Experiences of engineering thermodynamics students during online learning:

Lessons for post-pandemic

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Abstract
Since the outbreak of the COVID-19 pandemic, the education sector has been seriously impacted, leading to the migration of academic offerings to online learning mode. This investigation focuses on the experiences of engineering students offering Thermodynamics as a subject at a University of Technology in South Africa, as they transition to online academic platforms. Resource availability, such as a quantitative learning platform and access to computer laboratories on campus, as well as other institutional supports, were evaluated. A total of 100 students offering the Engineering Thermodynamics module participated in the surveys and responded to the questionnaire. The study identified various constraints that affected the students' learning experience due to the online learning format, including connectivity issues, time management, inadequate university support, limited understanding of online learning platforms, and high cost of data. Various strategies were recommended to address the challenges faced by engineering students during the transition to online learning. By implementing these strategies, the online learning experience can be enhanced for students facing similar challenges in their academic pursuits.
Keywords: COVID-19. Online learning. Engineering education. Thermodynamics. South Africa. Resource availability. Time management. Online learning platforms.

List of abbreviations
TAM – Technology Acceptable Model.
UTAUT – Unified theory of Acceptance and Use of Technology.
COI – Community of Inquiry.
TFL – Technology for E-Learning

1. Introduction

The COVID pandemic has left many people in a state of devastation (Ewim *et al*., 2021), particularly to the education sector (Macias *et al*., 2022). It is by far one of the most disastrous outbreaks that ever hit the world. Due to its unexpected entrance, a lot of countries were not able to deal with the effects of this pandemic adequately, as many countries were not prepared nor equipped with the health and safety infrastructure required to prevent the spread of the virus (Sanyaolu *et al*., 2021). Many countries started taking action, developing safety protocols, equipping health facilities, transition from face-to-face learning to either online or hybrid, and diverting budgets meant for other infrastructure to the prevention of COVID-19 after they have been hit by death, sicknesses, and trauma brought about by the disease (Gereffi, 2020; Mikeska *et al*., 2022; Shang *et al*., 2021). These have left some countries in the developing nation in debt or in total dependence on wealthy countries for the supply of resources needed to curb the spread of the virus (Srivastava *et al*., 2020). Proper medical systems were not available to treat people suffering from this very contagious virus. Indeed, there was a lot of confusion about this virus and since people were not aware of the unique symptoms (because the symptoms of the COVID-19 virus are like other communicable diseases that people suffer) and the actual harm that it could cause if it was not taken seriously. This was one of the main reasons for the very rapid increase in COVID-19 cases (Bhaskar *et al*., 2020; Livingston *et al*., 2020). However, as time went on, countries began to study this virus to learn how to adapt as well as develop the medical infrastructure to accommodate the rapidly increasing infection rate.

South Africa, being a developing country soon devised strategies to deal with the spread of this virus. Lockdown measures were introduced at the beginning of the pandemic. Although the lockdown substantially decreased the infection rate, the economy had taken a very severe downturn (Mbunge, 2020). Many companies and institutions did not know how to deal with this, as the different lockdown levels affected different categories of organizations or institutions. At one level or the other, some organizations were restricted or not permitted to open their facilities or to attend to the public in a way that could compromise public safety and place more pressure on the already strained public health workers and facilities. The lockdown, which was of different levels, caused some organizations or institutions to even close completely and lay off workers.

The lockdown rules did not only affect companies, but also academic institutions, particularly students, lecturer-student interaction, and engagement, across the country (du Plessis *et al*., 2022; Landa *et al*., 2021; Mtshweni, 2022). The lockdown regulations made the students in public and private universities across the country face an unfamiliar situation. Both public and private institutions had to act swiftly to maintain quality education while ensuring the safety of their students in compliance with the necessary protocols and lockdown restrictions. Hence, tertiary educational institutions, especially those offering engineering courses, needed to adopt new ways of bringing learning to their teaming students. According to Watts *et al*. (2022), modules or subjects that were traditionally facilitated using face-to-face were redesigned to be presented online. This is because failure to do so was envisaged to be pregnant with devastating effects in the long run (Asgari *et al*., 2021) as the mode of delivery of most subjects had to be changed from physical to virtual.

