

Factors Affecting Online Teaching and Learning Amidst Covid-19 in College of Science and Technology

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Abstract

COVID-19 had an enormous influence on students, teachers, and educational institutions all over the world, as it did on so many other aspects of everyday life. Schools and colleges were closed across the world to comply with social distancing initiatives. In order to ensure education continuity, the traditional mode of face-to-face learning has been replaced by online learning. This paper sets out to determine the factors affecting online teaching and learning amidst COVID-19 in College of Science and Technology. The research is based on a mixed methodology consisting both qualitative & quantitative approach which is used mainly to gain more in-depth understanding of the factors that affect online teaching and learning for both tutors and students. Firstly, the quantitative approach is applied whereby an online survey will be carried out in order to see the core factors in the bigger picture. The survey was conducted via Google form for the students and collected the data from 297 respondents. It was then followed by the qualitative approach whereby four teachers and nine students were interviewed (semi-structured interview) to validate the findings collected from the survey and consequently find the recurring factors. Then, to get a true integration of data and the relations between the qualitative and quantitative aspects of the data sets, the Dedoose software is used to analyze as a whole rather than two different components that must be pieced together. It was found that network connectivity, equipment availability for practical classes, nature of student and tutors, data insufficiency, favorable environment, module content and how adaptive student and tutor were to online platform were the factors identified affecting online teaching and learning at CST during Covid-19.

Keywords: Online teaching and learning, Factors, Equipment availability, Network connectivity, Student characteristics, Tutors characteristics, Data insufficiency, Favorable environment, Module content

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1. Introduction

In the education system, online teaching and learning is the most prevalent form of distance education and that cannot halt during curfew period. The education that is provided via the Internet is also known as “e-learning” among other terms. And it is a source of information due to its ubiquity (availability anywhere and anytime) (Kessler, 2018). The most popular virtual classroom applications are zoom, google classroom, Moodle blackboard, BigBlueButton (Slijepčević, 2020). This virtual classroom is an online classroom environment that helps students to live interact with tutor while participating in learning activities and hence replace the face to face classroom teaching and learning. As a result, advancements in educational technology have crossed classroom borders, ensuring that learning is available at all times.

In context to the Royal University of Bhutan (RUB), the Virtual Learning Environment (VLE) was launched in the Year 2011 and has been using it since then. It is considered one of the most effective pedagogy tools for enhancing the quality of education (Park, 2011). It is our assumption that most colleges under RUB are using virtual learning platforms like zoom, and BigBlueButton for online mode of education amidst COVID-19. Indeed virtual learning environments are not effective and interactive among students and teachers until students are sent home due to novel coronavirus. This pandemic forced teachers and students to use VLE in order to keep going in the learning and teaching process in the college i.e., through virtual learning platforms students can access learning materials and continue with the semester from home

The first positive case of covid-19 was confirmed and declared on Bhutan Broadcasting Service (BBS) by his Excellency Lyonchen Lotey Tshering on 6th March, 2020 (Palden, 2020). Palden says that the government immediately banned the tourists’ visits and closed the schools and institutes in Thimphu, Paro and Punakha where the first covid-positive person has visited. After two weeks since the first covid-positive case was detected, schools and universities were closed nationwide on 18th of March, 2020. Hence, all the students of College of Science and Technology were sent home in an effort to maintain social distancing and prevent community spread.

The closure compelled all the students and teachers to teach and learn via online methods which led to leaving the traditional method of face-to-face teaching and learning behind (Elumalai et al., 2020). This method of online teaching-learning was ad hoc for both the students and teachers, thus many complaints were made about the online mode of learning whereby different individuals had their own perspective about this mode of learning.

According to UNESCO (2020), it confirms that university closures during Covid19 have implications for students, such as disrupted learning, which results in students missing out on opportunities for growth and development. Most students have claimed that online learning is not as comfortable as face to face learning. And students are deprived of opportunities like exchange programs and not having access to equipment for practical class in online mode of learning. However, there are no concrete proven reasons for online learning being uncomfortable as of now. With the shift in such mode of teaching-learning across the country and in particular within the College of Science and Technology, there were greater concerns about the challenges and issues and how productive the learning is among the students via the online mode. So, it is essential to find out the factors that affect online teaching and learning especially for students and staff of College of Science and Technology (CST).

2. Literature Review

A qualitative research was done by Jiminez, Rodriguex and Vidal (2016) to determine the important role and their function in online teaching. They have interviewed 29 course tutors and all the responses were recorded with prior permission from the interviewee. The collected data was analyzed using Atlas.ti software and found out that there are three macro-categories after re-categorizing. They are tutor resources that include materials, communication tools, activities and tasks, technical aspects, forum and content. Tutor's functions and tasks is also one of the macro-categories of roles and function of the tutors that include tutor's task, attention, tutoring and support, organization and planning and all the work undertaken by tutor in the performance of his/her duties. The last category is student's characteristics that comprise all features that characterize the students. They defined these as the role and function of tutor on online learning.

