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Application of Cognitive, Behavioral, and Emotional Adaptability Lens for Interpreting the Teaching Experiences of Engineering Instructors during a Switch to Remote Instruction*

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Emergency remote teaching (ERT) was necessary as the COVID-19 pandemic swept across the world. Most ERT studies describe the experiences of students and instructors without a theoretical grounding. The purpose of this paper is to demonstrate how the Cognitive, Behavioral, and Emotional Adaptability model (CBEAM) can be used to interpret instructors' experience with a significant disruption. Weekly CBEAM-informed surveys were administered to engineering instructors at a U.S. university in the seven weeks following the March 2020 switch to ERT. These surveys captured the activities that instructors ($n = 39$) engaged in to support their teaching, their emotions, and their challenges and successes. Descriptive statistics were used to examine instructors' experiences in terms of each dimension of the CBEAM across time. The instructors engaged in more self-teaching activities than organized workshops to aid their transition. Instructors' community-based interactions generally decreased over time, though final assessment concerns spurred conversations with support staff. Instructors' emotions were consistently more positive than negative. Successes and challenges centered on the student experience and course-related aspects. The CBEAM, with minor modifications, can be used to collect instructors' holistic experiences in other instances of change or disruptions to teaching and can give insight into the supports that instructors need.

Keywords: engineering education; pandemic; adaptability; COVID-19

1. Introduction

The United Nations Sustainable Development Group has stated that the COVID-19 pandemic "created the largest disruption of education systems in history, affecting nearly 1.6 billion learners in more than 190 countries and all continents" [1] (p. 2). Those impacted were not only learners but also the instructors who were responsible for teaching these learners. The pressing need to shift rapidly from face-to-face instruction to remote instruction induced by the COVID-19 pandemic left little time for the thoughtful planning and design of instruction that typifies quality online learning. While 46% of U.S. higher education instructors had taught an online course prior to the pandemic and two-thirds of those had received professional development with online learning [2], the situation required significant deviations from best-practices for the design and delivery of online learning to account for the evolving crisis [3]. To enable evaluation and research on the disruption, the crisis -induced education delivery mode needed to be differentiated from online learning. The phrase emergency remote instruction (ERT) was proposed by Hodges et al. [3] to describe teaching situations in which instruction must be temporarily delivered remotely due to an emergency or crisis. The phrase ERT is used throughout this paper to refer to the nature of instruction engineering faculty engaged in during the first months that COVID-19 impacted university education.

Higher-education faculty, even in non-COVID times, experience pressures to change their instruction and instructional practices. Those pressures come from a variety of sources such as changes in or a need to better meet accreditation agency requirements, changes in student outcomes expectations, and directives from department advisory boards, department curriculum committees, and institutional entities. Some of the needed changes are focused on content, some are about pedagogy and the desire to employ evidence-based practices to improve students' experiences and outcomes. The degree to which faculty individually engage in making change depends on a variety of individual, institutional, and environmental factors. Urgency is not typically felt under these pressures, so change comes with time. Then came the COVID-19 pandemic. The pandemic forced instructors around the world to rapidly alter their course delivery method – sometimes in as little as one or two weeks. The faculty response to the COVID-19 pandemic showed that rapid change is possible and that

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instructors demonstrated some level of adaptability. But particulars on the ways in which instructors were adaptable is unknown. A better understanding of higher education faculty adaptability can help reshape faculty development programs and institutional policies and supports for future emergency disruptions of the types that prognosticators predict as related to health, climate change, war/conflict, famine, and people migration resulting in displacement or disruption, even in first-world countries where education systems appear to be stable.

1.1 Literature Review

Research has demonstrated the barriers and challenges that instructors at universities faced both within and outside of engineering during ERT. Research has emerged from multiple countries (e.g., Spain [4], Indonesia [5], Denmark [6], Russia [7], Italy [8], and the United States [9, 10]) and has focused on capturing educators' experiences in terms of barriers and challenges, well-being, and resilience.

