit.ly/3EgVYKE)

Data manipulation and analysis

The collected data for sample groups were analyzed with descriptive statistics i.e.; Frequencies (*f*), Percentages (*%*), Means ($\bar{x}$) and Standard Deviation (*S.D.*) where appropriate. The Pearson correlation (ρ) was used to present the trend and strength of the relationship between CGPA and TEF-score of 3rd trimester of 2018 (On-site teaching) and 3rd trimester of 2019 (Online teaching) (in Appendix A). The Multivariate Analysis of Covariance (*MANCOVA*) and corresponding the post-hoc Tukey-HSD method was used to determine significant trends between teaching approaches and ICT use patterns that affect either TEF-score and CGPA or both. For the MANCOVA analysis, side effects of classroom size on analytical results were conducted by setting "Class Size" as the controlled variables for this study.

To identify significance with Tukey-HSD, the pattern of the Teaching approach and ICT usage were encoded as a sequence of digit numbers (corresponding with top 3 popular selections from sample groups). The patterns encoded were described as follows;

- Positions of numbers (3 digits from left to right): are sequence of top 3 popular usage approaches variables.
- Definition of a digits: value representation on each position i.e.; "1" is Unused (0% usages), "2" is Low usages (1-39%), "4" is Medium usages (40-79%), and "8" is High usages (80-100%).

Example: A pattern of the top 3 Teaching approach variables was represented as "218" (the list of teaching approaches is presented in Table 1). It is teacher used the F2F at Low usages, unused of Pre-recorded teaching videos and High usages of Homework and Assignments.

This encoding process was used to manipulate other variables data for the multiple comparison analysis.

Results

Teaching approaches usage

Table 1 Percentage of teaching approaches used within SUT classes during the 2019 of COVID-19 pandemics

	Teaching approaches	**Usage ratios (%)**					
		Unused	**1-20%**	**21-40%**	**41-60%**	**61-80%**	**81-100%**
TS-1	F2F (Live teaching)	252 (44.06%)	***196*** ***(34.27%)***	18 (3.15%)	20 (3.50%)	27 (4.72%)	59 (10.31%)
TS-2	Pre-recorded teaching videos	41 (7.17%)	45 (7.87%)	46 (8.04%)	16 (2.80%)	73 (12.76%)	***351*** ***(61.36%)***
TS-3	Video recorded of other (selected by teacher).	467 (81.64%)	82 (14.34%)	2 (0.35%)	4 (0.70%)	2 (0.35%)	15 (2.62%)
TS-4	Homework and Assignment	165 (28.85%)	***236*** ***(41.26%)***	51 (8.92%)	28 (4.90%)	77 (13.46%)	15 (2.62%)
TS-5	Small group discussion	419 (73.25%)	30 (5.24%)	20 (3.50%)	6 (1.05%)	–	97 (16.96%)
TS-6	Activity Based learning	412 (72.03%)	52 (9.09%)	53 (9.27%)	33 (5.77%)	5 (0.87%)	17 (2.97%)
TS-7	Problem Based learning	424 (74.13%)	51 (8.92%)	40 (6.99%)	12 (2.10%)	23 (4.02%)	22 (3.85%)
TS-8	Project Based learning	499 (87.24%)	11 (1.92%)	24 (4.20%)	4 (0.70%)	9 (1.57%)	25 (4.37%)

	Teaching approaches	Usage ratios (%)					
		Unused	**1-20%**	**21-40%**	**41-60%**	**61-80%**	**81-100%**
TS-9	Research Based learning	514 (89.86%)	24 (4.20%)	7 (1.22%)	2 (0.35%)	20 (3.50%)	5 (0.87%)
TS-10	Collaborative learning	472 (82.52%)	43 (7.52%)	22 (3.85%)	4 (0.70%)	17 (2.97%)	14 (2.45%)
TS-11	Inquiry Based Learning	452 (79.02%)	83 (14.51%)	5 (0.87%)	5 (0.87%)	23 (4.02%)	4 (0.70%)
TS-12	Role-playing Model	502 (87.76%)	54 (9.44%)	16 (2.80%)	–	–	–
TS-13	Gamification	548 (95.80%)	18 (3.15%)	–	2 (0.35%)	–	4 (0.70%)
TS-14	Computer simulation & virtual classroom	556 (97.20%)	8 (1.40%)	–	4 (0.70%)	2 (0.35%)	2 (0.35%)
TS-15	Other approach	553 (96.68%)	7 (1.22%)	12 (2.10%)	–	–	–

Teaching approaches vary at SUT especially compared with those used in online teaching (Table 1). The most common online teaching technique was (TS-2) Pre-recorded teaching videos, (61.36% assigned students to observed pre-recorded videos between 81-100% of teaching time). The second most common learning activities were (TS-4) homework and assignments (41.26% assigned work to students from 1-20% of teaching time). The third most common was (TS-1) F2F (live teaching), 34.27% of samples used it at 1-20% of teaching time.

Information and Communication Technology for teaching support usage

Tables 2-5 show usage ratios of Information and Communication Technology (ICT) in the several functions in SUT teaching process during the first wave of COVID-19 pandemic.

Table 2 Percentage of using ICT for Classroom Communication within SUT classes during the 2019 of the COVID-19 pandemics

	Communications	Usage ratios (%)					
		Unused	**1-20%**	**21-40%**	**41-60%**	**61-80%**	**81-100%**
TEC-1	ZOOM MEETING	167 (29.20%)	99 (17.31%)	–	8 (1.40%)	39 (6.82%)	***259 (45.28%)***
TEC-2	GOOGLE MEET	463 (80.94%)	39 (6.82%)	2 (0.35%)	2 (0.35%)	–	***66 (11.54%)***
TEC-3	MICROSOFT TEAM	567 (99.13%)	–	–	–	–	5 (0.87%)
TEC-4	CISCO WEBEX	534 (93.36%)	36 (6.29%)	–	–	2 (0.35%)	–

