Online Learning and COVID-19 in Higher Education: The Value of IT Models in Assessing Students' Satisfaction

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Abstract—In online learning, students' 'fit' (or satisfaction) with necessary technologies has become a vital component in assessing their learning efficacy, especially during the COVID-19 pandemic. While current studies have noted the impact of the curriculum, the instructor, and the learner, there is insufficient understanding of factors that predict students' satisfaction with online learning during the crisis [38]. Existing studies focus on pre-pandemic circumstances, where online learning was a minor part of the higher education (HE) paradigm. This study assesses HE students' use (i.e. 'fit') with online learning via their perception, behavioral intention, and satisfaction. By utilizing the Information Technology (IT) models of Task-Technology Fit (TTF) and Unified Theory of Acceptance and Use of Technology (UTAUT), the study investigates if, from students' perspective, pedagogical theories are aligned with the IT models, using the quantitative survey method to gather input from students across various disciplines in a Singaporean university. Standard descriptive and correlation analyses studied the link between factors and their influence on online learning satisfaction. Significantly, the IT models are found to be valuable in assessing online learning satisfaction. Recommendations arising from the study provide helpful strategic guidelines for future online learning, which apply to Singapore and online learning design in general, particularly in this time of paradigm change.

Keywords—online learning, COVID-19, higher education, task-technology fit, Unified Theory of Acceptance and Use of Technology, behavioral intention, students' satisfaction, TTF, UTAUT, information technology

1   Introduction

With the consequences globally of COVID-19 in 2019 ranging from travel restrictions to school and campus shutdowns, estimations are that educational lockdown has impacted around 1.8 billion students [57]. The immediate worldwide response in higher education (HE) of moving from face-to-face education to online technologies has connected students in processes such as enrolment, teaching and learning (TL), communication and networking, student management, and course assessment. While growth in the adoption of online technologies for HE TL before COVID-19 was high with almost US$20 billion investments globally in 2019 and US$350 billion projected by 2030 [53], at COVID-19's onset when TL turned to online delivery, a predictable surge in the use of online learning tools and applications was reported. This included language apps, virtual tutoring, Software, and video conferencing [53].

In Singapore, during the pandemic, the government stressed whole Home-Based Learning (HBL) for all education from April 2020 [35]. Consequently, in HE, teachers and students used online TL through fully online and hybrid lessons [22] [26]. Despite the drastic changes worldwide, as reflected in Singapore, little is known about the students' perceptions of their COVID-19 online learning experiences, especially when students are key stakeholders in effective online learning. Although Singapore leads regionally with over 80 percent internet penetration [64], online learning challenges those students with limited or no internet access [22][100]. Also, in such countries with good internet infrastructure, there are questions about the ability of students and teachers to interact effectively through the medium of learning technology [97]. However, the fully-online approach may be limited in the long term [87]. At the same time, some staff has online teaching competencies; work is required to increase the readiness of academic staff, students, and the infrastructure for a successful transition to online learning. In online learning in HE, staff must cope with increased preparatory work, difficulty gauging students' understanding, and encouraging students' class participation [37] [54] [80].

The existing HE literature on online learning during COVID-19 has emphasized the educators' perspective as they transform onsite learning materials for use in the online learning context [14] [62]. However, the student's perspective as they necessarily move from onsite seminars to online learning during the pandemic has received little attention, and this is also the case concerning Singapore (e.g. [31] [45][56]). The focus for research has been on pre-pandemic times where online learning generally occupied only part of the curriculum, or it was optional to the highly-preferred onsite learning [41].

The abrupt paradigm shift to online learning in HE has challenged students' ability to continue learning effectively with learning technology. It is increasingly apparent that students will need to use online learning technologies fully for all courses for the foreseeable academic period. Today's situation has been completely transformed in most courses compared with onsite learning as the default learning mode pre-pandemic. With students as critical stakeholders in practical education, the research mentioned above gap needs to be bridged by studies assessing students' perceptions of their abrupt transition to mandatory online learning for the foreseeable time.

Thus, as HE online learning globally remains dominant in 2020 and beyond, it is equally important to use more advanced online TL instruments and approaches to sustain and improve practices [74]. Information Technology (IT) models like Task-Technology Fit (TTF) and Unified Theory of Acceptance and Use of Technology (UTAUT) have been well-used in assessing users' uptake and perceptions of technological devices in various domains other than HE, such as healthcare, library information services and mobile banking [95] [90] [65]. However, there has been little research attention to the use of these models in HE. This study shows substantial merit in using such models with HE online learning, especially when pedagogical theories are aligned with the models. As frameworks, they provide this study with a snapshot of students' experiences in COVID-19 online learning.

It is beneficial to study students' use, perception, behavioral intention, and satisfaction with online learning to identify areas for improvements and to identify good practices. In assessing students' online learning experiences during COVID-19 in a Singaporean HEI, this paper shows the capacity of models such as TTF and UTAUT to gain a broad understanding of students' online learning experiences. This guides future online learning strategies in both Singapore and globally.

The following sections review the literature on online learning in general, in the Singaporean context, and COVID-19, followed by theoretical underpinnings and relevant models for assessing students' online learning satisfaction. Next, the study methods are described, followed by a discussion of data analysis and results. Finally, recommendations based on critical findings are made for developing enhanced HE online learning.

2   Literature review

Thematically, in this paper, previous research is organized by subsections according to different aspects of the topic [3], as summarised in Table 1.

Table 1. Summary of literature analysis

#	Main theme	Aspects of analysis	Examples of related studies
1	Online learning	Online learning development and definition	[42][92][42]
		Learning theories related to online learning (behaviorism and constructivism)	[9][70][84]
		Online learning development and practice in Singapore	[14][20][62][87]
		Factors and impacts of COVID-19 on online learning practices and effectiveness	[13][75][53]
2	IT models	Understanding the Task-Technology Fit (TTF) model	[34][37][38][47][54]
		Understanding the Unified Theory of Acceptance and Use of Technology (UTAUT) model	[90][24]
		Relevance and benefits of TTF and UTAUT models	[65][91][94]
		Gaps in the use of both models (and proposed framework)	[76][[24]
3	Factors of online	Students' use of online learning ('fit')	[3][65][5]

	learning (inde-pendent varia-bles)	Students' perception of online learning	[22][16][67][91]
		Students' behavioral intention with online learning	[1][73] [7]
4	Online learning satisfaction (dependent variable)	Definition and general aspects of online learning satisfaction	[27][96][48]
		Factors influencing students' online learning satisfaction	[21][22][54][54]

2.1 Online learning and pedagogy

Currently, online learning is taking the lead in education globally. Existing for many decades in HE [4] [22] and used since the early 1990s [42], online learning has evolved from distance education and correspondence courses to mobile-based learning or mobile learning [84].