A national survey conducted in the United States (US) during mid-May of 2020 with nearly 5,000 instructor responses identified several challenges that instructors faced when teaching online [10]. Challenges included engaging students in remote learning, course delivery, and assessment. Instructors indicated a shift in their perception of the effectiveness of online learning compared to pre-COVID (45% more favorable compared to 17% more negative) [10]. A second survey in the US with over 4,000 responses from instructors found 34% experienced high levels of worries and stress (as measured on a 5-point Likert scale)[9].

A bibliographic review that focused on ERT and professors' mental health was conducted by Santos et al. [11]. The review did not include any publications that required a fee to access. A total of 203 articles were identified of which 11 were utilized in the review. A review of the articles resulted in two themes about professors and teaching: mental health and difficulties/challenges of ERT. Difficulties/challenges that professors encountered included difficulties with technology and a lack of in-person interactions. In terms of mental health, professors reported negative emotions such as anxiety, depression, tiredness, uncertainty, and fear [11].

Survey research about instructors' emotions is mixed due to studies often only posing negatively framed questions. For example, researchers reported instructors feeling more stress, a decline in psychological well-being, and issues with time management [12], but the questions participants were asked were framed in a negative manner without a positive opposite. One study presented both positive and negative emotions for participants to select from and when doing so, found more positive than negative emotions [13].

The research described above contributes to answering what Hodges and colleagues proposed as one compelling research question related to teaching during COVID-19: "Where did faculty, students, support personnel, and administrators struggle the most with ERT?" [3, Evaluating Remote Teaching section, para. 5]. Much of the research in the higher education context during the COVID-19 pandemic has focused on this question. However, much of this research has been conducted without theoretical underpinnings that would help draw out inferences concerning preparation and support for faculty for crisis teaching situations. In the current study, an adaptability theory was used to ground the design of engineering instructor focused data collection during the initial weeks of the COVID-19 closure of a university and subsequent interpretation of the results of this data.

1.2 Theoretical Framework (Adaptability)

The shift to ERT signified a disruption in routines that instructors had not experienced before. Instructors' reactions to COVID-19 induced changes to teaching and the ensuing uncertainty can be viewed through the lens of adaptability. Adaptability is defined as an individual's ability to regulate their personal resources to constructively respond to situations and events [14, 15]. Martin and colleagues' [15, 16] model of adaptability describes personal resources as being comprised of three elements (cognitive, behavioral, and emotional) that can be regulated. Cognitive regulation refers to the adjustments one makes to their thinking. Behavioral regulation refers to one's actions, and emotional regulation refers to modulating one's affective response.

To see how these elements bare out in the teaching domain, consider the original example Collie and Martin [17] use to describe a K-12 teacher responding to the "inherent novelty, change, and uncertainty that characterizes teaching work" (p. 31) under day-to-day conditions:

> "a teacher is asked to teach a new subject that is unfamiliar to them, effectively dealing with this change requires regulating thoughts to find connections between the new material and familiar topics (cognitive adaptability), regulating behavior to seek out a helpful person who has more knowledge and relevant resources in the new subject (behavioral adaptability), and regulating emotions such as anxiety or excitement to focus on finding a solution in a focused and timely manner (emotional adaptability)." (p. 31)

Under the conditions of the evolving COVID-19 situation that led to ERT, a parallel scenario for a

university instructor can be constructed to show how the adaptability elements apply. For example, consider an instructor having to learn how to use one or more remote technologies to facilitate remote exam administration (cognitive adaptability). Actions they might take include using internet resources, attending a workshop, or getting one-on-one help from instructional technology support staff (behavioral adaptability). They would need to regulate their emotions to quickly and reasonably learn the basics of the technologies amid other personal and professional worries (emotional adaptability).

A literature review of teacher adaptability by Collie and Martin [17] highlights the centrality of adaptability to a teacher's effectiveness in terms of responding to students' needs and outcomes as well as workplace factors. Among their stated implications for research, they point to a need to continue to expand the knowledge about teacher adaptability to answer questions like: What personal and contextual factors influence teachers' adaptability? How stable is a teacher's adaptability in the short and long term? Can teachers' adaptability be increased? Findings, Collie and Martin explain, have implications for practices that both support teachers given their current adaptability and enhance teachers' adaptability [17].