Mohammed, Ahmad, and Ahmad (2020) performed a study with 30 students and 31 experts in e-learning programs at six universities in Jordan and Saudi Arabia to learn about the success variables and difficulties of e-learning. From the papers they have reviewed, they have defined four categories of challenges, namely: Technological difficulties, individual difficulties, cultural difficulties and course difficulties. Next, for their paper they have performed semi-structured interviews as well as online interviews with the students and the expertize. The data collected was analyzed by thematic analysis using NVivo software. The challenges/issues found after the analysis in the study are : Change management issues- some still prefer face-to-face learning over e-learning, E-learning system technical issues, Financial support issues, Technological factors- hardware, software and network connectivity, E-learning system quality factors, Culture factors, Self-efficacy & trust factors

According to a report by Xu (2007), e-learning approaches are cost-effective, learner-centered, and have time and location flexibility, making it possible for a global audience to access and handle online learning programs more effectively. Some advantages of online learning include the ability for students to plan their studies at their leisure and the ability for faculty to reuse previously prepared course materials (Neumann, 1998).

A study by García & Weiss (2020) was to determine the students' performance during this Covid-19 pandemic and equity of the student. With this pandemic, there was a decrease in the learning time for the student thus, interrupting the learning process. This leads to the loss of interest in study for some students causing a decrease in the number of students attending the online class. They also found out that the lack of basic requirements to attend the online class and bad network connectivity in the countryside was also affecting the performance of the students. Their findings showed that teachers also need to undergo training and support for the student to perform better. Teachers who have undergone such training are able to convince the student and also conveniently teach them. And when students were in boarding schools, there was no problem for malnutrition and lack of shelter; some students with low financial income have to worry about the health insurance of themselves and their family.

A non-experimental quantitative research was done by Chung, Subramaniam & Dass (2020) at university in Malaysia with 399 respondents (116 male & 283 female). They found out that majority of female and more of the degree students were ready to take online courses than male and diploma students. They found that female students are more satisfied with online courses and intend to use online learning. Moreover, students prefer pre-recorded lectures uploaded than voice lectures given via WhatsApp.

They found out that internet connectivity was the major challenge faced by students followed by too many learning methodology adopted by various tutors. The experienced tutors used google classroom and other platforms like zoom and uploading pre-recorded video in YouTube. On the other hand, an inexperienced tutor used WhatsApp for delivering the lectures. They had other challenges like limited broadband data, slow personal laptop and devices, difficulty to focus while learning online, lack of motivation unlike face to face learning, difficulty in understanding the module content and lack of technical skills. From their research, they found that students don't want to continue with online learning if they were given a choice by their government.

3. Methodology

For this research paper, a mixed methodology (qualitative & quantitative) approach is used mainly to gain more

in-depth understanding of the factors that affect online teaching and learning.

In the mixed methodology, firstly, the quantitative approach is applied whereby a survey will be carried out in order to see the core factors in the bigger picture. The survey was conducted via Google form with the link shared to the students who are residing out of campus and the students and the staff who are residing within the college campus. The questionnaire was based on a 5 point Likert scale (5- strongly agree, 4-agree, 3-neutral, 2-disagree, 1- strongly disagree) (Elumalai et al., 2020).

The quantitative approach was followed up by the qualitative approach whereby teachers and students were interviewed (semi-structured interview) to validate the findings collected from the survey and consequently found out the recurring factors (Scribbr, 2019).