Online learning, education delivery via the internet [84] with the learner away from the tutor or instructor, uses technology to provide learning materials, interaction with the tutor and other students, and support learners [3, p.16]. Socially, it is a new process that increasingly complements distance learning and traditional face-to-face lessons [36].

With technology's ubiquitous and dynamic nature, online learning offers benefits for learners and instructors: flexibility and efficiency in access to educational content, instructions, and learning experiences beyond the traditional classroom (these promote its popularity) [11][33], and benefits for times of crises such as the COVID-19 pandemic. Furthermore, online learning, as the incorporation of Information and Communication Technology (ICT) into the educational system, should be viewed as necessary for modernizing TL techniques [92][42].

In utilizing various platforms for educational delivery, online learning may require different pedagogical approaches [42][54]. The new technologies provide instructors with valuable tools to improve TL, with recent technological advancements have led to new TL methods. However, studies have shown that students react differently to the online learning environment based on their ability level and attitude [67][68], with the outcome that instructors must be retrained in ICT to support good educational outcomes for students and instructors [42][54].

Scholars identify behaviorism and constructivism as pedagogical theories relevant to online learning. Behaviourism, with its emphasis on rewards, punishment, and repetition to drive learning to pre-defined and measurable learning outcomes [12], focuses on how people behave [70] and is seen in Skinner's early computer-assisted instruction (CAI) [70] [12]. Alternatively, constructivism which is highly relevant to HE TL today, maintains that learners construct new knowledge as they interact with their environment [84], including the online experience. The social constructivist theory of Vygotsky, Dewey, and Piaget perceives teachers and students interactively engaging [70] in a complex social process where users' knowledge is constructed via observing, interacting, and discussing [9] and is related to social cognition [28]. Technology, in line with social constructivist pedagogy, can aid interaction and communication to facilitate learning [12], and this aspect of learning can be assessed through TTF and UTAUT.

2.2 Online learning in Singapore

As a rapidly developing country in Southeast Asia, Singapore has used online learning to adapt learning in HE [17] quickly. While remote TL is not new in Singaporean HE, its use has increased markedly recently [14]. Singapore now has one of the highest Internet and social media consumption rates in Southeast Asia and globally [20], with the shift in Singaporean HE having occurred since 1997 [87] [78]. However, while some HEIs like Singapore Management University and Singapore Institute of Technology lead in technology integration in curriculum, the current reliance on online learning is abrupt for other HEIs. The latter have minimal online learning experience [41].

Several studies have discussed the online learning values and practices of Singaporean HE stakeholders. For educators, as online learning is seen as critical nowadays, the importance of adapting to changes and of using hybrid pedagogy is acknowledged as a means for HE to be relevant to students' and employers' evolving needs [62]. Online learning can provide rich learning experiences for students due to the range of online learning tools [56].

However, scholars note challenges with online learning implementation in Singapore: these include pedagogical concerns such as implementing authentic learning assessment, establishing bonds between educators and learners [14], and fostering students' online learning self-efficiency [56].

2.3 COVID-19 and online learning

COVID-19 forced sudden change to 'emergency rote learning' in HE globally and adjustments to learning approaches for all programs and students [75], impacting both asynchronous and synchronous learning [10][62]. HEIs now use several platforms to deliver content to render learning comfortable for students. The purpose of online learning has changed from the pre-pandemic objective of widening students' learning sources from dependence on teachers and updating workforce lifelong learning skills [13]. The pandemic has thus raised online learning's relevance and addressed the chasm created by the cessation of face-to-face teaching.

Nevertheless, challenges with online learning exist, especially in developing countries, and HEIs must now address its sustainability [77]. Challenges include teachers' lack of pedagogical content knowledge [75] and motivating students to use the necessary online learning [7].

Current studies have reported the link between the level of online learning performances during COVID-19 with factors such as instructor quality, course design, prompt feedback, and students' expectations [30], study and workload, enhancing engagement, and technical issues [27], learners' dimensions, technological characteristics, instructors' characteristics, and course management and coordination [83]. Nevertheless, there is insufficient understanding of factors predicting students' online learning satisfaction during such crises [41]. Few studies have assessed how HE students' 'fit' with online technology influences their behavioral intention and consequent satisfaction in online learning.

While COVID-19 has changed learning [25], it has provided the opportunity. Lewin (1958, [86]) presents three steps for change management: HEIs' unfreeze – change – refreeze [86]. 'Unfreeze' relates to HEI's changing from traditional approaches, mobilizing mechanisms in curriculum, delivery, and assessments, building resilience, and changing mindsets [86]. These opportunities build resilience into educational systems for current and future challenges, either internal or external [86]. This resonates with the Chinese government policy of "Suspending Classes Without Stopping Learning." Thus, with such a revolution in techno-academic blending, learning is ongoing. In addition, IT models provide for flexibility in time and place of learning [101].

2.4   Information Technology (IT) models

In assessing HE students' satisfaction with COVID-19 online learning, this study integrates the TTF with the UTAUT. Both models are commonly used in assessing users' uptake and perceptions of technological devices in various domains, as mentioned previously [38][51][52[55][72][71][53]. In Figure 1, Goodhue and Thompson [34] state that the TTF model emphasizes a good fit between technology and individual performance tasks [8]. As in Figure 2, Venkatesh et al. [90] state that people using technology are affected by four key concepts: facilitating conditions, performance expectancy, social influence, and effort expectancy. These impact user behavior and intention [47]. TTF consists of four constructs: task characteristics, technology characteristics, task-technology fit, and performance impact or utilization [34][38][51], used in various information system (IS) contexts such as e-commerce. UTAUT, a consolidation of eight IT/IS acceptance and use theories with ten constructs (facilitating conditions, performance expectancy, social influence and effort expectancy, gender, age, experience, voluntariness of use, behavioral intention, and use behavior [38][51][52][90]), has been chiefly used in organizational contexts.

In HE, while TTF and UTAUT models have been conceptualized for online learning in Yemen [3] and used in teachers' adoption of MOOCs [55][69], there is little attention on their use in assessing HE students' online learning experiences. Nevertheless, a limitation of the TTF model in student learning is its lack of focus on interrelating academic tasks [76], which include attending lectures, writing term papers, and reading textbooks. TTF needs to address how well the technology facilitates and improves "the set of interrelated learning tasks" [Rai, p. 2]. Also, a key element missing from the UTAUT model is the individual's behavior in adopting and using the technology [23, p. 721].

