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Instructional Development at a Time of Involuntary Changes: Implications for the Post-Pandemic Era

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Abstract

Public health measures taken during the COVID-19 pandemic resulted in a series of involuntary changes in teaching and learning from 2020 to 2022, which could have promoted instructional development among instructors in postsecondary education. In this research paper, we used the four components in Kirkpatrick's model of training evaluation—reactions, learning, behaviour, and results—to examine the data collected in summer 2022 from instructors of an engineering school of a public Canadian university. The analysis directed us to the following observations about the instructional development among faculty members in the engineering school during the pandemic. The teaching practices in most of the courses changed and most instructors consulted with resources for instructional support during the pandemic. The crisis during the pandemic serendipitously offered an unprecedented opportunity for instructional development toward online teaching. The instructional development is characterized by instructors' reactions to their own online teaching experiences, positive attitudinal changes and skill development among some instructors with respect to online teaching, as well as the alternative teaching practices that emerged during the pandemic. However, this instructional development was passive and reactive in nature, and will not reverse the typical in-person course delivery in engineering. In addition, instructors in the engineering school accessed school-based resources for instructional support more often than university-based resources; and this resource access pattern will be likely to continue. Implications of these findings for instructional development are discussed.

Keywords: instructional development, online teaching, teaching-stream faculty, instructional support, COVID-19 pandemic

1. Introduction

The context for this research paper was a series of involuntary academic changes at an engineering school of a comprehensive Canadian university as a result of public health measures taken during the COVID-19 pandemic. These changes at the Canadian engineering school included a mandatory shift to exclusive online teaching and learning modes in spring 2020, and the subsequent efforts in 2021 and 2022 to switch back to the in-person course delivery. Accompanied with the changes in the course delivery mode were adjustments to other teaching practices, including assessment and student support strategies. By summer 2022, in-person teaching and learning had resumed, but many faculty were no longer teaching in the same way as they were before the pandemic. In the broad social and educational contexts during the pandemic, the patterns in these changes on one Canadian campus were probably also seen in

many other universities in Canada and the United States. As such, the lessons learned from one campus can arguably be extended to other campuses in North America.

This paper focused on one area of educational changes during the pandemic—instructional development. The couple of years from 2020 to 2022 witnessed a significant growth of instructional development initiatives across all disciplines. These initiatives include digitally transforming the faculty development program [1], rebuilding existing resources such as the learning management system [2] and the university makerspace [3], and harnessing existing social networks [4]. Rather than documenting similar institutional initiatives for instructional development, in this paper we investigated the process and the results of instructional development among faculty members after a couple of years of involuntary changes in teaching and learning during the pandemic.

Specifically, this study examined the following three aspects of instructional development among faculty members of a Canadian engineering school: (a) changes in teaching practices; (b) the evolving views toward teaching; and (c) access to institutional supports in response to these changes. We aimed to address the following two sets of research questions:

1) In what ways did teaching practices change after two years of switching between in-person and online course delivery? From where did instructors seek support to navigate these rapid changes in teaching practices?
2) What did the instructional development look like during the pandemic for faculty members in an engineering school—in terms of changes in teaching practice, evolving views toward online teaching, and access to institutional supports?

By answering these questions, we aim to better understand the instructional development during the pandemic as well as its implications for future instructional development and engineering education practice.

2. Literature Review

Two areas of literature are relevant to this study: instructional development in engineering; and instructional development during the pandemic.

2.1 Instructional Development in engineering

The need for instructional development in engineering has become increasingly important over the past two decades [5]. This has been driven by several factors, including outcomes-based accreditation of engineering programs, changing demographics and attributes of engineering students, advances in instructional technology and cognitive science, and the increased emphasis on scholarship of teaching and learning in engineering education [6].

On postsecondary campuses, instructional development programs are typically offered by the teaching and learning centres of universities and colleges. These campus-wide programs, along with engineering-specific programs, are usually available to faculty members and graduate students in engineering. Possible structures of these programs can be workshops, courses, and seminar series; consulting, mentoring, and partnering arrangements' learning communities; and teaching certification programs [6]. Other professional development activities for teaching

improvement include reading literature, or writing an article or chapter on teaching, learning or assessment, and attending an engineering education conference [7]. These efforts were found to be positively related to use of student-centered teaching practices [7].