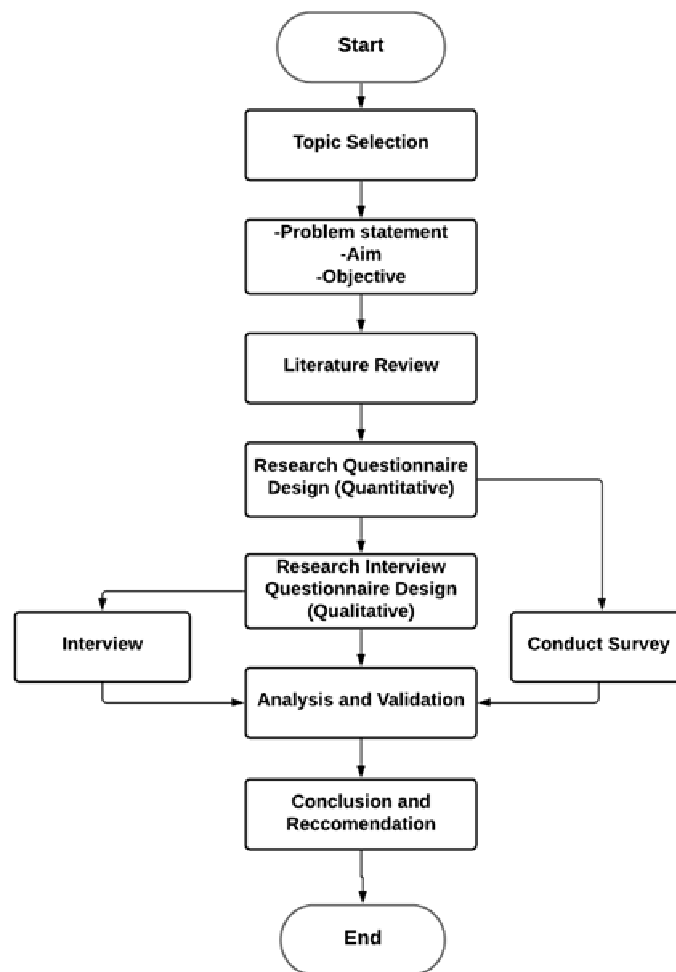


Figure 1. Research method

4. Data Collection

4.1 Sample Design

There are a total of 971 students and 82 lecturers in college of science and technology. Using the quantitative method, it is rarely possible to collect data from each and every student in CST. For this reason, we decided to go for probability sampling where we have randomly selected the students and made statistical inference about the whole group (McCombes, 2019). To be more precise, we chose a simple random sample, in which every member of the population has an equal chance of being chosen. For the sampling method, the formula used is the Slovin's Formula as behavior of the population is not known i.e., there may be no information about how the population will behave (such as surveying college students to get their genuine response on factors that affect online learning). Moreover, Slovin's formula estimates how large a sample size should be to ensure an acceptable level of consistency in the results (Ellen, S., 2020). The total sample size adopted for the study using Slovin's formula is 283 students.

297 responses

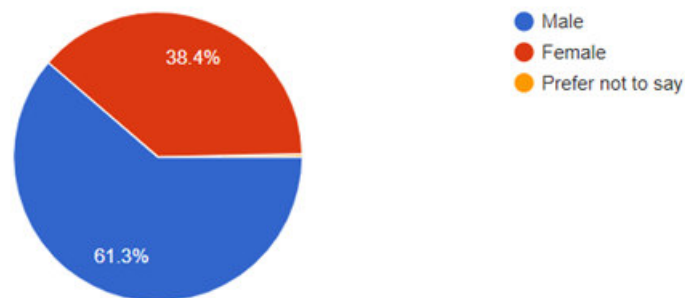


Figure 2. Total responses

There are total of 971 student in College of Science and technology who have attended online classes and for our study, we attempted the sample size of 283 students out of which 100% and more have responded with a total of 297 responses.

For the qualitative method, the method used is the convenience sampling, which is one of the non-probability sampling method. A convenience sampling simply includes the students and tutors who happen to be most accessible (McCombes, 2019). Among the student body, interviewees was selected from each batch of every department and the faculty who are most convenient were selected for the interview.

5. Data Analysis

Thematic analysis was used to analyze the data collected from the interview, which was done using Dedoose software. Braun and Clarke (2006) defined five steps for performing the thematic analysis: Familiarization with data, generating initial codes, searching for themes, identifying and naming themes, and generating the final report (Almaiah, Al-Khasawneh, & Althunibat, 2020)

Familiarization includes going through the data in general to get acquainted with it. Then there is the coding, which involves creating shorthand labels or codes to denote the content. The next step is to create themes, which are usually broader than codes and are made up of a collection of codes. Defining themes, which entails identifying precisely what is meant by each theme and determining how it supports understanding the data.

Table 1. Interviewee profile

Interviewee profile	
Interviewees	Status
P1	Student
P2	Student
P3	Student
P4	Student
P5	Student
P6	Student
P7	Student
P8	Student
P9	Student
P10	Tutor
P11	Tutor
P12	Tutor
P13	Tutor

Finally to write up the data analysis (Caulfield, 2020), Dedoose, a mixed methods data analysis framework was used to compile and enter both quantitative and qualitative data. Users can code qualitative data when linking it to quantitative data, and then filter or sort the coded qualitative data through use of "descriptors" (in this case, the responses to the Likert-type questions). This Dedoose software is a useful tool for mixed methods researchers, especially when dealing with large data sets. To get a true understanding of the relations between the qualitative

and quantitative aspects of the data sets, they should be analyzed as a whole rather than two different components that must be pieced together.

The codes and their descriptions are depicted in Table 2.

Table 2. Guide to data coding

Guide to data coding	
Code	Descriptions
Technical Challenges	The technical challenges includes all external technology variables like availability of equipment, device resources, network connectivity and tools that is one of the factors that effects online teaching and learning in CST.
Environment	It includes the factor such as surrounding or the home environment that have impacted the students and tutors in CST while teaching and learning online.
Social Behavior	It defines the personal characteristic/problem (i.e. concentration during online class) defined by the student and the tutors. It also includes one's financial background and support they get during online teaching and learning.
Adaptiveness to online platform	The content determines how adaptive the students and the tutors are to the online platforms (i.e. Zoom, BBB) used for online teaching and learning.
Module Content	It defines if the modules taught in College of Science and Technology (CST) is appropriate for online teaching and how much a student learns online.

The following Table 3 and 4 includes the codes, themes and the evidences that supports each factors which effect online teaching and learning. The results' presentation are taken from the survey questionnaire, interviewee narratives, codes, themes, and graphs.