	Communications	Usage ratios (%)					
		Unused	**1-20%**	**21-40%**	**41-60%**	**61-80%**	**81-100%**
TEC-5	LINE VIDEO CALL	521 (91.08%)	28 (4.90%)	23 (4.02%)	–	–	–
TEC-6	SKYPE	569 (99.48%)	–	–	–	–	3 (0.52%)
TEC-7	WEBINAR	572 (100.00%)	–	–	–	–	–
TEC-8	FACEBOOK LIVE	480 (83.92%)	***40 (6.99%)***	17 (2.97%)	4 (0.70%)	14 (2.45%)	17 (2.97%)
TEC-9	LARK Suit	572 (100.00%)	–	–	–	–	–
TEC-10	Other (LINE Group, Messenger)	538 (94.06%)	15 (2.62%)	2 (0.35%)	–	2 (0.35%)	15 (2.62%)

In Table 2, the most commonly reported tool is (TEC-1) ZOOM MEETING reported by 45.28% of samples that used it at 81-100% of teaching time. Followed by (TEC-2) GOOGLE MEET reported by 11.54% of samples that used it at 81-100% of teaching time, and the third most commonly reported tool was (TEC-8) FACEBOOK LIVE, reported by 6.99% of samples that used it at 1-20% of teaching time.

Table 3 Percentage of using ICT for Video and Screen recorders for Pre-recorded of teaching during the 2019 of the COVID-19 pandemics

	Video and screen recorder	Usage ratios (%)					
		Unused	**1-20%**	**21-40%**	**41-60%**	**61-80%**	**81-100%**
VR-1	OBS Studio	371 (64.86%)	–	18 (3.15%)	8 (1.40%)	22 (3.85%)	***153 (26.75%)***
VR-2	XSplit	572 (100.00%)	–	–	–	–	–
VR-3	Camtasia	542 (94.76%)	2 (0.35%)	8 (1.40%)	2 (0.35%)	–	***18 (3.15%)***
VR-4	LOOM	550 (96.15%)	2 (0.35%)	2 (0.35%)	13 (2.27%)	3 (0.52%)	2 (0.35%)
VR-5	Screencast O-matic	572 (100.00%)	–	–	–	–	–
VR-6	Others (ZOOM Meeting, Power-Point, et. al.)	397 (69.41%)	10 (1.75%)	2 (0.35%)	17 (2.97%)	–	***146 (25.52%)***

Table 3 shown the most commonly reported was (VR-1) Open Broadcaster Software (OBS) Studio reported by 26.75% of samples that used it at 81-100% of the teaching time. The second most popular was (VR-6) Others (ZOOM meeting, PowerPoint, et. al.) which were reported by 25.52% of samples that used it at 81-100% of teaching time, and third was (VR-3) Camtasia, where 3.15% of samples used it at 81-100% of teaching time.

Table 4 Percentage of using ICT for Content managements within SUT classes during the 2019 of the COVID-19 pandemics

	Content managements	**Usage ratios (%)**					
		Unused	**1-20%**	**21-40%**	**41-60%**	**61-80%**	**81-100%**
LMS-1	SUT E-Learning	200 (34.97%)	17 (2.97%)	17 (2.97%)	–	22 (3.85%)	***316 (55.24%)***
LMS-2	Google Classroom	458 (80.07%)	4 (0.70%)	–	5 (0.87%)	37 (6.47%)	***68 (11.89%)***
LMS-3	MOODLE Cloud	568 (99.30%)	4 (0.70%)	–	–	–	–
LMS-4	D2L (Bright Space)	572 (100.00%)	–	–	–	–	–
LMS-5	THAI MOOC	568 (99.30%)	4 (0.70%)	–	–	–	–
LMS-6	Open EdX	572 (100.00%)	–	–	–	–	–
LMS-7	Others (YouTube studio, Google site et. al)	546 (95.45%)	2 (0.35%)	3 (0.52%)	–	2 (0.35%)	***19 (3.32%)***

The most commonly reported tools used by teachers between 81-100% of the time were: ICT for Content managements ranking The SUT E-learning (LMS-1), a MOODLE Based Learning Management System with some development features by SUT (55.24% of respondents); followed by Google Classroom (11.89% of respondents); and Others (LMS-7) including YouTube studio, Google site and others (3.32% of respondents).

Table 5 Percentage of using ICT for Classroom participation within SUT classes during the 2019 of the COVID-19 pandemics

	Classroom participation	**Usage ratios (%)**					
		Unused	**1-20%**	**21-40%**	**41-60%**	**61-80%**	**81-100%**
TAC-1	SUT E- Learning (plugins)	250 (43.71%)	9 (1.57%)	10 (1.75%)	–	19 (3.32%)	***284 (49.65%)***
TAC-2	Google Application	433 (75.70%)	4 (0.70%)	6 (1.05%)	2 (0.35%)	8 (1.40%)	***119 (20.80%)***
TAC-3	Kahoot	549 (95.98%)	9 (1.57%)	***14 (2.45%)***	–	–	–
TAC-4	Poll Everywhere	562 (98.25%)	6 (1.05%)	4 (0.70%)	–	–	–
TAC-5	Mentimeter	562 (98.25%)	–	4 (0.70%)	4 (0.70%)	2 (0.35%)	–
TAC-6	Socrative	559 (97.73%)	–	–	13 (2.27%)	–	–
TAC-7	Padlet	561 (98.08%)	2 (0.35%)	–	2 (0.35%)	–	7 (1.22%)
TAC-8	Nearpod	570 (99.65%)	2 (0.35%)	–	–	–	–
TAC-9	Others (Edpuzzle, Quizizz, etc.)	562 (98.25%)	–	5 (0.87%)	2 (0.35%)	–	3 (0.52%)

Table 5 shows the most commonly reported tools for enhancing classroom participation used by teachers between 81-100% of the time were: ICT SUT E-learning (TAC-1) plugins (49.65% of respondents). Google Applications (TAC-2) with 20.80%, and (TAC-3) Kahoot, 2.45% of samples used it at 21-40% of teaching time. However, Padlet is an application for classroom participation that it was using at 81-100%.