The transition from in-person engineering classes to e-learning platforms is one of the commonest and most immediate changes that took place (Bir, 2019; McPherson & Pearce, 2022). On-campus, practical interactive sessions are a vital resource for students where their experiences become the basis of learning. Practical lessons are necessary for the skills development of students of engineering education. The replacement of in-person classes has the potential to impact

negatively engineering education through the loss of practical. This is because the shift of engineering education to online platforms has placed restrictions on the acquisition of vital practical skills and on-the-job experience. Stepping into this new phase of online education, in response to the COVID-19 pandemic, springs a whole new set of challenges that students and educators must overcome (DeCoito & Estaiteyeh, 2022). One of these challenges is efficient time management (Mila *et al.*, 2021), resource availability, peer support, and institutional support. These do not only apply to engineering students, but to lecturers and tutors of the faculties of tertiary institutions as well. With the numerous challenges introduced by the transition to online learning platforms, as experienced by both students and academic institutions, it became necessary to examine the readiness of some of the main entities. Hence, this research investigation analyses and discusses multiple factors that impact the engineering students' readiness to transition to online learning of Thermodynamics in response to COVID-19. The importance of studying thermodynamics lies in the fact that it is a fundamental part of physics and is applicable to many areas of science and engineering disciplines or professions. It provides a framework for understanding the behavior of matter and energy in various systems and is used to design and optimize many thermal systems related practical applications found in the residential, commercial, industrial and transportation sectors of the economy. For example, thermodynamics is critical in designing power plants, engines, refrigeration systems, etc. It also plays a significant role in the development of materials science and nanotechnology, as well as in understanding the behavior of living organisms. In summary, a second-year thermodynamics course is essential for students who want to gain a deeper understanding of the principles and applications of thermodynamics. Imparting the detailed knowledge required to achieve the desired outcomes set for thermodynamics course requires to a large extent that the students be physically present during practical session to enable them to be exposed to the working principles of thermal systems rather than virtual engagement.

1.1 Research questions

This study aimed to examine engineering students' experiences during online learning in response to COVID-19: A case of thermodynamics class at a University of Technology. Specifically, the study was designed to:

1. The following research questions guided the study.
2. What are engineering education students' perceptions of online learning?
3. What is the readiness level of engineering education students towards accessing classes online?
4. How do engineering education students access classes online?
5. What are the challenges faced by engineering education students in accessing classes online?

1.2 Aim and objectives of the study

This study aimed to examine engineering students' experiences during online learning in response to COVID-19: A case of thermodynamics class at a University of Technology. Specifically, the study was designed to:

1. Determine engineering education students' perception towards online learning.
2. Examine engineering education students' readiness to access classes online.
3. Investigate how engineering education students access classes online.
4. Reveal the challenges faced by engineering education students in accessing classes online.

2. Literature review

2.1 Online learning in higher education – student challenges

The year 2020 was very difficult, especially for students. According to Scott (2020), the lockdowns imposed on the economy and society as a result of the COVID-19 pandemic adversely affected the mental health and wellbeing of young people (Chadwick & McLoughlin, 2022).

Challenges faced by students affected them emotionally, academically, mentally and physically (Browning *et al.*, 2021; Lee *et al.*, 2021). Seetan *et al.* (2021) in their study on the pandemic's influence on the well-being of Jordan medical students reported that the global spread of COVID-19 brought about an adverse impact on medical students psychologically. The study considered six medical institutions of higher learning in Jordan involving a total of five hundred and fifty-three participants, used an online data gathering platform to collect data relating to social, demography and academic impacts on these students and deployed the Kessler psychological stress scale for the data assessment. The study found that concerning physical fitness, the pandemic negatively affected close to three-quarters of the participants. When the students were asked about the influence of the pandemic on their study, close to seven out of ten medical students responded that the spread of COVID-19 adversely affected them. In their social relationship with their fellow students and the public, close to sixty percent of the student were reported to have lost the social engagement that they had developed before the pandemic. In general, the stress brought about by these factors caused more than fifty percent of the participants to develop severe mental disorders as they were unable to access classes, clinical sessions, and laboratories.