Table 3. Codes, themes and sample assisting evidences

Codes, themes and assisting evidences		
Code	Themes	Assisting evidences
Technical Challenges	Equipment Availability	"...can't afford the tools required for the lessons..."(P1). "...availability of the equipment for practical classes..."(P2). "I think it would be ineffective for other department students due to unavailability of equipment."(P3). "my laptop used to get hanged"(P6). "Resources for conducting interactive online class"(P8).
	Network Connectivity	"don't have to worry about network issues and there would be no disturbances"&" Network issues Learning environment"(P1). "...reliability and sufficiency internet facilities."(P2). "Internet connection in your place"(P3). "...internet was not favorable ..."(P4). "..., there was some network connectivity problem.."(P6). "Internet connectivity: if there is poor internet connection, students"(P7). "Internet bandwidth must be enough"(P8). "...access to good internet, electronic devices..."(P9).
Social Behavior	Student characteristics	"i had to find my own space to study and it was difficult concentrating"(P1). "I can concentrate well, some concepts can be worked out practically"(P1). "I easily distracted and fall asleep many a times since there is nobody monitoring me"(P2)." I can better concentrate during the offline lessons..."(P3). "...difficult to understand the lesson just by looking at the screen..."(P4). "...we tends to forget..."(P5)." i would usually fall asleep.... bored."(P6). "...able to cope up with learning online..."(P7). "...trouble during assessment tasks since students would rarely put it in proper format"(P9).
	Tutor characteristics	"teacher only tends to explain all the numerical verbally..."(P5). "Teachers cannot assess students' learning like in offline class"(P7). "Competent teachers to use tools for creating online content."(P8).
	Data insufficiency	"we cannot recharge"(P4).
Environment	Favorable Environment	"...better environment..."(P1). "...not-so-good learning environment out there at my place"(P2). "...social distraction that diverted..."(P6)."... do not have environment conducive to learn..."(P7). "with proper environment setup,..."(P8). "...good environment have an advantage."(P9).

Codes, themes and assisting evidences		
Code	Themes	Assisting evidences
Adaptiveness to online platforms		"...online class was a bit challenging"(P1). "...i no more face any difficulty in using the tools that are used for the online mode of teaching and learning"(P2). "think that offline teaching/ face to face teaching is far more better..."(P3). "It was very difficult to adapt in this new mode of learning..."(P4). "i am very new to this kind of learning"(P5). "...not that adaptive to this mode of learning"(P6). "I was bit reluctant to study online"(P7). ".It was difficult for both teachers and students.."(P8). "...it was very new for them"(P9).
Module content		"For IT students, it is better as the tutor just need to show the demo and students and students can follow up" & "...it would be difficult to do the practical by themselves without a guide."(P1)." For IT department.....the practical classes taken online were quite effective"(P2). "Being an IT student I think that it doesn't really matter whether we take the practical modules online or offline..."(P3). "...difficult to understand the lesson just by looking at the screen.."(P4). "...it meaningless without experiencing ourselves."(P5)." Require competent education manager to design good instructional design"(P8)." . I only took....practical's onlinedid not enjoy it..."(P9).

Table 4. Codes, themes and assisting cases

Codes, Themes and assisting cases.			
Code	Themes	Total assisting cases	Total
Technical Challenges	Equipment Availability	P1, P2, P3, P6, P8, P10, P11	7/13
	Network Connectivity	P1, P2, P3, P4, P5, P7, P8, P9, P10, P11, P12, P13	12/13
Social Behavior	Student characteristics	P1, P2, P3, P4, P5, P6, P7, P9, P10, P11, P12, P13	12/13
	Tutor characteristics	P3, P5	2/13
	Data insufficiency	P4, P7, P10, P11	4/13
Environment	Favorable Environment	P1, P2, P6, P7, P8, P9, P11, P12	8/13
Adaptiveness to online platforms		P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13	13/13
Module content		P1, P2, P3, P4, P5, P8, P9, P13	8/13