Comparison of effective teaching approaches and ICT supporting
Teaching approach

Table 6 MANCOVA of Teaching approaches on Teaching effectiveness and Class grade point average

Independent Var.	Dependent Var.	Type III SS	df	MS	F	p-value
Class Size	CGPA	110.399	1	110.399	214.472	0.000
(Controlled var.)	TEF	26.658	1	26.658	141.335	0.000
TS-1	CGPA	1.371	3	0.457	0.888	0.447
(F2F Live teaching)	TEF	0.990	3	0.330	1.750	0.155
TS-2	CGPA	0.904	3	0.301	0.585	0.625
(Pre-recorded teaching videos)	TEF	0.140	3	0.047	0.248	0.863
TS-4	CGPA	0.930	3	0.310	0.602	0.614
(Homework and Assignment)	TEF	0.634	3	0.211	1.120	0.340
TS-1 * TS-2	CGPA	4.685	8	0.586	1.138	0.334
	TEF	1.556	8	0.194	1.031	0.410
TS-1 * TS-4	CGPA	6.684	9	0.743	1.443	0.164
	TEF	1.475	9	0.164	0.869	0.552
TS-2 * TS-4	CGPA	3.707	9	0.412	0.800	0.616
	TEF	1.696	9	0.188	0.999	0.438
TS-1 * TS-2 * TS-4	**CGPA**	19.744	19	1.039	2.019	**0.005****
	TEF	8.093	19	0.426	2.258	**0.001****

*** Statistically Significant at 0.01*

There was an interaction effect between 3 different teaching approaches (F2F Live teaching, Pre- recorded teaching videos, and Homework and Assignment) on Teaching effectiveness and Class grade point average with statistical significance at alpha of 0.01. Other mixes of teaching approaches did not significantly affect Teaching effectiveness and Class grade point average.

Table 6 shows the statistical significance of teaching patterns. The Tukey-HSD method was used to investigate and identify effective teaching patterns as shown in Table 7-8.

Table 7 Tukey-HSD test of teaching approach pattern on Teaching effectiveness and Class grade point average

Dependent Var.	Pattern (1)	Pattern (2)	Diff. Score	S.E.	p-value
CGPA[a]	**281**	242	0.555	0.137	**0.039***
	442	242	0.731	0.174	**0.021***
	848	242	0.513	0.115	**0.008****
TEF[b]	–	–	–	–	–

*** Statistically significant at 0.01, * Statistically significant at 0.05*

(a) Only the significant patterns were selected to report,

(b) There were the statistically significant for LSD method (Least Significance Difference Test)

Table 8 Average percentage of most popular teaching approaches usage

Teaching approaches	Unused	Low	Medium	High
		$\bar{x}$ (σ)	$\bar{x}$ (σ)	$\bar{x}$ (σ)
TS-1 (F2F Live teaching)	–	28.14 (9.83)	47.27 (9.61)	95.25 (8.50)
TS-2 (Pre-recorded teaching videos)	–	25.59 (8.97)	51.92 (9.81)	89.74 (9.99)
TS-4 (Homework and Assignment)	–	26.28 (9.28)	52.19 (9.75)	89.81 (10.00)

Mixing of the teaching approach pattern with an effect on CGPA are: (442) Medium use of "F2F Live teaching" (average of usage at 47.72%), Medium use of "Pre-recorded teaching videos" (average of usage at 51.92%), and Low use of "Homework and Assignments" (average of usage at 26.28%). (281) Low use of "F2F Live teaching" (average of usage at 28.14%), High use of "Pre-recorded teaching videos" (average of usage at 89.74%), and lack of "Homework and Assignments" (unused), and (848) High use of "F2F Live teaching" (average of usage at 95.25%), Medium use of "Pre-recorded teaching videos" (average of usage at 51.92%), and High use of "Homework and Assignment" (average of usage at 89.81%). These patterns yielded higher CGPA than (242) Low use of "F2F Live teaching" (average of usage at 28.14%), Medium use of "Pre-recorded teaching videos" (average of usage at 51.92%), and low use of "Homework and Assignments" (average of usage at 26.28%) with statistically significance at alpha of 0.01. Other teaching approaches and patterns lacked differences in CGPA.

ICT for support teaching approach

Table 9 MANCOVA of ICT for Communication on Teaching effectiveness and Class Grade Point Average

Independent var.	Dependent var.	Type III SS	df	MS	F	p-value
Class Size	CGPA	89.398	1	89.398	172.924	0.000
(Controlled var.)	TEF	23.812	1	23.812	126.438	0.000
TEC-1	CGPA	1.327	3	0.442	0.855	0.464
(Zoom Meeting)	TEF	1.069	3	0.356	1.892	0.129
TEC-2	CGPA	1.713	3	0.571	1.105	0.346
(Google Meet)	TEF	0.535	3	0.178	0.946	0.417
TEC-8	CGPA	1.031	3	0.344	0.664	0.574
(Facebook Live)	TEF	1.134	3	0.378	2.006	0.111
TEC-1 * TEC-2	CGPA	3.067	7	0.438	0.847	0.548
	TEF	2.036	7	0.291	1.544	0.147
TEC-1 * TEC-8	CGPA	2.894	9	0.322	0.622	0.779
	TEF	4.849	9	0.539	2.861	**0.002****
TEC-2 * TEC-8	CGPA	3.165	8	0.396	0.765	0.634
	TEF	2.276	8	0.284	1.510	0.148
TEC-1*TEC-2*TEC-8	CGPA	5.605	14	0.400	0.774	0.698
	TEF	4.161	14	0.297	1.578	0.077

*** Statistically significant at 0.01*

Use of 2 different ICT for Communication (Zoom Meeting and Facebook Live) affected the Teaching Effectiveness with statistical significance at alpha of 0.01 (Table 9). Other mixes of ICT for Communication approaches did not affect Teaching Effectiveness and Class Grade Point Average.