Another factor that appears to be distinctive in the context of Canadian engineering schools and postsecondary education in general is the increase of teaching-stream faculty members within the academic workforce over the past two decades. Unlike the United States, where nearly 70 per cent of faculty members have teaching as their primary responsibility [8], the full-time, continuing faculty appointment with the primary responsibilities limited to teaching-related activities was introduced in the early 2000s to research-intensive Canadian universities, out of educational, ethical, and pragmatic considerations [9, 10]. These teaching-stream faculty members are known for having a positive impact on the quality of teaching and the quality of student learning experience [10]. Arguably, they also play a positive role in instructional development in engineering. However, this is rarely studied in engineering education research.

2.2 Instructional Development During the Pandemic

As mandatory online teaching was implemented during an emergency situation, instructors had to adapt to the new teaching mode in an abrupt way in Spring 2020 and learn how to teach effectively in the imposed online educational environment from Fall 2020 to Fall 2022. Hence, the practical needs for instructional development in the unprecedented online environment grew exponentially during the pandemic.

Several issues in teaching and learning emerged during this time of disruptions. In addition to those issues resulting from the unfamiliarity among many instructors with online pedagogies, tools and resources, increased inequalities for students in terms of internet access were reported in many publications (e.g., [11-13]). To address these issues, a variety of resources were created to meet the growing needs, from course design (e.g., tips for designing HyFlex courses, in [14]) to creating specific teaching resources (e.g., effective educational videos in [15]). Pedagogy of care was advocated [16] and resilient pedagogy was created [17]. Faculty development initiatives (for example, [1, 3]) were put in place to support instructors to acquire necessary teaching skills to meet the emerging needs. As a result, digital learning opportunities significantly increased in almost all countries ([13, 18]), and various innovative pedagogical and assessment practices were implemented in engineering (e.g., [19-22]). This appears to be true in all disciplines.

3. Conceptual Framework

We used Kirkpatrick's model of training evaluation to conceptualize our study. Donald Kirkpatrick proposed his four levels of training evaluation criteria in four short articles in 1959-60 and offered a full account in a handbook chapter in 1967 [23]. The more detailed accounts of this model can be found in his book "Evaluating Training Programs: The Four Levels" [24, 25].

Kirkpatrick's model of training evaluation consists of four "causally linked" and "positively intercorrelated" levels (P. 331) [26] in a sequence of reactions, learning, behaviour, and results. The level of *reactions* measures how program participants react to a training program, or "customer satisfaction" (p. 21) [25]. The level of *learning* refers to "the extent to which

participants change attitudes, improve knowledge, and/or increase skills" (p. 22) because of program participation. The level of *behaviour* is defined as "the extent to which change in behavior has occurred because the participant attended the training program" (p. 22). In addition, four conditions are necessary for behavioural change to occur: the person must (a) have a desire to change; (b) know what to do and how to do it; (c) work in the right climate; and (d) be rewarded for changing (p. 23). The level of *results* refers to "the final results that occurred" because of the program participation (p. 25). Examples for these final results can be increased production, improved quality, and decreased costs (p. 25). The model posits that results should be evaluated based on the pre-specified objectives of the training program.

As Kirkpatrick's model offers a systematic way of evaluating the process and the outcomes of participating in a training program, it is appropriate for studies on instructional development initiatives. The model has been modified and used in literature reviews that examined studies on instructional development in medical education [27]. In the general context of postsecondary education, the level of results in Kirkpatrick's model has been operationalized as changes within teachers, institutional impact, and change within students [28].

In our study, we adapted Kirkpatrick's model to the context of academic disruptions during the COVID-19 pandemic. While our study did not intend to focus on specific instructional development initiatives, we conceptualized the series of involuntary academic changes from 2020 to 2022 as one incident that triggered a myriad of instructional development endeavours—on both organizational and individual levels. The mandatory, exclusively online course delivery during the pandemic could have resulted in changes in instructional development in terms of reaction, learning, behaviour, and results. More specifically, the required shift to exclusively online teaching and learning during the pandemic represented an "imposed" educational environment—one type of environmental structures [29], which entailed changes in teaching practice as well as institutional supports through faculty development initiatives. In response to these changes, instructors could have reacted to online versus in-person course delivery differently; their teaching beliefs related to course delivery modes could have evolved; they could have developed new knowledge and skills for teaching; they could have implemented new practice to address online learning needs; and ultimately, their online course instruction could have improved or stayed at the same level as before the pandemic. As a result of this two-year incident of imposed instructional development, instructors' preferred ways of teaching could remain the same or change when they are no longer required to use one course delivery mode. As such, all these aspects can be characterized in terms of the four levels in Kirkpatrick's model—reaction, learning and behaviour and results. This paper aims to characterize instructional development among faculty members during the pandemic on these four levels.