6. Result

6.1 Network connectivity

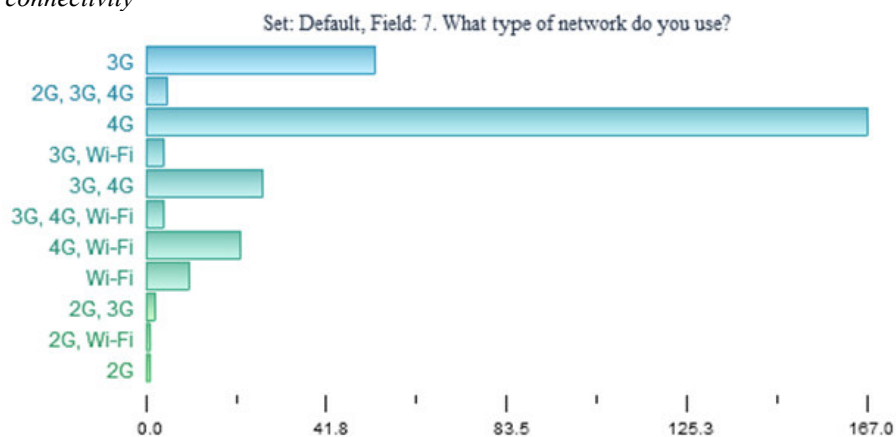


Figure 3. Types of network

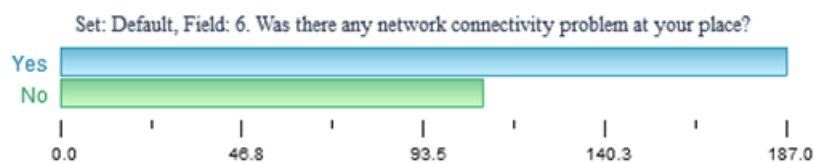


Figure 4. Network connectivity problems

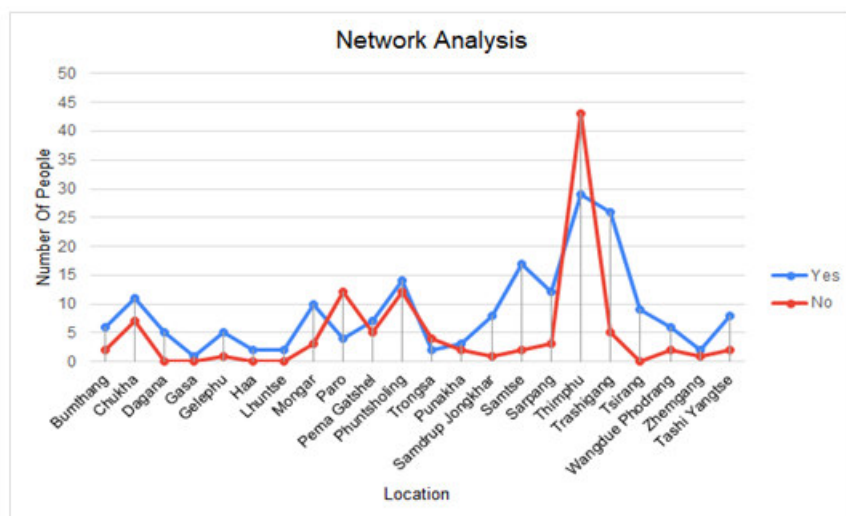


Figure 5. Network analysis

Figure 4 shows that many of our respondent uses 4G network apart from other types of network considering 4G to be the fastest network available in our country. However, Figure 5 shows that 187 respondents out of 297 have network issue while attending online classes. From inter-dzongkhag network analysis as shown in Figure 6, it depicts that many of our respondent were living in Thimphu where network bandwidth was sufficient to attend online classes. Other places like Paro and Trongsa are having less network issues while majority of other places are facing unstable network challenges. From the graph, we find that places like Samtse, Trashigang and Tsirang are having worse network connectivity compared to another Dzongkhags. Hence, from the analysis we know that even if most of the students have 4G connection, they still face network issues that can be considered as one of the factors that affect online teaching and learning.

6.2 Availability of equipment

Set: Default, Field: 3. Do you have all the basic equipment (laptop, mobile phones) to attend online classes?

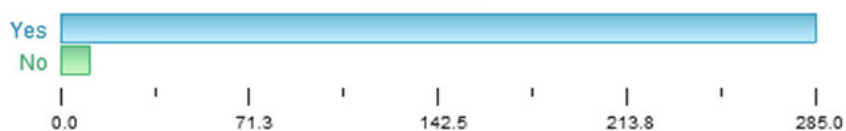


Figure 6. Equipment availability for online classes

Set: Default, Field: 4. Which device do you use for online learning?