Villani *et al.* (2021) conducted an online-based survey on the influence of COVID-19 on the well-being of students at a University in Italy. The study considered factors such as anxiety and depression, understanding of the preventive measures, social disengagement, and willingness to contribute to supporting the health workers during the pandemic. A total of five hundred and one participants were considered in the study. The study found out that about seventy-three percent of the participants experienced depression, while thirty-five percent were considered to have fallen into unplanned anxiety. As a result of the imposed lockdown, more than seven out of ten could not have the privilege to socialize or see their friends. In general, it can be deduced from the open literature that COVID-19 has presented a lot of opportunities and challenges in the education sector (Wieselmann & Crotty, 2022).

Online learning had been the most useful learning method implemented during this time of COVID-19. Lots of students are greatly affected by the lockdown brought by the pandemic (Nganga *et al.*, 2020). The study under review was conducted at a University of Technology, where online learning was introduced due to the COVID-19 lockdown as students could not carry out contact class learning as a process of reducing the contamination and spread of the virus. The platforms used by the lecturer and students in Thermodynamics II to access online learning at the University of Technology were Moodle TLZ, Outlook emails, and Microsoft Teams.

3. Theoretical framework

The Technology Acceptance Model (TAM) is an appropriate theoretical framework for investigating students' experiences during online learning in response to COVID-19. TAM is a widely accepted model that explains how individuals perceive and adopt technology (Davis, 1989). According to TAM, perceived usefulness and perceived ease of use are two significant factors that influence an individual's intention to use technology. Perceived usefulness is the degree to which an individual believes that a particular technology will improve their performance or productivity. In the context of online learning, perceived usefulness can refer to the extent to which students believe that online learning can effectively replace face-to-face learning. Engineering students require practical and hands-on experience, which may not be possible in an online learning environment. Therefore, the perceived usefulness of online learning may be lower for engineering students compared to students in other disciplines. Perceived ease of use refers to the degree to which an individual believes that using a particular technology will be effortless (Davis, 1989). In the context of online learning, perceived ease of use can refer to the extent to which students believe that online learning platforms are user-friendly and accessible. Engineering students may have limited experience with online learning platforms, which may affect their perceived ease of use.

TAM has been used in previous studies to investigate students' experiences during online learning. Bamufleh and Alradady (2021) examined the factors that influenced the acceptance and adoption of online education platforms by university students in Saudi Arabia during the COVID-

19 pandemic, utilizing the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Technology Acceptance Model (TAM). A quantitative survey was carried out on 708 university students, and the findings indicated that performance expectancy and facilitating conditions had impacts on the students' attitude towards using the platform attitudes subsequently affected their behavioral intention. In contrast, the study revealed that effort expectancy did not have a significant influence on attitude.

In addition to TAM, the Community of Inquiry (CoI) framework can also be used to investigate students' experiences during online learning. The CoI framework is based on the premise that online learning involves three essential elements: cognitive presence, social presence, and teaching presence (Garrison *et al*., 1999). Cognitive presence refers to the extent to which learners are able to construct meaning through interaction with course materials and other learners. Social presence refers to the extent to which learners are able to establish a sense of community and develop interpersonal relationships with other learners. Teaching presence refers to the extent to which instructors are able to facilitate and direct learning activities. The CoI framework has been used in previous studies to investigate online learning.

In summary, TAM and the CoI framework are appropriate theoretical frameworks for investigating students' experiences during online learning in response to COVID-19. TAM can be used to investigate students' perceptions of online learning.