4. Data Source and Analysis Methods

The data sources for this paper consisted of responses to a faculty-wide instructor survey (n=106, including 81 completed ones) and individual instructor interviews (n=11). We collected these data in July to August 2022 from an engineering school of a comprehensive university in Ontario, Canada. These data sources were part of a larger research project with the research ethics protocol approved by the Canadian university.

In the survey, instructors were asked about the changes in their teaching practices and their professional development activities from 2020 to 2022; their perceptions of certain teaching practices in terms of teaching effectiveness; and their views on how to move forward. The response rate of the instructor survey was 20%, based on the completed 81 responses. Of the 81 instructors who completed the survey, 64% were tenure-stream faculty members, and 36% were teaching-stream faculty members or sessional instructors. The respondents had varying lengths of teaching experience, with 43% having taught more than 20 years, 29% having 11 to 20 years of teaching experience, and 28% having less than 10 years of teaching experience. While the vast majority of the respondents taught engineering technical cores, 9% taught complementary studies courses (i.e., humanities, social sciences, and business courses). Most of the respondents (>70%) were white and male.

The interviews focused on the effective teaching practices that instructors had introduced from 2020 to 2022, and their plans for future teaching. Of the 11 interviewees, three instructors taught engineering courses but in different engineering fields while others were instructors who taught courses in other disciplines than engineering. We recruited most of these participants via a question in the instructor survey and a few from student recommendations.

In Table 1, we have mapped the specific topics asked in the instructor survey and interviews onto the elements in our conceptual framework.

Table 1. Mapping data sources onto the conceptual framework

Elements in the Conceptual Framework	Elements in the Data Sources (instructors' perspectives)	Sections to report the findings
The trigger for instructional development: mandatory exclusive online course delivery	Changes in teaching practices Access to instructional development opportunities	Section 5.1
Reaction	Perceptions of teaching effectiveness under in-person and online modes	Section 5.2
Learning (attitudes, knowledge and skills)	Interest in online versus in-person teaching Self-efficacy in online teaching skills	Section 5.2
Behaviour	New teaching practice introduced to meet online needs	Section 5.2
Results	Likelihood for teaching online versus in person in the future Likelihood for using particular instructional development opportunities in the future	Section 5.3

In our analysis, we used the descriptive statistics and thematic analysis for analyzing the quantitative and qualitative data. We triangulated the results from the instructor survey and interview data to identify the patterns on each element in the conceptual framework.

5. Findings

We have organized the findings based on the key elements in our Conceptual Framework to create a "story line" of instructional development during the pandemic. This story line connects the findings that addressed the three research questions.

5.1 The Context for Instructional Development During the Pandemic

The findings in this section addressed the first research question: *In what ways did teaching practices change after two years of switching between in-person and online course delivery? From where did instructors seek support to navigate these rapid changes in teaching practices?*

Our data showed that teaching practices changed to varying extents for most instructors when compared to before the pandemic, and that the vast majority of instructors accessed some sort of professional development activities during the pandemic. These constituted the context for institutional development during the pandemic.

Specifically, half of the respondents to the instructor survey (n=105) reported that their teaching practices during the pandemic changed "quite a bit" or "very much" as compared to before the pandemic; another 37% indicated some change; and another 17% indicated no or very little change. The reported changes mainly took place in preparation time (65% of the respondents), course delivery mode (65%), ways of supporting students outside class (55%), and assessment methods (42%); and about one-tenth indicated a substantial change in the course content. The following quotes illustrate some of these changes.

> *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)

> *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)

Of those instructors who completed the survey (n=81), 85% (i.e., 69 instructors) reported having accessed at least one of the eight options in the survey for instructional support during the pandemic. As shown in Table 2, the most widely accessed one was the online resources provided by the education technology office based in the engineering faculty (75%), followed by the online resources offered by the University's teaching support centre (45%), peer instructor support (42%), and personal instructional consultation with engineering's education technology office (41%). In addition, a higher proportion of instructors accessed engineering's internal resources than those offered by the University's teaching support centre. For example, 35% indicated having accessed workshops offered by the engineering education technology office, in

comparison to about 17% who reported having attended workshops offered by the University's teaching support centre.