If one assumes adaptability is an inherent aspect of teaching, then adaptability can be used as a lens for exploring university faculty's teaching experiences in times of change and conceiving of professional development strategies for crisis and non-crisis times. Thus, this current study seeks to address the first research question posed by Hodges et al. [3] and lay the groundwork for answering their second research question: "How can we adapt our processes to respond to such operational challenges in the future?" [Evaluating Remote Teaching section, para. 5.] By applying a lens of adaptability, it is believed that a holistic multi-dimensional framework can be used to make sense of instructors' ERT experiences and consider what support systems instructors need during future teaching changes or disruption events.

1.3 Purpose and Research Questions

The purpose of this study was to apply an adaptability framework to the collection and interpretation of university educators' experiences during the COVID-19 pandemic. This study aims to contribute to an understanding of one field of university instructors' experiences with teaching during the initial months of ERT. Engineering instructors are an interesting participant group because they have been notably resistant to change [18]. Engineering instructors' activities (self-directed and community), emotions (positive and negative), and perceptions of normality in comparison to pre-COVID times were examined in the context of instructors' successes, challenges, and solutions to challenges with teaching. Specifically, the research question addressed in this study was: *What were the cognitive, behavioral, and emotional expressions of adaptability of engineering instructors during the forced change to emergency remote teaching from March 2020 to May 2020?*

2. Materials and Methods

A longitudinal study [19] was devised to collect engineering instructors' experiences during ERT. This panel study was designed to collect and analyze engineering instructors' cognitive, behavioral, and emotional expressions of adaptability periodically for the remainder of the Spring 2020 semester. The study is described in detail below.

2.1 Setting and Participants

This study took place at a research-intensive university in the College of Engineering in the Midwest of the United States. The university announced closure on March 12th and resumed classes remotely on March 30th after a two-week preparation period that included a planned week-long mid-semester break (Fig. 1). Instructors were encouraged to re-think student assessments, including ideas for alternative forms of assessment, and they were given resources on how to design and administer online assessments. The remote course delivery method (synchronous, hybrid, asynchronous) was not mandated, but the university released the following statement for instructors to consider when making the synchronous versus asynchronous remote delivery decision:

> "As students have been encouraged to leave campus and return to their permanent residences, it's important to consider the challenges of synchronous remote learning for students who are in different time zones, have difficulties accessing the internet, have to share a family computer, and need to address emerging family situations. At the same time, the familiar cadence and structure of regularly-scheduled meetings can provide a framework that is comforting and encourages progress through the material. Instructors are strongly encouraged to make all of their course content available asynchronously. Post materials, including perhaps brief pre-recorded lectures, for students to access as they are able to do so." [Executive Vice Chancellor, 2020, email message to author, March 22].

During this transition period, instructors were given information about communicating with students remotely. This included a request that instructors update their course syllabus (or specifications, contracts, and outlines that document communi-

cating course expectations to students) to include the new or revised course expectations going forward and indicate how students could connect with their instructor. The university teaching center offered two workshops on moving courses online on March 18th. Sixteen workshops were provided by the College of Engineering's teaching center between March 13th and 26th on eight different remote instruction topics (e.g., using the learning management system, communicating with students, teaching using video conferencing). For the remainder of the semester, both the university and college periodically posted online additional resources concerning remote instruction. Instructors' physical access to campus resources continued until April 8th when the campus was closed to all non-essential personnel. The semester concluded on May 8th with grades being due by May 15th (Fig. 1).

All Spring 2020 engineering instructors from all seven departments of engineering were invited to participate in this research study (N = 161); 57 instructors volunteered to participate. For this study, data were only included from those that taught undergraduate engineering courses and held tenure-leading (six-year probationary period), tenured, and professors of practice (PoP, those dedicated to teaching with no research appointment) faculty positions (n = 39). These inclusion criteria were applied as individuals work in full-time permanent positions have different motivations for teaching than those that are contracted to teach for short periods of time (e.g., lecturers, adjuncts) [e.g., 20, 21].

