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Challenges and opportunities in online engineering education online

Dr. Mory Ghomshei

Mory Ghomshei is a faculty member at School of Construction and Environment, at British Columbia Institute of Technology (BCIT), also an adjunct professor at University of British Columbia and McGill University. He is an international expert and consultant in energy sustainability.

Dr. Farzan Ghaffari P.Eng P.Eng., British Columbia Institute of Technology
William Oching

Challenges and opportunities in online engineering education, during and post pandemics

Mory Ghomshei[1], Farzan Ghaffari, William Oching

British Columbia Institute of Technology (BCIT), Burnaby, B.C., Canada

1- Corresponding author: mmohieddinghomshei@bcit.ca

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Abstract

Corvid-19 Pandemic was a turning point in post-secondary education. Engineering education was specially impacted by the Pandemic, due to its experimental and real-world components, which are often difficult, if not impossible, to be effectively and efficiently delivered online.

While some text-based courses can be delivered remotely, there are major challenges in online delivering of those course components which are related to physical experiments, laboratory simulation and field-scale collaborative works .

Educational software and hardware related to Virtual Reality (VR) and Augmented Reality (AR) are currently being used in most engineering programs. These tools are excellent in improving the students' perception about real-case situations, but cannot replace hands-on and group experiences. While online education during the Pandemic provided an opportunity to explore new frontiers in VR and AR technologies, a major challenge is to bridge between these technologies and the field reality and with person-to-person interaction.

This paper is a semi-quantitative study on the impact of the Covid-19 pandemic on engineering students at British Columbia Institute of Technology (BCIT). Pre-pandemic students' performance have been compared with performances after return to campus in the fall of 2021. Data clearly show that the level of knowledge of students and or their aptitudes to acquire knowledge has been negatively impacted by the pandemic, as observed by tangible increase in the rate of failure in core courses.

This paper also discusses about the importance of field and human components in engineering education and proposes solutions to reduce the negative impact of online education in engineering disciplines, should it happen again in the future. One suggested strategy, will be designing safe laboratory and field experiments to complement the remote education.

Introduction

Covid-19 had impacted the world on all aspects from economy to education. While the effect of the Pandemic on the economy is expected to be short-term, the impact on education could remain

for a long time. From primary schools to universities all students, suffered at both psychological and pedagogical levels due to the Pandemic. The impact on engineering students were specially more noticeable due to the practical nature of the discipline, which demands laboratory and field exercises. Engineering also demand a higher level of interaction not only between the students and instructors, but also between the students themselves. This means that there are many educational tasks in engineering which cannot be accomplished efficiently solely at long-distance.

American Society for Engineering Education (ASEE, 2020) has conducted a qualitative survey of more than 200 members, including faculty, administrators, and students on the effect of Covid-19 on educational activities. This work was followed by a quantitative study (ASEE 2021) which showed that "the pandemic has adversely impacted student learning" in all engineering schools. Based on the findings of these studies, ASEE recommended other studies to be conducted "to better gauge the impact that sudden online teaching has had on teaching methods, as well as comparisons of grades in specific professors' classes as they have been taught in pre-pandemic semesters versus pandemic-affected semesters. Following this recommendation, we have carried out a semi-quantitative study on the electrical and mechanical engineering students from British Columbia Institute of Technology (BCIT), comparing marks before and after the pandemic, with an aim to assess the effect of the pandemic on the students' learning.

Data and Method

Our objective for data collection and analysis is to compare the learning performance of engineering students before the Pandemics with that of during pandemic (after return to physical contact). The data during the online teaching period were not considered.

Students' performance before the pandemic was considered as a benchmark to be compared with their performance after restoring the in-class teaching (in fall of 2021). This comparison is believed to gauge the efficiency (or inefficiency) of the on line mode of teaching.

Considering a quantitative approach, we compared pass/fail rates for a number of terms and courses before the pandemic and the fall term of 2021, which was the 1st term when students returned to class on campus. Seven core engineering courses covering topics in circuit design, computer programming, physics and thermal fluid sciences in the electrical & mechanical engineering and technology programs that were offered in the fall of 2021 were chosen for the study. (Table 1). These courses were selected on the basis that the pass/fail rates being conspicuously outside the statistical uncertainty. The number of students enrolled in each course are about 30.