While both models have limitations, there is merit in using them in online learning in HE, particularly when pedagogical theories are aligned. Thus, as seen in Figure 3, both models are combined in this study's theoretical framework. This approach reflects past studies that have combined UTAUT and TTF models in explaining user's adoption of technology in mobile banking, library information service, and MOOCs [102] [65][91] [94].

For TTF, [32] studies show that online tools will be used if the technology is aligned with users' needs and perceptions [38][41][51][52][57][67]. Hence, if inap-

propriate tools are used, task performance is less efficient. The model tests two significant technology outputs in determining the 'fit': an individual's use of the technology and its utility for performing the task. In addition, the UTAUT model's four core areas contribute to a user's technological behavior and can be combined with TTF. These are moderated by factors such as an individual's experience, age, and gender [70].
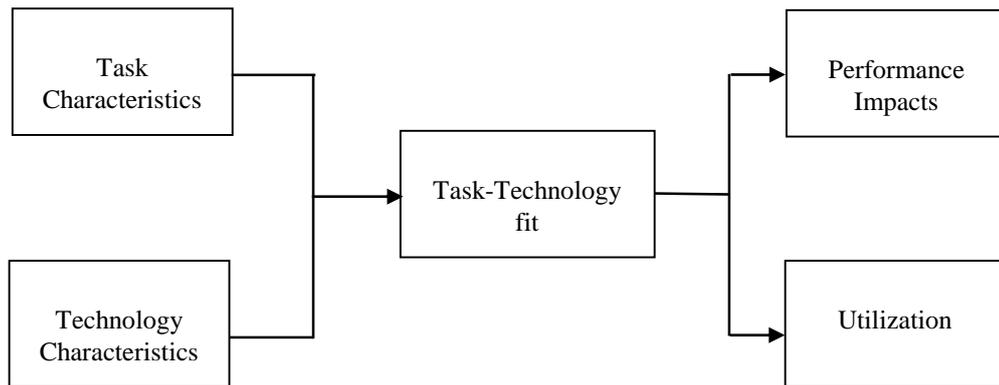
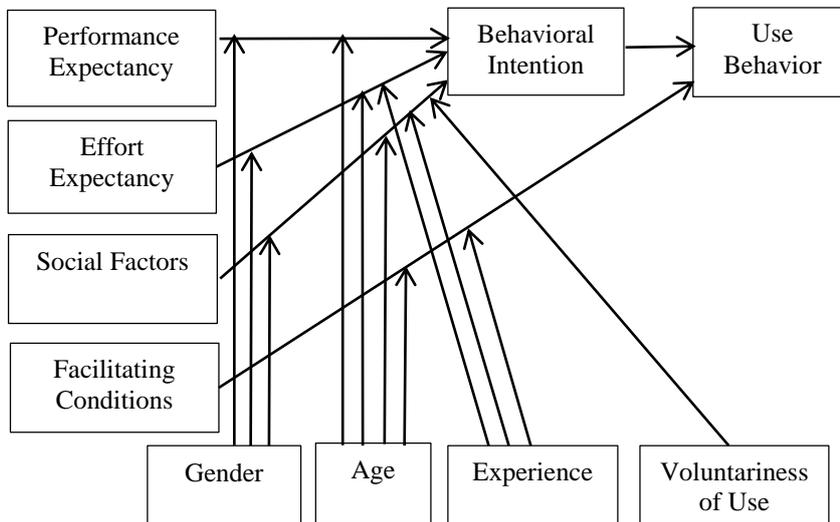Source: Goodhue and Thompson, (1995)

Fig. 1. Task-technology fit [34][46]

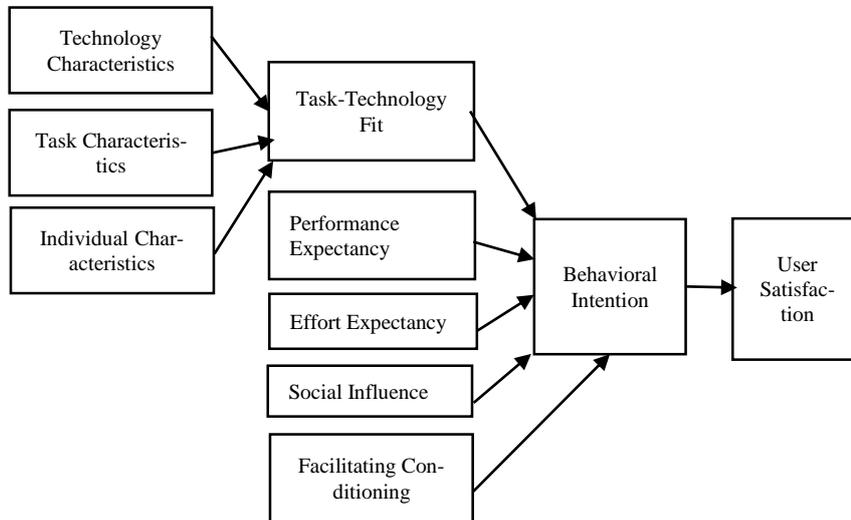**Fig. 2.** Unified Theory of Acceptance and Use of Technology

Fig. 3. Proposed theoretical framework – combination of TTF and UTAUT

2.5 Students' use and perception of online learning

Through the constructs of task characteristics, technology characteristics, task technology fit, and utilization, the TTF model points to a user adopting new technology as suitable for efficient completion of their daily tasks [51][52][65]. Utilization, or actual use, precedes and positively affects user satisfaction concerning the frequency of technology usage [3]. Students' use of online learning was significantly linked with other factors, such as students' attitudes and behavioral intention [5].

The UTAUT model focuses on user perception of the technology [91], including perceived usefulness and ease of use, perceived enjoyment [99], and satisfaction [16]. [103]. Studies discuss user perception in terms of theories of "technology acceptance" [43]. Students' perceptions of online learning interventions can be influenced by how it correlates with their educational needs and expectations [67].

2.6 Students' behavioral intention to use online learning

Students' intention to use online learning is vital in successful online learning implementation and is used to identify factors that can affect the desired behavior [1]. Behavioral intention focuses on predicting learners' behaviors towards using the intervention/ technology for learning purposes [18][55]. The Theory of Reasoned Action (TRA) identifies behavioral intention as the "cognitive representation of an individual's readiness to perform a given behavior, whereby it is considered to be the immediate antecedent of behavior" [68, p.305].

In online learning, users' behavioral intention is multi-faceted, linked to other variables, and directly impacted by the four factors of technology acceptance in the

UTAUT model: facilitating conditions, performance expectancy, social influence, and effort expectancy [47]. Studies have observed that students' behavioral intention to use online learning can be moderated by other contextual factors, such as gender and scientific discipline [7], perceived risk [15], and differences in individual beliefs [73].

