Institute for Studies in Transdisciplinary Engineering Education and Practice
UNIVERSITY OF TORONTO

Toward More Effective Teaching and Learning in the Post-Pandemic Era: Perspectives of Students and Instructors of the Faculty of Applied Sciences and Engineering, University of Toronto

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Executive Summary

This report presents the major findings from an ISTEP research project that was funded in 2022 for a special call for the Learning and Education Advancement Fund (LEAF) of the Office of the Vice President & Provost of the University of Toronto. The project was entitled "Toward More Effective Teaching and Learning in the Post-Pandemic Era." It involved a collection of **four data sources** in summer 2022 from undergraduate students and instructors at the Faculty of Applied Science and Engineering (FASE): student survey responses, student focus groups, instructor survey responses, and instructor individual interviews.

Integration of the information generated from the four data sources has led to the following **six findings**. We have included evidence for each of these findings in this report.

1. Students' interpretation of learning effectiveness went beyond knowledge retention and application.

2: The course delivery mode made a difference in students' learning experiences (particularly peer interactions, time use, and learning activities), which in turn affected their perceptions of learning effectiveness.

3. Most students and instructors favoured in-person course delivery and assessment while a small but still important proportion preferred online learning and teaching.

4. Alternative assessment and teaching practices emerged from academic changes during the pandemic.

5. Amid student needs, challenges to implement a mixture of in-person and online instruction persisted.

6. Most instructors' teaching practices and attitudes toward teaching have changed since the start of the pandemic.

Based on the findings above, we make the following **recommendations**:

Individual instructors. While many respondents strongly supported in-person course delivery and learning assessment, we encourage instructors to complement it with some elements of asynchronous learning (e.g., introducing some course materials through pre-recorded short videos or readings), and diversify assessment methods (e.g., assignment-based assessment and online quizzes). Our findings show that some students benefit from a mixture of in-person and online learning, and assessment methods beyond the in-person assessments that were typical before the pandemic.

Student support professionals. Organize workshops and other training opportunities to help students better understand the different ways in which participating in in-person class sessions and viewing recordings of class sessions can benefit their learning so that they can choose how to learn more effectively. Our findings suggest that students might not have been aware of how learning in the classroom and learning from recordings made a difference to their learning outcomes as they were navigating various learning options.

Teaching support professionals. Support instructors that choose to use different instruction modes. This can include:

- continuing to provide necessary resources for teaching in-person classes;
- recommending strategies for facilitating a (asynchronous and synchronous) mixture of in-person and online instruction when needed;
- increasing training opportunities related to using and creating digital resources for instructors.

Our findings show challenges in implementing various ways of mixing in-person and online instruction, such as an increased workload involved in creating asynchronous lecture videos, and lack of technological and human resources for implementing a dual delivery; and instructors expressed a need for greater learning on how to use and create digital resources.

Our Faculty (FASE). Provide the necessary infrastructure and mechanisms to facilitate using a variety of instruction and assessment approaches to more effectively achieve learning outcomes. This can include:

- Creating policies and processes to allow the use of various course delivery and learning assessment modes per instructors' choice, as alternative options and comfort with them have emerged from the academic changes over the past couple of years;
- Equipping classrooms with the appropriate technologies (e.g., smart board) to facilitate implementation of various instruction modes, such as technology-supported in-person teaching, and in-person and online dual delivery (a HyFlex model), and providing enough TAs for courses with a dual delivery design.

Our findings suggest several facilitators and barriers (see Table 5, p. 36) as FASE, along with other academic divisions of our University, is moving toward an educational environment that could feature more digital and flexible learning in the future.

Please contact Professor Greg Evans at greg.evans@utoronto.ca or Dr. Qin Liu at qinql.liu@utoronto.ca, should there be any questions about this document.

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Background of the Project

Contexts

This LEAF+ project was situated in the context of the return to in-person teaching and learning at the Faculty of Applied Science and Engineering (FASE) at the end of the academic year of 2021-22. The broader context is a series of involuntary academic changes that took place at the University of Toronto and other universities in Canada as a result of public health measures implemented from Spring 2020 to 2022 during the COVID-19 pandemic.

Prior to 2022, ISTEP researchers attempted to capture the experiences of undergraduate engineering students and FASE instructors during the pandemic through three student surveys and one instructor survey. The results from analyses of these data sources were presented in three reports:[1]

- Online Learning and Teaching during the Pandemic: Engineering Students' Perspectives in 2020-2021 (2021)
- Transition to Remote Learning: Engineering Students' Perspectives in Spring 2020 (2020)
- FASE Instructors' Experiences and Perceptions during the Recent Transition to Online Teaching (2020)

In the Winter Term of 2022, almost all undergraduate courses at FASE shifted to in-person instruction in mid-February after several weeks of online course delivery. This academic division-based context allowed us to design some survey questions to capture the changes in students' learning experiences before and after the shift to in-person instruction.

Objectives

The main objectives of this project were to:

(a) identify aspects of online and in-person instruction that promoted or detracted from effective or efficient teaching or learning;
(b) examine the influence of the switches between in-person and online on the views of students and instructors with respect to what makes teaching and learning effective;
(c) investigate the aspects/components of online and in-person instruction that students and instructors are more willing, interested, or motivated to retain or develop in the future; and
(d) explore a potential balance between online and in-person instruction that can provide a more effective educational environment to be implemented over the coming years.

Data Sources

In summer 2022, we collected the following four data sources from undergraduate engineering students and FASE instructors.

[1] Available at https://istep.utoronto.ca/research/papers-and-reports/

Table 1. Four data sources collected for the project

Data Collection Methods	Participants	Timelines of Data Collection
FASE Student Survey on Learning Effectiveness	251 undergraduate engineering students (including 157 completed ones)	May 6 – Jun 13, 2022
Student focus groups	15 undergraduate engineering students via five focus groups (each for 1.5 hours)	July 20 – August 9, 2022
FASE Instructor Survey on Teaching during the Pandemic	109 FASE instructors (including 81 completed ones)	June 16 – July 11, 2022
Instructor interviews	11 instructors from various disciplines (0.5 – 1.5 hours long)	August 4 – 29, 2022

The demographic and academic background information about the survey participants is reported in the **appendices** in an aggregate format.

Main Findings

An integration of the information generated from the four data sources have directed us to the following **six** findings:

Finding 1.

Students' interpretation of learning effectiveness went beyond knowledge retention and application.

In the Student Survey, "learning effectively" was defined in terms of knowledge retention and application — "how well you learn in terms of understanding and retaining knowledge and being able to apply it in different contexts."

However, in their responses to open-ended questions in the Student Survey and in the discussion at the focus groups, students interpreted learning effectiveness more broadly than knowledge retention and application. They understood learning effectiveness as being related to the following four interpretations:

- Better conceptual understanding

  [ProfNames]'s [CourseName] teaching style in which students sit in groups during lecture helped me learn more effectively by enabling me to communicate more effectively with my peers about lecture material. (#215, a first-year student)

  The online videos helped me learn effectively during the fall term (Sept 2021- Dec 2021). The online videos were more concise and to the point, they were generally explained better than the synchronous (in-person) lectures in the winter 2022 term. (#217, a first-year student)

- Better engagement in course materials

  In person learning is more effective at times since professors can keep students actively engaged through questions and "reading people's faces" (#4, a second-year student)

  In person lectures are the most effective as it creates an atmosphere where you are surrounded by students learning and It is much more engaging, and it is also easier to ask questions (both to professors and peers). it is also the most effective when the lectures are recorded and are available for view afterwards, so that students can review them while studying. (#75, a second-year student)

  in terms of being effective, like learning effective, I think just being engaged through the entire semester, not getting tired of the course after a month and really just kind of directing my own learning, (ST3, a focus group participant)

- Flexibility in managing their own learning

  I learned that course effectively, that was in my third year, the end of the course, because I was able to kind of go at my own pace and determine what I wanted to learn when. (ST3, a focus group participant)

  Classes that allowed for flexibility were classes that i learned most effectively in. I felt that online classes provided more flexibility and allowed me to learn at my own pace and gain a better understanding of material. (#11, a third-year student)

- Being quicker to understand course materials or get questions resolved

> *Professors or TAs being easily reachable via Piazza helped me learn effectively because I could get my questions answered within a few hours, rather than needing to wait for weekly office hours.* (#2, a second-year student)
>
> *Mainly because I knew it took me significantly less time to ... or I perceived that it took less time for me to understand concepts in that course or those courses when they employed these methods, as opposed to,[as] if it was the cut and dry, here's all the lecture slides.* (ST1, a focus group participant)

While some students interpreted learning efficiency[2] as relating to learning effectiveness (as shown in the quotes below by ST4 and ST5), others differentiated between the two in terms of online versus in-person learning modes (ST2).

> *I believe efficiency and effectivity kind of go hand in hand. Things that are effective are efficient. Yeah. And personally for me, that was kind of my measure of effectiveness, my willingness to engage in the course.* (ST4, a focus group participant)
>
> *So I thought that kept me really engaged in the class, I never fell asleep in that class. And then I realized that when I came to talk about efficiency in that particular class, because of how engaged I was during the lecture time, I did very little homework, but then I still did really well in the class when I came to final examinations.* (ST5, a focus group participant)
>
> *So I think of effectiveness as how much knowledge I can retain and apply after the course is done whereas efficiency would be how much time I put into gaining that knowledge. And so I would think of effectiveness as a baseline and efficiency would be the time it takes to achieve that effectiveness. ... I do not think my online experience was effective, but I thought it was really efficient. ... So for me, it was efficient when I can watch asynchronous videos at two times speed and I would not have to worry about having to copy down notes. Right. But then afterwards I would revisit the video at two times again to jot down everything because I like having a holistic view of the topic at hand, right. Then I can piece together the order that it makes sense in my head before I write everything down so I can structure my notes accordingly and it helps me bring all the concept together. And the reason why I said online was not effective is because overall, all my courses had tutorials or labs and the online labs and tutorials were not as effective as the in person ones. So I feel like even though it was more efficient online, I was never able to apply the same way as I did in person. And so I wasn't able to retain the information as well.* (ST2, a focus group participant)

Related to learning efficiency, the Student Survey results also revealed that students were more likely to find online learning to be efficient than to be effective: about 40% of the respondents found online learning more efficient than in-person learning, as compared with 17% suggesting that they learned more effectively when instructors introduced course materials online.

As a summary, engineering students found that they learned effectively when they

- developed better conceptual understandings of course materials
- felt engaged in course materials
- had the flexibility in managing their own learning
- were quicker to understand course materials or get questions resolved, which was more about learning efficiency.

[2] In the student survey, a definition of "learning efficiently" was provided: "how fast you learn; that is, the amount and quality of learning achieved for the given investment of time and energy."

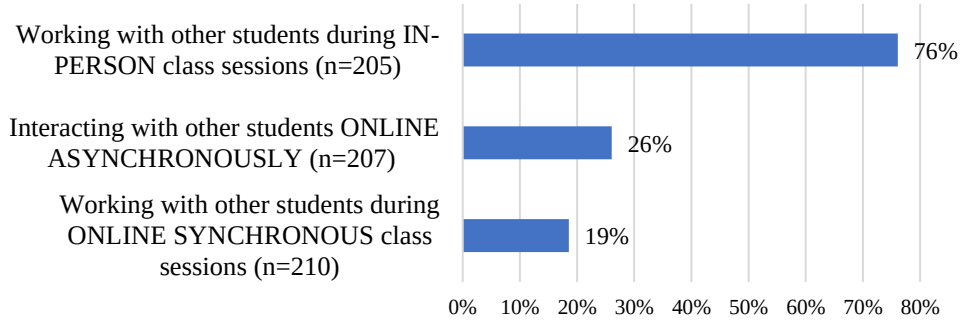
Finding 2.

The course delivery mode made a difference in students' learning experiences (particularly peer interactions, time use, and learning activities), which in turn affected their perceptions of learning effectiveness.

Impacts on Peer Interactions

Only about 1/10 (13%) of the student survey respondents found it easier to interact with students when course delivery was online. Further, as shown in Figure 1, most students (76%) found working with other students during in-person class sessions *substantially* (i.e., "quite a bit" or "very much") contributed to their learning effectiveness, as compared to 1/5 to 1/4 of the respondents who reported so when learning online synchronously or asynchronously. These results suggest that how easy it was to interact with peers made a difference to students' perception of learning effectiveness. This aligned with an observation in our earlier paper[3] that decreased interpersonal interactions in online learning settings affected students' knowledge acquisition.