Other metrics such as the overall average grade distribution and student's grade by course and term were also examined but no firm conclusion could be drawn from these data. Data had been collected by the institutional research office of British Columbia institute of Technology.

The core courses selected for the study were those that had prerequisite courses on fundamental subjects. Most of the courses taken after pandemic (in fall of 2021) had their prerequisites taken online during the Pandemic.

	Pre-COVID Performance					During COVID performance				
		Pass		Fail			Pass			
Course	Term	No. Students	% Pass	No. of students	% Fail	Term	No. Students	% Pass		% Fail
ELEX2105	201810	12	92%	1	8%					
	201830	21	84%	4	16%					
	201910	14	82%	3	18%	202130	2	50%	2	50%
	201930	22	92%	2	8%					
ELEX2120	201810	16	80%	4	20%					
	201830	14	88%	2	12%					
	201910	16	73%	6	27%	202130	1	33%	2	67%
	201930	23	79%	6	21%					
ELEX2125	201810	18	95%	1	5%					
	201830	17	85%	3	15%					
	201910	16	93%	6	7%	202130	1	33%	2	67%
	201930	23	88%	6	12%					
PHYS2143	201810	12	92%	1	8%					
	201830	10	100%	0	0%					
	201910	41	100%	0	0%	202130	2	67%	1	33%
	201930	6	100%	0	0%					
ELEX2845	201830	1	100%	0	0%					
	201930	16	100%	0	0%	202130	6	83%	1	17%
MECH3325	201830	4	100%	0						
	201930	18	100%	0	0%	202130	4	80%	1	20%
MECH3355	201830	5	100%	0	0%					
	201930	15	88%	2	12%	202130	3	50%	3	50%

Table 1 – Fail and pass data collected for core engineering courses (Electrical and Mechanical Engineering at BCIT). The digits 10 and 30 is preceded by year of the academic term refer to Winter and Fall terms, respectively of a given year.

Results and Discussion

In this study students' performance in four terms prior to pandemic and students' performance in the Fall of 2021 term were considered for comparison. More data (i.e. from more terms) were collected for the before Pandemic benchmark to enhance the statistics. The data for after return to class are obviously limited to the fall term of 2021, as more data is not yet available.

Data shows that prior to COVID-19 pandemic, 88% and 12% of students passed and failed respectively while in the Fall of 2021 term, 61% and 39% passed and failed respectively (Figs 1 &2). The results clearly reveal the serious negative impact of the pandemic on the learning performance of students, as the number of students failed in the same courses (Table 1 and Fig. 1 and 2) is significantly higher that can be attributed to anxiety, absences sickness or precautionary measures enforced by health authorities, among other factors.

As for the reason for this sharp decline in students' performance, there are a variety of factors which could be considered. Some of these factors could be related to behaviours acquired during the Pandemic. The learning habits of many students changed after being forced to study for almost two years in virtual modes. For instance, the level of multitasking, which was evident during virtual

classrooms persisted and even increased during the fall term of 2021. With returning to class, instructors at BCIT were not satisfied with students' focus, which could be the result of acquired habits of multitasking.