The majority of participants were male (74.4%), though they were somewhat underrepresented in the study compared to the college's demographics (81%). There were additional discrepancies in demographic subgroup representation between the survey participants and the college. Associate and Full tenured professors were underrepresented in the data (38% vs. 65%) while Assistant Professors and Assistant PoPs were overrepresented in the data (31% vs 23% and 23% vs 8%, respectively). Participants from the civil engineering were overrepresented (26% vs 13%) and electrical and computer engineering and chemical and biomolecular engineering were underrepresented (<10% vs 17% and <10% vs 16%, respectively).

2.2 Survey Instrument

A survey instrument was designed to periodically capture instructors' teaching experience. Two senior researchers constructed items to map to the CBEAM dimensions (Table 1) [15]. Consideration was given to creating an instrument with a minimum number and complexity of items given the stress instructors were under. Items focused on teaching-related activities instructors engaged in, the emotions they felt, and their perceptions of the normality of these activities and emotions during a week of instruction. Items also asked instructors to describe successes and challenges they experienced during the week. The resulting survey consisted of seven items: two multiple-select, two multiple-choice (Likert), and three open-ended items.

The behavioral dimension of adaptability was captured through a multiple-select item about the teaching-related activities in which participants engaged. As shown in Table 2, the teaching activities from which instructors could select included five self-directed activities (e.g., I taught myself something new) and five community-based activities (e.g., I had a casual conversation with a colleague) [22]. These activities were selected because they demonstrated the behaviors (actions) that instructors could take to adapt their teaching to ERT.

Emotional adaptability was captured through a multiple-select item that included a randomly dis-

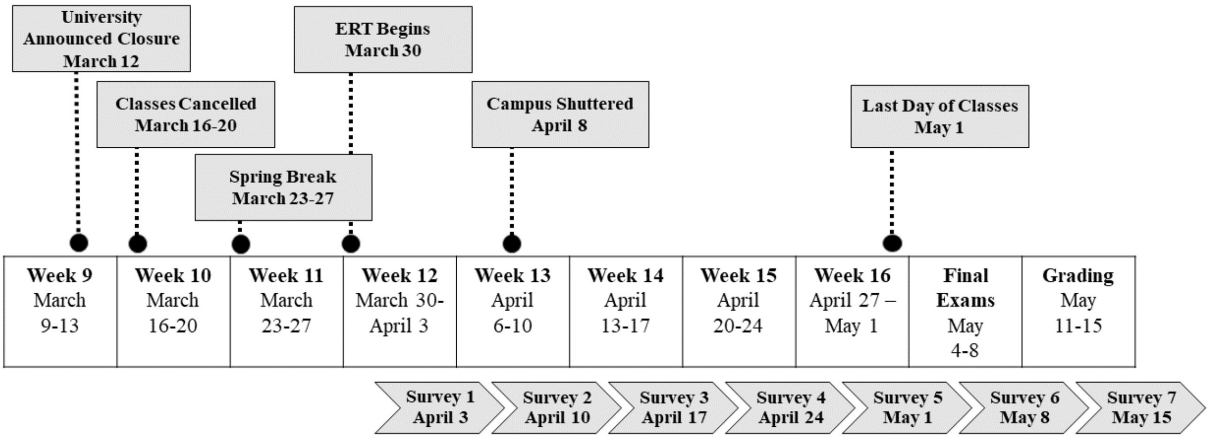


Fig. 1. Timeline of university's transition to ERT and survey administration.

Table 1. Survey items

Items	Response Type	Martin et al. [15] Dimensions
Which activities (with regards to teaching or technologies for teaching) have you engaged in during the past week? [Click on all that apply]	Multiple-Select (Table 2)	Behavioral
In general, the activities I indicated above are similar to those in which I have engaged in a typical week prior to the COVID-19 mandate for remote instruction.	Likert-Scale[1]	
Which words best describe how you felt about teaching this past week? [Click on all that apply]	Multiple-Select (Table 3)	Emotions
In general, the feelings I indicated above are similar to those I have felt in a typical week prior to the COVID-19 mandate for remote instruction.	Likert-Scale[1]	
Describe a teaching success you had this past week.	Open-ended	Cognitive
Describe a teaching challenge you are having or anticipate having.	Open-ended	Cognitive
How do you plan to address the challenge you described above?	Open-ended	Cognitive

[1] Four-point scale (1 = "strongly disagree" to 4 = "strongly agree").