2.7 Online learning satisfaction of HE students

Student satisfaction is also complex, multidimensional, and related to the value of the learning experience [27]. For HEIs worldwide, satisfaction motivates students to work hard, achieve success, and persist in their studies [21][22]; a positive link between higher student satisfaction levels and higher graduation rates has been reported [22]. For instance, in Somalia, academic performance was strongly related to satisfaction in academic achievement and study retention [6].

For online learning, satisfaction concerns students' attitude, which results from assessing their educational experience and facilities and service quality [96]. Students' online learning satisfaction may include learner relevance, active learning, authentic learning, learner autonomy, and technology competence [48].

Various studies have shown that students' satisfaction with online learning is significant in promoting successful educational delivery. However, a study in an Indian university [54] emphasized that online tools have to be explained in advance to students to avoid misunderstanding and affect the predicted outcomes [54].

3 Research focus and significance

This study addresses the need to understand students' online learning experiences during COVID-19 and is anchored on two Information Systems models: TTF [34] and UTAUT [90]. These models provide validated frameworks to assess the 'fit' of users with technology, that is, the alignment of the technology with the users' situations and needs and the online learning technology's fitness for students' study.

The findings from this study of the current shift to online learning in Singapore are helpful for the enhancement of online learning. The Singaporean setting of sound technical infrastructure and teachers generally experienced with online delivery means the study can focus on the *students' response* to their online learning, rather than shortcomings of, for instance, infrastructure and teacher training. Significantly, while other online learning studies may have used various pedagogical frameworks, this study contributes by applying technologically-based models designed to assess users' satisfaction in other domains: it seems opportune to apply these to HE, as occurs in this study.

The findings provide insight into the design of effective online learning for the current and post-COVID-19 HE society.

The aims are to investigate:

1. How do students in the case study university use online learning and perceive its implementation during the COVID-19 crisis?

2. What are the students' perceived behavioral intentions to use online learning during and after the pandemic?
3. What is the level of student satisfaction in the use of online learning at the university?
4. Do students' use and perception and their behavioral intention to use online learning influence their online learning satisfaction?
5. What are the critical issues in implementing online learning for the case study university during the pandemic?
6. From the above perspectives, what are the recommendations for the design of effective online learning for the post-pandemic HE, applicable for Singapore and globally?

4 Research methodology

4.1 The study

This exploratory study was mainly quantitative, gathering primary data through the survey method. An open-ended question elicited respondents' qualitative comments and suggestions about their online learning experience.

4.2 The study subjects

This study involved HE students in Singapore through the convenience sampling method, with 119 undergraduate students selected from three disciplines: technology, business, and social sciences in a Singaporean university. University ethics approval was obtained before the project was implemented.

As seen from the respondents' profiles (Appendix A), the majority were female (70.6%) and mainly between 21 to 30 years old (49.6%). The students varied by levels and study programs, i.e., from foundation or pre-university level until degree level and across various disciplines of study, including technology, business, accounting, management, language, and social sciences.

4.3 Instrumentation and data collection

The general TTF framework guided the investigation of the online tools' fitness in delivering the subject content for the respondents. The survey thus addressed key facets of TTF and UTAUT: user's satisfaction with the technology they used and the extent of their technology usage. For UTAUT, the survey assessed the users' behavioral patterns/actions according to their perceptions of the technology's ease of use and its usefulness for their study. In applying these models, the closed-ended survey items adopted questions from several studies: computer efficacy [88], suitability [46], perceived usefulness, perceived ease of use [38][64][52][72], perceived fit [38][51][98], communication, collaboration, and resource/ material sharing [72], use of online tools [82], satisfaction and effectiveness [79], as well as general attitude and

behavioral intention [90]. The aspects of online learning addressed in the survey are shown in Table 2. Collaboration and communication survey items concern the technology's facilitation of a constructivist rather than behaviouristic study approach.

Due to the closure of HEIs in Singapore, researchers could not collect data by the direct face-to-face approach, and the online method of survey distribution was used instead. The surveys were developed and administered through the Google Form platform with the survey link sent to the students' emails. Before responding to the survey, the students made it clear that their participation was completely voluntary and anonymous, with findings aggregated. A total of 119 student responses were received and recorded.

Table 2. Cronbach's Alpha

#	Variables	No. of items	Cronbach's Alpha
1	Computer Efficacy	9	.801
2	Flexibility	3	.778
3	Suitability for Learning	3	.866
4	Perceived Usefulness	3	.809
5	Perceived Ease of Use	3	.863
6	Perceived Fit	4	.845
7	Communication	3	.873
8	Collaboration	3	.823
9	Resource/ Material Sharing	3	.847
10	Online Learning Tools	6	.770
11	General Attitude	3	.922
12	Behavioral Intention	3	.938

4.4 Data analysis

IBM Statistical Package for the Social Sciences (SPSS) software was used to analyze the survey data, with statistical analyses being reliability, descriptive, and Pearson correlation analyses. Firstly, a statistical reliability test was conducted to measure the internal consistency of all variables. Table 2 shows the results of Cronbach's alpha values.

Then, standard descriptive statistics of frequencies and means were calculated for each survey item to provide information about respondents' demographic profiles, perceptions of their online learning, use of online learning tools, attitudes, behavioral intention, and satisfaction towards online learning. The degree of student satisfaction with educational mode has implications for students' achievement as demotivated students may limit their study effort. The IT models used in this study measure student satisfaction through assessing the elements of computer efficacy, flexibility, suitability for learning, perceived usefulness, perceived ease of use, perceived fit, communication, collaboration, resource/material sharing, online learning tools, general attitude, and behavioral intention. Finally, Pearson correlation analyses were run to identify significant relationships and associations between the study's variables.

In addition to the statistical analyses, manual thematic analysis was done on the data gathered from the open-ended survey question, which elicited respondents' comments on using their online learning.

5 Findings

This section presents the study findings related to the research questions, as indicated in the section headings.

5.1 The survey

The reliability of the items relating to students' perception and attitude to the use of online learning as well as their satisfaction with it were found to be high, as in Table 2 on Cronbach's Alpha, particularly for survey items on general attitude towards the technology and the intention to use it (behavioral intention). The other survey items are also acceptably high in reliability. All Cronbach's alpha values ranged between 0.7 to 1.0, exceeding the conventional minimum of 0.70 for reliability [63]. Therefore, all variables used were deemed to be reliable.