Figure 1. "Thinking about your experiences in the Winter Term, how much did you find that interacting with other students contributed to making your learning more effective?"
(Percentage of those indicating "quite a bit" or "very much" on a 4-point scale)



The association between students' perceptions of learning effectiveness and their experiences of interacting with peers and the instructor under in-person and online course delivery modes was also reaffirmed by the student comments in response to the survey.

> *[ProfNames]'s [CourseName] teaching style in which students sit in groups during lecture helped me learn more effectively by enabling me to communicate more effectively with my peers about lecture material.* (#215, a first-year student)

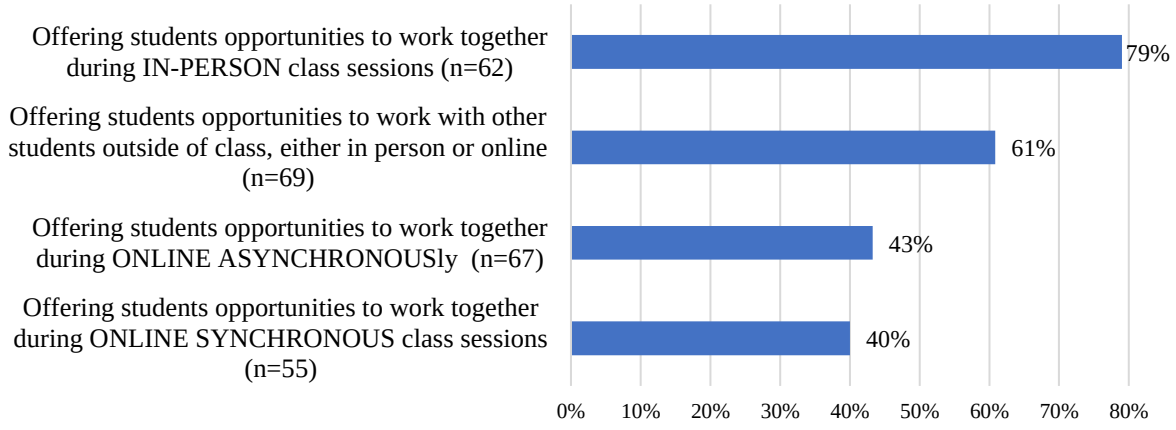
[3] Sweeney, J., Liu, Q., & Evans, G. (2021). *Investigating the impact of online learning on engineering students' socialization experiences during the pandemic*. Proceedings of the annual Canadian Engineering Education Association conference. DOI: https://doi.org/10.24908/pceea.vi0.14864

Online delivery of classes makes it harder to interact with classmates and professors in informal contexts, which restricted my ability to dive deeper into subjects as I often do near the end of in-person classes. (#284, a first-year student)

Online: The chat function of online learning helped me as it reduced the stress associated with asking a question in class. There was more anonymity, and I didn't have to worry about the instructor not being able to hear me yell across the room. In Person: In person classes allowed me to ask my peers questions for clarification during class and to build relationships with peers which was critical to my success. While online I developed no new friendships and found that I worked much more independently. It was through talking with peers that I was able to develop the most understanding of concepts. (#320, a first-year student)

Along the same line, respondents to the instructor survey also identified offering students opportunities for peer interactions as an effective teaching practice. As shown in Figure 2, when these peer interaction opportunities were offered in an in-person setting, a much higher percentage of instructors (79%) found them to contribute to teaching effectiveness than when these opportunities were offered on line (either synchronous or asynchronous).

Figure 2. Perceptions of practices contributing to teaching effectiveness
(Percentage of those indicating "quite a bit" or "very much" on a 4-point scale)



Instructors found that opportunities for peer interactions under in-person and online course delivery modes had contributed to student learning in multiple ways. As shown in the following quotes, in-person peer interactions motivated students to learn (#44) and helped build friendship and teamwork (#121); online peer interactions were made easier through the chat function of the online platform (#67); and peer interactions enhanced collaborative learning regardless of the instruction mode (#104).

The energy level during online team tutorial is about half of that in-person. First online year students were very camera shy - thus we were unable to see 80-90% of our students - major hindrance. Second online year this has markedly improved so that we were unable to see 10-20% of our students only. We did winter term in 2022 both online (Jan) and in-person (Feb-April). Thus we were able to compare both method[s] in the same term. In-person was much more effective and more motivational for the students. (#44, an instructor survey respondent)

Providing opportunities for students to work in groups for in-person activities (e.g. tutorials, labs) helped them form friendships and practise teamwork. (#121, an instructor survey respondent)

One of the things I enjoyed during online teaching was the class chatter in the chat. Even though I didn't see the students faces, I could see that the students were engaged, and enjoying one anothers' company. This was something that disappeared when we came back to in-person in February. (#67, an instructor survey respondent)

I believe our in-class (both in person and online) live discussions both as individual groups and then one large group was extremely beneficial and I received positive feedback from students as such. They enjoyed discussing course concepts and case studies in small breakout groups. Whether we were online or in-person I had students work in groups and then create a "slide" on google slides to present to the entire class with a summary of the key points of their discussion. Students could then use this created slide show to study for the exam. (#104, an instructor survey respondent)

Impacts on Time Use and Learning Activities

In February 2022, FASE instructors were asked to shift the course delivery mode from online to in-person. In this context, students were asked in the Student Survey to indicate the time they had spent on certain learning activities before and after the return to in-person course delivery.

This shift of the course delivery mode affected how most of the students used their time for schoolwork. As shown in Table 2, nearly 3/5 (57%) of the respondents indicated either an increase or a decrease in their time spent on schoolwork after the return to in-person course delivery during the Winter Term of 2022 whereas slightly over 2/5 (43%) of the respondents reported a change (an increase or a decrease) in their time spent on extra- or co-curricular activities. Particularly, 5% of the respondents reported that the time they spent on schoolwork and extra/co-curricular activities both increased while 27% indicated that they both remained unchanged. Moreover, about 30% reported having spent more hours on schoolwork (34%) and / or extra- or co-curricular activities (28%).

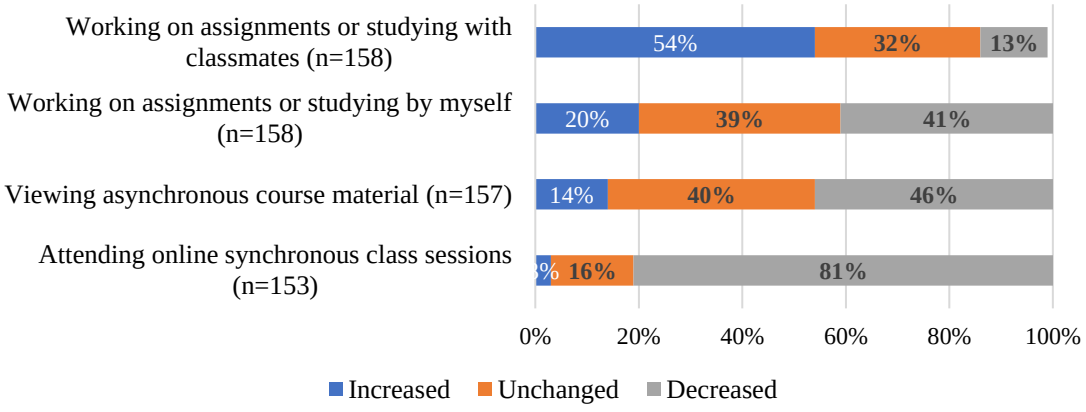
Table 2. Individual-level changes in time use after the return to in-person course delivery in Winter Term of 2022: Time on schoolwork versus extra- or co-curricular activities (n=163)

		Time on extra- or co-curricular activities			
		Increase	Unchanged	Decrease	Sub-total
Time on schoolwork	Increase	**5%**	21%	9%	**34%**
	Unchanged	11%	**27%**	4%	42%
	Decrease	12%	10%	2%	**23%**
	Sub-total	**28%**	58%	**15%**	

Further, the return to in-person course delivery also significantly affected the amounts of time students spent on specific learning activities. After the return to in-person course delivery,

respondents indicated that *on average* they spent *less* time[4] attending online synchronous class sessions (a very large effect size), viewing asynchronous course materials (about a medium effect size), and working on their own (a small effect size), but spent *more* time working with their classmates[5] (a medium effect size). The individual-level changes in time spent on those learning activities are shown in Figure 3.

Figure 3. "Before and after the return to in-person course delivery during the 2022 Winter Term, how did you allocate the hours you spent on schoolwork?"



Students spent more of their time on in-person learning than using online resources after the return to in-person. Table 3 shows that 75% of the respondents indicated having attended more than 60% of in-person class sessions after the return to in-person course delivery.[6] There was a considerable drop in the proportion attending most or almost all online synchronous sessions before versus after the return (64% to 36%) and viewing most or almost all asynchronous course material (62% to 52%).

[4] Specifically, attending online synchronous class sessions (M = 1.62, SD = 1.15 after the return vs. M = 3.88, SD = 1.74 before, $t(152) = -14.92$, $p < .001$, $d = -1.21$), viewing asynchronous course materials (M = 2.35, SD = 1.50 after the return vs. M = 2.97, SD = 1.54 before, $t(156) = -5.69$, $p < .001$, $d = -0.45$), and working on their own (M = 3.80, SD = 1.34 after the return vs. M = 4.15, SD = 1.41 before, $t(157) = -3.44$, $p < .01$, $d = -0.27$).

[5] time working with their classmates (M = 3.04, SD = 1.66 after the return vs. M = 2.25, SD = 1.54 before, $t(157) = 6.95$, $p < .001$, $d = 0.55$).

A commonly used interpretation for Cohen's d is: small (d = 0.2), medium (d = 0.5), and large (d = 0.8) (Cohen J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. New York, NY: Routledge Academic.)

[6] We suspect that those students who were more engaged in their academic work and school activities were more likely to respond to the survey; therefore, these results may not represent the situation of all engineering students.

Table 3. Proportion of learning opportunities used before and after the return to in-person course delivery

Learning opportunities	Course delivery modes*	n	Very little or Some (< 40%)	About half (40-60%)	Most or Almost all (> 60%)
In-person sessions I attended	Mainly in-person course delivery	162	14%	10%	**75%**
Online synchronous sessions I attended	Online course delivery	163	18%	18%	**64%**
	Mainly in-person course delivery	163	58%	6%	**36%**
Asynchronous course material I viewed	Online course delivery	160	20%	18%	**62%**
	Mainly in-person course delivery	159	33%	14%	**52%**

*In mid-February 2022, most of the courses shifted from an online mode to a mainly in-person delivery.

In summary, when the impacts of course delivery modes on peer interactions and learning activities were put together, we found that both students and instructors perceived that the ways and levels of peer interactions through various learning activities enabled by in-person versus online instruction modes made a difference to learning and teaching effectiveness.

Finding 3.

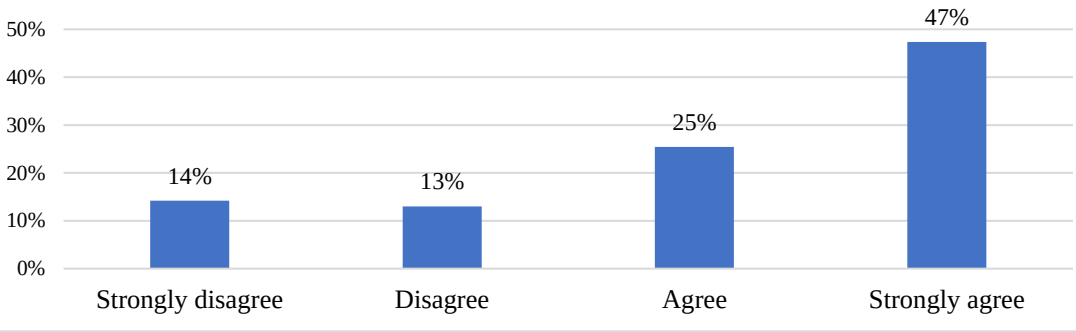
Most students and instructors favoured in-person course delivery and assessment while a small but important proportion preferred online learning and teaching.