Table 2. Teaching activities listed in the survey [22]

Multiple Select Items: Activity Types	Abbreviations	Activity Category
I taught myself something new.	TaughtSelf	Self-Directed
I referred to [my university-based] online resources for teaching.	UnivRes	
I referred to other online [not my university] based resources.	nonUnivRes	
I attended a teaching related workshop.	Workshop	
I read about effective teaching practices.	Read	
I sought help on something specific from a colleague.	GotHelpColl	Community-based
I had a casual conversation about teaching with one or more colleagues.	CasConvo	
I sought help from professional teaching and learning staff.	GotHelpStaff	
I pointed one or more colleagues to resources on teaching.	DirectedColl	
I actively helped one or more colleagues.	HelpedColl	
None of the above	No Activities	–

played list of 48 emotions (Table 3). Drummond's Vocabulary and Emotions/Feelings [23] was a starting point for the development of this list of emotions. Drummond's list provided a list of emotions divided into 10 categories of approximately 42 words each parsed among three levels (i.e., strong, medium, and light). It was intended to be used by professionals who need to identify emotions of children. As such this list overemphasized negative emotions with eight negative categories and only two positive categories. To balance the positive and negative emotion options, five new categories were added to provide antonyms to the existing negative categories. Further, Drummonds' Caring category was split into Caring and Committed because the words listed under Caring reflected two different aspects of caring - caring about oneself and caring about others. The list of words used in this study were intended to represent those used by participants to describe their feelings. The context of higher education and engineering instruction was considered when selecting three words to represent a range of emotion in each category.

A six-member panel of experts in engineering education research and engineering instructors were personally invited to review the emotions survey item to provide a degree of validity marker. This review occurred after the surveys were administered due to the pressing need to not miss the window of opportunity to capture instructors' emotions as the pandemic's impact on teaching was unfolding. The experts completed this review via an online survey tool [25]. One item asked the experts to indicate whether they agreed (on a 4-point Likert agreement scale) that the words in each emotion category related to the category heading. Two categories received only three of six agreements: Committed and Remorseful. The expert comments on the Committed category indicated the word Interest did not fit, but their reasons seem to indicate that Interest is a lower intensity word (i.e., "Interests fade and devotion doesn't."), which was intended. Since the expert comments related to intensity and not to category fit, the Committed category was kept during the analysis. Comments on Remorseful indicated that Embarrassed did not fit, though again the reasons seem to indicate a lower intensity or a lack of guilt element. For the other emotions categories, two received four agreements, five received five agreements, and seven received six agreements. While there are some identified weaknesses in the emotion survey

Table 3. Instructor emotions options included surveys [24]

Category	**Positive Emotions**		
Happy	Excited	Happy	Pleased
Adequate[1]	Empowered	Competent	Certain
Committed[2]	Devoted	Trusting	Interested
Caring	Compassionate	Sympathetic	Thoughtful
Positive[1]	Optimistic	Hopeful	Encouraged
Stable[1]	Composed	Content	Calm
Braced[1]	Supported	Included	Connected
Accomplished[1]	Triumphant	Satisfied	Relieved
Category	**Negative Emotions**		
Depressed	Defeated	Distressed	Disappointed
Inadequate	Powerless	Overwhelmed	Unsure
Fearful	Intimidated	Nervous	Cautious
Confusion	Flustered	Frustrated	Uncomfortable
Hurt	Devastated	Devalued	Minimized
Angry	Outraged	Irritated	Resentful
Lonely	Isolated	Alienated	Detached
Remorseful	Exposed	Guilty	Embarrassed

[1] Category added to [23].
[2] Caring was split to focus on Committed (caring about oneself) and Caring (about others).

items, the purpose with regards to this analysis was to capture a high-level sense of emotional adaptability. Therefore, all categories were retained for analysis to preserve the balance of positive and negative antonyms.

Following the behavior item and the emotions item, participants were asked to identify if the activities or emotions, respectively, that they indicated were similar to those of a typical week prior to the COVID-19 mandate for remote instruction (Table 1). These items were included to help establish instructors' perceptions of the degree to which their activities and emotions were representative of a given week during the semester.