Table 10 Tukey-HSD test of ICT for communication on Teaching effectiveness and Class grade point average

Dependent Var.	Pattern (1)	Pattern (2)	Diff. Score	S.E.	p-value
TEF[a]	**81**	11	0.148	0.031	**0.000****
	81	14	0.107	0.030	**0.032***
	81	21	0.173	0.050	**0.044***
	82	11	0.155	0.033	**0.000****
	82	14	0.113	0.032	**0.038***
	82	21	0.180	0.051	**0.040***

*** Statistically significant at 0.01, * Statistically significant at 0.05*

(a) Only the significant patterns were selected to report

Table 11 Average percentage of ICT for communication usage

Communication	Unused	Low $\bar{x}$ (σ)	Medium $\bar{x}$ (σ)	High $\bar{x}$ (σ)
TEC-1 (Zoom Meeting)	–	25.06 (8.70)	50.47 (9.99)	94.16 (9.09)
TEC-2 (Google Meet)	–	24.54 (8.39)	49.45 (10.01)	92.05 (9.80)
TEC-8 (Facebook Live)	–	30.21 (10.00)	44.79 (8.54)	95.95 (8.03)

In Table 10-11, the mix of ICT Communication tools that have an effect on TEF are: (81) High use of "Zoom Meetings" (average of usage percent at 94.16) and lack of "Facebook Live" (Unused), and (82) High use of "Zoom Meetings" (average of usage at 94.16%) and Low use of "Facebook Live" (average of usage at 30.21%). Both of these patterns yield TEF higher than the pattern of (11) lacking both "Zoom Meetings" (Unused) and "Facebook Live" (Unused), (14) lack of "Zoom Meetings" (Unused) and Medium used of "Facebook Live" (average of usage at 44.79%), and (21) Low use of "Zoom Meetings" (average of usage at 25.06%) and lack of "Facebook Live" (Unused) with statistical significance (alpha of 0.05). Other ICT Communication supporting patterns showed no statistical differences on TEF.

Table 12 MANCOVA of ICT for Content management on Teaching effectiveness and Class grade point average

Independent Var.	Dependent Var.	Type III SS	df	MS	F	p-value
Class Size	CGPA	101.060	1	101.060	193.596	0.000
(Controlled var.)	TEF	29.666	1	29.666	156.792	0.000
LMS-1	CGPA	1.832	3	0.611	1.170	0.320
(SUT E-learning)	TEF	0.198	3	0.066	0.348	0.790
LMS-2	CGPA	0.395	3	0.132	0.252	0.860
(Google Classroom)	TEF	0.603	3	0.201	1.062	0.364
LMS-7	CGPA	0.090	3	0.030	0.057	0.982
(Others LMS)	TEF	0.783	3	0.261	1.380	0.247
LMS-1 * LMS-2	CGPA	1.811	8	0.226	0.434	0.902
	TEF	1.859	8	0.232	1.228	0.278
LMS-1 * LMS-7	CGPA	3.190	6	0.532	1.019	0.411
	TEF	1.249	6	0.208	1.100	0.360
LMS-2 * LMS-7	CGPA	0.800	6	0.133	0.255	0.957
	TEF	1.126	6	0.188	0.992	0.429
LMS-1*LMS-2*LMS-7[b]	CGPA	0.146	3	0.049	0.093	0.964
	TEF	2.013	3	0.671	3.547	**0.014***

** Statistically significant at 0.05*

(a) There were the statistically significant for LSD approach

The 3 different ICT for content management (SUT E-learning, Google Classroom, and Other LMS) impacted teaching effectiveness significantly (alpha of 0.05). While, using only one ICT Communication supporting and other mixing between 2 differences ICT Communication supporting failed to significantly affect Teaching Effectiveness and Class Grade Point Average. However, Post-hoc analysis revealed that mixing of 3 different ICT content management strategies were not substantially different from other approaches.

Table 13 MANCOVA of ICT for Video and screen recorder on Teaching effectiveness and Class grade point average

Independent var.	Dependent var.	Type III SS	df	MS	F	p-value
Class Size	CGPA	21.076	1	21.076	40.320	0.000
(Controlled var.)	TEF	3.149	1	3.149	18.314	0.000
VR-1	CGPA	0.134	2	0.067	0.128	0.880
(OBS Studio)	TEF	0.023	2	0.011	0.066	0.936
VR-3	CGPA	2.152	3	0.717	1.373	0.250
(Camtasia)	TEF	0.523	3	0.174	1.013	0.387
VR-6	CGPA	0.092	3	0.031	0.058	0.981
(Other video recorder)	TEF	0.943	3	0.314	1.828	0.141
VR-1 * VR-3	CGPA	0.724	3	0.241	0.462	0.709
	TEF	0.681	3	0.227	1.320	0.267
VR-1 * VR-6	CGPA	1.281	4	0.320	0.612	0.654
	TEF	0.590	4	0.147	0.858	0.489
VR-3 * VR-6	CGPA	0.131	1	0.131	0.251	0.616
	TEF	0.003	1	0.003	0.018	0.893
VR-1 * VR-3 * VR-6	CGPA	0.000	0	-	-	-
	TEF	0.000	0	-	-	-

Using only one of each, and the interaction between use of 2 or 3 different ICT for video and screen recorder (OBS Studio, Camtasia, and other video recorder) had no significant effect on the Teaching Effectiveness and Class Grade Point Average (Table 13).

Table 14 MANCOVA of ICT for Classroom participation on Teaching effectiveness and Class grade point average

Independent Var.	Dependent Var.	Type III SS	df	MS	F	p-value
Class Size	CGPA	95.683	1	95.683	184.177	0.000
(Controlled var.)	TEF	24.633	1	24.633	130.488	0.000
TAC-1	CGPA	0.268	3	0.089	0.172	0.915
(SUT E-learning plugin)	TEF	0.528	3	0.176	0.932	0.424
TAC-2	**CGPA**	5.990	3	1.997	3.844	**0.009****
(Google Application)	TEF	0.981	3	0.327	1.731	0.158
TAC-3	CGPA	0.565	3	0.188	0.363	0.780
(Kahoot)	TEF	0.208	3	0.069	0.368	0.776
TAC-1 * TAC-2	CGPA	5.150	8	0.644	1.239	0.272
	TEF	2.368	8	0.296	1.568	0.129
TAC-1 * TAC-3	CGPA	5.435	8	0.679	1.308	0.234
	TEF	0.696	8	0.087	0.461	0.884
TAC-2 * TAC-3	CGPA	3.979	9	0.442	0.851	0.569
	TEF	1.442	9	0.160	0.849	0.571
TAC-1*TAC-2*TAC-3	CGPA	5.423	8	0.678	1.305	0.236
	TEF	1.786	8	0.223	1.183	0.305

*** Statistically significant at 0.01*

Only the use of "Google Application" affected Teaching Effectiveness with the Class Grade Point Average at alpha of 0.05 (Table 14). While other uses of ICT and interactions between usage of 2 or 3 differences ICT for classroom participation had no effect upon differences in Teaching effectiveness and Class grade point average.