Students' Perspectives

Eight observations from the *student survey data* supported a strong preference among *most* students for an in-person educational environment.

Observation 1 (self-reported activity). Over 70% of the respondents indicated that when both options were made available to them, they attended more in-person class sessions than online sessions.

Figure 4. "Thinking about your experiences of learning online and in person over the last two years, how much do you agree or disagree that the following statements?"
"Attended more in-person sessions when in-person and online options were both available" (n=169)



Observation 2 (self-evaluation). Nearly 70% of the respondents indicated that the return to in-person course delivery during the 2022 Winter Term was beneficial to their learning (i.e., 5 to 7 on a 7-point scale in Figure 5).

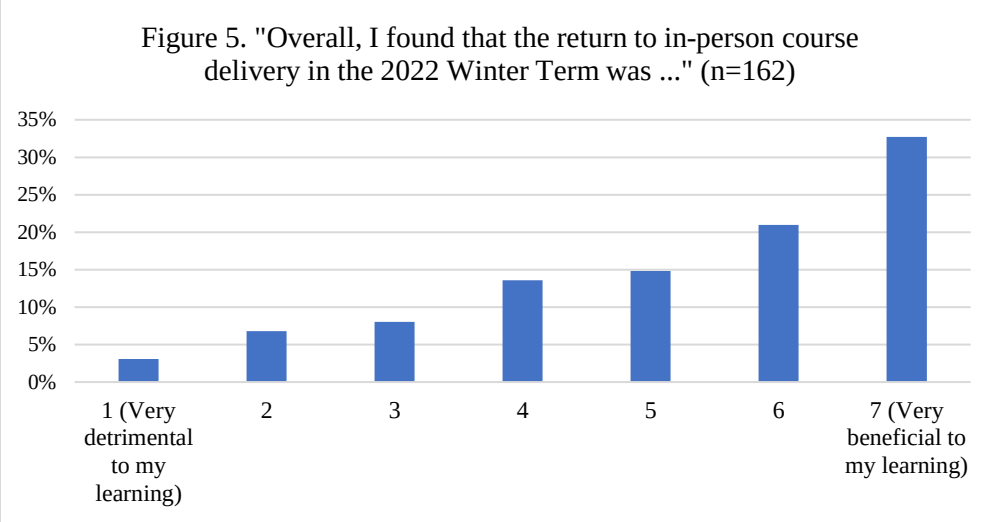


Figure 5. "Overall, I found that the return to in-person course delivery in the 2022 Winter Term was ..." (n=162)

Observation 3 (self-evaluations). About two-thirds of the respondents indicated that when learning in an in-person environment, they felt more motivated (65%) and found learning more effective (70%) than when courses were delivered online (Figures 6a and 6b).

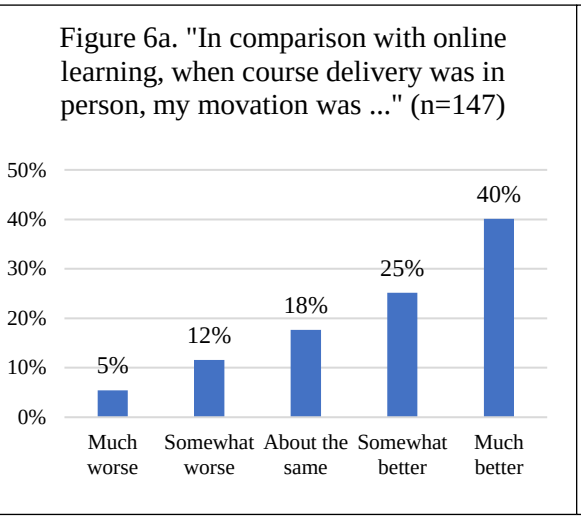


Figure 6a. "In comparison with online learning, when course delivery was in person, my movation was ..." (n=147)

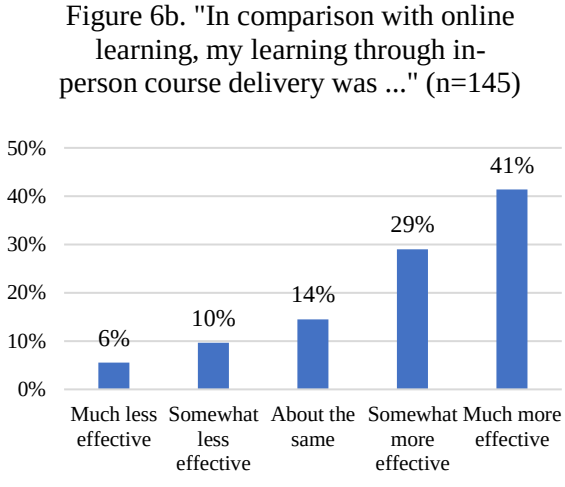
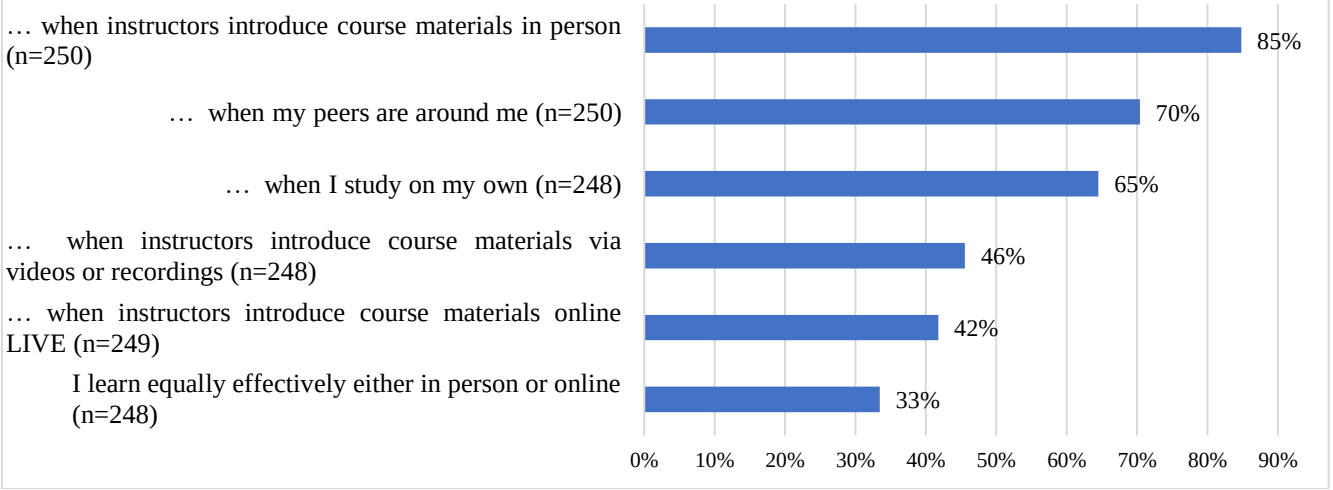


Figure 6b. "In comparison with online learning, my learning through in-person course delivery was ..." (n=145)

Observation 4 (self-evaluation). Most students favoured being introduced to course materials in person over online (either synchronously or asynchronously). As shown in Figure 7, most of the respondents (85%) indicated that they learned more effectively when instructors introduced course materials in person, representing a much higher percentage than those who reported that they learned more effectively when instructors introduced materials via videos or recordings (i.e., asynchronously, 46%) and online live (i.e., synchronously, 42%).

Figure 7. Perceptions of learning effectiveness under various learning modes:
"I learn more effectively when ..."
(Percentage of those indicating "usually true" or "almost always true" on a 4-point scale)

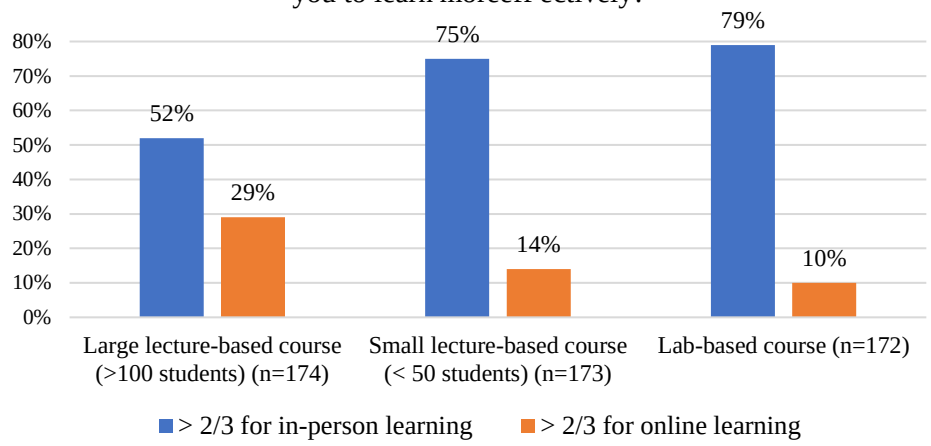


Observation 5 (preference). A general tendency of preferring in-person class time over online learning (synchronous and asynchronous) was noted among students. On average, the respondents preferred a higher portion of weekly learning time for a lecture-based course to be allocated to in-person class time (M = 4.58,[7] SD = 2.37) than viewing online asynchronous materials (M = 2.42, SD = 1.74) and online synchronous class time (M = 1.80, SD = 1.56), with medium and large effect sizes respectively (d = .67 and .85).

Observation 6 (student recommendations). A much higher proportion of the respondents recommended over 2/3 of the class time to be allocated to in-person learning versus online learning. As shown in Figure 8, 52% vs. 29% of the respondents recommended over 2/3 of the class time be allocated to in-person learning vs. online learning respectively in a large lecture-based course. This contrast was much larger for small lecture-based courses (75% vs. 14%) or lab-based courses (79% v. 10%).

[7] The survey question was on a 10-point scale, with 1 = 0-10% and 10 = 90-100%.

Figure 8. "In a future course,what proportion of the class time should be allocated to online versus in-person learning to help you to learn moreeff ectively?"



In particular, first-year students were more likely to indicate that they learned more effectively through in-person course delivery (Figure 9a, Kruskal-Wallis $H(3) = 15.24$, $p < .01$[8]). First-year students, on average, recommended a higher proportion of the class time to be allocated to in-person learning for large lecture-based courses than third- and fifth-year students (Figure 9b); the difference was statistically significant, $F(4) = 5.00$, $p < .01$, $\eta^2 = .09$.

Figure 9a. "I learn more effectively when instructors introduce course materials in person"

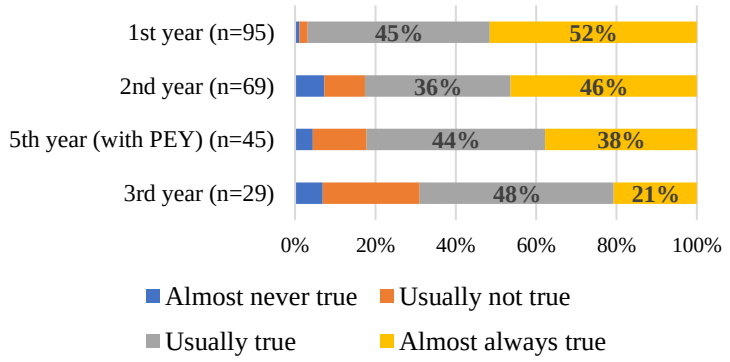
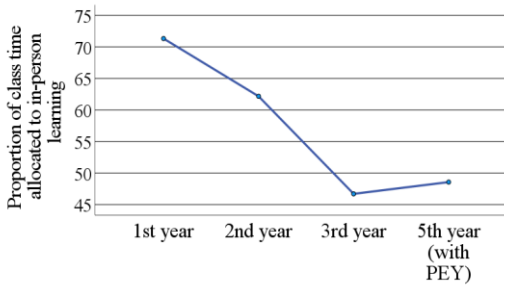


Figure 9b. Mean plot for recommended proportion of class time allocated to in-person learning for a large lecture-based course: Students by year of studies



Observation 7 (self-evaluation about assessment methods). Student survey respondents provided a much better evaluation of in-person assessments with aids over online assessments although many found in-person assessments more stressful. As shown in Figure 10a, half of the

[8] A Kruskal-Wallis test was used to detect significant differences among more than two groups. H value is reported here, along with degree of freedom (in this case, df =3). When the p value is less than .05, the result indicates that there was statistically significant difference among the groups being compared, presumably at least between the group with the highest mean rank and the group with the lowest mean rank (in this case Mean $\text{Rank}_{\text{first-year}} = 134.50$, the highest; Mean $\text{Rank}_{\text{3rd-year}} = 84.47$, the lowest).

respondents ranked in-person learning assessment with aids as the top option, much higher than the other three assessment methods. The difference in the ranking was statistically significant,[9] $w = .27$, $p < .001$. Further, Figure 10b shows that about 3/5 of the respondents found in-person assessments to be more stressful, and nearly a quarter found in-person assessment to be more difficult.