Cognitive adaptability was collected with the use of three open-ended items. These items asked the participants about their teaching successes and challenges and how they planned to address their challenges. Including open-ended cognitive items on the survey allowed the participants to provide additional context relative to their perceptions of teaching as well as their thinking about their instructional processes and problem-solving strategies.

2.3 Data Collection

IRB approval was obtained prior to data collection (protocol code 20200320352EX, approved on March 27, 2020) and participants provided consent digitally. The weekly surveys were administered using an online survey tool [25]. The first survey link was sent on April 3, 2020 and the final survey link was sent on May 15, 2020 for a total of seven surveys (Fig. 1). Surveys opened in the afternoon on Friday and closed on Tuesday at midnight. One reminder was sent to participants for each survey on Monday. It was found that instructors had completed course-related activities prior to survey 7, so this survey was removed from this analysis as it provided no additional information.

While a total of 39 participants met the inclusion criteria for this study, between 30 and 36 instructors completed any given survey. Thirty-one participants completed five or more surveys and four participants completed three or fewer surveys. Table 4 shows the number of participants who met the inclusion criteria and completed each survey.

2.4 Data Analysis

The data analysis consisted of both quantitative and qualitative analyses. The quantitative analysis focused on the closed-ended response items of the survey concerned with teaching related activities and emotions and the perceived normalcy of each. The qualitative analysis focused on the open-ended prompts concerned with successes, challenges, and solutions to challenges. For the analyses, surveys were grouped into three periods: Period 1 (Survey 1 and 2), Period 2, (Survey 3 and 4), and Period 3 (Survey 5 and 6) (Table 4). Periods were selected based on preliminary work with the data set [26] that indicated there were three distinct periods of instructor activity: start-up with ERT, followed by a more business-as-usual interval, and then a bringing of the semester to a close. Within each period, participants' responses were retained if they completed both surveys (Table 4).

Table 4. Instructor participation per survey and period

	Period 1 Weeks 12–13		Period 2 Weeks 12–13		Period 3 Finals & Grading	
	Survey 1	**Survey 2**	**Survey 3**	**Survey 4**	**Survey 5**	**Survey 6**
No. of Participants	35	36	30	33	33	33
Period Inclusion	32	32	27	27	32	32

2.4.1 Quantitative Analysis

For the teaching-related activities, the responses were parsed by activity category: self-directed activities and community-based activities. To capture the central tendency and distribution of the frequency with which participants selected self-directed activities or community-based activities on each survey, box-and-whisker-plots were generated to show the mean, median, and inter-quartile range (IQR) of the frequencies of the responses. The exclusive median method was used to compute the IQR to not understate the variance in the data. Within activity type, the number of participants who selected a given activity at least once in each period were counted. Percentages of individuals engaging in each activity were computed for visual comparison across periods using radar plots.

In a similar fashion, the emotion responses were parsed into positive and negative emotions. For each survey, the central tendency and distribution of the frequency with which participants selected positive and negative emotions and emotions within different categories were represented in box-and-whisker-plots. The percentage of participants who selected an emotion within each category at least once in each period were visualized using radar plots.

Instructors provided two level-of-agreement responses to each of the items concerning whether the teaching related activities they engaged in and the emotions they felt were typical of a pre-COVID semester per period. These responses were combined. If a participant agreed on both surveys within a period, their responses were categorized as Agree. If a participant disagreed at any level on both surveys, their responses were categorized as Disagree. Combinations of agree and disagree for the period were categorized as Mixed. Percent of participants in the categories of Agree, Mixed, and Disagree were determined for each period.

2.4.2 Qualitative Analysis

Inductive thematic analyses [27] of instructors' responses to the open-ended survey items were completed, one for the Successes and Challenges and one for Solutions to the Challenges. Trustworthiness was established with multiple coders [28]. The coding process was described in detail in [26]. To summarize, two undergraduate researchers, one working with the Successes responses and one working with the Challenges responses, developed initial codes, with senior researcher oversight. A single codebook was iteratively negotiated through constant comparison [29]. Then, through an iterative process of double-coding a selection of data and discussing discrepancies, an inter-rater-reliability (IRR, [27]) of 0.88 as measured by Cohen's Kappa was established by the two undergraduate researchers. These codes were revisited by the original coders plus three more senior researchers who together checked the entire data set and sought consensus on all codes [29]. For Solutions codes, a single researcher who had coded the Challenges data translated the existing Successes and Challenges codes in terms of Solutions. The code "no plan" was added during this initial stage of coding. As coding progressed, additional codes were added as needed to help categorize the participants' responses.

