Original Article

Association of Online Learning Tools and Students' Health: A Case Study During the COVID-19 Pandemic

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Abstract:

Objective: This study aimed to determine the health effects on undergraduate students from online learning and connectivity devices, characterizing the association between significant confounding factors and the prevalence of health symptoms among undergraduates.

Material and Methods: This cross-sectional study was conducted from July to August 2021 and involved 219 undergraduates selected by simple random sampling from an academic institute within Thailand. Data were analyzed using Chi-square and Kendall's tau-c tests. All data were collected through a self-administered questionnaire.

Results: Among participants, (1) tablets and smartphones were the major devices used (97.7% and 77.2%, respectively), (2) the prevalence of nervous-related and mental symptoms was over 80% for headache, dizziness, fatigue, difficulty concentrating, stress, tiredness and anxiety, (3) the Chi-square test results for laptop devices revealed an association with anxiety and burnout effects (p-value<0.05 for all), while anxiety presented as a positive correlation coefficient of Kendall rank (0.003), with desktop PC devices, and (4) learning media including video, PowerPoint and academic articles, played a major role in affecting health; especially academic articles, which exhibited a positive relationship in all related effects.

Conclusion: The use of learning media during the Coronavirus Disease-19 (COVID-19) pandemic has had an impact on students' mental health. Decisions regarding implementing mitigation measures and monitoring programs should be reconsidered to reduce risks to students' health.

Keywords COVID-19, health impact, online learning, technology connectivity, undergraduate student

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Introduction

Over the past few years, the World Health Organization (WHO) has reported numerous cases of the Coronavirus Disease-19 (COVID-19) in many countries and declared it a global pandemic. As part of its endeavor to mitigate the spread of COVID-19, the Thai government implemented a series of public measures, which involved measures such as promoting social distancing and temporarily suspending activities at venues that typically experience significant gatherings, including educational institutions. The implemented measures resulted in a transition to a new teaching and learning platform, wherein the methods changed dramatically; from face-to-face classroom instruction to remote or distance learning, with the utilization of various digital platforms. Distance learning, also known as online learning, is a form of education that separates teachers from students during the instruction and learning process. It effectively utilizes a wide range of technology and tools to enrich the students experience[1,2]. Recently, researchers have focused on investigating the impacts of distance learning on educational skills and found that the success of online learning depends on many factors, including accessibility, the usage of appropriate methods, connectivity devices, course contents and assessment criteria[3]. This rapid transformation has resulted in various challenges for both instructors and students[4,5].

Engaging with a curriculum that has transitioned from in-person to online electronic learning mode was a primary focus during the lockdown periods[6]. Numerous types of media, such as video, satellite TV, computer applications, and both local and web-based learning platforms, are capable of delivering text, audio, images, animation and streaming video[7]. According to this transformation, numerous studies conducted among university students have shown a significant relationship between teaching and learning tools, learning approaches, academic progress and study outcomes[8–10]. In addition to these factors, some researchers have revealed evidence of functional health problems linked to limitations in internet access, connection quality and insufficient digital skills[11–14]. Many types of evidence have shown a higher prevalence of stress, anxiety, and other mental health problems compared to those related to other epidemics[15–19]. However, some have reported that the learning materials and devices may eventually affect the health of students; especially in terms of psychological impacts[20].

The primary objective of this study was to assess the impacts of distance learning and connectivity devices on the physical and mental health of Thai undergraduate students. The results could assist institutions in implementing mitigating measures to reduce the potential risk of low educational performance and the prevalence of health problems among students.

Material and Methods

Cross-sectional survey

To investigate the association between online learning and technology connectivity in relation to health effects, a self-administered questionnaire was used for data collection. The study was conducted from July to August 2021, and included undergraduate students that experienced online learning during the COVID-19 outbreak. The number of student samples to be collected, using simple random sampling, was calculated according to the formula proposed by Yamane[21]: as shown in Equation (1). Wherein: n represents the sample size, Z denotes the confidence level value (1.64), p signifies the proportion of the student population to the total number of students (0.442), q represents $1-p$, and e signifies the margin of error: which was set at 0.05.