5.2 Students' use and perceptions of online learning

Computer efficacy. These survey items measured the respondents' skills in using various computer tools in their learning. The overall mean of 3.76, as in Table 3, indicates the respondents' moderate level of computer efficacy. Expressly, most respondents agreed they have good basic computer skills, particularly in using the internet, email, word processing, spreadsheet, and presentation applications. However, less than 50% agreed about their good efficacy with media-related and web-based skills, except for conferencing Software.

Table 3. Descriptive statistics (computer efficacy)

#	Items (Overall mean = 3.76, SD = .594)	Mean	SD
a. Basic Computer Skills			
1.	I can: use the internet and email (e.g., Hotmail, Outlook, Yahoo, Gmail, and Unimail) to search for information and resources, and communication.	4.62	.487
2	use a word processor to create, edit, format documents for specific purposes (e.g., Microsoft Word), use a spreadsheet to record data, compute simple calculations, represent data in tables and graphs (e.g., Microsoft Excel).	4.38	.781
3	Microsoft software (e.g., Microsoft PowerPoint) for classroom delivery (presentation, documentation, notes).	4.55	.563
b. Media-related Skills			
1	I can use website editors (e.g., Microsoft FrontPage, Macromedia Dreamweaver) to create/modify web pages.	3.04	1.224

2	use video editing software (e.g., Microsoft MovieMaker, Adobe Premier, and Ulead VideoStudio) and graphic editors (e.g., Microsoft Paint, Adobe Photoshop) to create/ modify resources for learning.	3.24	1.118
3	use animation software (e.g., Macromedia Flash, Authorware, and Director) to create animations.	2.55	1.102
c. Web-based Skills			
1	I can: use blogging for personal use.	3.66	1.069
2	use conferencing Software (e.g., Yahoo, IM, MSN Messenger, ICQ, and Skype) for collaboration	4.17	.847
3	use learning management systems (e.g., Blackboard, IVLE, WebCT, and Moodle) to support learning.	3.66	1.122

Flexibility. Table 4 indicates that respondents generally positively perceived the flexibility aspect of online learning (overall mean = 4.16), particularly for time and place, self-learning path, and improved learning.

Table 4. Descriptive statistics (flexibility)

#	Items (overall mean = 4.16, SD = .725)	Mean	SD
1	Online learning allows me flexibility in time and place.	4.44	.697
2	Flexibility through online learning has improved my learning.	3.85	1.014
3	Flexibility in online learning allows me to study at my own pace and independently.	4.18	.873

Suitability for learning. As in Table 5, the overall mean for this variable was 3.89, a pretty high level of positive perception. More than 70% of the respondents agreed that using online tools is suitable for their learning since the HEI has adequate support mechanisms, mainly from academic and administrative staff and in presenting subject content.

Table 5. Descriptive statistics (suitability for learning)

#	Items (overall mean = 3.89, SD = .706)	Mean	SD
1	I have been provided with enough academic support for online learning.	3.89	.842
2	The subject content presented in online learning is versatile enough.	3.82	.744
3	I have enough support from teachers and administrative staff for online learning.	3.94	.795

Perceived usefulness (PU). Table 6 shows a moderate level of perceived usefulness among the respondents, with an overall mean value of 3.42. While most respondents agreed that online learning allows them to share their study tasks with others instantly (mean=3.65), less than 50% found that online learning is helpful for quick communication with others than face-to-face learning. The majority also did not find it is easier to establish, maintain, control, and improve their relationships through online learning (mean=3.23).

Table 6. Descriptive statistics (PU)

#	Items (overall mean = 3.42, SD = .940)	Mean	SD
1	Online learning allows me to communicate with more people in a shorter period compared with face-to-face learning.	3.38	1.120
2	Online learning allows me to share my tasks (studies) in a short time (speedily).	3.65	.944
3	Online learning makes it easier to establish, maintain, control, and improve my relationships.	3.23	1.231

Perceived ease of use (PEOU). For this variable, the respondents recorded a pretty high level of positive perception (overall mean = 3.87), as in Table 7. Almost 80% agreed they adjusted easily to online learning and found ease in using the online features. The majority also revealed clear and understandable interaction with teachers and other students in online learning, even without expert support (mean=3.67).

Table 7. Descriptive statistics (PEOU)

#	Items (overall mean = 3.87, SD = .704)	Mean	SD
1	My interaction with teachers and other students using online learning is clear and understandable, without expert help.	3.67	.771
2	I find it easy with little mental effort to use the features of online learning.	3.89	.831
3	In general, I accommodate online learning with ease.	4.03	.780

Perceived fit. Similarly, Table 8 shows a pretty high perceived fit of online learning among respondents (overall mean = 3.81). Almost 80% of respondents perceived online learning helps them to complete their tasks satisfactorily through different online tools and features. Compared to pre-pandemic, there was also an increased level of confidence in using online learning for enhancing knowledge.

Table 8. Descriptive statistics (perceived fit)

#	Items (overall mean = 3.81, SD = .674)	Mean	SD
1	I can complete my learning tasks satisfactorily with online learning through different online tools and features.	3.93	.686
2	I can get support for technical challenges I face in my online learning.	3.77	.848
3	I feel confident BEFORE I use online learning to enhance my knowledge.	3.67	.835
4.	I feel confident AFTER I use online learning to enhance my knowledge.	3.85	.880

Communication. Table 9 reveals the respondents' moderate positive attitude to online learning for communication (overall mean = 3.66). More than 70% agreed that online learning improves communication of announcements about courses, classes, or school, and more than 60% said online learning improves course material delivery, resources, and class discussions. However, several (19.3%) did not agree that online learning improves communication between teachers and students.

Table 9. Descriptive statistics (communication)

#	Items (overall mean = 3.66, SD = .843)	Mean	SD
1	Online learning (educational technology for learning) improves communication between teachers and students.	3.46	1.040
2	Online learning improves the delivery of course material, resources, and class-room discussions.	3.63	.882
3	Online learning improves communication of announcements about courses, classes, or school.	3.88	.904

Collaboration. Similarly, Table 10 shows respondents' moderate positive attitude in using online learning for collaboration (overall mean = 3.56). Around 70% found online learning as appropriate for exchanging course-related information. However, only 50.4% agreed that online learning improves student group work, and a lesser percentage found that online learning encourages those of similar academic interests and needs to form groups and communities.