Table 15 Tukey-HSD test of ICT for Classroom participation on Teaching effectiveness and Class grade point average

Dependent Var.	Pattern (1)	Pattern (2)	Diff. Score	S.E.	p-value
CGPA[a]	**2**	1	0.0867	0.031	**0.028***
	2	4	0.0981	0.037	**0.044***

** Statistically significant at 0.05*

(a) Only the significant patterns were selected to report

Table 16 Average percentage of Information and Communication Technology for classroom participation usage

Classroom participation	Unused	Low $\bar{x}$ (σ)	Medium $\bar{x}$ (σ)	High $\bar{x}$ (σ)
TAC-1 (SUT E-learning plugin)	–	33.35 (9.43)	55.39 (8.42)	97.30 (6.83)
TAC-2 (Google Application)	–	29.17 (9.97)	55.41 (8.40)	91.49 (9.89)
TAC-3 (Kahoot)	–	30.08 (10.00)	47.05 (9.56)	86.80 (9.48)

Table 15-16 shows only use of "Google Applications" in (2) Low usage (average of usage at 29.17%) for classroom participation given CGPA higher (1) Unused and (4) Medium usage (average of usage at 55.41%) is statistically significant. Other use ratios of "Google Application" for classroom participation had no significant effect upon CGPA.

Conclusion

The COVID-19 pandemic caused a slew of unexpected challenges for educators globally. Thus, most institutions, including Suranaree University of Technology (SUT) were forced to implement online teaching. This research investigated teaching practices and effectiveness at SUT based on ICT use to facilitate teaching. The data collected from 377 SUT students and 217 SUT lecturers. During this pandemic crisis, SUT provided ICT services and training in effective teaching & assessment via online platforms. The authorities responsible for such training were: (1) The Center for Educational Innovation and Technology (CEIT), (2) The Faculty Development Academy (FDA), (3) The Center of Computer Service (CES), (4) The Center of Educational Service (CES), (5) The Center for Library Resources and Educational Media (CLREM). And the university also facilitated by provided a location for 7 of studio recorder rooms with multi-media system and technician support. Moreover, to support "Work (Learn) From Home", the university granted the urgent (short term) budgets for all SUT staffs and students to get the internet service from their Internet Provider Service (ISP).

The data collected shown that the top 3 teaching approach usages are (1) Pre-recorded teaching videos (61.36% of sample used it at 81-100% of teaching time), (2) Homework and assignments (41.26% of sample used it at 1-20% of teaching time), and (3) F2F (live teaching) (34.27% of samples used it at 1-20% of teaching time). The usage of ICT for support teaching in 4 categories including; (1) Communication; (2) Video and screen recorders; (3) Content management; and (4) Classroom participation.

The top 3 of ICT for communication were (1) ZOOM MEETING (45.28% of samples used it at 81-100% of teaching time), (2) GOOGLE MEET (11.54% of samples used it at 81-100% of teaching time), and (3) FACEBOOK LIVE (6.99% of samples used it at 1-20% of teaching time). ICT for video and screen recorder were (1) Open Broadcaster Software (OBS) Studio (26.75% of samples used it at 81-100% of the teaching time). (2) Others application

e.g., ZOOM meeting, PowerPoint, etc. (25.52% of samples used it at 81-100% of teaching time), and (3) Camtasia (3.15% of samples used it at 81-100% of teaching time). ICT for Content management were (1) SUT E-learning (55.24% of samples used it at 81-100% of teaching time), (2) Google Classroom (11.89% of samples used it at 81-100% of teaching time), and (3) Others LMS e.g., YouTube studio, Google site, etc. (3.32% of samples used it at 81-100% of teaching time). Finally, ICT for Classroom participation were (1) SUT E-learning plugins (49.65% of samples used it at 81-100% of teaching time), (2) Google Applications (20.80% of samples used it at 81-100% of teaching time), and (3) Kahoot (2.45% of samples used it at 21-40% of teaching time). The Padlet is an application for classroom participation that was used at 81-100%.

Multivariate analysis of covariance (MANCOVA) revealed that the most effective teaching patterns that effect on "Teaching Effectiveness Score" and "Class Grade Point Average" are mixed of (1) Pre-recorded teaching videos (Medium usage), (2) Homework and Assignments (Low usage), and (3) F2F live teaching (Low usage). ICT for support teaching that effect on quality of teaching is (1) ICT for communication (i.e., Zoom meeting), (2) ICT for classroom participation (i.e., Google Application). While ICT for content management is necessary however it is less significant on teaching effectiveness and class grade point average.

"Pre-recorded teaching videos" seems to be the most common teaching technique adopted during the pandemic. Lecturers typically implemented familiar approaches that are logistically simple to their teaching mission. In the first wave of pandemic, SUT established a special collaborative between 5 units to service for online teaching process and teaching video record process. Using video recordings is a passive process which succeeded students must be capable of "self-efficacy", essentially confidence in their own ability to complete their tasks (Race et al., 2021). Students must also self-regulate their behaviors to enable their own learning (Ferńandez-Alonso et al., 2017; Laurie & Jason, 2016) in a pre-recorded video setting. Self-regulation is a vital trait for Adult Learners especially during the pandemic where mental health problems have become exacerbated (Pelikan et al., 2021; Carr et al., 2017). However, long recorded videos (for at least 2 hours of teaching period) have been shown to be of limited utility, and have resulted in reduced engagement over time. Wong (2020) suggested that to improve recorded video quality, educators should consider (1) Displaying key information (2) Using proper pictures relevant to the topic (3) Using proper sound relevant to topic (4) Segmenting the video clips into small parts (5) Eliminating of extra information, and (6) Displaying videos during mid-class sessions (if used teaching materials during class).