Figure 10a. "Thinking about your experiences learning online and in person over the past two years, how would you rank the following learning assessment methods in terms of better allowing you to demonstrate your learning?" (Percentage of being ranked as the top choice)

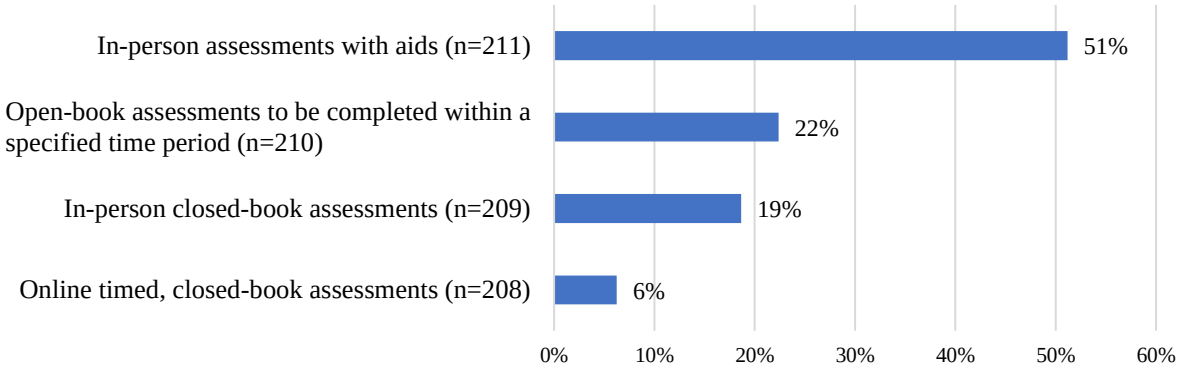
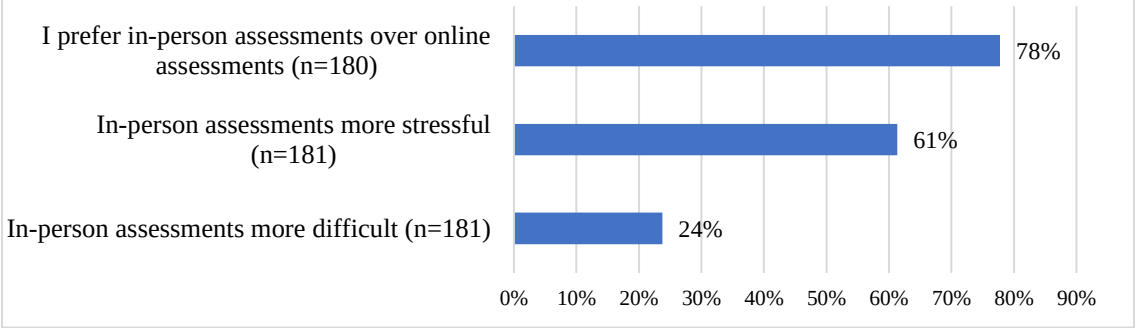


Figure 10b. "Thinking about your experiences of learning online and in person over the last two years, how much do you agree or disagree with the following statements?" (percentage of those indicating "agree" or "strongly agree" on a 4-point scale)



Observation 8 (student comments). Students' preference for in-person learning was also shown in their comments in response to the student survey and focus group questions. Students explained that the in-person environment with more effective interpersonal interactions helped them stay motivated (#320), learn from each other (#320, ST1), and catch up with course materials (#179).

[9] Kendall's W test was used to inspect the agreement among the rankings of formal assessment methods (in this test, N = 187, df = 3).

> *In person it felt like I was working with everyone to get through the program and learn the content. I could empathize with others on things that were challenging as well to realize that I was not the only one struggling. This helped me to stay motivated and to not get down on myself. I was also able to effectively learn from my peers in person, whereas online I worked almost completely independently.* (#320, a first-year student)

> *Ultimately, I think it should be predominantly in person. If you're going to do an online section, it should only be, I'd say at most like a third of your courses for a semester, because I feel like the interactions between students is really ... at least for me, has always been really critical for me to learn effectively and efficiently, because I've always been a very collaborative person working off of other people. And then online doesn't really offer that*. (ST1, a focus group participant)

> *having in person lectures/tutorials/labs/test/exams are much more effective and contributed to my learning than any online activities. Having online means its easy to skip, knowing that the lecture recordings will be posted - many students were not caught up with the lectures because the system made this possible, and performed less than when everything was in person. Having all activities in person helps the most with following the academic plan and learning.* (#179, a fifth-year student with PEY)

While most students favoured in-person course delivery and assessment, it is important to note that a small but important proportion of students had a completely different perspectives. Figure 5 shows that 18% of the respondents indicated that the return to in-person course delivery was detrimental to their learning. Similarly, Figures 6a and 6b indicate that about 1/6 of the respondents felt more motivated (16%) and found learning more effective (17%) online. Figure 7 suggests that 15% of the respondents did not find learning more effective when instructors introduced course materials in person.

Student comments suggested that these "minority" students who preferred online learning were more likely to be commuters (#206, #31, #13), have health concerns (#206), or have developed a more self-directed learning style (#243).

> *I was very happy with the online part of the term because I was able to attend all lectures for the first time this year. I think students with chronic medical conditions or commuters, often have to miss lectures for different reasons. Online learning removed the time inequality from students because we were able to study for the same amount of time, and attend the same number of lectures.* (#206, a first-year student)

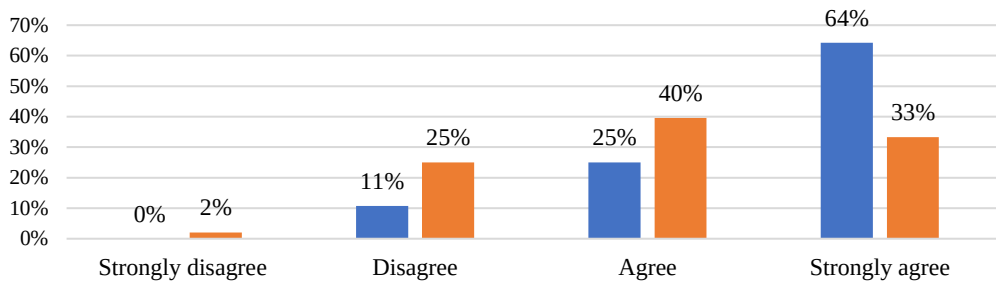
> *I felt in-person classes felt too long and it was hard to concentrate during the full class time. I think commuting played a role in making learning less effective and hindered my participation in classes.* (#31, a second-year student)

> *[In online learning] 1. I felt less distracted when I was at home which allowed me to focus better on the lectures and course material. 2. Having recorded lectures gave the option to pause and replay parts that were unclear. 3. I felt less tired and more motivated during online learning because I did not have to commute to campus (1 hour there and 1 hour back) 4. I felt overall less pressure and anxiety during online learning which improved my mental health, therefore improving my motivation and learning.* (#13, a third-year student)

> *The reason why I prefer online study is simple. It makes me follow my own pace, by which I can check the high-quality lecture recordings whenever I want. Also, the UOFT professors' online materials are really good!* (#243, a third-year student)

When students who found the switch to in-person course instruction to be detrimental to their learning were compared to those who found switch to in-person instruction beneficial, a much higher proportion of those favouring online course instruction than those favouring in-person instruction (64% vs. 33%) strongly agreed that they preferred to follow their own pace in learning (Figure 11). This suggests an association between preference for online versus in-person course delivery and a self-directed learning style, $X^2(3, N=124) = 9.04$, $p < .05$, Cramer's $V = .27$. That is, many of those in the "minority" group who favoured an online course instruction mode appeared to be self-directed learners, a characteristic that should be promoted as a pathway to lifelong learning.

Figure 11. "I preferred to follow my own pace in learning": Comparing students with contrasted perspectives (29 students in Group 1 vs. 96 students in Group 2)

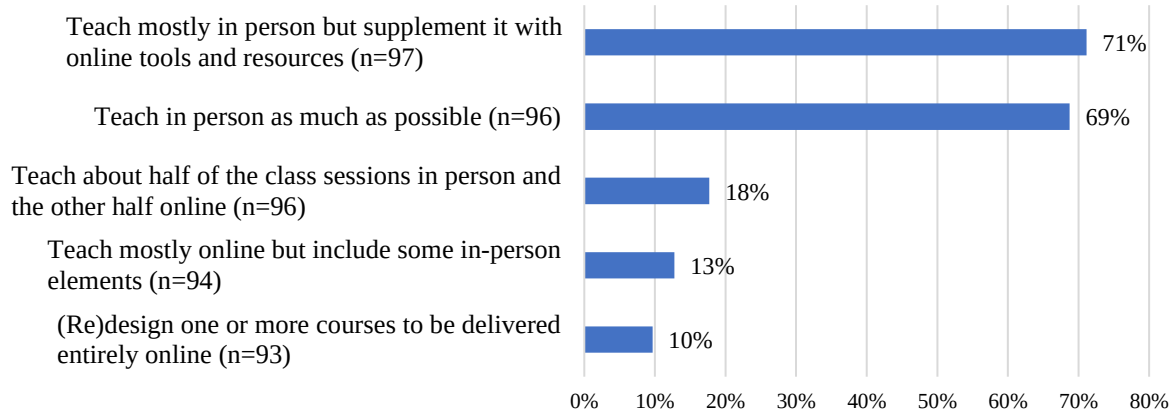


Instructors' Perspectives

The responses to the instructor survey revealed similar patterns as those from the student survey. As shown earlier in Figure 2, a considerably higher proportion of the respondents to the instructor survey indicated that offering students opportunities to work together during in-person class sessions (versus similar opportunities for students to work together online) substantially contributed to teaching effectiveness.

In a similar vein, about 70% of the instructor respondents indicated that they were likely to "teach mostly in person but supplement it with online tools and resources" and "teach in person as much as possible"; and about 1/10 indicated that they were likely to teach mostly or entirely online (Figure 12).

Figure 12. "Given the choice and your teaching experience over the past two years, how likely are you to adopt the following teaching practices once the pandemic is over?"
(Percentage of those indicating 5, 6 or 7 (Very likely) on a 7-point scale)



However, the reasons that instructors provided in favour of in-person teaching were somewhat different than the students' perspectives. Instructors often related their preference for in-person teaching to their perceptions of challenges in online teaching, such as difficulty in gauging students' understanding (#105), less desirable experiences than in-person teaching (#64), unsatisfactory learning outcomes (#79), and lower student satisfaction (#105).

> *Despite my best efforts to adjust to online teaching during the pandemic, teaching outcomes and student satisfaction with the courses were measurably lower. It is too easy for students to not pay attention and impossible to gauge how students are grasping the material in real-time during the lectures.* (#105, an instructor survey respondent)

> *I have taught online courses before the pandemic and never found the experience to be as good as in-person teaching. When the entirety, or even majority, of the learning is online, the negative elements seem (to me) to be exacerbated*. (#64, an instructor survey respondent)

> *Everyone (myself and the students) enjoyed the flexibility of online teaching. However, once we returned to optional in-person lectures, it became very clear that there was a large gap in learning and demonstrated test performance between those who were attending in-person and those who were attending online. As an experiment, I calculated the midterm average for those who were in regular attendance and those who were attending primarily online, and there was a 19.6% difference in the mean score between those two groups. (And, while I didn't conduct an explicit test of this in 2020-21, my clear impression was that learning outcomes were similarly compromised in those years as well.) As a result, while I love the flexibility, I will give strong preference to in-person teaching going forward.* (#79, an instructor survey respondent)

In summary, considerable evidence from our study pointed to a strong preference among most engineering students and FASE instructors for in-person learning and teaching over online while a minority of students and instructors favoured the online mode.