$$n = \frac{Z^2 pq}{e^2} \qquad \text{Equation (1)}$$

A total of 219 participants were enrolled from an academic institute within Thailand. This study assessed various health effects; including symptoms related to nervousness and mental health, as observed in previous studies. These symptoms included headaches, dizziness, fatigue, difficulty concentrating, stress, tiredness, anxiety and burnout syndromes[15,22]. The study protocol adhered to the principles of the Declaration of Helsinki and received approval from the Ethics Committee for Research Involving Human Subjects (COA. No. 2021-076) before data collection. Inclusion criteria required participants to be full-time bachelor's degree students in the academic year of 2020, with over six months of experience in online class study. Participants provided demographic information, lifestyle behaviors, and health status through a validated online-based questionnaire, as evaluated by experts to ensure its effectiveness in capturing relevant data. The questionnaire also incorporated elements related to online classes and health effects adapted from previous studies[9,23-26]. The instrument consisted of three parts. In the first part of the survey, students reported their demographic details (gender, age, year of study, weight, and height), described their lifestyle behaviors (hours of sleep daily), and described their online class participation (duration per session and day). In the second part, respondents reported details of online learning and critical elements of online classes modified from their related previous studies. In the last part, students were asked to rate the level of mental health effects corresponding to their previous study; including stress, tiredness, anxiety and burnout syndrome (1=none of the time, 2=a little of the time, 3=ome of the time, 4=most of the time, and 5=all of the time).

Statistical analysis

Descriptive statistics, encompassing measures such as frequency, mean, percentage and standard deviation, were employed to analyze the dataset. Subsequently, associations between online learning elements, connectivity devices to health performance were investigated through Chi-square analysis. Kendall rank correlation coefficient (Kendall's tau-c) was employed to indicate the tendency relationship within the rectangular contingency tables[27]. A p-value less than 0.05 indicated statistical significance. These statistical procedures were conducted using Statistical Product and Service Solution (SPSS, Version 18.0, SPSS Ltd., USA).

Results

Characteristics of participants

The study enrolled 219 undergraduate participants, with an average age of 20.0±1.2 years. The participants consisted of more females (87.2%) than males (12.8%). Participants were distributed across different academic years; encompassing 2nd- to 4th-year students, with the majority being 3rd-year students (46.6%), followed by 2nd- and 4th-year students (30.1 and 23.3%, respectively). The mean and standard deviation values of their body mass index (BMI) were 21.6±3.8 kg/m^2, indicating an optimal weight status[28]. In terms of weekly physical activity, the majority (58.9%) reported an unstable workout routine, while 26.0% reported no exercise at all. Demographic characteristics of participants are presented in Table 1. Notably, more than three-quarters (76.3%) reported sleeping less than eight hours daily. Regarding study habits, 65.3% (n=143) of participants reported studying for more than 3 hours per study session, while 34.7% (n=76) studied for less than 3 hours. The vast majority (96.3%) indicated a daily study duration of less than 8 hours, with 43.8% reporting 6 to 8 hours and 52.5% reporting 3 to 6 hours. Only 3.7% (n=8) reported studying for more than 8 hours daily.

Table 1 Participant characteristics (n=219)

Characteristic	n	%
Gender		
Male	28	12.8
Female	191	87.2
Year of study		
Bachelor 2	66	30.1
Bachelor 3	102	46.6
Bachelor 4	51	23.3
Age (years)		
Mean±S.D.	20.0±1.2	
Body mass index (BMI)		
Mean±S.D.	21.6±3.8	
Daily sleeping hours		
≤8 hours	167	76.3
>8 hours	52	23.7
Weekly workout duration		
Everyday	9	4.1
Three times weekly	24	11.0
Unstable	129	58.9
Not exercising	57	26.0
Study duration per session		
≤3 hours	76	34.7
>3 hours	143	65.3
Study duration daily		
More than 3 hours and less than 6 hours	115	52.5
More than 6 hours and less than 8 hours	96	43.8
More than 8 hours	8	3.7

S.D.=standard deviation

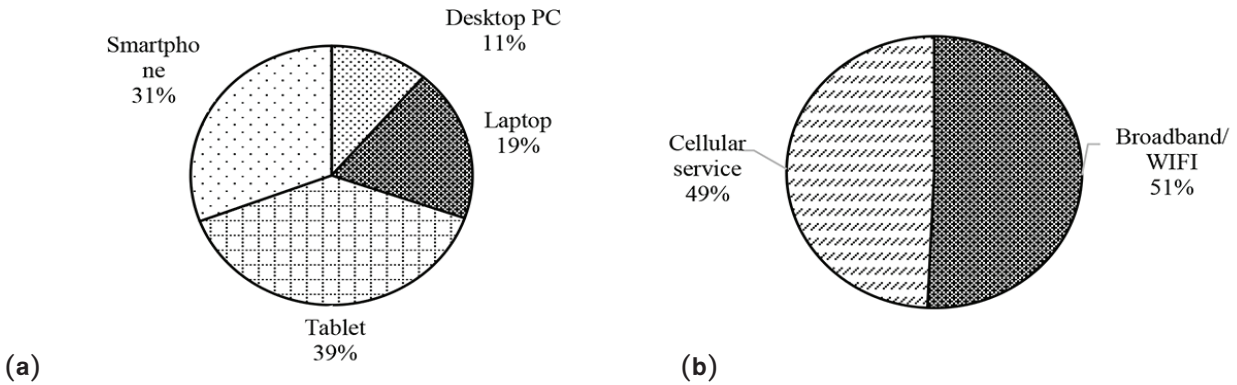**The usage of devices and internet connectivity**