Other teaching approaches, i.e.; "Homework and Assignment" and "F2F live teaching", continue to be used by SUT lecturers in the standardized teaching processes (at low usage percent). "Homework and Assignments" have been consistently used for teaching since the university was formed; They remain an effective way to assess student achievement from pre-recorded videos and other course content. Homework and assignment scores were the primary source of evaluation by SUT lecturers during the 3^{rd} trimester of 2019. Daniel (2020) suggests that teachers should include varied assignments and work that corresponds with the learning contexts. Prommin & Jutharat (2019) indicated that the homework influenced the students'

ability to acquire knowledge, developed learning skills, and increased academic achievements. Also, Rośario et al. (2015) noted that homework (follow-up practices) promotes student feedback and aid in correcting student misunderstandings. However, extraneous homework assignments increase time spent on homework and is linked to decreased academic achievement at the individual level (Ferńandez-Alonso et al., 2017). Greenwald & Holdener (2019) suggested that university instructors have transitioned toward online homework systems that enhance student access to immediate feedback while reducing faculty grading time.

Face to Face teaching still plays an important role for real-time tracking of student understanding corresponding based-on the Branson (2000) teaching and learning model for the digital age. Wang (2008) indicates that communication and social interaction provide opportunities to collaborate and flexibly share both problems and knowledge with the students. Most students still require F2F teaching which seems to enhance SUT student learning and make more classroom are active. Kristiansen et al. (2019) showed that students changed behaviors, participated more and co-operated throughout the learning process to achieve higher learning standards with F2F teaching. In addition, when teachers promote small groups and cooperative learning, in class engagement tends to improve (Cavanagh, 2011).

Communication via ICT is necessary when teaching online. Both "Zoom Meetings" and "Facebook Live" affected teaching effectiveness. High use of "Zoom Meetings" with low use of "Facebook Live" or the lack of using Facebook Live led to effective teaching practices. Real-time communication is the main function of ICT, "Zoom Meetings" were developed for teleconferences for the audience to communicate with teachers via voice. It has further provided functions for separating into small groups and activity controls i.e.; screen sharing, small group discussion (Bowen, 2020). At that time, "Zoom Meeting" has greater functionality for lecturers than "Facebook Live" which was specifically designed for video streaming and using text-typing for communication between the audience and presenter. However, Zoom Meeting still has limitations use for non-commercial license i.e.; Time-connection limited, and number of concurrent connections. Which it was obstacle of using with the large class sizes in SUT i.e.; Calculus, Physics etc.

Classroom participation via ICT is also a vital component of teaching activities. To facilitate classroom participation, use of "Google Applications" provided yielded significantly higher-Class grade point averages. Even a low use of Google Applications is sufficient to improve the learning quality. Creating the quiz via Google Forms (Google Application) is a process that is mostly used by SUT Teachers. It helped increase the active nature of classes. Correspondence weekly online quizzes based on prescribed preparatory material can both act as an incentive for preparatory reading and help enhance active learning (Cook & Babon, 2017).

Use of ICT for content management is also compulsory for online teaching. The SUT teachers used "SUT E-learning", "Google Classroom", and Other LMS like Google sites, Padlet and others as content management systems. Although, there were no significant differences between the learning management system and their effects on Teaching effectiveness or Class grade point average. In contrast, Ghilay (2019) indicated that there are

statistically significant differences of LMS activity between "Low activity level" (e.g.; uploading files, sending announcements) and "High activity level" (Additional of Low activity level e.g.; Restriction of resource accessing, monitoring of learners' activity, etc.). Mostly, SUT lecturers used LMS at low levels which the different LMS have sufficient to provide this basic function. This suspect issue would be reason for the lack of differences among LMS systems.

Similarly, there were no differences on Teaching effectiveness and Class grade point average based on different choices of ICT for Video and screen recorders. O'Callaghan et al. (2015) indicated that 2nd and 3rd year students positively responded to lecture recordings on the flexible accessing and the ability to re-watch. Yet, O'Callaghan et al. (2015) found no consistent finding of benefit of lecture recordings on student grades. The SUT students are only the consumers of the final product of ICT from Video and screen recorders. It corresponded to a moderate score of an item in "SUT teaching effectiveness survey forms (TEF)" based on "Quality of the documents and teaching materials: Appropriateness of format, Ease of understanding, and content coverage". Marketa & Pavlina (2021) demonstrated "Video lecture quality" and "Course length" (Length of content) both have positive links to learning achievements.

In summary, the effective teaching patterns are (1) Pre-recorded teaching videos at 40-100% of teaching time (Medium to High usage), with both (2) Face-to-Face (F2F) live teaching in varying range (1 - 40% of teaching time) (Low usage), and (3) Homework and Assignments in varying ranges (Unused - 40% of teaching time) (Low usage or unused). The ICT compulsory for supporting effective teaching processes include: (1) ICT for communication i.e. Zoom Meeting, and (2) ICT for classroom participation i.e. Google Application. Both types of ICT are functional for the F2F teaching process. In addition, ICT for content management is a supplement technology. As described above, more beneficial of this study would lead to well planning of using of teaching approaches and ICT for support teaching which it could be integrated as E-courseware. Homework and Assignments as empirical evidence of learning progress should be provided in proper ratios. And The F2F could be embedded in some period of course for following up with the progress of student self-learning. These findings can aid and guide the Faculty Development Academy (or any other educational units in other universities) to support and enhance the quality of online learning by providing the training courses that related with; How to produce the high quality of teaching videos; Utilizing ICT in teaching to enhance learning; Effective approaches to encourage student participation in online teaching. Our findings correspond to the Generic Model of Wang (2008) with the aim to scaffold students to help individuals meet the course learning outcomes via ICT and Social interaction. However, online teaching is relied on the Internet connection performance. So, important issues that the university should support are educational applications, and provide strategies to access the (high speed) internet to improve the teaching experience for both the learner and instructors.