4. Methods

The study adopted a quantitative and descriptive survey research design. This survey method is appropriate when a group of people or items are studied by collecting and analyzing data from only a few people or items considered to be representative of the entire group (Aspers & Corte, 2019; Bengtsson, 2016; Nyumba *et al*., 2018). It is used in finding the conditions or relationships that exist and opinions that are held by a group. The design was considered appropriate for this study because the opinion of a representative sample of the population regarding the engineering students' experiences during online learning in response to COVID-19. The population was the entire 100 engineering students who registered for Thermodynamics II at the University of Technology under review. Sampling was not done because the population was small, hence all 100 students were used for the study. Out of this, 75 students, representing 75% returned the questionnaire. Table 1 depicts the distribution of students who responded to the questionnaire.

5. Results and discussion

The results are presented in line with the research questions that guided this study, and the discussion of the results are based on student's perception, challenges of online learning.

5.1 *Students' perception of online learning*

Table 1 presents the demography of the students that responded to this survey. There are approximately 83% male students and 16% female students, though one (1) student preferred not to disclose his/her gender. The main research question is: what is engineering education students' perceptions towards online learning and their readiness to access classes online? In their responses, the participants answered by selecting one of the three options of 'Agree', 'Somewhat Agree' or 'Disagree'. Analysis of the factors that influenced the respondents in their responses is stated below. The students responded based on the themes which are significance of online learning, academic performance, skills, goals and time setting, updates and announcement, reliability of the learning platforms, relationship with lecturer, lecturer support to students, learning challenges, network connectivity, workspace and university support.

Table 1 – Summary of responses based on gender.

Response by gender	Number of students	Percentage respondents (%)
Female	12	16
Male	62	83
Prefer not to say	1	1
Total	75	100

5.1.1
The
significance of online learning

Table 2 shows that 85% of students agreed that online learning has been useful to them. Those who agreed that it was advantageous for them to complete the academic year were rated 44%, the same as those who somehow agreed. These are considered positive responses higher than the rate of students who disagreed. The majority of students depict that online learning is useful and important to students who were affected by COVID-19 lockdown restrictions.

Table 2 - Responses to online learning perception.

	Questionnaire	A	SA	D
		%	%	%
1	I understood the significance of students having to learn online during the time of COVID-19	85	15	0
2	Online learning helped me to complete my academic year	44	44	12
3	I was provided with a clear understanding on how to use the e-learning platforms	52	35	13
4	I was very good at setting my goals	38	50	12
5	All my assignments and tasks were recorded and submitted before the due dates	54	20	8
6	I was always seeking assistance and guidance from my lecturer	29	56	15
7	I had good communication with the lecturer	29	38	33
8	I managed my time very well	35	48	17
9	The lecturer was always available for inquiries	38	42	19
10	The lecturer provided enough learning material and useful sources of information	48	37	15
11	I became familiar with the platforms we were using to access online learning	73	24	4
12	I regularly checked my emails for announcements	71	27	2
13	I was familiar with the technicalities of the respective online platforms	60	37	4
14	The platforms we were using for communication (MS Teams, DUT Moodle and Outlook emails) are adequate and effective	60	35	6
15	Online learning is easier than on-campus learning.	29	27	44
16	I did overcome all the challenges associated with online learning	37	44	19
17	I was able to adapt to working under pressure due to the COVID-19 pandemic	46	37	17
18	I had a workspace that I used when I needed to work without distractions	50	38	12
19	I had enough data to complete all my tasks online	31	37	33
20	I had a good network connectivity	35	44	21
21	DUT provided me with sufficient data to excess learning online	31	42	27
22	I adapted to the new way of leaning	37	58	6
23	The lecturer was well prepared to lecture online	46	35	19
24	I used multiple sources to support my online learning	50	40	10
25	I consider COVID-19 to be advantageous academically	19	42	38

A = Agree, SA = Somewhat Agree, D = Disagree

5.1.2 Academic performance

Online learning requires students to gather information using different online resources to support better academic performance (Olayemi *et al*., 2021). The above questionnaire responses depict that 44% of students agreed that the online learning implementation helped them to improve their academic record, the same rate as those who chose to somewhat agree, while 12% disagreed.