To attend online classes, participants indicated they had access to various devices, including desktop computers, laptops, tablets and smartphones. Figure 1 (a) illustrates that most of the participants (n=214) possessed tablets, 169 participants also had smartphones, 105 had laptops, and only 62 had personal desktop computers. Regarding internet connectivity at home, participants reported nearly equivalent access to broadband service and cellular phones, with approximately 79.9 and 77.6% of participants, respectively, as depicted in Figure 1 (b).

**Heath impacts in relation to online learning methods**

Figure 2 displays the occurrence of symptoms during online learning among undergraduate participants; specifically those related to nervousness and mental health. The majority of these symptoms were reported at rates exceeding 80%, including headache, dizziness, fatigue, difficulty concentrating, stress, tiredness and anxiety. Burnout syndrome, on the other hand, was reported at a rate of approximately 63.9%. The frequency of occurrence for these health symptoms is presented in Figure 3. Six out of eight symptoms occurred more than 3 times per week, while the headache and burnout syndrome were reported as occurring less than 3 times per week. All symptoms occurred regularly, ranging from 6.8% to 25.1%, with the highest frequency observed for the symptom of dizziness.

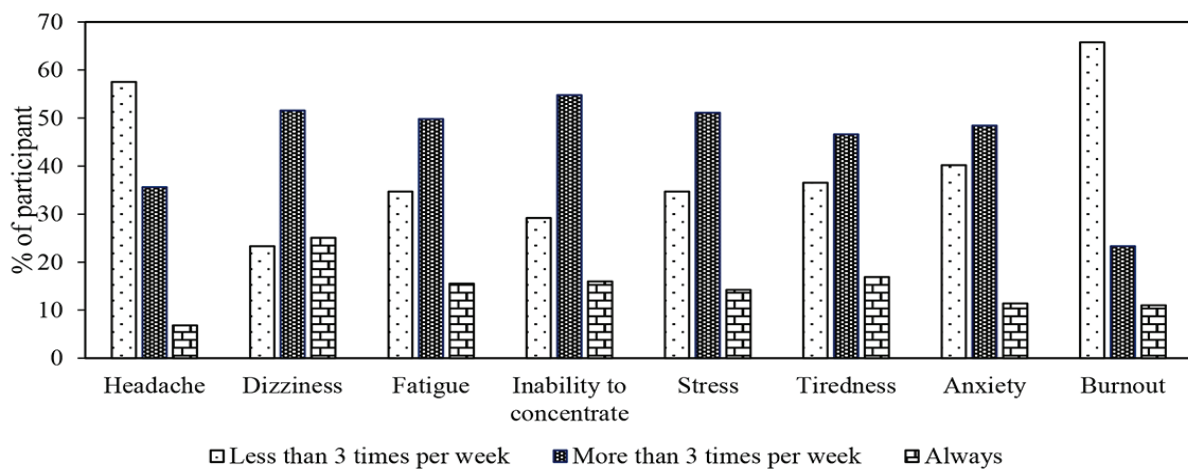**The association between technology connectivity and health impacts**

Table 2 presents the relationship between technology connectivity and health symptoms. The use of desktop PCs and laptops showed significant associations with anxiety (p-value=0.019 and p-value=0.036, respectively). Additionally, the use of laptops tended to increase the symptoms of burnout syndrome (p-value=0.027). No significant relationships were observed between other devices, including tablets, smartphones, and internet connectivity in relation to health impacts. When considering the Kendall rank correlation coefficient, a positive correlation was found between desktop PCs and anxiety: as shown in Table 3. In contrast, laptop devices showed negative correlations with both anxiety and burnout effects, with values of –0.114 and –0.148, respectively.