Table 2. Instructors' access to resources for instructional development

Resources for instructional development accessed	n	% (of 69)
Online resources provided by engineering's education technology office	52	75%
Online resources provided by the University's teaching support centre	31	45%
Peer instructor support	29	42%
Personal instructional consultation with engineering's education technology office	28	41%
Newsletters offered by the engineering's education technology office	26	38%
Workshops offered by the engineering's education technology office	24	35%
Workshops offered by organizations outside the University	13	19%
Workshops offered by the University's teaching support centre	12	17%
Personal instructional consultation with the University's teaching support centre	8	12%

Notably, teaching-stream faculty members and sessional instructors appeared to be more likely to access resources for instructional development. As shown in Table 3, 50% of the teaching-stream faculty members and sessional instructors accessed 4 to 5 resources, in comparison to 13% of the tenure-stream faculty members who did so.

Table 3. Comparison between two instructor groups in the number of instructional development resources accessed

Number of instructional development resources that an instructor accessed	Teaching-stream or sessional instructors		Tenure-stream instructors	
	n	% (of 26)	n	% (of 46)
0	2	8%	10	22%
1 to 3	8	31%	25	54%
4 to 5	13	50%	6	13%
6 to 8	3	12%	5	11%

5.2 Instructional Development in Online Teaching

The findings in Sections 5.2 and 5.3 have addressed the second research question: *What did the instructional development look like during the pandemic for faculty members in an engineering school?*

Our data revealed that the instructional development during the pandemic was exhibited via:

(a) instructors' perceptions of effectiveness of in-person versus online teaching activities, based on their own teaching experiences during the pandemic;

(b) increased interest among some instructors and high self-efficacy in online teaching among most instructors;

(c) the new teaching practice that instructors began to implement in response to the online educational environment.

Perceived Effectiveness of In-person vs. Online Teaching

In the survey, instructors were asked to rate how much they felt certain teaching practices had contributed to making their teaching more effective on a 4-point scale. Table 4 shows the ranking of eight aspects of online teaching, with four of these aspects compared with the ratings of the corresponding aspects of in-person teaching. These results suggest that:

- Instructors found the online outside-of-class activities (for example, staying active on online discussion forums and offering online office hours, that is, #1 and #2 in Table 4) to be more effective than online in-class activities (getting students to work together in class—#7)
- Instructors found some teaching activities (getting students to work together in or outside class, that is, #5 and #7 in the table) to be less effective online than implemented in person while perceiving other teaching activities (offering office hours and providing low-stakes self-assessment quizzes—#2 and #6) to be more effective online than in-person.

Table 4. Ranking of certain instructional activities by the level of their contributions to teaching effectiveness

Rank	Survey question items	n	% of those indicating "quite a bit" or "very much"
1	Staying active on online discussion forum (e.g., Quercus and Piazza)	77	58%
2	Offering *online* office hours	84	56%
	Offering *in-person* office hours	65	46%
3	[Using the inverted classroom approach] Posting pre-recorded lecture and/or assigned readings prior to the class and using live class sessions for discussion and other active learning activities	70	50%
4	Recording live class sessions (in-person or online) and then posting them for student use at their discretion	81	49%
5	Offering students opportunities to work together *online asynchronously* (e.g., discussion forums, peer feedback)	67	43%
	Offering students opportunities to work with other students outside of class, either in person or online	69	61%
6	Providing low-stakes self-assessment quizzes *online*	51	41%
	Providing low-stakes self-assessment quizzes *in person*	34	29%
7	Offering students opportunities to work together during *online synchronous* class sessions	55	40%
	Offering students opportunities to work together during *in-person* class sessions	62	79%
8	Providing virtual labs in preparation for in-person lab activities	32	25%

The ranking is based on the descending order of % those indicating "quite a bit" or "very much" in a five- point Likert scale.

In their comments, instructors explained why they found in-person classes more effective than online sessions while other instructors shared the effective aspects of an online class that made teaching effective. For example, while both instructors (#44 and #67) related their teaching

effectiveness to students' learning engagement, they gauged ways of student engagement in different ways: not being able to see the students detracted from the first instructor's perception of teaching effectiveness whereas the second instructor interpreted the in-class active use of the chat box as being indicative of student engagement.