One senior researcher combined codes that were similar in nature into themes [27]. Consensus on the themes was reached with a second senior researcher. The Successes and Challenges themes are described in Table 5; the Solutions to Challenges themes are described in Table 6. Radar plots were constructed to show the percentage of all codes each theme represented in each period.

3. Results

Results from each of the CBEAM dimensions are presented below. For ease of understanding of the instructors' ERT experiences, the dimensions are presented in an order that begins with describing their activities (behavior), followed by their emotions, and then their thinking about their successes and challenges (cognitive). For each of the behavioral and emotional dimension survey items, results of participants' responses are first described in general and then a comparison of instructors' responses across the three periods is made. Finally, their degree of agreement of the normality of their responses is presented. The presentation of the cognitive dimension results focuses only on the comparison between periods.

Table 5. Successes and Challenges themes

Theme	Definition
Student Experience	Relates to how students experience instruction including their performance in terms of the instructors' assessment, obstacles faced by students both academic and personal, completion of work, student engagement in course activities, and students' reactions, feedback, or emotions.
Methods of Interaction	Relates to interaction dynamics as compared to pre-COVID times including instructors providing students with course content help and instructors communicating with students.
Course Related	Relates to all course-specific aspects including academic integrity, course design and content delivery, exams/quizzes, grading, and instructors completing tasks associated with delivering the course content.
Materials, Tools, and Technology	Relates to access to resources, learning about or implementing technology tools and services, and technical issues experienced by students and instructors.
Instructor Related	Relates to the instructors' emotions and feelings, time management, improving or further developing their teaching practices or changing their mindset, and any personal challenge (e.g., sickness, work-life balance).

Table 6. Instructor Solutions to Challenges themes

Theme	Definition
Changing/Modifying Course Elements	Challenge(s) will be solved through changing/modifying a course element including grades, assessments, and assignments.
Student Check	Challenge(s) will be solved through contacting students directly to ensure their personal and academic well-being.
Learning	Challenge(s) will be solved through self-directed learning or from seeking input/help from others including students and other faculty.
Personal	Challenge(s) will be solved with a focus on internal change via personal improvement or time management.
Technology	Challenge(s) will be solved through the adaptation or adoption of a new technology.
No Plan	The instructor has not indicated a plan to solve their challenge.

3.1 Behavioral Dimension of Adaptability

Fig. 2 displays the number of activity types that instructors indicated engaging in at least once during each week of the Spring 2020 semester starting in week 12 with Survey 1. During the preparation period and the first week of ERT (Period 1), instructors indicated the most engagement in self-directed and community-based activities. While all but one instructor reported engaging in one or more community-based activities during the preparation period, three indicated engaging in zero self-directed activities. The number of self-directed and community-based activities selected generally declined across Period 2 (weeks 14 and 15) and increased slightly in Period 3 (final exams and grading).

A detailed look at non-participation in both self-directed and community-based activity types revealed the extent of the decrease in participation in these activities. In Period 1, four instructors self-reported engaging in none of the teaching activities for one of the two weeks. In Period 2, seven participants self-reported engaging in none of the teaching activities for one of the two weeks, with two participants engaging in no activities in both weeks. In Period 3, ten participants self-reported