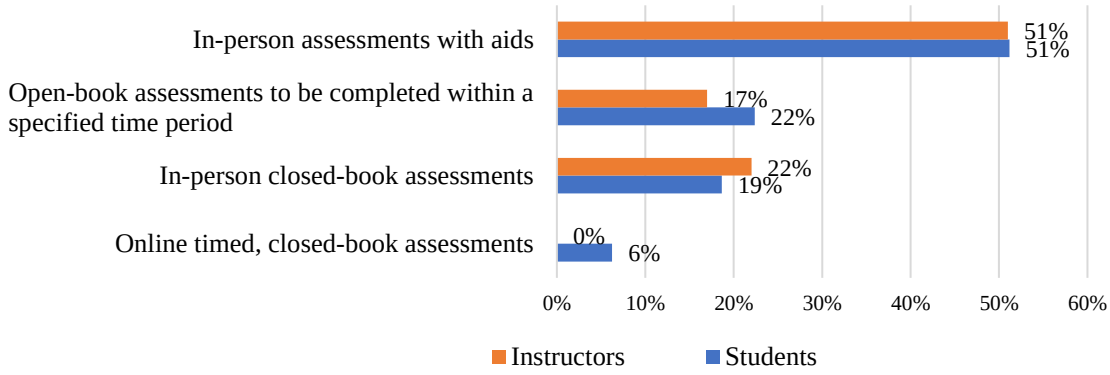
Finding 4.

Alternative assessment and teaching practices emerged from academic changes during the pandemic. These resources and practices represent emerging student engagement opportunities that were less utilized before the pandemic or reinforce some of the effective practices already implemented in engineering education.

Assessment Methods

In-person assessments with aids. As shown earlier in Figure 10a, 51% of the respondents to the student survey selected in-person assessment with aids as the top choice to allow them to demonstrate their learning. Similarly, 51% of the respondents to the instructor survey also ranked in-person assessments with aids as their top choice among the four formal assessment methods (Figure 13).

Figure 13. "How would you rank the following learning assessment methods in terms of better allowing you / students to demonstrate your / their learning?" (Percentage of being ranked as the top choice)



The following quotes showed that both students and instructors found in-person assessment with aids to be effective for assessing learning because this method places greater emphasis on knowledge application than regurgitation.

> *I think now professors are recognizing that, in engineering, what's more important is your grasp of the concept, rather than being able to memorize all these equations and not know how to apply them. I think that's why they let us take our notes and stuff into the exams now because they're like, "What's more important is that we see you apply the information on a test, rather than just regurgitate something that's in the notes."* (ST10, a student focus group participant)

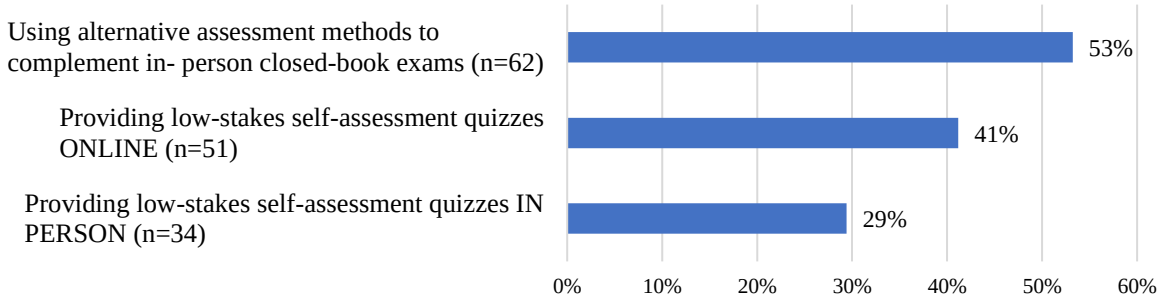
> *Assessments that are open-book or with aids (formula sheets) are a pedagogically more effective way of ensuring that learning is taking place (rather than memorizing for a closed-book exam). This is true for both in-person and online exams.* (#93, an instructor survey respondent)

> *In person with aid sheet is the best. The act of preparing an aid sheet is a great learning process. In engineering, no analytical courses should be closed book - it's about understanding, not memory abilities.* (#58, an instructor survey respondent)

Alternative assessment methods. Slightly over half (53%) of the respondents to the instructor survey indicated that "using alternative assessment methods to complement in-person closed book exams" substantially contributed to making their teaching more effective (Figure 14).

In particular, a higher proportion of the respondents reported a substantial contribution of providing low-stakes self-assessment quizzes *online* (41%) than *in person* (29%). This suggests that low-stakes self-assessment quizzes can be an effective online formative assessment method.

Figure 14. "Thinking about your teaching experiences during the 2021-22 academic year, how much do you feel that the following practices contributed to making your teaching more effective?" (percentage of those indicating "quite a bit" or "very much" on a 4-point scale)



Some instructors shared that regular online quizzes were an effective and efficient assessment method (#93). However, other instructors expressed academic integrity concerns about online assessments (#100).

> *Regular timed assessments (e.g. quizzes) can now be conducted online in large classes with significant meta-data to investigate incidences of academic misconduct. But most importantly, they can be regularly conducted and reinforce student learning at more regular intervals than a mid-term and final exam format. Online testing platforms (especially for more math-oriented courses in which algorithmic questions can be designed) are highly scalable (whether 20 students or 2000 students), efficiently graded (automatic, and students see score after the test), less prone to petitions (same test for everyone). Such mini-tests can be offered almost daily without any logistical problems (in the way in-person mini-quizzes will be logistically inefficient), and can be connected to online resources so that even in the test/exam a consolidating learning experience occurs.* (#93, an instructor survey respondent)

> *Any online assessment has the potential for academic dishonesty. Online assessment is by far the most efficient, but doesn't gauge learning well so who cares?* (#100, an instructor survey respondent)

In addition, some instructors found assignment-based assessments to be effective to their courses but did not consider this type of assessments to be efficient (#23 and #104). "Efficiency" in the instructor survey was described as "the ratio of how well the method assesses students learning to the amount of instructor time and energy required to implement the method."

In my courses, students must synthesize theory and practice and there is no benefit in memorization. There is, however, a great benefit in being able to find material online to provide evidence for their arguments. It is the argument which is graded, not the supporting material. … My methods are not efficient. Exam prompts are individualized in order for me to evaluate the students on the cumulative development of understanding in the course. My responses and feedback are generally quite detailed. (#23, an instructor survey respondent)

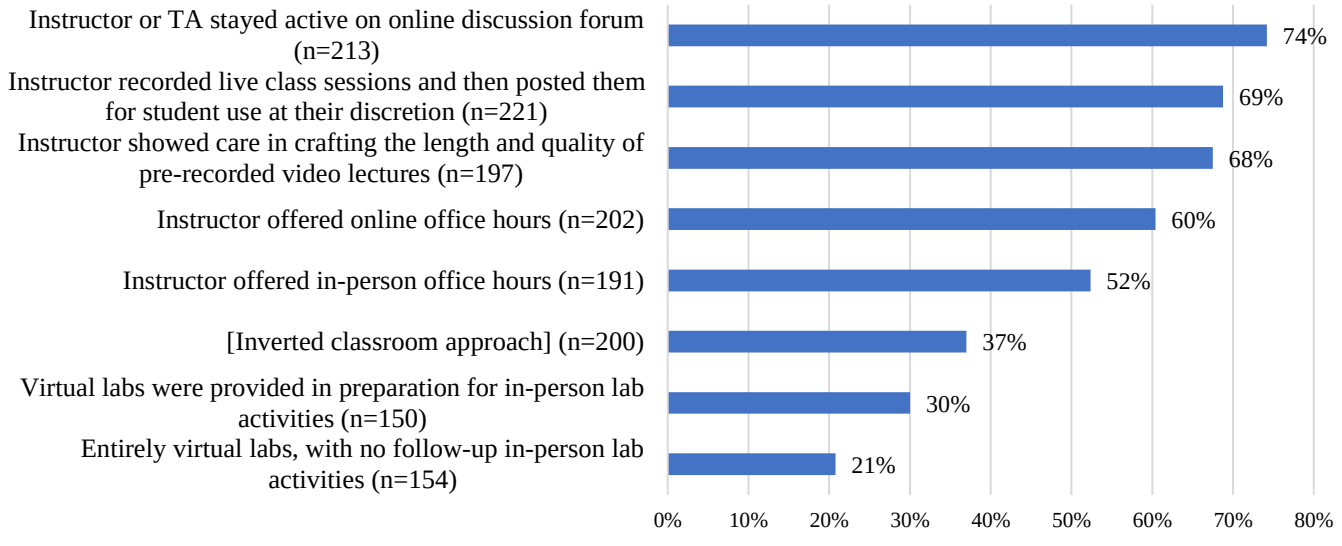
Instead of an in-person or online exam I would rather students be actively utilizing the knowledge they gained in the class through contribution to an individual project or term paper. Due to the nature of the class an exam may not be the best choice. … in terms of efficiency an in-person or online exam using Crowdmark would be more efficient than grading individual projects. (#104, an instructor survey respondent)

Teaching Practices

With respect to teaching practices, over two thirds of the engineering students felt that the following teaching practices had substantially contributed to their effective learning (i.e., the first three items in Figures 15):[10]

- Active online discussion forum
- Availability of live class recordings
- Availability of carefully created pre-recorded video lectures

Figure 15. "Thinking about your experiences in the Winter Term (2022), how much did you find the following teaching practices, if applicable, contributed to making your learning more effective?"
(Percentage of those indicating "Quite a bit" or "Very much" on a 4-point scale)



[10] This figure also shows that use of the inverted classroom approach and virtual labs were less favourable to effective learning in most students' mind. The question on use of the inverted classroom approach was "Instructor posted pre-recorded lectures and/or assigned readings prior to the class and used live class sessions for discussions and other active learning activities."

However, instructors did not hold all the same perspectives as students. Strikingly different perspectives were found with respect to availability of live class recordings. As shown in Figure 14, nearly 70% of the respondents to the student survey found the availability of live class recordings had substantially contributed to their learning effectiveness, a finding that also emerged from our analysis of the student survey data collected from 2020 to 2021.[11] In contrast, only 49% of the instructor respondents indicated that "recording live class sessions (in-person or online) and then posting them for student use at their discretion" contributed substantially to their teaching effectiveness.

Many students shared that availability of live class recordings was helpful for their review of course materials (#11, #21, #40), time management (#11, #40), and well-being (particularly for those students with health concerns) (#40, #123). However, some students also became aware that these recordings had hindered their effective learning by letting them skip in-person classes and fall behind. (#179).

> *Having a recording of lectures, regardless of how they are presented originally is very helpful - it is useful for reviewing concepts, going at my own pace if needed, or self-managing my schedule. That being said I much prefer in-person delivery. I find it much easier to keep my focus while in person, and I come to class more*. (#11, a third-year student)
>
> *Recorded lectures were definitely the most helpful of all teaching practices. Being able to review, pause, and rewind material that the instructor covered which then was directly tested on in assessments was much more helpful than the alternative of only live lectures and then hoping that the material given by notes or textbooks after classes mirrored that covered in lecture. Furthermore, since many engineering lectures build upon previous lectures, when one eventually misses one of the 40 lectures per course per semester, it is must easier to catch up and get back on track. Otherwise, with only live lectures, it is almost impossible to get back in the saddle after even the slightest bit of missed material.* (#21, a second-year student)
>
> *Absolutely recorded lectures/tutorials. Being able to review content later has helped me a lot, and I frequently learn things that I may have missed the first time. It also gives me peace of mind in case I can't come due to health reasons. I also can schedule when I do my learning so I can learn at times when I'm most focused. It takes a lot of stress off of commuting and cuts down on time wasted waiting in between breaks in my schedule.* (#40, a third-year student)
>
> *Professors who made an effort to do a great job of fully recording their lectures (including the boards), and taking care to ensure the quality of the videos were actually good were invaluable. I struggle from health problems that were further exasperated by the pandemic, and it meant I was too sick or vulnerable to come to class sometimes, and certainly more often than many of my peers. Professors committed to making learning accessible allowed me to flourish, and it showed in the best marks I got this year ([CourseNames]).* (#123, a third-year student)

[11] Liu, Q., & Evans, G. (2021). Online learning and teaching during the pandemic: Engineering students' perspectives in 2020-2021. Institute for Studies in Transdisciplinary Engineering Education and Practice, University of Toronto, ON. Available at https://istep.utoronto.ca/files/2021/11/Reports-on-FASE-online-learning-survey-results-Final.pdf

> *Having recorded lecture hindered effective learning because it did not force me to keep up with the lecture material - sets the mindset that I can always watch later and that "later" never happens. Also it made me hard to go to school for other classes because if I have 2 courses with lecture recording and 1 course with not on a certain day of the week, I could not force myself to commute to school for the one lecture without the recording - having recordings just became an excuse to be fall behind in everything and lose the chance to interact with peers at school. This was not the case pre-covid era, I went to school everyday, learning was happening and I learned most by interacting with other students and working collaborative with them. I couldn't see this happening even in winder semester of 2021-2022 when lectures were back in person, because there were recording available and no one showed up to class. It was no different than being an online school*. (#179, a fifth-year student with PEY)

In contrast, more instructors than students expressed their concerns about the quality of recordings of live lectures (#55), less effective learning among students who learned course materials from the recordings (#60; #99), and a reduced in-person class attendance (#58, #99).