Table 10. Descriptive statistics (collaboration)

#	Items (overall mean = 3.56, SD = .798)	Mean	SD
1	Online learning encourages people with similar academic interests and needs to form groups and communities.	3.44	.962
2	Online learning is an appropriate platform for the exchange of course-related information.	3.81	.805
3	Online learning improves student group work.	3.43	1.005

Resource/material sharing (RMS). The overall mean of 3.97 for the RMS factor (Table 11) indicates respondents' many positive attitudes in using the various online learning resources and materials. The majority agreed that there is freedom and un-limited access to using and sharing online learning resources and materials.

Table 11. Descriptive statistics (RMS)

#	Items (overall mean = 3.97, SD = .628)	Mean	SD
1	Online learning provides resources to share a variety of resources and learning materials.	3.98	.736
2	Online learning provides rich multimedia resources and media support to improve the educational experience.	3.85	.721
3	Online learning provides me with unlimited access.	4.08	.696

General attitude. As in Table 12, respondents have a positive attitude in using online learning. They mostly agreed that using the tools with fun elements is a good idea, thus preferred by the respondents.

Table 12.   Descriptive statistics (general attitude)

#	Items (overall mean = 4.02, SD = .825)	Mean	SD
1	Using educational technology is a good idea.	4.15	.755
2	Educational technology makes my work more fun and exciting.	3.96	.933
3	I like using educational technology in learning.	3.96	.960

Use of online learning tools. Results indicate the respondents' frequency of using online tools for their learning. The majority mainly used online office suites (40.3%), followed by video-sharing applications like YouTube (34.5%) and social networking (25.2%). However, only a few students used blogs and social bookmarking applications frequently. Several respondents listed the use of other online tools, like online discussion applications such as Zoom and Google Meet, graphic design tools, emails, text messaging, and online newspapers or articles.

5.3 The behavioral intention of using online tools for learning outcomes

Descriptive results on respondents' behavioral intention of using online tools for learning are in Table 13. The overall mean (3.99) suggests respondents generally had a positive intention in using online learning. The aspect that the majority agreed on was using online learning in their current and upcoming semesters.

Table 13.   Descriptive statistics (behavioral intention)

#	Items (overall mean = 3.99, SD = .884)	Mean	SD
1	I intend to use educational technology in this and the coming semester.	3.96	.986
2	I predict I would use educational technology in this and the coming semester.	4.07	.880
3	I have actual plans to use educational technology in this and the coming semester.	3.94	.941

5.4 Students' online learning satisfaction

As in Figure 4, most respondents felt satisfied with their online learning experience. Table 14 shows that they liked study location flexibility most, lack of need to go on-campus, and flexible study time. Table 15 shows the respondents' least preferred aspects, with most respondents noting online learning deficiency compared with face-to-face TL, and some respondents were less satisfied due to their time spent on computers.
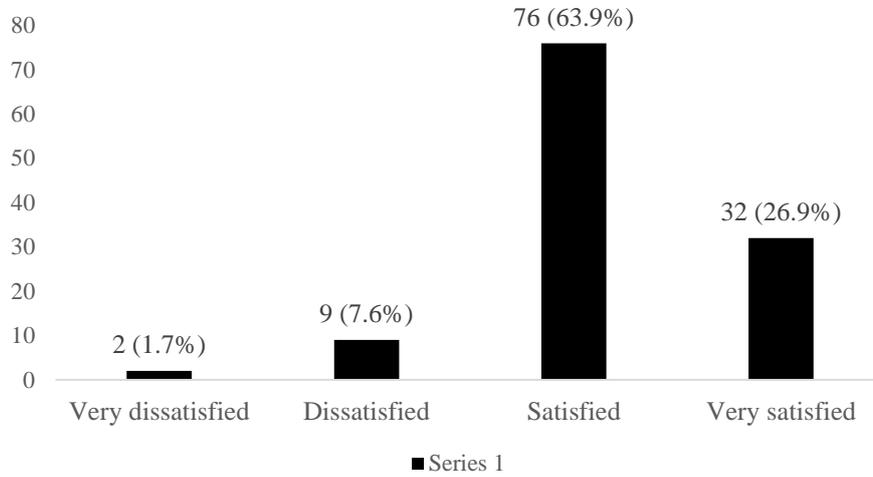
Fig. 4. Overall satisfaction or dissatisfaction with online course(s) taken this semester (mean = 3.16; SD = .624)

Table 14. Frequency analysis for: "What do you like MOST about taking online courses?"

	Frequency	Percent
The online delivery methods	6	5.0
Limited face-to-face interaction	3	2.5
The flexibility of study location	40	33.6
Reliance on my self-discipline	2	1.7
The flexibility of study time	29	24.4
Spending time on the computer	3	2.5
Less need to go to campus	34	28.6
Total	119	100.0

Table 15. Frequency analysis for: "What do you like LEAST about taking online courses?"

	Frequency	Percent
The online delivery methods	13	10.9
Limited face-to-face interaction	44	37
The flexibility of study location	5	4.2
Reliance on my self-discipline	12	10.1
The flexibility of study time	3	2.5
Spending time on the computer	27	22.7
Less need to go to campus	3	2.5
Teaching/ teacher factor	2	1.7
Classmate's factor	5	4.2

Internet/ technical issues	2	1.7
University factor/ infrastructure	1	0.8
Study/ work factor	1	0.8
No answer	1	0.8
Total	119	100.0

The survey also enabled respondents to express their satisfaction with the effectiveness of online learning. Six general themes emerged from the responses, where online learning was effective in supporting students' learning due to:

1. *Flexible and convenient*: students can obtain information efficiently and flexibly anytime, anywhere.
2. *Efficient and time-saving*: online learning is an efficient way for learning without the hassles of traveling and time limitations.
3. *Affordable and cost-saving*: online learning helps reduce the physical cost of learning, especially traveling.
4. *Enhanced learning styles and experiences*: online learning supports 21st-century learning and complements traditional TL.
5. *Suitable for adult learning*: online learning is beneficial for adult learners who juggle work and study commitments
6. *Supportive for health and wellness*: online learning is seen as the panacea for TL during the pandemic.

5.5 The link between students' use, perception, behavioral intention, and satisfaction of online learning

Table 16 shows the correlation analyses of all variables. All pairs of the variables are significantly correlated at either 0.01 or 0.05 level, except for computer efficacy and RMS. All online learning factors were significantly correlated to general attitude and behavioral intention.

A strong positive correlation exists between the general attitude and behavioral intention (r = 0.860), suggesting that students' general attitude towards online learning significantly influences their intention. Students' perception factors (perceived fit and flexibility) and other attitude factors (i.e., communication, collaboration, and RMS) also indicate a moderate positive correlation (r values above 0.50). Therefore, these variables are potential factors for students' intention to use online learning.