Figure 1 Technology connectivity for attending online classes (a) Learning devices; and (b) Internet connectivity
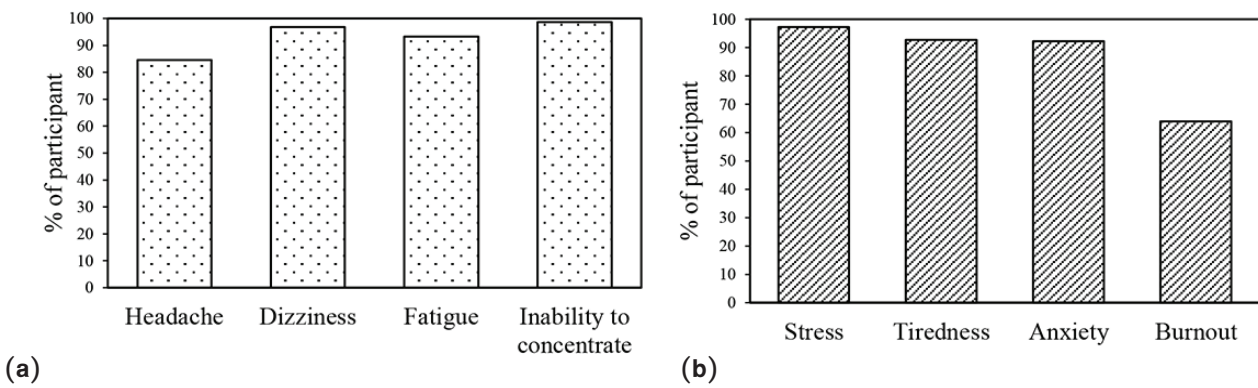
Figure 2 Prevalence of health symptoms among the participants (a) Nervous–related symptoms (b) Mental health symptoms

Figure 3 Frequency of occurrence of health symptoms among the participants

Table 2 Association of technology connectivity (learning devices and internet connectivity) to health symptoms

Types of health	Learning devices				Internet connectivity	
	Desktop PC	Laptop	Tablet	Smartphone	Broadband/WIFI	Cellular service
Headache	0.325	0.390	0.780	0.582	0.937	0.284
Dizziness	0.403	0.297	0.681	0.584	0.569	0.689
Fatigue	0.298	0.523	0.239	0.364	0.993	0.384
Inability to concentrate	0.846	0.094	0.790	0.343	0.382	0.349
Stress	0.782	0.468	0.704	0.534	0.213	0.182
Tiredness	0.397	0.490	0.525	0.830	0.889	0.794
Anxiety	0.019	0.036	0.512	0.596	0.128	0.468
Burnout	0.256	0.027	0.089	0.495	0.272	0.655

p-value by chi-square test <0.05

Table 3 Kendall's test for significant learning devices and health symptoms

Learning devices	Health effects	Kendall's tau-c
Desktop PC	Anxiety	0.003
Laptop	Anxiety	−0.114
	Burnout	−0.148

The relationship between elements of online learning and health effects is displayed in Table 4. The use of video was associated with fatigue (χ^2=10.618, df=4, p-value=0.031), while the use of PowerPoint media significantly contributed to difficulty concentrating (χ^2=12.892, df=4, p-value=0.012). When academic articles are used in the online class, tiredness was impacted (χ^2=12.840, df=4, p-value=0.012). Daily study duration was significantly linked to various health effects (p-value<0.05 for all). The summative assessment process was related to burnout effects (χ^2=11.383, df=4, p-value=0.023). Academic load also displayed a significant positive relationship with anxiety (χ^2=16.826, df=8, p-value=0.032). Regarding supportive facilities during online learning classes, non-backrest desks and chairs were associated with two types of health effects: difficulty concentrating and stress (χ^2=11.875,

df=4, p-value=0.018 and χ^2=11.928, df=4, p-value=0.018, respectively).

When analyzing the Kendall rank correlation coefficients, positive correlations were found as follows: the use of academic articles and tiredness; daily study duration and various health effects, including headache, dizziness, fatigue, stress, and tiredness, summative assessment process and burnout syndrome, academic workload and anxiety. Conversely, negative Kendall's tau-c values were found between the following factors: the use of video and fatigue; the use of PowerPoint media and difficulty concentrating; daily study duration and both anxiety and burnout syndrome; the use of desk and chair without backrest and both difficulty concentrating and stress.