> *The instructor might be teaching in-person, but nonetheless students demanded recordings of the in-person lecture. A recording of an in-person session posted online is not the same as an online lecture prepared to be online. This "modal flip-flopping" was detrimental to the instruction, and it stemmed from the expectation created on students that all types/modes of instruction would be made available to them. This expectation was real.* (#55, an instructor survey respondent)

> *Because I recorded all of my in-class lessons and posted them, I found attendance to drop - reducing in-class interactions.* (#58, an instructor in response to the question on practices that detracted from effective in-person teaching)

> *The issue with dual offerings (fully remote synchronous and lecture capture for in person) is that a large group of students would choose to watch recordings afterwards and this negatively impacted student learning.* (#60, an instructor)

> *Posting recorded lectures seems to discourage students from attending in-person lectures which is a problem in my opinion as some students don't seem to pick up the material as well--perhaps multi-tasking when watching?* (#99, an instructor)

Students found an active online discussion forum was helpful for them getting questions answered promptly.

> *Professors or TAs being easily reachable via Piazza helped me learn effectively because I could get my questions answered within a few hours, rather than needing to wait for weekly office hours.* (#2, a second-year student)

On the instructor side, while 58% indicated that staying active on online discussion forum substantially contributed to their teaching effectiveness, other instructors held quite a different perspective about this practice.

> *Online asynchronous forums (e.g., Piazza) are antithetical to a discursive approach to teaching and put all authority into the instructor's hands rather than co-construction of knowledge as happens in a real office hour.* (#87, an instructor)

For both students and instructors, pre-recorded lecture videos added value to student learning. Students found that carefully created pre-recorded lecture videos were more condensed than live lectures (#3, #217), and motived students to learn more (#17). Instructors found that these videos better prepared students for the class sessions (#124). However, creating these videos increased instructors' preparation time even though they could reuse some of recorded videos created for the previous class cohort.

> *pre-recorded lectures are usually shorter than in-person lectures because they're more condensed and less time is wasted with in-class distractions.* (#3, a second-year student)

> *The online videos helped me learn effectively during the fall term (Sept 2021- Dec 2021). The online videos were more concise and to the point, they were generally explained better than the synchronous (in-person) lectures in the winter 2022 term.* (#217, a first-year student)

> *One of my online classes had the lecture's overarching concepts explained in a ~20-min video with really high production value (background music and short video clips/gifs except when highly technical concepts are being discussed, something akin to an intro sequence to help mentally get in the groove of the course, quick minute summary at the end, short video duration), and then the more in-depth technical explanations/mathematical concepts were put into written documents afterwards which were required readings and included different information from the video so it actually gave me motivation to read it.* (#17, a fifth-year student with PEY)

> *Video lectures with live Q&A sessions was extremely well received by students, as they got to absorb material at their own pace and schedule and come to live sessions with in depth questions.* (#124, an instructor)

In summary, while in-person assessment with aids were favourable to half of the students and instructors, low-stakes online self-assessment quizzes and assignment-based assessments were also recognized as effective. With respect to teaching practices, while most students found active online discussion forum, and availability of live class recordings and carefully created pre-recorded video lectures to be conducive to their effective learning, some instructors held different perspectives, most prominently on availability of live class recordings.

Finding 5.

Amid student needs, challenges to implement a mixture of in-person and online instruction persisted.

Student Needs

While student survey results revealed a strong preference for in-person course delivery among most students (as presented in Finding #3), at least some students preferred a combination of in-person and online learning opportunities in their learning experiences. As shown earlier in Figure 8, 29% of the students recommended over 2/3 of the class time for online learning in a large lecture-based course.

Along a similar line, as shown in Table 4, about half (46%) of the respondents preferred that 10 to 40% of weekly learning time for a typical lecture-based course be in-person; and nearly 2/3 (57%) of the respondents preferred 10 to 40% of weekly learning time be allocated to viewing online asynchronous course materials whereas less than 1/3 (30%) preferred 10 to 40% of weekly learning time be allocated to online synchronous class time. Further, of those respondents who indicated that 10 to 40% of learning time should be used for in-person class time (n=78), 59% also indicated that 10 to 30% of learning time should be allocated to viewing online asynchronous course materials whereas 33% indicated that 10 to 30% of learning time be allocated to online synchronous class time (not reported in Table 4). These comparisons between the preferred time for online synchronous and asynchronous learning activities reveal a preference among students for asynchronous online learning over synchronous online learning. Moreover, 59% of the students agreed that some time (10 to 40%) should be allocated to self-directed learning (Table 4).

Table 4. Students' preferred distributions of the expected 10 hours per week of learning time among certain learning activities[12]

Learning activities	n	0 to 10%	10 to 40%	40 to 70%	70 to 100%	Mean (SD)
Portion for in-person class time	168	10%	**46%**	32%	12%	4.58 (2.37)
Portion for self-directed learning	167	4%	**59%**	34%	4%	4.15 (1.67)
Portion for viewing online asynchronous course materials	169	34%	**57%**	6%	2%	2.42 (1.74)
Portion for online synchronous class time	167	64%	**30%**	4%	2%	1.80 (1.56)

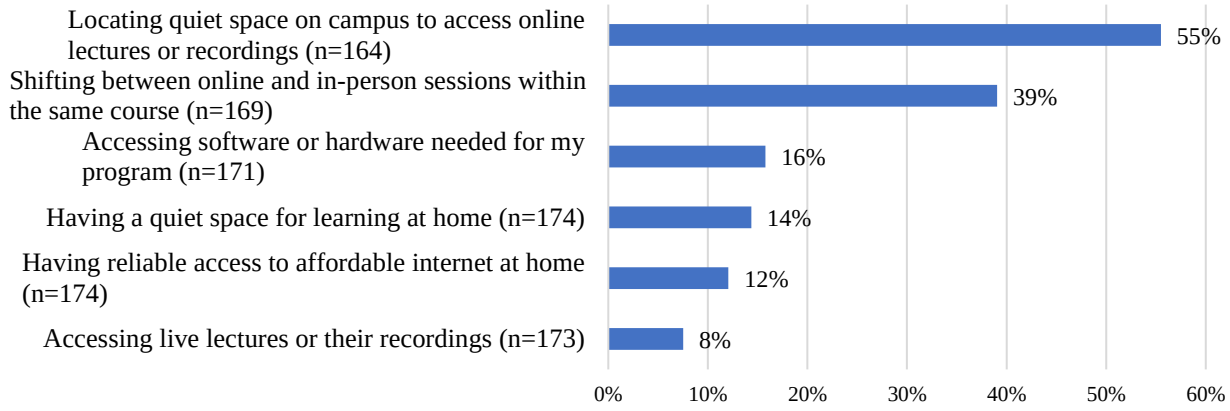
These data are arranged in the descending order of the mean values.

[12] The original survey question was: "For most FASE lecture-based courses, students are expected to spend roughly 10 hours per week learning. Consider a typical lecture-based engineering course, how would you prefer that these 10 hours per week of learning time be distributed among the following possible learning activities? (These portions should add up to about 100%)"

Challenges

Students reported substantial challenges when learning through a mixture of in-person and online course delivery modes, including finding space on campus to access online lectures or recordings (55%), transitioning between online to in-person class sessions (39%), and accessing a quiet space for learning (14%) and reliable and affordable internet at home (12%), as shown in Figure 16.

Figure 16. "What challenges did you experience when learning with a mixture of in-person and online instruction?"
(Percentage of those indicating "quite a challenge" or "a huge challenge" on a 4-point scale)



Similarly, some instructors found teaching in a dual delivery[13] mode to be challenging in terms of student engagement (IN7). Others indicated that more technological and human resources would be needed for implementing a dual delivery model of teaching and learning (IN10).

> *And towards the end of last winter 2022 is hybrid teaching. Hybrid teaching is a bad experience for everyone involved. It's grueling on the faculty member or the instructor because you're doing it once and everyone's getting the same experience. No. People online are getting a crappy experience because poor connection. They can't see everyone in the classroom. They're not included in the discussion. That puts down on the resources of the instructor. If you've got one instructor and then one TA who's managing the chat or managing the online group, then you're okay. But hybrid is like being in two places at once. That's my experience. I had a camera in the room. I was paying attention to the students in the physical space, and I had to pay attention to the students online. And I couldn't engage with both in the same level. My number one is in person, my number two is online, and my number 100 is hybrid.* (IN7, an instructor interviewee)

[13] Although the term "hybrid" was used in these quotes, these instructors were referring to the dual delivery mode, in which a live class session is cast online to allow students outside the classroom to attend at the same time. By a definition provided by the University of Toronto (https://its.utoronto.ca/about/your-workplace-environment/hybrid-hub/#faq), a *hybrid* course refers to "a course that has been designed such that students participate through a mix of online and in-person interaction. Hybrid courses do not require instructors to accommodate virtual and in-person participation in real time through the use of webinar technology in the classroom."

> *The ability to do recording from your teaching station was only introduced in January 2022, where it was always available in Zoom. So these are examples of technologies that everybody in the whole world is using it, and U of T says no. Even during the class times, if you go to a class in* [U of] *Toronto, there is no whiteboard, there is a blackboard with chalk. The ability to see it if you take a video camera over Zoom is subpar, because the contrast between white and writing is much clearer than a black green board, and than a white chalk. So if you are saying "I want to have something that would be more visible for the students on Zoom," in hybrid approach, it doesn't exist. … One best practices in other institutions, including applying a smart board, including applying a solution that works for hybrid teaching. Make sure that if somebody's offline they could actually see your board. All these little things that are best practices elsewhere, and I think we are able to apply.* (IN10, an instructor interviewee)

With respect to asynchronous online learning opportunities such as use of pre-recorded lecture videos, the challenge was mainly associated with increased preparation time for instructors.

> *Development and production of about 150 short video lecturettes! … I hadn't realised the amount of time and effort needed to convert a fully in-person course to one involving asynchronous materials …* (#41, an Instructor Survey respondent)

More specific to the switch between course delivery modes in the middle of the Winter Term of 2022, some instructors found the mixture of online and in-person course delivery to be particularly challenging as they noted a disruption to the existing student engagement and student-instructor interactions (#93).

> *Due to the confusion around when classes would be held in person or online, students did not have a good model of best practices for engagement. Online (even from pre-covid days) is best driven by students, typically disposed to social media, they know and can easily adapt to the protocols. The same is true of in-person activities, but the unpredictable mix of in-person and online disrupted what students knew as protocols, and thus they were quite disengaged. In fact, when we returned to in-person classes, only 6 out of 42 students actually showed up for class… In-person classes had to start as online (due to lockdowns) which significantly disrupted the engagement I had with my students. Having taught completely online classes, I knew how to build community, but the unplanned hybrid model was definitely detrimental to the teacher-student interactions, general engagement from students (confused & reclusive), and overall energy and vitality that was evident in the past few years when i taught the same course in pre-covid.* (#93, an instructor survey respondent)

In summary, while some students indicated their desire for a mixture of in-person and online instruction (particularly asynchronous online learning), challenges were reported in ways of implementing such a mixed mode of instruction, including finding quiet space on campus to access online resources and switching between class sessions in different instructional modes on the part of students, and creating asynchronous lecture videos, and offering dual delivery courses on the part of instructors.