A further correlation analysis studied the link between students' perception, general attitude, and behavioral intention with their satisfaction with online learning, i.e., the item of students' satisfaction with their online course(s). Table 17 shows significant positive correlations between students' satisfaction, all variables, and students' attitude and behavioral intention to use online learning. Perceived Fit indicates the highest correlation value, and general attitude and behavioral intention are moderately positively correlated with satisfaction.

Table 16. Correlation analyses between all variables

Variables	Computer efficacy	Flexibility	Suitability for teaching	PU	PEOU	Perceived Fit	Communication	Collaboration	RMS	General Attitude	Behavioral Intention
Computer efficacy	1										
Flexibility	.286**	1									
Suitability for teaching	..347**	.481**	1								
PU	.254**	.478**	.459**	1							
PEOU	.258**	.510**	.494**	.443**	1						
Perceived Fit	.342**	.554**	.537**	.500**	.705**	1					
Communication	.197*	.577**	.508**	.671**	.610**	.664**	1				
Collaboration	.228*	.429**	.376**	.636**	.515**	.596**	.714**	1			
RMS	.144	.452**	.468**	.463**	.585**	.638**	.670**	.572**	1		
General attitude	.225*	.636**	.409**	.530**	.501**	.649**	.688**	.586**	.597**	1	
Behavioural intention	.277**	.528**	.341**	.436**	.454**	.637**	.570**	.534**	.510**	.860**	1

* Correlation is significant at the 0.05 level (2-tailed);
** Correlation is significant at the 0.01 level (2-tailed).

Table 17. Correlation between factors and satisfaction

Variables	Correlation Coefficient (r)
Computer efficacy	.207*
Flexibility	.525**
Suitability for teaching	.561**
PU	.478**
PEOU	.525**
Perceived Fit	.608**
Communication	.561**
Collaboration	.506**
RMS	.494**
General attitude	.569**
Behavioural intention	.500**

* Correlation is significant at the 0.05 level (2-tailed);
** Correlation is significant at the 0.01 level (2-tailed).

5.6 Key Issues/Challenges of online learning

Students' issues in the HEI's online learning implementation are seen in Table 18.

Table 18. Online learning key issues

Issue	Respondents' Survey Views and Evidence
Pedagogy	Queries of learning effectiveness in online learning: limit students' engagement and grasp of subject content. Some students find online learning challenging, especially subjects with physical and hands-on activities. Comments: "Online lessons can easily pose understanding problems if lecturers failed to transfer the knowledge to students through online sessions," and "some material can lack clarity as the written word can be misinterpreted."
Interaction and communication	Although online learning is helpful for education during the pandemic, gaps exist in social interactivity and connectivity. Comment: online learning is "challenging for those who do not like to speak up or who have a bad environment" in setting up online learning, especially for group discussions.
Connectivity and accessibility	HEI needs technical support for students who lack technological skills/familiarity or have poor internet connection/infrastructure. Comments: Some "may lose out on the discussion aspect of online lecture, thus resulting in lower participation marks" and "the main purpose of lecturer is to teach and not assist with student technical issue… it wastes precious study time of student and teacher".
Wellness and health aspects	Long term, students can be affected physically and mentally with the time and energy spent on computer use. Comments: "The use of computers has increased drastically," and students "tend to be very drained at the end of the day."

6 Discussions of findings and recommendations for enhanced HE online learning

6.1 Students' use and perceptions of online learning

This study shows that the students were highly favorable in using online learning, especially flexibility, suitability for learning, perceived ease of use, and perceived fit. However, respondents indicated a moderate positive perception about computer efficacy and perceived usefulness, particularly in terms of interaction and communication. In terms of attitude, respondents generally had a positive attitude in using online learning, primarily for resource or material sharing. Nevertheless, they had a moderately positive attitude in terms of communication and collaboration.

Overall, respondents' positive attitudes and acknowledgment of flexibility, suitability, ease of use, fit, and several aspects of usefulness in this study support the suitability of TTF and UTAUT models for HE [50][69]. Several studies also indicate similar findings where online learning was perceived positively by students in supporting their learning in crises [32][51][54]. For example, Mishra et al. found that HE students saw online learning helping them engage in their studies; however, they needed stronger relations with others in online learning [54].

6.2 Students' behavioral intention to use online learning

The study shows that the students generally had a positive intention of using online learning for the current semester and the upcoming semesters. This finding indicates respondents' positive perception and acceptance, which suggests positive prospects for HE online learning in Singapore during and post-pandemic.

This corroborates with other studies of HE online learning globally [7][43][15]. For instance, a study of HE students in Jordan found positive prospects for students' behavioral intentions to adopt online learning following the pandemic [7]. Another study found positive and encouraging behavioral intentions among university students towards online learning [43].

6.3 Students' perceived satisfaction with online learning

Students engaging with studies is essential as it underpins academic success. Overall, the findings show that students positively perceived their online learning and were satisfied, so were they motivated to use it. Online learning was deemed adequate for the student's learning during the pandemic because of: flexibility and convenience; efficiency and time-saving; affordable and cost-saving; enhancing learning styles and experiences; suitable for adult learning; supportive for health and wellness.

HE students' satisfaction towards the use of online learning tools and applications was explored in several studies [51][31][32][45]: Guan et al.'s study reported that adult learners in one major Singaporean university are primarily satisfied with online 'chunked' lectures [31]. In another study, instructors' quality, course design, prompt feedback, and students' expectations positively impacted their satisfaction in online learning [32].

6.4 The link between students' use, perception, behavioral intention to use, and satisfaction with online learning

The correlation analyses show significant positive relationships between all variables, suggesting that students' perception, attitude, and satisfaction can determine their behavioral intention to use online learning. Students' general attitude indicates the highest positive correlation to their behavioral intention.

These findings comply with studies that showed the influence of students' perception, usage, and behavioral factors on their satisfaction in using online learning (e.g.[32][71][93]). For example, a study of digital learning objects and experiment simulation tools reported that effective use of ICT tools could encourage students to develop positive attitudes towards the science subject [71]. Similarly, another study observed that students' behavioral intention in embracing and using online learning was significantly linked to its perceived usefulness, perceived ease of use, social factor, and quality of life [93]. On the other hand, one study did not observe a significant relationship between behavioral intention and other aspects of online learning implementation: content quality and a prior online learning experience [7].

For online learning satisfaction, this study supports the findings of a recent Singaporean study of a significant correlation between instructor presence and online learning self-efficacy and HE students' online learning satisfaction [51]. Students' behavioral intention was found to be positively linked to their online learning satisfaction [15]. Students' positive perception was also predicted to positively impact their online learning satisfaction, based on encouraging behavior towards online learning implementation in a university in India [43].