5.1.3 Online learning and platform skills

The use of online learning platforms goes into consideration with a better understanding of how to use the online learning resources and knowledge to explore online learning (Naji *et al*., 2020). In the survey where students were asked if they were provided with a clear understanding of how to use online learning platforms, 52% of students agreed, 35% somewhat agreed and 7% of students disagreed with the question. The university introduced Technology For E-Learning (TFL) this program was to teach students about the use of online learning platforms and some technological skills for students to practice and attempt questions to test their technological know-how. Technology for the e-learning program also allowed conversations on Microsoft teams where students can ask any general questions that support their online learning and help to familiarize themselves with the implementation.

5.1.4 Goal setting and time planning

Students are mostly provided with lots of tasks to complete (Yang *et al*., 2021; Zurlo *et al*., 2020), that require good planning and time management in order to avoid working under pressure (Schwartz *et al*., 2021; Simionescu *et al*., 2022). Working under pressure because of failing to manage time very well, may be disadvantageous to the outcomes of assignments. Students may end up making mistakes that they are unable to spot because of rushing to a finish line. Therefore, students were asked if they are able to set their own goals. The majority of students responded somewhat agree, where they were asked about goal settings these are neutral results. Also, the majority of students agreed that their assignments and tasks were completed and submitted in time. Timekeeping goes together with goal settings; these factors respond to the positive results on the readiness of students.

5.1.5 Updates and announcements

The transition required each student to stay updated about what needs to happen and follow up by regularly checking lecturer announcements about the classes and tests. In most cases, students do not check their emails regularly, they wait for other students to pass the announcements on their WhatsApp groups. This has a bad effect because students may not know about the oncoming tests. 71% of the students often check their emails for announcements.

6.1.6 Learning platform's reliability

The platforms used for online learning were effective and adequate, as reported in the survey by 60% of students who responded. The university uses Moodle, Microsoft teams and Outlook emails to support online learning.

5.1.7 Relationship with the lecturer

Good communication and enquiries from lecturers are advantageous during online learning (Du & Chaaban, 2020). The majority of students responded that they somehow agreed that they had good communication with the lecturer and that they were contacting their lecturer every time they had enquiries. The problem is that most students asked another student every time they encounter difficulties during their own time of studying. Therefore, it is very important that students consider effective communication with the lecturer because you get more interest in that module than there are possibilities that a student will do excellent in the module.

5.1.8 Lecturer support to students

The lecturer supports students by providing enough learning materials and sources of information to students, making time for online consultation with students in groups or as individuals, and being prepared to lecture. On these factors, Thermodynamics II students responded positively, they agreed that they were provided with enough learning material and had all the attention they needed from the lecturer (Du & Chaaban, 2020).

5.1.9 Online learning challenges

Many students were affected by lockdown restrictions brought by the pandemic. Students seem to have overcome all the challenges associated with online learning, these challenges could be a shortage of data, bad network connectivity, lack of learning space, hunger, etc. The 44% of students somewhat agreed that they were able to overcome the challenges they faced due to the transition to online learning. 37% of the students agreed, however, 19% of students are the fewest number of students who disagreed. This still reveals that students were ready for the transition to online learning.

5.1.10 Online learning compared to contact learning

COVID-19 pandemic had given students an experience with both methods of learning and student got all the experience and were debating about which one of these two is the most preferred. In this survey, students expressed mixed opinions on which method of learning works better for them, where most students about 44% disagreed with the statement saying online learning is easier than campus learning, while 29% agreed and 27% somewhat agreed. It can be deduced that most students prefer contact learning. This shows that students were negatively impacted by the transition to online learning.

5.1.11 Network connectivity

Online learning needs students to have good network connectivity, and access to the internet so they can fully attend and participate in all their learning activities. All learning materials are sent and received via the internet. Therefore, the internet is the key to online learning. Students cannot engage themselves in online learning while in short for data to connect to the internet. Many respondents of 35% agreed that they had good internet connectivity, while 44% majority somewhat agreed and 21% of the students disagreed. Even though not all students could afford to always pay for data fees, they were trying, by all means, to stay connected.