Finding 6.

Most instructors' teaching practices and attitudes toward teaching have changed since the start of the pandemic.

Changes in Teaching Practices

Half of the respondents to the instructor survey indicated that their teaching practices changed substantially (i.e., the "quite a bit" or "very much" option of the survey question), as compared to before the pandemic (Figure 17a). Changes mainly took place in preparation time, course delivery mode, ways of supporting students outside class, and assessment methods; and only about one-tenth indicated that course content substantially changed (Figure 17b).

Figure 17a. "Overall, how much have your teaching practices changed, as compared to before the pandemic?" (n=105)

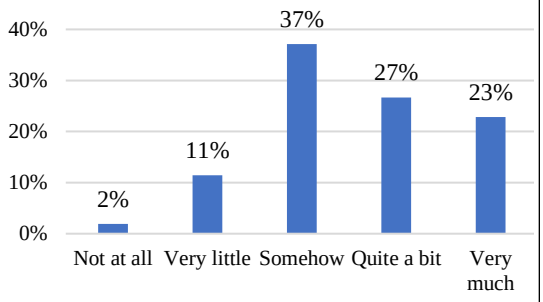
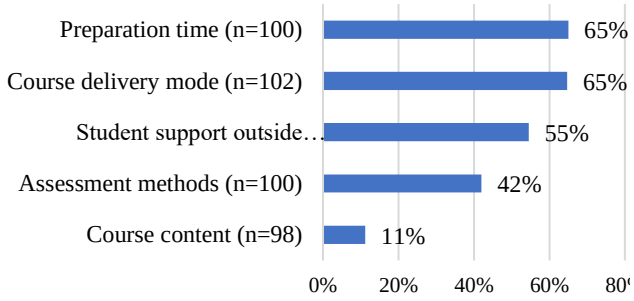


Figure 17b. Areas of changes in teaching practice, as compared to before the pandemic:
(Percentage of "quite a bit" or "very much")



The following quotes illustrate some examples of changes that occurred over the couple of years during the pandemic.

> *Course content-wise, I made certain courses were as thorough and comprehensive as pre-pandemic. However, I had to change the mode of delivery to accommodate online learning. The immediate impact for me was over a doubling in preparation time, as I had to learn how to make high-quality video recordings with integrated "whiteboard" lessons. Assessment methods were somewhat altered (e.g. quizzes were marked electronically through Crowdmark and not on paper). Supporting students outside class was also drastically different, as I replaced in-person office visits with online Q&A.* (#93, an instructor survey respondent)

> *Content: often could not cover as much online Delivery: many videos created, used webcam/doc cams, Zoom Preparation time: about double the preparation Assessment methods: online exams had to be a completely different format to lower effect of cheating Supporting students: bookable virtual office hours and more 1-on-1 meetings.* (#42, an instructor survey respondent)

> *I used an inverted classroom approach in a senior undergraduate course: 2 hours of short lecturette videos per week, with 1 hour of in-person Q&A. The in-person lecture was quite engaging. Overall, students seemed to appreciate this delivery method.* (#119, an instructor survey respondent)

Self-Efficacy in Teaching

Good news that emerged from the Instructor Survey data was that by the end of the academic year 2021-22, over four-fifths of the instructors felt confident or very confident about their ability to use technologies to support in-person instruction, and their ability to delivery some class sessions online (Figures 18a and 18b). (q23) While we cannot ascribe these levels of self-efficacy to the mandatory online course delivery during the pandemic alone, we find these results quite impressive, considering that four-fifths of the FASE instructors had never taught in an entirely online environment before the pandemic, as shown in the results of the 2020 May instructor survey.[14]

Figure 18a. "How confident do you feel about your ability to use technologies to support in-person instruction?" (n=78)

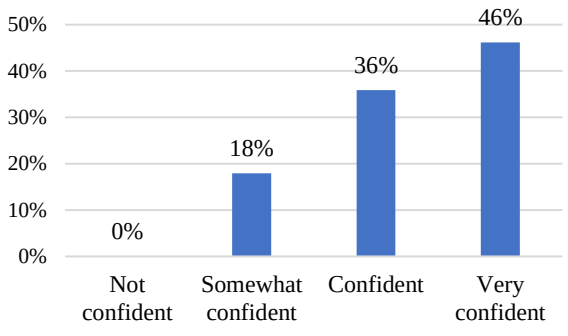
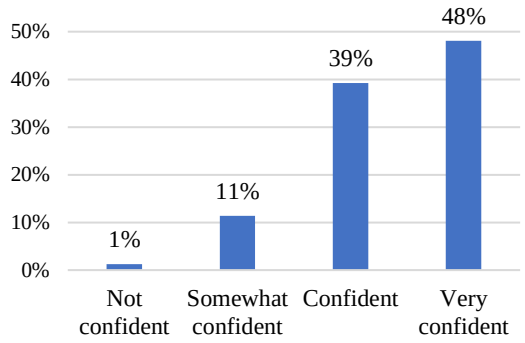


Figure 18b. "How confident do you feel about your ability to deliver some class sessions online?" (n=79)

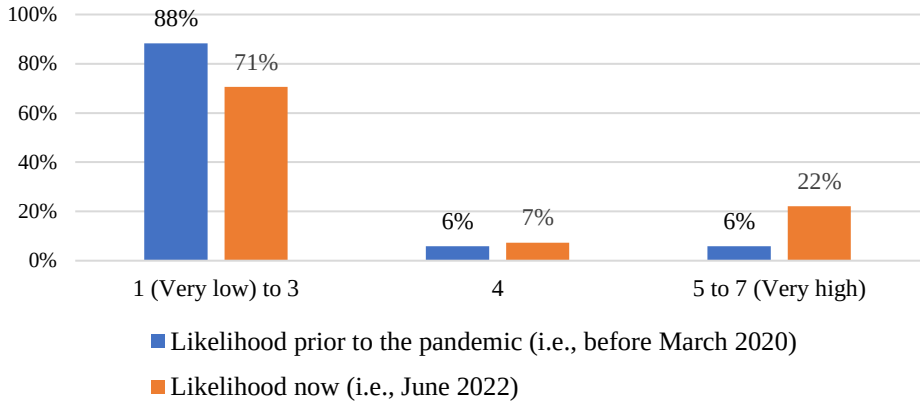


A concern that surfaced from the Instructor Survey data was related to the increasingly challenging educational environment for instructors. A respondent to the instructor shared their experiences by saying "Academia is brutal. I am constantly exhausted and struggling to stay energized. Working from home was the first time my job felt manageable." (#88)

One indicator for this concern was the likelihood ratings for choosing to leave academia in the next five years that were compared between the time of data collection and prior to the pandemic. As shown in Figure 19, a much higher proportion of the respondents (22% vs. 6%) indicated that they were likely to choose to leave academia in the next five years at the time of the survey administration (June 2022), as compared with before the pandemic (before March 2020); the result from a Wilcoxon Signed Ranks Test showed that this difference was statistically significant, $T = 120$, $z = 3.51$, $p < .001$.

[14] Liu, Q., Sweeney, J., & Evans, G. (2020). *FASE Instructors' experiences and perceptions during the recent transition to online teaching: Report on the Instructor Survey at the Faculty of Applied Science & Engineering*. Institute for Studies in Transdisciplinary Engineering Education and Practice, University of Toronto. Available at https://istep.utoronto.ca/files/2020/06/Report-on-the-FASE-Instructor-Survey-Final_2020-05-22.pdf

Figure 19. "How likely were/are you to CHOOSE to leave academia (e.g., seek a different career) in the next five years?" (n = 68, excluding those who indicated retirement as a reason)



Reasons for wanting to leave academia included high workload, burnout and inadequate institutional supports during the rapid academic changes during the pandemic, as illustrated in the following quotes.

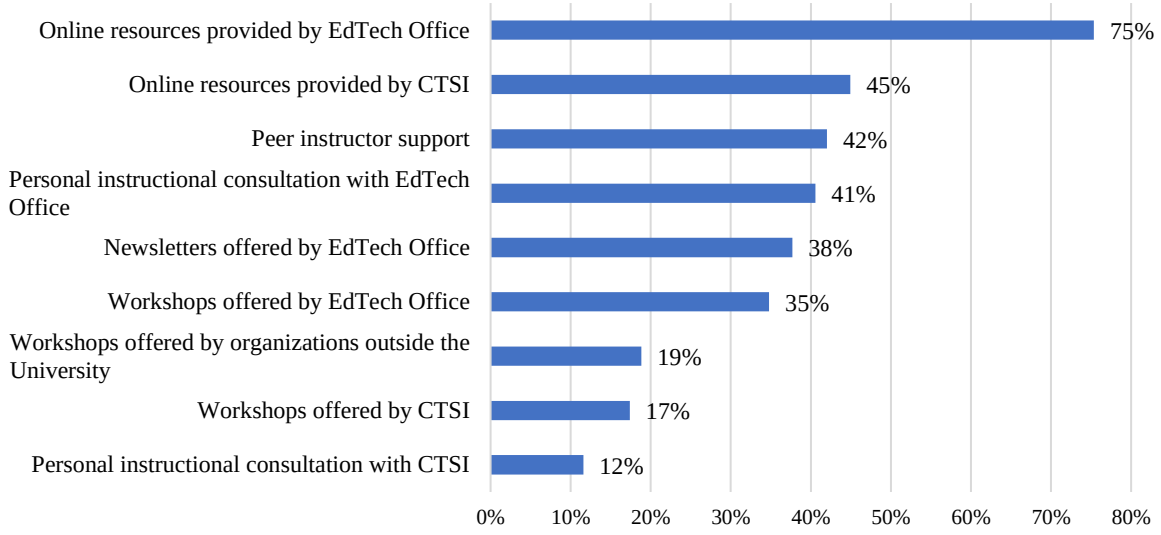
> *The pandemic greatly increased the load on me as an instructor, in every area of the course: teaching, labs, office hours and evaluations. The enrolment in my course also increased substantially over the past few years. Personally, I feel that almost no tangible support was offered to offset (or even recognize) this extra load... and, in most tangible ways, my personal experience was that support for instructors has considerably diminished. On the support side, I pleaded repeatedly for more TAs, each of the past three years... and, instead, received fewer TAs every year. As a result, I have had to now remove three assignments from my course that I think used to add considerable value.* (#79, an instructor survey respondent)

> *Workload is going up and up with no bounds. Myself and my colleagues have been close (or beyond) the threshold of burnout constantly over the last two years. The university administration and leadership dropped huge tasks on us time and again and it is absolutely unsustainable*. (#51, an instructor survey respondent)

Institutional Supports

Respondents to the instructor survey reported having accessed various resources for instructional support during the pandemic. Three-fourths indicated having accessed the online resources provided by EdTech Office (Figure 20).

Figure 20. "Which of the following instructional supports did you access over the past two years?"
(percentage of those indicating having accessed the support, n=69)



Of the 28 responses on the most helpful resources instructors used, the most repeated ones were:

- Peer support (8 responses)
- Online resources (6 responses)
- Supports provided by the EdTech Office, including individual consultation, workshops and online resources (5 responses)

In the meantime, some instructors (26 responses in total) shared the areas in which they would like to improve their teaching practice. The most often repeated areas were:

- Creating or using digital resources (7 responses)
- Enhancing student engagement (6 responses)
- Improving learning assessment (5 responses)

Here are three more detailed responses describing areas in which instructors would like to improve their teaching practice:

> *Re-designing the structure of the class (lecture => mini-videos, better use of chat for side-bar discussions in class, video engagement with students), re-designing teaching approaches towards a more learner-centred classroom. Seamless technology that allows me to use an iPad & apple pencil, while switching from ppt to web browser and back to tablet.* (#93, an instructor survey respondent)

> *Closer interaction with students to understand any hidden concerns re. the various aspects and concepts of the course, while keeping the level of material delivery high enough to meet real - world state-of-the-art knowledge requirements.* (#31, an instructor survey respondent)

> *Use of online tools to facilitate assessments and grading. I would also like to know more about how to track student usage of online resources to better understand how they interact with this information outside of class.* (#113, an instructor survey respondent)

Attitudes toward Teaching

Responses to the instructor survey and individual instructor interviews revealed the following three types of attitudes among FASE instructors toward in-person versus alternative teaching modes.