This project occurred in the situation of rapidly changing from the traditional teaching process to the online teaching process and the result shows that there are some of the teaching

patterns integrated with ICTs are effective. However, there are some issues that should further study is warranted. The rapid changes may have also limited teaching approaches use and ICT for supporting in teaching activities. The proportion of ICT usage in this study are mostly usage with the Pre-recorded teaching videos approach. So, this result would provide guidance in the design and planning effective E-courseware that mostly uses video and online material for self-study. However, there are many teaching approaches e.g.; Project Based Learning, Problem Based learning, Collaborative Learning. and other advances that ICT could be use to enhance it. Further study of ICT in depth at varying scales could reveal insight into the mechanisms driving effectiveness of ICT during the global COVID-19 pandemic.

Acknowledgement(s)

The authors thank the committee of SUT institute research of the Division of Planning for approving and grant funds for our project. And also thank you for all of anonymous reviewers who given valuable advised to improve this publication.

References

Bowen, H. (2020). *Using zoom for school: What are the pros & cons?* Retrived from https://videoconfguide.com/zoom-for-school/

Branson, R. K. (2000). *Education' s burning platform 3*. Retrived from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.110.886&rep=rep1&type=pdf

Carr, K. A., Rosemary, A. B., & Onyango, J. (2018) Lifelong learning to empowerment: Beyond formal education, *Distance Education*, *39*(1), 69-86.

Cavanagh, M. (2011). Students' experiences of active engagement through cooperative learning activities in lectures. *Active Learning in Higher Education*, *12* (1), 23-33.

Cook, R. B., & Babon, A. (2017). Active learning through online quizzes: better learning and less (busy) work. *Journal of Geography in Higher Education*, *41* (1). 24-38.

Daniel, S. J. (2020). Education and the COVID-19 pandemic. *Prospects*, *49*, 91-96.

Dziuban, C., Graham, C. R., Moskal, P. D., Norberg, A., & Sicilia, N. (2018). Blended learning: The new normal and emerging technologies. *International Journal of Educational Technology in Higher Education*, *15*(3), 1-16.

Elson, S. (2014). A Comparison of online/face-to-face students' and instructor's experiences: Examining blended synchronous learning effects. *Procedia - Social and Behavioral Sciences*, *116*, 4250-4254.

Ferńandez-Alonso, R., Álvarez-D´ıaz, M., Súarez-Álvarez, J., & Mun˜iz, J. (2017). Students Achievement and Homework Assignment Strategies. *Frontiers in Psychology*, *8*(286), 1-11.

Gacs, A., Goertler, S., & Spasova, S. (2020). Planned online language education versus crisis-prompted online language teaching: Lessons for the future. *Foreign Language Annals*, *53*(2), 380-392.

Garrett, T. (2008). Student-centered and teacher-centered classroom management: A case study of three elementary teachers. *Journal of Classroom Interaction*. *43*(1), 34-47.

Ghilay, Y. (2019). Effectiveness of learning management systems in higher education: Views of lecturers with different levels of activity in LMSs. *Journal of Online Higher Education*, *3*(2), 29-50.

Gogus, A. (2012). *Active Learning*. In: Seel, N. M. (Ed.). Encyclopedia of the Sciences of Learning. Boston, MA: Springer.

Greenwald, S. J., & Holdener, J. A. (2019). The Creation and implementation of effective homework assignments (Part 1): Creation. *Primus*, *29*(1), 1-8.

Harris, B. N., McCarthy, P. C., Wright, A. M., Schutz, H., Boersma, K. S., Shepherd, S. L., Manning, L. A., Malisch, J. L., & Ellington, R. M. (2020). From panic to pedagogy: Using online active learning to promote inclusive instruction in ecology and evolutionary biology courses and beyond. *Ecology and Evolution*, *10*(22), 12581-12612.

Hoffman, H. J., & Elmi, A. F. (2021). Comparing Student Performance in a Graduate-Level Introductory Biostatistics Course Using an Online versus a Traditional in-Person Learning Environment. *Journal of Statistics and Data Science Education*, *29*(1), 105-114.

Hoidn, S., & Klemenčič, M. (Eds.) (2020). *The routledge international handbook of student-centered learning and teaching in higher education* (1st ed.). London, UK: Routledge.

Ireri, B. N., Omwenga, E. I., Oboko, R., & Wario, R. (2017). *Developing pedagogical skills for teachers: A learner-centered approach for technology supported instructions* (pp. 128-144). In Keengwe, J., & Onchwari, G. (Eds.). Handbook of Research on Learner-Centered Pedagogy in Teacher Education and Professional Development. Pennsylvania, USA: IGI Global.

Kaplan, A. (2015). *Lifelong Learning: Conclusions from a Literature Review*. Retrieved from https://files.eric.ed.gov/fulltext/EJ1243611.pdf

Klemenčič, M. (2017). From student engagement to student agency: Conceptual considerations of European policies on student-centered learning in higher education. *Higher Education Policy*, *30*(1), 69-85.

Krejcie, R. V. , & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, *30*(3), 607-610.

Kristiansen, S. D., Burner, T., & Johnsen, B. H. (2019). Face-to-face promotive interaction leading to successful cooperative learning: A review study. *Cogent Education*, *6*(1), 1-19.

Lathan, J. (2021). The Complete List of Teaching Methods. Retrieved from https://onlinedegrees.sandiego.edu/complete-list-teaching-methods/

Laurie, A. S., & Jason, H. S. (2016). Enhancing student success in online learning experiences through the use of self-regulation strategies. *Journal on Excellence in College Teaching*, *27*(2), 57-75.

Madhuri, G. V., Kantamreddi, V. S. S. N., & Prakash Goteti, L. N. S. (2012). Promoting higher order thinking skills using inquiry-based learning. *European Journal of Engineering Education*, *37*(2), 117-123.