Discussion

The use of mobile and other electronic devices for learning and various activities; including social and content interaction, has been acknowledged by generations born during the technology revolution[29,30]. Regarding the results, undergraduate participants predominantly opted for tablets and smartphones for their learning activities during the pandemic. Some researchers have mentioned that new technologies can evoke negative feelings throughout

Table 4 Significant association of elements of online learning and health effects

Elements of online learning	Health effects	Chi-square (df)	p [a]	Kendall's tau-c
Using video media	Fatigue	10.618 (4)	0.031	−0.016
Using PowerPoint media	Difficulty concentrating	12.892 (4)	0.012	−0.020
Applying academic articles	Tiredness	12.840 (4)	0.012	0.036
Study duration per day	Headache	28.541 (8)	0.000	0.003
	Dizziness	21.347 (8)	0.006	0.051
	Fatigue	24.633 (8)	0.002	0.008
	Stress	17.377 (8)	0.026	0.010
	Tiredness	22.787 (8)	0.004	0.081
	Anxiety	24.532 (8)	0.002	−0.030
	Burnout	17.523 (8)	0.025	−0.042
Summative assessment process	Burnout	11.383 (4)	0.023	0.034
Academic workload	Anxiety	16.826 (8)	0.032	0.056
Using desk and chair without backrest	Difficulty concentrating	11.875 (4)	0.018	−0.085
	Stress	11.928 (4)	0.018	−0.112

[a]p by chi-square test

the learning process[29]. Numerous studies have indicated that online learning places significant mental pressure on students[9,22]. Stress, tiredness, and anxiety were some of the most commonly reported symptoms among participants. However, anxiety was only shown to have a significant relationship with desktop PCs and laptops. This finding corresponds to those of studies conducted during the lockdown period, which demonstrated that the e-learning application mode significantly disturbs students' psychological health, including depression, sleep patterns, social interaction and academic performance[20,31,32]. From the findings, it is evident that anxiety and burnout effects were significantly linked to the use of learning devices (p-value<0.05). However, only desktop PCs exhibited a positive relationship, implying a similar tendency between these factors. In contrast, the use of laptop devices is associated with negative outcomes. This value indicates opposing trends between these factors.

Regarding the elements of online learning, both learning materials and supportive tools were linked to health effects and undergraduate participants performance. Fatigue was found to be potentially caused by the use of video media in learning. This corresponds with other studies that have identified symptoms of: 'zoom fatigue' when videoconference meetings were held throughout the day[33,34]. Daily study duration presented a significant positive correlation with health effects, including headache, dizziness, fatigue, stress, tiredness, anxiety and burnout. It is noteworthy that most undergraduate participants engaged in 6 to 8 hours of daily study, which is a common practice among Thai students. Related studies have recommended that the optimal class duration for achieving the best outcomes should be limited to one hour[35–37]. Based on the results and related literature, these statistics signal the need for regular mental health screening of undergraduates during distance learning. Additionally, other key findings of this study suggest that certain elements of online learning can lead to a prevalence of major health symptoms, including summative assessment, academic workload and equipment/ features. Summative assessment and academic workload exhibited a positive relationship, as indicated by tau-c, while the availability of desks and chairs without backrests presented the opposite effects.

Conclusion

In conclusion, this study delved into the health effects experienced by undergraduate students engaged in online learning during the COVID-19 pandemic. The study considered various factors; including the types of electronic devices utilized, internet connectivity, the prevalence of both physical and mental health symptoms, and elements of online learning. The results highlighted several key trends. Tablets and smartphones emerged as the primary devices of choice among students, and the prevalence of nervous-related and mental health symptoms was alarmingly high. Moreover, a positive association was found between the choice of learning tools and the manifestation of health symptoms. Regarding elements of online learning and health symptoms, significant associations were observed for factors such as the use of video and PowerPoint media, the application of academic articles, daily study duration, summative assessment processes, academic workload and the availability of features during distance learning. It was also evident that the selection of learning devices was associated with the risk of anxiety and burnout. These findings can provide valuable insights for policymakers and educators in developing strategies that enhance course materials and establish monitoring programs for regularly health screenings undergraduates engaged in distance learning.

Limitations

Limitations were encountered in this study. The study design was only able to identify significant risk factors, and could not establish cause-and-effect relationships between the variables. For further research, it is recommended to conduct large-scale office studies in various curricula and faculties. Additionally, conducting a comparison between the period during the pandemic and regular situations would provide valuable data for devising effective plans to mitigate health impacts on undergraduates.

Conflict of interest

All authors declare no conflicts of interest.

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