Type 1. In-person mode prevails.

> *The past two years have made me much more excited to teach in-person, particularly in less formal, more student-led settings such as one-on-one support. However, if in the future I might expect more frequent shifts between online and in-person teaching, this will make me less interested in pursuing work as an instructor overall, as I feel it harms the effectiveness and the legitimacy of post-secondary teaching institutions.* (#85, an instructor survey respondent)

> *all of these affected my interest - the exhaustion of doing everything over screens, and the extra time required to develop and deliver courses online on top of living through 2 years of a pandemic decreased my enjoyment of teaching. Teaching in person provides stimulation and connection with students that is very challenging to do over video conferencing -especially as most students do not turn their cameras on.* (#114, an instructor survey respondent)

Type 2. Opening up to new possibilities.

> *These past couple years have opened the door to endless possibilities in teaching and I'm pleased to see the university has embraced these new technologies. In the past we would have countless meetings on campus, and I'm happy to see that most of those have shifted to zoom or teams. It's exciting to see so many new options available for teaching and working in academia, and most importantly, that instructors are given a fair bit of freedom to explore the options that are best for their courses.* (#43, an instructor survey respondent)

Type 3. Getting more interested in online teaching.

> *1) I am now very interested on How to master teaching on-line courses, using all tech resources and 2) how to learn the usage of all technology in some future off-line classes (in person), special mention with external international guest speakers (abroad) connected on-line to the physical classroom in campus.* (#69, an instructor survey respondent)

> *I would like to maintain a fully online course, as there are clear benefits for the students and their learning styles. It is clear that from exposure to YouTube, MOOCs and other online resources, that online teaching can enrich the depth and speed of their learning. However it requires effort on the part of the instructor to create an engaging online course, which I am happy to put in. I've had a few students tell me they were skeptical when hearing my course was online but found it to be a very good learning experience.* (#124, an instructor survey respondent)

In summary, FASE instructors' teaching practice, teaching self-efficacy, and views toward teaching evolved considerably amidst the academic changes as a result of the pandemic. While various institutional supports were available, some instructors experienced burn-out. More institutional supports will be needed to help instructors better navigate the changed educational environment in the post-pandemic era.

Final Observations

Over the past couple of years, there have been increasing calls for digital and flexible learning in the postsecondary academic communities. Based on the six findings reported earlier, we have identified the following facilitators and barriers as FASE, along with other academic divisions of the University, is moving towards an educational environment that could feature more digital and flexible learning in the future.

Table 5. Identified facilitators and barriers for implementing digital and flexible learning strategies at FASE

Facilitators	Barriers
Both students and instructors experienced online learning and teaching, acquired digital skills, and became more confident in navigating a digital environment. Some students and instructors, although a minority, appreciated online learning and teaching. Some students indicated their desire for a mixture of in-person and online instruction (particularly, including some asynchronous online learning). Some of the assessment and teaching practices that emerged during the pandemic can become catalysts for building a digital and flexible learning environment. Knowledge accumulated about the advantages and disadvantages of in-person versus online instruction modes will help inform future initiatives.	Most students and instructors showed a strong preference for in-person course delivery and assessment. They might resist moving to a mixture of in-person and online instruction. Teaching in a digital learning environment tends to require a heavier workload for instructors. Some of the differing perspectives among students and instructors about flexible learning might be hard to reconcile. More human and technological resources and quiet spaces for online class sessions / meetings will be required for supporting an educational environment with a mixture of in-person and online instruction modes.

Appendices: Background of Survey Respondents

Appendix A.
Demographic and Academic Background of Student Survey Respondents

The *Engineering Student Survey on Learning Effectiveness* (referred to as the Student Survey in this report) was administered online via REDCap from May 6 to Jun 13, 2022 to all undergraduate engineering students who took courses at the Faculty of Applied Science and Engineering (FASE) during the Winter Term of 2022.

A total of 251 students provided responses to the Student Survey; and 157 students completed the survey while others answered some of the survey questions. The tables in this section present the characteristics of these 157 respondents who completed the survey.

The response rate for the Student Survey was only 3%. However, the frequency distributions of the respondents by engineering program and year of study aligned with those of the FASE undergraduate student population in the academic year 2021-22, as shown in Tables A1 and A2. This means that the survey sample, to some extent, represented the student population in terms of engineering program and year of study. Table A4 and Figures A1 to A4 show that the survey responses included voices of diverse student groups with respect to gender, residential status, race, sexual orientation, and disability.

Table A1: Frequency distribution of respondents by program

Engineering Program	Survey Respondents (Total: 156)		Student Population (Excluding PEY) (Total: 4870)*
	n	%	%
TrackOne	12	8%	5%
Chemical Engineering	12	8%	10%
Civil Engineering	17	11%	8%
Mineral Engineering	0	0%	1%
Computer Engineering	24	15%	17%
Electrical Engineering	11	7%	10%
Engineering Science	43	28%	21%
Industrial Engineering	10	6%	14%
Materials Science & Engineering	12	8%	9%
Mechanical Engineering	15	10%	5%

* The total undergraduate student population, excluding PEY students, was 4870 in the academic year 2021-22, according to the 2022 Annual Report: https://www.engineering.utoronto.ca/files/2022/09/By-The-Numbers-AR2022.pdf

The result from a one-sample Chi-square test was insignificant, $X^2(9, N = 156) = 11.39$, $p > .05$. Therefore, the frequency distribution of the survey sample by engineering program had no statistically significant difference from that of the student population.

Table A2: Frequency distribution of respondents by year of study

Year of Study	Survey Respondents (Total: 157)		Student Population (Excluding PEY) (Total: 4870)
	n	%	%
1st year	53	34%	27%
2nd year	42	27%	28%
3rd year	23	15%	24%
PEY	2	1%	
4th year	37	24%	21%

The result from a one-sample Chi-square test was insignificant, $X^2(3, N = 157) = 5.19$, $p > .05$. Therefore, the frequency distribution of the survey sample by year of study had no statistically significant difference from that of the student population.

Table A3 shows that most of the respondents (77%) completed 5 or 6 courses in the Winter Term of 2022. This was the workload context in which they shared their learning experiences when responding to the Student Survey.

Table A3: Number of courses completed during the Winter Term of 2022

Number of courses completed	n	%
4 or fewer courses	20	16%
5 courses	36	30%
6 courses	57	47%
7 or more courses	9	7%
Total	122	100%

Figures A1 and A2 show the frequency distributions of the respondents by gender and residential Status. Women and domestic students were over-represented in the sample.[15]

Figure A1: Distribution by gender (n=134)

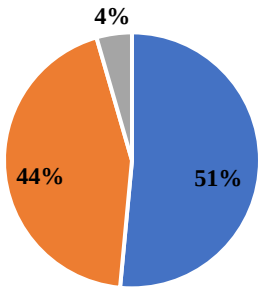
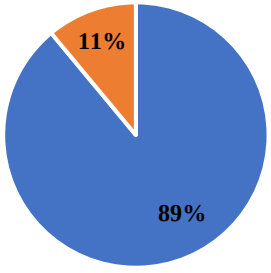


Figure A2: Distribution by residential status (n=136)



[15] In 2021-22, 39% of FASE undergraduate enrolment was women and 29% were international students, according to the 2021-22 Annual Report (https://www.engineering.utoronto.ca/files/2022/09/By-The-Numbers-AR2022.pdf)

Figures A3 and A4 show the frequency distributions of the respondents by sexual orientation and registration with Accessibility Services. Compared with the results from our May 2020 survey,[16] the proportion of those who registered with Accessibility Services was about the same (8% and 9%) whereas the percentage of self-reported LGBTQ+ students was higher (23% vs. 15%).

Figure A3: Distribution by sexual orientation

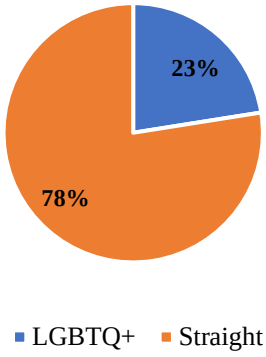


Figure A4: Whether registered with Accessibility Services

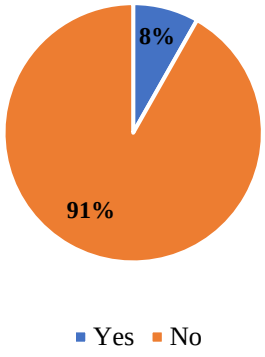


Table A4: Frequency distribution of the respondents by racial identity

Racial Identity	n	%
Black	2	1%
Chinese	51	38%
East Asian, excluding Chinese	6	4%
Latino/Latina/Latinx/Hispanic	2	1%
Middle Eastern	5	4%
South Asian	19	14%
Southeast Asian	2	1%
West Asian	3	2%
White	26	19%
Other	1	1%
More than one racial identity	17	13%
Total	134	100%

[16] Available at https://istep.utoronto.ca/files/2020/08/FASE-Student-Survey-Report-on-Transition-to-Remote-Learning-July22-2020.pdf

Appendix B.
Demographic and Academic Background of Instructor Survey Respondents

The FASE Instructor Survey on Teaching Practice (referred to as the Instructor Survey in this report) was administered online via REDCap from July 20 to August 9 2022 to all instructors who taught at the Faculty of Applied Science and Engineering (FASE) during the Winter Term of 2022.

A total of 109 FASE instructors provided responses to the Instructor Survey, and 81 instructors completed the survey. As shown in Figure B1, the respondents included sessional instructors, and teaching-stream and tenure-stream faculty members. The response rate among the faculty members was 20%.[17] The respondents had varying lengths of teaching experience, with 43% having taught more than 20 years (Table B1). They taught various types of courses (Table B2). Most of the respondents (>70%) were white and male (Figure B2 and Table B3).

Figure B1: Distribution of respondents by appointment (n=72)

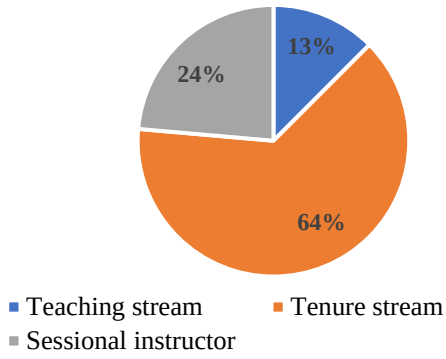


Table B1: How many years have you taught at the postsecondary level (at FASE and elsewhere?

Years of teaching	n	%
Under 5 years	11	14%
6-10 years	11	14%
11-15 years	16	21%
16-20 years	6	8%
Over 20 years	33	43%
Total	77	100%

Table B2: Types of courses that respondents taught

The courses you taught were primarily ...	n	% (of 80)*
Core technical courses	54	68%
Elective technical courses	38	48%
Complementary Studies or Humanities & Social Sciences courses	7	9%
lecture-based (including those using active learning strategies)	73	91%
lab-based	22	28%
project-based	15	29%
design-based	23	19%
seminar-based	5	6%
at the undergraduate level	57	71%
at the graduate level	37	46%

*The percentages will not add up to 100% as respondents could select multiple options.

[17] According to the 2021-22 Annual Report, there were a total of 280 faculty members (teaching stream and tenure stream) in 2021-22.

Figure B2: Distribution of respondents by gender (n=71)

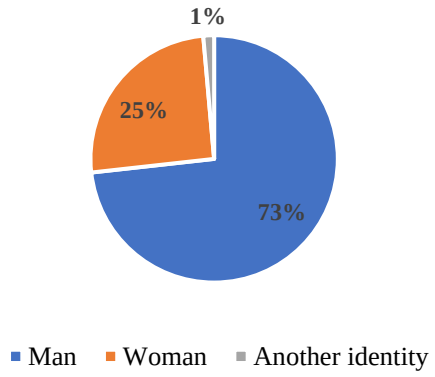


Table B3: Distribution of respondents by racial identity

Racial identity	n	% (of 66)
Chinese	6	9%
Latino /Latina / Latinx / Hispanic	1	2%
Middle Eastern	3	5%
South Asian	3	5%
West Asian	1	2%
White	49	76%
Other	3	5%
More than one racial identity	1	2%