> *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 in the same term. In-person was much more effective and more motivational for the students.* (#44)

> *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 another's company. This was something that disappeared when we came back to in-person in February.* (#67)

Both these quantitative and qualitative results suggested that instructors were learning how in-person and online teaching could or could not work while they were teaching during the pandemic.

Interest in Online Teaching

In the survey, instructors were asked to rate their interest in online and in-person teaching prior to the pandemic (i.e., before spring 2020) and at the time of data collection (i.e., July 2022) on a 7-point scale. On average, the interest in online teaching increased moderately from 2020 (M = 2.36, SD = 1.49) to 2022 (M = 3.73, SD = 2.02), $t(100) = 6.25$, $p < .001$, $d = .62$. In contrast, the interest in in-person teaching decreased moderately from 2020 (M = 6.26, SD = 1.08) to 2022 (M = 5.59, SD = 1.74), $t(99) = -4.54$, $p < .001$, $d = -.46$. This contrast can also be seen in the individual-level comparisons between the two points in time. As shown in Table 5, three-fifths of the respondents indicated an increased interest in online learning in summer 2022 while about one-third indicated a decreased interest in in-person learning.

Table 5. Individual-level changes in interest in online and in-person learning from before spring 2020 to July 2022

	Interest in online learning		Interest in in-person learning	
Change in interest	n	%	n	%
Decrease	15	15%	32	32%
No change	25	25%	60	61%
Increase	61	60%	7	7%

Self-Efficacy in Online Teaching

Instructors were also asked to indicate their level of confidence about their abilities in two aspects of online teaching on a 4-point scale. Over four-fifths of the respondents felt confident or very confident about their ability to use technologies to support in-person instruction (82% out of

78), and their ability to deliver some class sessions online (87% out of 79). These high levels of self-efficacy were impressive as four-fifths of the instructors in this engineering school had never taught in an entirely online environment before the pandemic, according to the result from our instructor survey in spring 2020 [30].

Exploration of New Teaching Practices

Instructors shared a number of teaching practices they had experimented during the pandemic. The following quotes illustrated three examples: introduction of online practice quizzes (#124), refinement of presentation slides (IN5), and better use of online breakout rooms (IN3). The latter two quotes also illustrated how instructors gathered feedback from their students and used the feedback to improve their online teaching.

> *I used online practice quizzes worth no marks to gauge understanding and to encourage class engagement. As they were anonymous, I found I had more responses than I would typically get in class which helped tremendously for clarifying materials. This is partially due to the fact that students can take their time in responding, instead of in the moment.* (#124, an instructor teaching a lecture-based engineering course)

> *When I was teaching the course in-person, it was half PowerPoint slides, half chalk. PowerPoint was typically for introducing the methods just because I found it writing equations. … When we went to online, I essentially transcribed everything to PowerPoint including the examples. And over the first time I was teaching the course, I was regularly interacting with the students and trying to get their feedback on the slide presentation. And I got very good feedback — less material on each slide, including more animation and transitions. So I adapted pretty much in that first year I taught online. I felt I started out, it was a bit dry, but by the end of the year, they seemed quite happy with the way I was presenting the slides, the pace, how the material was being introduced through animations and using color and especially highlighting on the slide when I was talking about something in particular to draw their attention to it rather than just saying it.* (IN5, an instructor teaching numerical methods in engineering)

> *In an online environment, there's some distance from the student, you don't really feel you can get personal relationship with your students. So, to counter this, what we've introduced were every student would have a half an hour meeting, one on one with the instructors. And we set that up, not in class that was outside of class time. And in these meetings, we talked about the course, we got feedback about the course but we very specifically asked about breakout rooms. How was the time in the breakout rooms? How were the questions in the breakout rooms? When did you find that you were having awkward silences? When did you find that it was working well? And so, we were able to modulate, to change how we designed the breakout rooms as the course went along. The breakout rooms in the writing lab are a little less awkward in the sense that the task at hand is very clear.* (IN3, an instructor teaching writing to engineering students)

5.3 Results of Imposed Instructional Development

The results from the imposed instructional development toward online teaching can be seen in instructors' anticipation of (a) future teaching practice and (b) future access to instructional development resources.