5.1.12 Workspace

The biggest problem that students may need to overcome with learning online is being distracted (Nganga *et al*., 2020). It could be a detraction that comes in the environment and while using the platform online, for example, the pop-up notifications. Whether the respondents had a good workspace for learning, 50% agreed while 38% somewhat agreed and 12% disagreed.

5.1.13 University support

The university can support students by providing them with data bundles, allowing students to enter laboratories and the library for effective purposes of learning. Most students do not have laptops in addition to the high cost of data and lack of communication with the lecturer. As shown in Table 3, the majority of by lack of support from the university, which respondents, 17 (33%) faced data bundles challenges in order to attend long hours of classes (Nganga *et al*., 2020). The majority of students (42%) somewhat agreed that the institution provided them with data bundles, while 31% agreed, the 27% disagreed. Although there are still students who think they were not satisfied with the support of the data bundle allocated, we can still conclude that most students were satisfied with the data bundles they received.

5.2 Challenges of online learning

The study investigates the online learning challenges and Thermodynamics II students' readiness to transition to online learning at a University of Technology. Familiarity, adaptation and experience with online learning are very important in determining the success of online learning implementation. The level of student experience has been measured to determine the success of the implementation.

One major finding is the positive response and opinions about online learning coming from the majority of students. While some of the students were working effectively on the online learning, some experienced challenges in understanding the technicalities of e-learning. Taking different opinions from individuals is useful in understanding peoples' experience because people react differently to every problem they may be facing and also, react differently from each other. The survey depicts students having different feelings between "agree, somewhat agree and disagree" about this transition due to COVID-19.

In this study, most students responded positive to online learning, however, few students still prefer contact class learning. This is because these few students that prefer contact classes do not have experience of how to use platforms, do not have a good workspace, and cannot afford to buy enough data to access learning, network connectivity problems, some experienced destructions due to load shedding (Laher *et al*., 2019; Laher *et al*., 2021; Masebinu *et al*., 2020).

According to this study, the students expressed different feelings about this whole COVID-19 era that left students vulnerable, depressed, having to work under pressure in stressful conditions, devastated, lonely, confused, in bad conditions etc. These may have been very worse if one had lost their relatives because of the pandemic, having to deal with trauma and loads of schoolwork. Some struggled to pass due to the implemented way of learning.

Despite all the negative impacts faced, some students found COVID-19 very advantageous to their academics, as they performed exceptionally well compared to before COVID-19, and they even got exposed to many opportunities and experiences. The characteristics of these studies based on a further enquiry were isolated to the following:

➢ Self-discipline: Students who did well during the pandemic likely had good self-discipline and motivation to continue studying and learning even without the structure of in-person classes.

➢ Adaptability: The pandemic forced students to adapt to new learning environments, such as online classes and virtual laboratories. Those who were able to adapt quickly and efficiently found it easier to stay on track with their studies.

➢ Time management: With more time spent at home, students were able to manage their time better and allocate more hours to studying.

➢ Access to resources: Students who had access to high-quality online resources, such as virtual laboratories and online textbooks, found it easier to excel in their studies.

➢ Passion for the subject: Finally, students who were truly passionate about thermodynamics found that the pandemic provided them with more opportunities to explore the subject deeply, through research or projects, for example. This led to greater engagement and success in their studies.

Continuing, students responded to the ways they want their online learning to be improved on the study, some stated that the system of learning at the university is at its own very best, while others reacted. They want to be provided with enough data to fully participate in the online learning and learning facilities such as digital devices, and access to computer labs and libraries. There are several times whereby the university Moodle system crashed, and students were unable to write their test, which changed the action plan and consumed more time, they want the issue of using excellent servers to be brought forward.