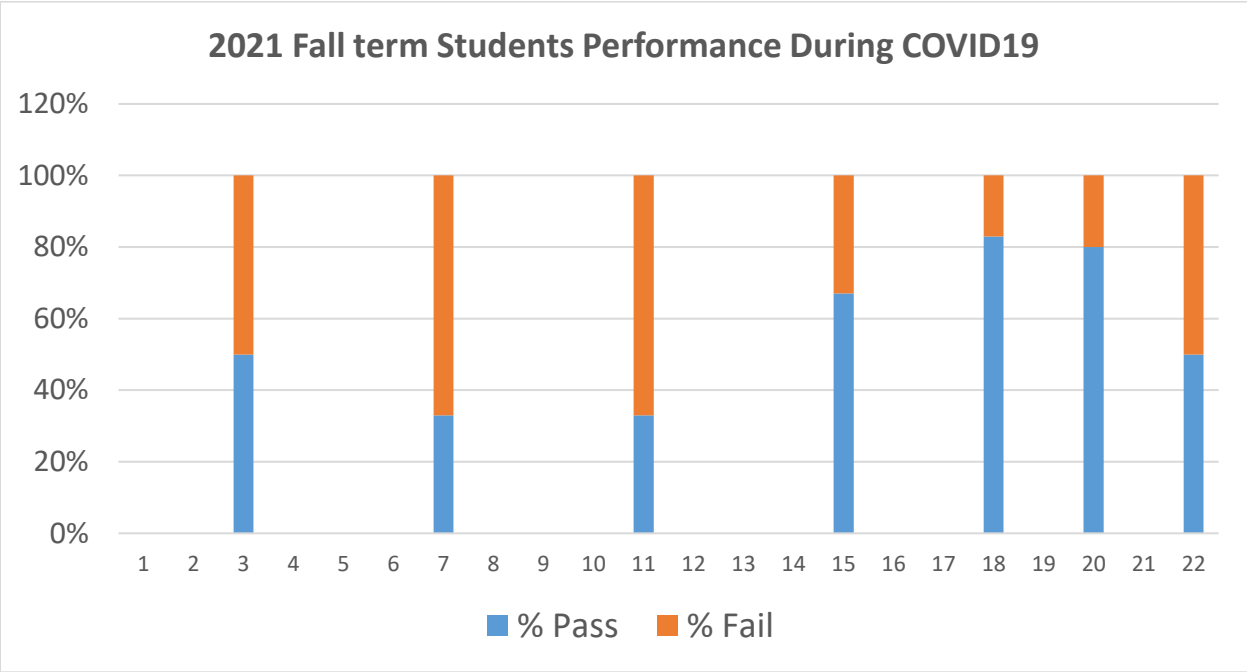

FIG 1 – showing the performance of students in the 2021 Fall term. Each bar represents one course in one term – seven courses in one term