Anticipation of Future Teaching

Instructors were asked to indicate how likely they were to adopt five options provided in the survey for future teaching. These options had different foci on in-person and online teaching, using a 7-point scale from "very unlikely" (1) to "very likely" (7). Table 6 shows that the majority of the respondents favoured in-person teaching (Items d and e in the table) over teaching practices with significant online components (Items a and b).

Table 6. Likelihood for adopting certain teaching practices in the future

Teaching practices	n	% of those having indicated 5, 6 or 7
a. (Re)design one or more courses to be delivered entirely online	93	10%
b. Teach mostly online but include some in-person elements	94	13%
c. Teach about half of the class sessions in person and the other half online (either synchronously or asynchronously)	96	18%
d. Teach in person as much as possible	96	69%
e. Teach mostly in person but supplement it with online tools and resources (e.g., posting lecture slides or study guide, and setting up assignment submission)	97	71%

Further, qualitative data suggested that polarized views existed among faculty members about their future choice of the instructional mode, as illustrated by the following two contrasting quotes. Most instructors favoured in-person teaching as revealed in the first quote whereas those favouring online teaching as demonstrated in the second quote constituted the minority.

> *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)

> *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)

Future Instructional Development

On the same 7-point scale, instructors were asked how likely they were to access certain instructional support resources in future. Consistent with the patterns in accessing resources during the pandemic (shown earlier in Table 2), a higher proportion of the respondents favoured the engineering school's internal teaching support over campus-wide support (Table 7).

Table 7. Likelihood for accessing various instructional development resources in the future

Resources	n	% of those having indicated 5, 6 or 7
Online resources provided by the engineering school's education technology office	76	58%
Newsletters offered by the engineering school's education technology office	77	44%
Personal instructional consultation with the engineering school's education technology office	76	43%
Peer instructor support	78	41%
Workshops offered by engineering school's education technology office	77	36%
Online resources provided by the university's teaching support center	79	35%
Workshops offered by the university's teaching support center	78	29%
Workshops offered by organizations outside the university	77	27%
Personal instructional consultation with the university's teaching support center	79	23%

Some instructors (26 responses) shared the areas in which they would like to improve their teaching practice. The major desired areas for improvement were creating or using digital resources (#93), enhancing student engagement (#31), and improving learning assessment (#113), as illustrated in the follow quotes.

> *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)

> *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)

> *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)

6. Implications for Instructional Development

In this paper, we conceived of the mandatory, exclusively online teaching implemented from 2020 to 2022 in postsecondary education in response to the COVID-19 pandemic as a case of imposed instructional development for online teaching, and used Kirkpatrick's model of training evaluation (Kirkpatrick, 1994; Kirkpatrick and Kirkpatrick, 2006) to characterize the instructional development as a result of the pandemic and interpret our findings. Our data collected from the instructors of an engineering school of one public Canadian university have informed us of the following in response to our three research questions. First, it is evident that the teaching practices in most of the courses changed and most instructors consulted with

resources for instructional support during this unusual time. Second, although our data did show that not all these instructional changes and not all the efforts for instructional development were related to the required online teaching, our findings suggest that the crisis during the pandemic serendipitously offered an unprecedented opportunity for instructional development toward online teaching in engineering education. This instructional development was exhibited through instructors' reactions to their own online teaching experiences in comparison to in-person teaching, positive attitudinal changes and skill development among some instructors toward online teaching, as well as the newly introduced teaching practices during the pandemic. Third, instructors in the engineering school accessed more school-based resources for instructional development than university-based support during the pandemic; and this resource access pattern will be likely to continue.

The characteristics identified above demonstrate a distinct type of instructional development that would not have happened in the usual teaching practice before the pandemic. While changes in attitudes, knowledge and skills are typically gained from active participation in workshops or other training opportunities, instructors' learning in these domains amidst the involuntary academic changes during the pandemic was passive and reactive in nature. The instructors had to learn and adapt when they were performing the required tasks—teaching in an exclusively online environment. In this sense, instructors' professional development was actualized in a setting of on-the-job-training, so to speak. Past studies show that effective on-the-job training requires self-efficacy, prior experience with the tasks, managerial support, and less pressure of workload [31]. We have learned from our data that this "on-the-job training" toward online teaching happened when instructors had generally low self-efficacy in online teaching and little prior experience with online teaching tools, experienced a significant increase in workload, and received inadequate guidance and coaching in the early stage of the pandemic. However, after two years of online teaching practice, many instructors reported notable improvement in online course design and teaching, and some of the improvement benefited from instructors' amenability to student feedback. This means that the instructional development toward online teaching, through the "on-the-job training" during the pandemic, was tangible although this "training" happened involuntarily. On the other hand, a small proportion of instructors (15% in our sample) sought after no or little instructional support during the pandemic; their instructional development on the job was likely to have occurred haphazardly.