6.5   Critical issues in online learning implementation

Issues emerging in online learning implementation from the study are that students' satisfaction/'fit' needs to be considered more specifically, as seen in the individual survey items in this study, as discussed below. One of the main issues indicated in the respondents' qualitative comments was gaps in interaction and connectivity. Similarly, in the survey items, mean scores on the items concerning communication and collaboration were slightly lower: as seen in Table 6, the mean score for online learning supporting the establishment and maintenance of personal relationships was 3.23; Table 10 were for the items on online learning supporting students forming groups, the mean was 3.44, and for supporting group work it was 3.43; in Table 9, the mean score for the item on improving teacher/student communication was 3.46. This is underlined by the relatively lower scores received for media and web-related tools used for interactivity. Other recent studies also observed similar findings whereby the need for interaction and communication was emphasized by HE students [67] [68]. A social constructivist pedagogical approach highlights the importance of student activity and interaction in learning for enhanced learning outcomes.

Apart from interaction and communication, other issues indicated in Table 18 include pedagogy, connectivity and accessibility, and wellness and health concerns. These have similarly been observed in other studies, including limitations of access on usability and reliability [68], pedagogical development of ICT [42], internet access [71], and eyesight and general body health concerns [54].

Despite these issues, which suggest areas for further development, the findings are that students perceived that online learning supported their independent learning, as evident in its benefits such as flexibility and convenience and suitability for adult learning. In turn, these reflect independent learning and support constructivist pedagogy.

6.6   Recommendation for designing effective post-pandemic online learning

Students' learning satisfaction is crucial in designing a learning intervention as they are critical users of the pedagogical technique/s employed [68]. The following recommendations for enhanced online learning arise from students' quantitative responses and qualitative survey comments.

− **Interactivity.** The study shows that students desire interactivity and active, independent learning (in line with a constructivist approach). Interactivity is crucial in

attracting and retaining students in online education [54][61]. Students who consistently access an online learning intervention use it for collaboration purposes [68]. Thus, teachers and instructors should be responsive and active [67], maximize communications with students and encourage participation and collaboration/communication. These motivate students in their studies and are critical 21st-century learning skills in both on- and offline- learning [44].

— **Positive learning reinforcement.** The study shows students' perceptions and attitudes on their satisfaction and behavioral intention in online learning. Online learning providers should motivate students through positive learning reinforcement, such as praise, social attention, privileges, marks, and tokens for interactive and active class participation. This increases the likelihood of repeated actions (as per the behaviouristic approach) and motivates students [2].

— **Personalized and adaptive learning.** The study highlighted students' appreciation of flexibility and convenience in online learning. Thus, online learning design should support personalized learning for students with diverse learning preferences and needs, using a range of media approaches [19] to address students' level of understandings, skills, and interests; that is, online learning design should modify the presentation of material in response to students' learning preferences [97].

— **Versatile and multi-platform.** As online learning is necessary for crises such as COVID-19, applications should be practical, ubiquitous, accessible, and affordable for the benefit of all students. A multi-platform online learning system with learning content integrated to various accessing devices offers versatile, accessible, and affordable learning for all students [30].

— **Virtual mentoring.** The study shows that support and guidance are required for both lecturers and students. Virtual mentoring by academic and/or administrative staff or peers creates a sense of community and motivates students by offering academic, technological, and emotional support when challenges arise. This enhances the individual's sense of belonging and motivation and assists with access to technical, wellness, academic resources, support, empathy in career and psychosocial development, trust and rapport, role modeling, and self-advocacy [60].

7   Conclusions and future research

While online learning has been the key globally in continuing HE TL during COVID-19, little is known of students' perceptions and satisfaction with their online learning during this period. Such data is the basis for online learning improvement to motivate students to maximize their use of technology.

This study finds that the TTF and UTAUT models were suitable for assessing the students' fit and satisfaction with their online learning and are suitable for use in HE, as they have been used in other domains in previous studies. The models provided a framework to design surveys about students' satisfaction and can be used in HEIs in Singapore and more widely. ICT profoundly alters the teachers' function, which extends beyond the traditional manner of working, as they serve as intermediary supporters in assisting students in obtaining information [42].

On the other hand, emerging from the study are issues encountered that may demotivate students in their studies, and these provide direction for improvements to online learning practices. Overall, as students' communication and collaboration supported by online tools recorded relatively lower mean scores than other survey items, curriculum re-design should consider subject content and teachers' role in promoting interactivity, thus motivating students to use the technology and engage in their studies. The HE mindset should move from one-way content delivery to collaborative and communicative online learning. In all, online learning developments should motivate students by addressing issues related to their satisfaction with their online learning, which concurs with the findings of COVID-19 HE researchers [29].

Since this study involved undergraduate students from one Singaporean university, findings cannot be generalized to the country's whole population of HE students. Further studies using TTF and UTAUT models with pre-university and postgraduate students would provide data concerning the value of these models for these student cohorts. As respondents in this study are more mature in age than school-leaver students and more likely to be more independent in their study, future studies could be replicated with school-leaver-aged students. Another limitation is that this study's cohort is mainly female students. While this might be interesting in itself, it would be more beneficial to investigate the issues of this study across gender lines and to investigate why more females than males have responded to the survey, especially when contextualized to their study disciplines.

The results of this study are in line with another study where teachers' views toward teaching innovation and the direct application of new teaching methods in both live and remote teaching are considered beneficial and necessary [71]. Simultaneously, this study investigates the nature of instructors who can educate in a fundamentally new way, integrating teaching with innovation under challenging conditions. Future research could also include regulators such as Ministry of Education personnel who aim to shift from linear to holistic approaches, especially when current educational development methodology may seem inappropriate now that technology is the focus.

8 Acknowledgment

9 References

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11   Appendix A

Table 19.   Respondents' demographic profiles (N = 119)

	Frequency	Percentage (%)
Gender		
Male	35	29.4
Female	84	70.6
Age		
20 years old or below	6	5
21-30 years old	59	49.6
31-40 years old	33	27.7
41-50 years old	12	10.1
51-60 years old	7	5.9
61 years old or above	2	1.7
Level of education currently studying		
Foundation/ Pre-U	16	13.4
Diploma	2	1.7
Degree	101	84.9
Study Programme		
Business/ Marketing/ Entrepreneurship	7	5.9

Social science/ Sociology/ Social work	27	22.7
Psychology	7	5.9
Language	21	17.6
Law/ Political Science	1	0.8
Management/ HRM	11	9.2
Communication	13	10.9
Security Studies	16	13.4
General Studies	14	11.8
Unspecified	2	1.7