Lecturers and departmental staff should listen to students' enquiries and respond to them. The issue of assignment due dates, students are given loads of work including the assignments, and if the assignment due date is short, students may end up compromising on whether to do an assignment

or carry on studying for their upcoming tests. The disadvantage of online learning is that it has a lot of work to do including tests and assignments also practical reports. The lecturers must improve the method of recording the online lectures to last longer for students to be able to view lesson recordings at any time, the previous experience is that the recordings on Microsoft Teams may last for 20 days and then expire.

The time that should be taken for students to scan and upload their test documents must be increased because some students may experience problems regarding network connectivity. Some want lecturers to refer students to YouTube links for that particular concept taught that that relate with the lecture (Breslyn & Green, 2022). This is because the students feel that they want more information for them to understand that lesson.

Out of all these improvements required by students, some students find it difficult to adjust to online learning, they wish the process of teaching and learning could return to contact especially tests. They find it difficult because if the submission time elapses online, they are almost likely to fail automatically but as for tests written on campus, the students are still able to submit their scripts to the examiners even after using up the given time.

The findings from this study as shown in Table 3 summarize the challenges that could prevent effective online learning some of which include, costly data to access the internet, poor network connectivity, power outage, lack of access to library facilities, limited access to computers, inability to manage time very well, inadequate support from the institution (Tamrat & Teferra, 2020). These results are similar to the study conducted by (Dube, 2020) on COVID-19. Where he revealed that students will face problems accessing online learning, especially those who live in rural areas were mostly going to be affected by the transition. The challenges have not limited the online learning, instead have led to many developments to support online learning. The introduced method of learning requires students to have an appropriate device, such as a smartphone, laptop, computer, or tablet, if not then students are very likely not to participate in the online learning.

5.3 Online learning improvement strategies
- Timely assessment of students' prior technological knowledge and behavioral attributes for the deployment of interventions and progress monitoring.
- Active engagement between the instructors and students to engender participation and inclusivity.
- Effective course design and delivery approach to improve retention.
- Synergistic relationship among the stakeholders

5.4 Linking the results to the TAM and COI models
The findings of this study on the challenges of online learning and students' readiness to transition to online learning at the University of can be related to both the Technology Acceptance Model (TAM) and the Community of Inquiry (COI) model.

The positive response and opinions about online learning coming from the majority of students can be linked to the TAM, which suggests that the attitude towards using technology is influenced by perceived usefulness and perceived ease of use. The students who responded positively to online learning may have perceived it as useful and easy to use.

On the other hand, the challenges faced by some students in understanding the technicalities of e-learning, the lack of experience with online learning, and the need for familiarity and adaptation can be linked to the COI model. The COI model emphasizes the importance of social presence, cognitive presence, and teaching presence in the online learning environment. The challenges faced by some students could affect their ability to participate fully in the online learning environment and impact their social and cognitive presence.

The findings also highlight the various challenges faced by students during the COVID-19 pandemic, including limited access to technology and internet connectivity, lack of access to library

facilities, and inadequate institutional support. These challenges are similar to those identified in other studies and suggest the need for institutions to provide necessary resources and support to enable effective online learning.

6 Conclusions

In this research, various factors regarding students' experiences of online learning during the COVID-19 pandemic were discussed which also included a survey from the Thermodynamics II class of 2020. The factors were investigated and analyze to the establish readiness of engineering students offering Thermodynamics II to transition from contact learning to online multi-modal learning. Although many students faced challenges, a positive attitude was attained by the engineering students. This was a positive change as this newly reformed system may serve as a catalyst for future academics. Though students had an abrupt transition they acted in the best manner that they could, to accommodate themselves. The institution also did this to ensure that students don't fall behind and that there are no major interruptions in their academics. All this was done whilst ensuring the safety of learners and members of the institution. The university adapted to the change very timeously and set up all necessary safety measures and COVID-19 protocols to maintain the safety and health of all students and staff members. In conclusion, future engineers are expected to be able to handle the pressure that comes with any implemented changes, in this case, to be able to cope with working under stressful conditions and be able to adapt to any transition that occurs because it may bring a positive impact on their academic. After much research and properly analyzing data and information attained from students, it is evident that students are ready and accommodating to the transition to a full online-based academic atmosphere.

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