The existing faculty development literature in engineering education seems to focus more on program-based instructional development initiatives (for example, [6]). These instructional development initiatives are critical to prepare effective engineering educators for the next generation of engineers. However, our study has revealed that another type of instructional development—instructors' self-initiated instructional development—was also at play. This kind of instructional development was exhibited in instructors' access to online resources, individual consultation, instruction workshops, and peer support (shown in Tables 2 and 7). The matter of the fact is that this kind of instructor-initiated instructional development is taking place everywhere on campus—quietly though, in most cases. This is happening when the instructor introduces a new approach to teaching in response to certain student needs, implements an active learning activity they never tried before, or adjusts a learning assessment assignment to allow students to better demonstrate their learning. It is also happening when the instructor discusses teaching practice with their peers, reads about effective teaching practice in literature or writes

about what they tried out in their course. Instructors are a community of reflective practitioners. Their self-initiated instructional development activities should not be ignored in faculty development research.

Further about instructors' self-initiated instructional development, our data based on one Canadian engineering school showed the differences among faculty members in pursuing instructional supports: teaching-stream faculty and sessional instructors appear to be more likely to access instructional development resources than tenure-stream faculty members. This can be explained by their primary responsibility for teaching, which can motivate them to seek instructional support more often than tenure-stream faculty members. Arguably, the differential efforts made by teaching-stream versus tenure-stream instructors when seeking instructional support could mean that the teaching-stream faculty members may have grown more in their instructional development than their tenure-stream colleagues. This speculation is subject to further investigation.

Further, our findings corroborate the importance of the teaching support office housed within academic divisions to instructional development. At the engineering school in our study, the discipline-based instructional resources, including teaching tips on its website, workshops, and individual consultation, were more widely accessed by instructors than the campus-wide resources provided by the university's teaching support center. Hence, at least in terms of resource access, discipline-based instructional development initiatives appear to play a larger role than those initiatives targeting all disciplines. The higher value instructors have placed in the locally based teaching support office may be related to the fact that the staff in these offices are better versed in discipline-based knowledge and teaching context. How to help instructors balance and better utilize the resources offered by the school-based and the university's centralized teaching support offices can be a consideration for the program design of these offices.

Last but not the least, our findings suggest that two seemingly contradictory situations were happening simultaneously. On one hand, tangible instructional development toward online teaching was observed in the engineering school as a result of the pandemic; this means that learning was occurring. On the other hand, most instructors still favour the in-person instructional mode at the end of the "interventions" of the imposed online teaching. Many instructors find in-person teaching more effective, although they are capable of teaching online; and they choose to teach mostly in person when online teaching is no longer required. This result sounds negative, relative to the learning that had occurred. One could argue that these two situations represent a misalignment between the learning and result levels in Kirkpatrick's evaluation model. However, the explanation for this plausible misalignment needs to be explored outside Kirkpatrick's model, as the model was designed for intentional interventions. One possible explanation can be the predominantly problem- and project-based learning in engineering education, which requires effective interactions between individuals and groups [32]. How to effectively navigate the problem- and project-based learning environment using online media can pose severe challenges to most engineering instructors. Similar challenges associated with experiential learning activities and interpersonal interactions, when courses are delivered online, probably exist in other disciplinary settings as well. On a positive note, the academic changes that were imposed by the pandemic have serendipitously created a myriad of

opportunities for online pedagogies, for example [14-17], all of which will foster a new level of digital learning when the pandemic is fading away. How to optimize online tools and resources to complement typically in-person teaching presents another question for all engineering instructors committed to enhancing engineering education.

The evidence presented in our study suggests that engineering education practice is at a juncture of change. It is foreseeable that some of the emerged alternative practices during the pandemic will sustain, partly because of the significant instructional development toward digital learning from 2020 to 2022 and particularly through those instructors who embrace the change. The remaining questions raised during the pandemic, including student engagement and learning assessment design in the post-pandemic context, will continue to revitalize the practice of instructional development in the years to come.

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