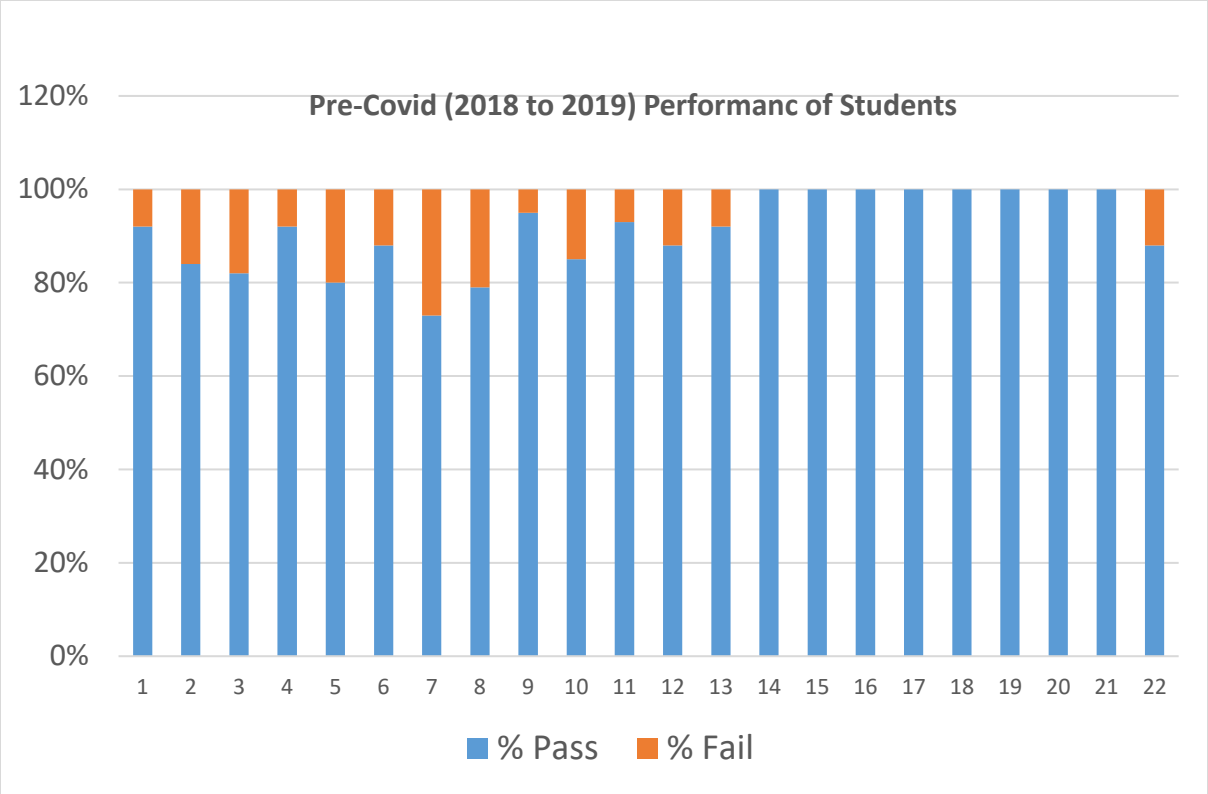

FIG 2 – Showing the performance of students in the Prior to Pandemic (benchmark). Each bar represents one course in one term – the same courses as in Fig. 1 but for more terms.

Study of psychological and behavioural roots and causes of students' performance is beyond the scope of this paper. Yet, setting the analysis in a more practical and objective context, we believe that most important factors in weakening students' performance can be related to two chief issues:

1. Weakening of students background in fundamental science
2. Weakening of students capability to learn at the class

During the pandemic, students' background in fundamental engineering subjects had weakened because of lack of physical contact with instructors and other students. Also during the one and a half years of getting used to on-line learning, students had lost, to some extent, their aptitude to focus at the class and communicate directly with instructors.

Engineering students had also the habit of discussing the content of their courses with their classmates and do the exercises and reviewing of courses in groups of two or more. During the pandemic, students lost their contacts with each other and were obliged to learn at home without

having the opportunity to communicate effectively with their classmates. After returning to campus, the students had somehow lost their willingness or habits to make study in groups. Before the pandemic more students where seen studding together (in groups of two and more). Sadly, after the campus, most students were seen to be reading alone by themselves.

The degradation of marks and learning habits among engineering students have also been observed and assessed in a number of other studies, which were carried out during the Pandemic. Ahag et al (2020) conducted a study on the effect of Covid-19 on engineering students from Singapore, Sweden and Taiwan. Their study was focused on the transition from physical classrooms to online environment. They also investigated the effect of the Pandemic on examination activities and students' perception about future. The outcome of the study indicated that the transition from physical contact to on-line created important psychological, behavioural and cultural shocks, which could take time to be remedied.

The possibility of cheating has been a major problem, not only for schools accreditations but also for hard-working students who have been complaining about exams being not competitive and unfavorable for students who did not cheat.

It is suggested that special workshops be designed for engineering students to help them with regaining their focus at the class and returning to their social habits related to working in group and also to improve their communication skills both with instructors and their classmates.

As for preparedness for eventuality of future pandemics, Hosseini and Koohi (2021) studied the difficulties of online-studies and suggested a few useful solutions such as development of more advanced online learning and assessment tools that might aid in a better delivery of engineering courses. These new tools should take into consideration the importance of enhanced communication and discussion at virtual classes.

One other recommendable strategy, will be designing safe laboratory and field experiments to complement the remote education. Special health protection tools and guidelines (similar to those used at hospitals) can be developed and used for bringing students and instructors together for certain experiments, workshops and examinations, which cannot be effectively delivered online.

As a conclusion, we believe that virtual reality and augmented reality can certainly provide valuable tools for improving the online learning process. . Nevertheless, none of these technologies can replace the physical contact at the class and the real group discussions that students enjoy on campus.

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