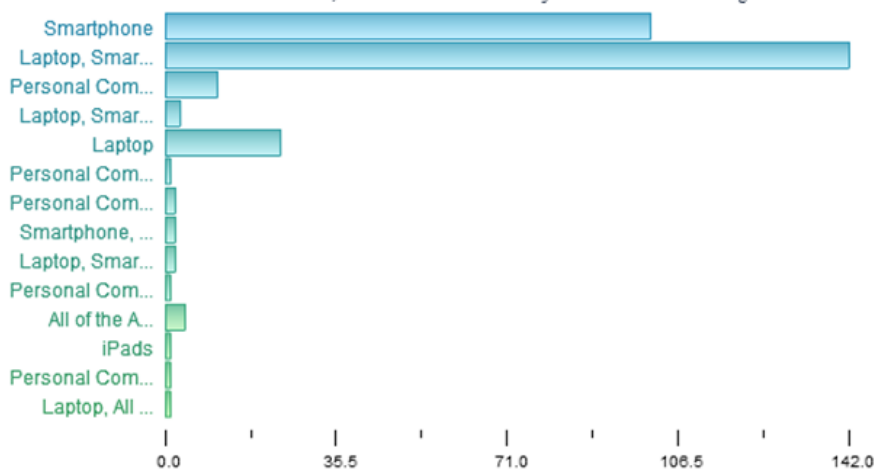


Figure 7. Devices used for online classes

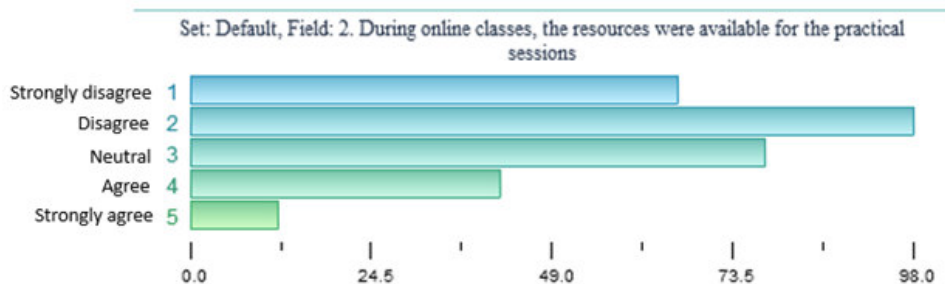


Figure 8. Resources availability for practical classes

The analysis from Figure 7 and 8 depicts that, almost all the students are having the basic devices like laptops or smart phones or both with which they can attend their online classes and they could watch the pre-recorded sessions uploaded by their tutors. However, being a technical college, many modules taught are associated with practical components in general. Due to this fact, maximum of the respondent agrees or strongly agrees that they don't have the appropriate resources like enough RAM to download the software or the latest laptop modules which support different software or availability of the practical tool carried out for the practical classes as depicted in Figure 9. To sum up, unavailability of devices with required resources is another factor that affects online teaching and learning in CST.

6.3 Student and Tutors Characteristics

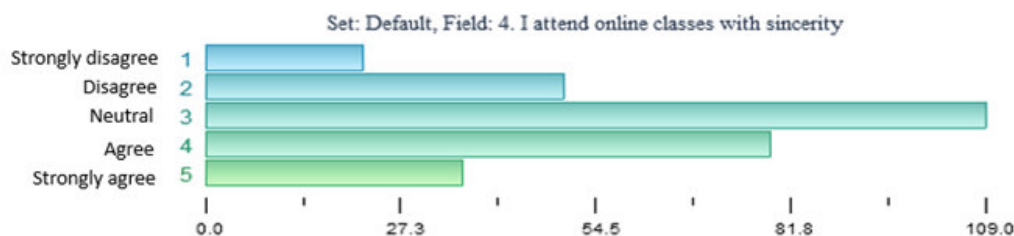


Figure 9. Resources availability for practical classes

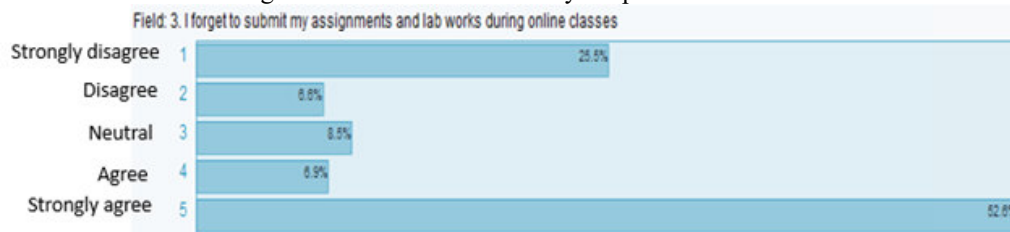


Figure 10. Student forgetting to submit assignments online

Figure 10 shows that maximum students opted for neutral when asked if they attended online classes with sincerity, there were some who disagreed as well as some who agreed on it. This shows that the characteristics of the students vary from individual to individual. But Figure 11 shows that maximum of the students strongly agreed that they forget to submit their online assignments and there were students who disagreed as well. Hence from this analysis we can conclude that without monitoring and control, students fail to be attentive. And when it comes to tutors' characteristics, through interviews some stated that coming up with different strategies to teach like using of polls to ask questions make the students understand better. Hence, characteristics of both the students and tutors is one of the factors that affect online teaching and learning.