Marketa, R. & Pavlina, K. (2021). Effects of video lecture design and production quality on student outcomes: A quasi-experiment exploiting change in online course development principles. *Electronic Journal of e-Learning*, *19*(3), 170-185.

Murphy, L., Eduljee, N., & Croteau, K. (2021). Teacher-Centered versus Student-Centered Teaching. *Journal of Effective Teaching in Higher Education*, *4*(1), 18-39.

O'Callaghan, F. V., Neumann, D. L., Jones, L., & Creed, P. A. (2015). The use of lecture recordings in higher education: A review of institutional, student, and lecturer issues. *Education and Information Technologies*, *22*(1), 399-415.

Oleksandra, P., Srecko, J., Vitomir, K., Shane, D., Dragan, G., & George, S. (2015). *The history and state of blended learning* (pp. 55-92). In Preparing for the digital university: a review of the history and current state of distance, blended, and online learning. Alberta, Canada: Athabasca University.

Ossiannilsson, E. (2016). *Challenges and opportunities for active and hybrid learning related to UNESCO Post 2015*. In Keengwe, J., & Onchwari, G. *(*Eds.*)*, Handbook of Research on Active Learning and the Flipped Classroom Model in the Digital Age (pp. 333-351). Pennsylvania, USA: IGI Global.

Pelikan, E. R., Lüftenegger, M., Holzer, J., Korlat, S., Spiel, C., & Schober, B. (2021). Learning during COVID-19: The role of self-regulated learning, motivation, and procrastination for perceived competence. *Z Erziehungswiss*, *24*, 393-418.

Prommin, S., & Jutharat, J. (2019). Impact of homework assignment on students' learning. *Journal of Education Naresuan University*, *21*(2), 1-19.

Race, A. I., Jesus, M. D., Beltran, R. S., & Zavaleta, E. S. (2021). A comparative study between outcomes of an in-person versus online introductory field course. *Ecology and Evolution*, *11*(8), 3625-3635.

Rośario, P., Núñez, J. C., Vallejo, G., Cunha, J., Nunes, T., Súarez, N., Sonia Fuentes, S., & Moreira, T. (2015). The effects of teachers homework follow-up practices on students EFL performance: A randomized-group design. *Frontiers in Psychology*, *6*, pp.1-11.

Schleicher, A. (2020). *The impact of COVID-19 on education: Insights from education at a glance 2020*, OECD, Paris. Retrieved from https://www.oecd.org/education/the-impact-of-covid-19-on-education-insights-education-at-a-glance-2020.pdf

The United Nations Educational, Scientific and Cultural Organization (2020). *A new vision for lifelong learning and a world worth living in.* Retrieved from https://en.unesco.org/futuresofeducation/news/newvision-lifelong-learning-and-world-worth-living

The United Nations Educational, Scientific and Cultural Organization (2021). *COVID-19: How the UNESCO global education coalition is tackling the biggest learning disruption in history*. Retrieved from https://en.unesco.org/news/covid-19-how-unesco-global-education-coalition-tackling-biggest-learning-disruption-history.

Ustun, A. (2019). Effects of mobile learning in blended learning environments. *Bilgive İletisim Teknolojileri Dergisi*, *1*(1), 1-14.

Wang, Q. (2008). A generic model for guiding the integration of ICT into teaching and learning. *Innovations in Education and Teaching International*, *45*(4), 411-419.

Wong, D. (2020). Effectiveness of learning through video clips and video learning improvements between business related postgraduate and undergraduate students. *International Journal of Modern Education, 2*(7), 119-127.

Xiao, J., Sun-Lin, H.Z., Lin, T.H., Li, M., Pan, Z., & Cheng, H.C. (2020). What makes learners a good fit for hybrid learning? Learning competences as predictors of experience and satisfaction in hybrid learning space. *British Journal of Educational Technology*, *51*(4), 1203-1219.

Appendices

Appendix A Correlation between Teaching effectiveness score and Class grade point average

The Pearson correlation showed that the Class grade point average of 3rd trimester 2018 and the Class grade point average of 3rd trimester 2019 were highly positively correlated (0.731) positive. Whereas teaching effectiveness between trimester 3rd of 2018 (TEF3_18) and trimester 3rd of 2019 (Figure A1) were weakly correlated (0.342). The high linear correlation suggests that SUT staff graded classes consistently across years. The linear correlation of CGPA3_19 and TEF3_19 (0.166) was lower than that of CGPA3_18 and TEF3_18 (0.210). The rapidly changing teaching platforms may have affected the teaching scores with a low level of relationship clustering.

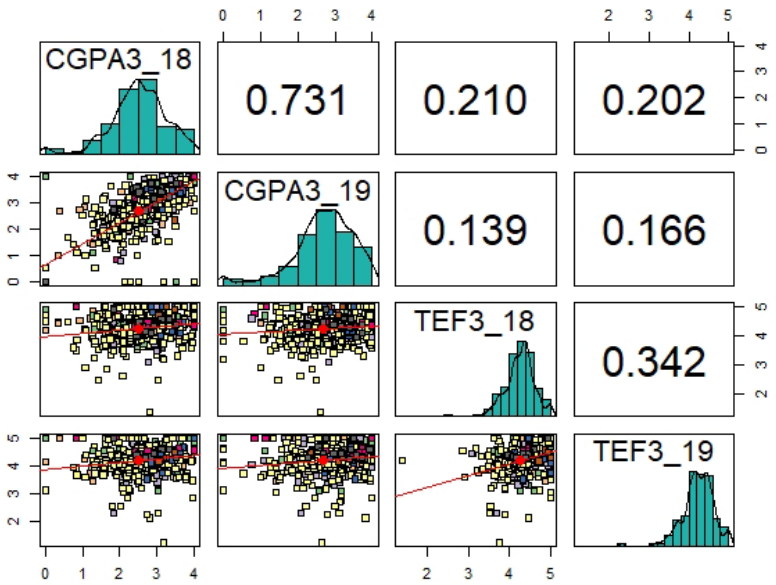


Figure A1 Relationship between teaching and learning performances of the previous and current trimester