6.4 Data consumption

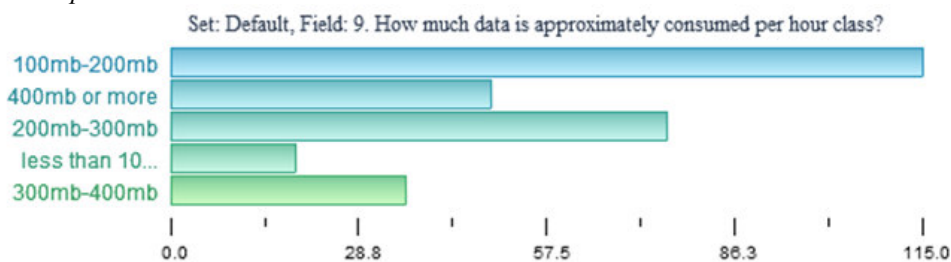


Figure 11. Data consumption per hour class

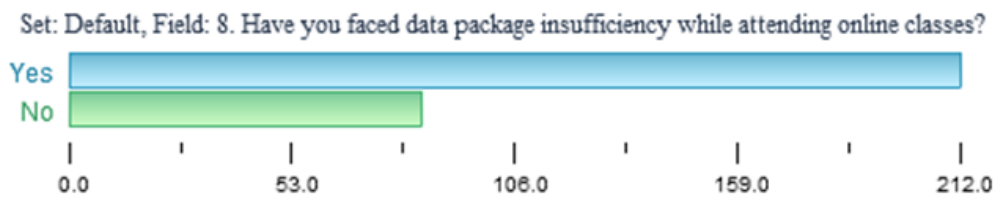


Figure 12. Data insufficiency while attending online classes

From the survey we found that there were 115 students who said 100mb to 200mb of data is used in an hour class, 70 students said 200 mb to 300mb of data is used, 30 students responded that 300mb to 400mb of data are being consumed, and 41 of the students said that more than 400mb of data are being used. Considering the response of the majority that is 100 to 200mb, where in a day, a student have five to seven hour classes where again they have to revisit the lessons and also explore more, this indicates that the data consumption is quite high. From Figure 13, it indicates that 212 student have faced data insufficiency and 79 did not have any issues related to data insufficiency. And when interviewed, they said that because of the data insufficiency they would miss online classes and only learned through the recorded session at the end. Hence data consumption is also a factor that affects online teaching and learning

6.5 Favorable environment

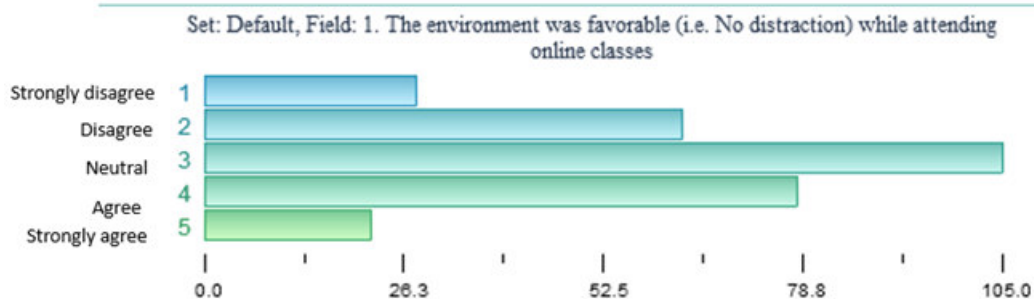


Figure 13. Favorable environment

The data obtained from the survey depicts that the environment from where they have attended online classes were not affecting their online lessons for most of the student but there are also students who agree and disagree in these regards as shown in Figure 14.

From the interview, we found that the surrounding environment have effects on how much a student learn, concentrate, or listen on to the content taught during online classes and these are some of the statements given by interviewee:

“I find the offline mode of teaching much better compared to the online mode. This is solely because of the not-so-good learning environment out there at my place. I easily distracted and fall asleep many a times since there is nobody monitoring me.”(P2).

“i had to find my own space to study and it was difficult concentrating.”(P1).

Therefore, in the context of CST as well, the favorable environment is one of the factors that affect online teaching and learning.

6.6 Module content

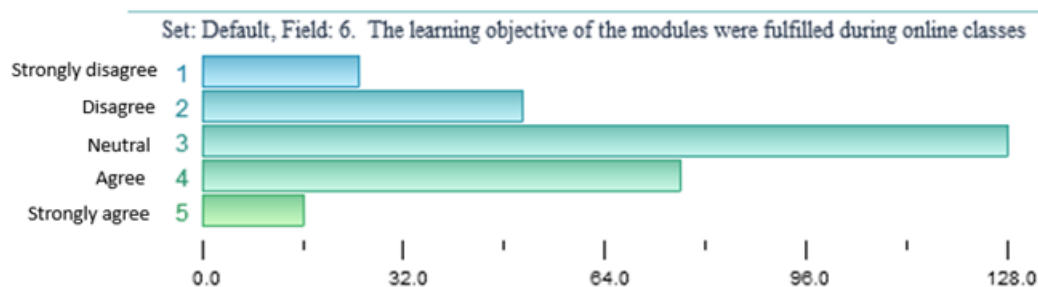


Figure 14. Fulfilment of learning objectives

The finding depicted in the Figure 15 shows that students are least bothered about whether the module objectives are fulfilled or not but from the interview, it was found that it is infeasible to learn practical oriented modules online. These are some of the statement given by the interviewee:

“I would say that the practical’s taken online were not effective because for the practical modules, we

require some equipment to conduct on and even if it was based on some software, our laptops use to get hanged demotivating us to carry our practical.”(P6).

“It’s challenging for practical modules to take online, nevertheless, with proper environment setup, it is doable” (P8).

In conclusion module content is also taken into account as one of the factors that affect online teaching and learning.

6.7 Adaptiveness to online platforms

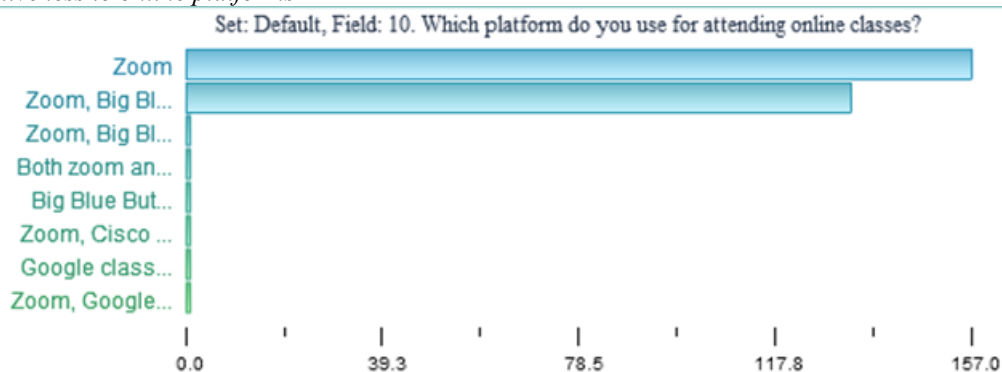


Figure 15. Different online platforms

Zoom application was found to be the top most application used by majority of the tutors to take online classes followed by other e-learning platforms. Since online learning was very new, both tutors and students have faced difficulties adapting to the tools used. But with time, many students and tutors were able to use the tools up to the basic requirement. From the interview, we found out that many prefer to have classes offline rather than online. Given below are some of the statements given by interviewee:

“I think that offline teaching/ face to face teaching is far better than online teaching because I can better concentrate during the offline lessons compared to online.”(P3).

“It was very difficult to adapt in this new mode of learning because it was difficult to understand the lesson just by looking at the screen”(P4).

“It was difficult for both teachers and students initially”(8)

Hence, adaptiveness to online platform is one of the factors affecting online teaching and learning.

7. Limitations and suggestions for future studies

This research found that network connectivity, equipment unavailability for practical classes, nature of student and tutors, data insufficiency, favorable environment, module content and how adaptive was student and tutor to online platform were the factors that affected the online teaching and learning at CST. A similar research by Mohammed, Ahmad & Ahmad (2020) found similar factors like technological factors, e-learning quality that include module content and adaptiveness to online platforms. They have additional factors like culture factors due to the fact that the university they choose allows international students having different cultures.

Research done by Chung et al., (2020) have gender affecting students’ performance and satisfaction about the modules taught online where they found that females are comparatively better on performance and satisfaction during online classes. This is because their study has an almost equal number of female and male respondents. While almost 3/4 of the respondents of this research are male due to the fact that there are more number of male studying at CST. Other factors are defined similar to this research.

Considering the above limitations, this research can be done in-depth to add more credentials to these findings. The domain of this research can be expanded to all Royal University of Bhutan (RUB) and not restricted to the College of Science and Technology to get more detailed factors affecting online teaching and learning in the nation. Additionally, there is a possible way to know what are the opportunities available and challenges faced by students, tutors, and administrators.

8. Conclusion

COVID-19 had an influence on academic institutions all over the world's traditional learning methods. As an alternative to resuming education; school, and college administrations across the country have opted for online teaching and learning. While online learning is proving to be beneficial in protecting students' and teachers' health in protecting from the deadly virus. But if measured in terms of teaching and learning, it is not as successful as traditional method of teaching and learning.

This paper focused on finding the factors that hindered online teaching and learning at the College of Science

and Technology during COVID-19 pandemic. Such kind of research was not carried out earlier, with this work we could investigate and uncovers all factors that affected the online teaching and learning environment at CST. The result obtained will be a novel contribution to the college administration to review and utilize the findings in order to ensure that online teaching-learning systems become more effective from now and henceforth. The findings of this research are based on the empirical evidence, where data was first collected from those who have done online learning and teaching through survey questionnaires and then interviewed by using a convenience sample, which is one of the nonprobability sampling methods. After that, the code qualitative data was linked to quantitative data using Dedoose software.

According to the test conclusions, the respondents in this research addressing to the 71.7% students faced data insufficiency where most of students claimed that the data consumption rate was almost 100mb - 200mb per hour class. The result of this study also indicated that the student characteristics is one factor where most of the students are complacent and not submitting the assignments and other works on time.

The availability of equipment and favorable environment for online learning are other few more factors determined though this study. The students from lower income groups faced difficulties as they don't get the facilities like high quality electronic devices and a good environment to take online lessons. And the other factor is module content where it's challenging for practical modules to be taken through online without proper environment setup. Apart from aforementioned factors, students also reported a few other difficulties like lack of interactive learning which purely depends on tutor characteristics and absence of traditional classroom socialization. These are the findings and we could sum up that these are the prevalent factors that hindered online teaching and learning amidst COVID-19 in CST.

A functional structure made up of holons is called holarchy. The holons, in coordination with the local environment, function as autonomous wholes in supra-ordination to their parts, while as dependent parts in subordination to their higher level controllers. When setting up the WOZIP, holonic attributes such as autonomy and cooperation must have been integrated into its relevant components. The computational scheme for WOZIP is novel as it makes use of several manufacturing parameters: utilisation, disturbance, and idleness. These variables were at first separately forecasted by means of exponential smoothing, and then conjointly formulated with two constant parameters, namely the number of machines and their maximum utilisation. As validated through mock-up data analysis, the practicability of WOZIP is encouraging and promising.

Suggested future works include developing a software package to facilitate the WOZIP data input and conversion processes, exploring the use of WOZIP in the other forms of labour-intensive manufacturing (e.g. flow-line production and work-cell assembly), and attaching a costing framework to determine the specific cost of each resource or to help minimise the aggregate cost of production.

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