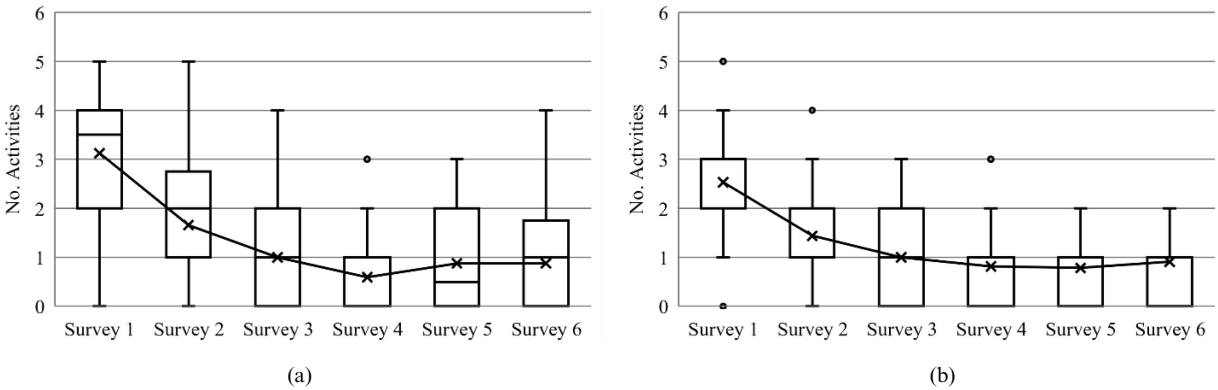


Fig. 2. Number of (a) self-directed and (b) community-based activity types selected at least once per instructor per survey.

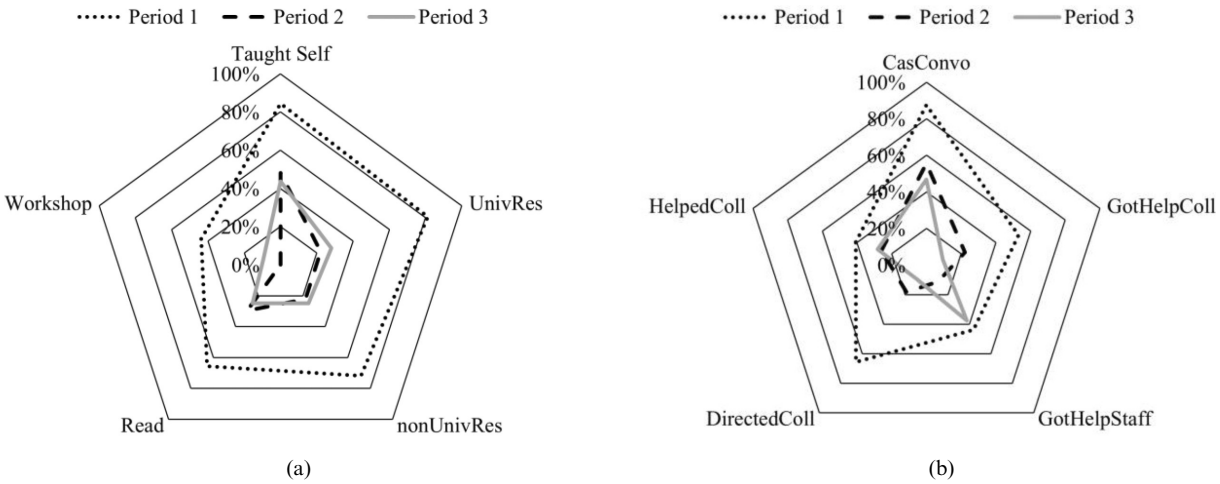


Fig. 3. Percent of instructors selecting specific (a) self-directed and (b) community-based activities at least once in each of the three periods (Period 1 – Weeks 12–13, Period 2 – Weeks 14–15, Period 3 – Final Exams and Grading).

engaging in none of the teaching activities for one of the two weeks, with two participants engaging in no activities in both weeks.

Fig. 3 provides a more detailed look at the specific activity types instructors selected. This radar plot indicates the percentage of instructors that selected an activity at least once during a given period. Regarding self-directed activities, the pattern in Fig. 3(a) is similar to that in Fig. 2(a); there was a high level of activity in Period 1 which decreased in Period 2 but slightly increased for some specific activities (i.e., Workshop and use of University and non-University Resources) in Period 3. Within each period, the type of activity instructors indicated most often was Taught Self, with over 40% of participants engaging at least once in the activity in all three periods. Participants used a combination of university and non-University resources. Workshops in general were the activity type instructors engaged in the least in all periods. This study's participants over-represented those engineering faculty who attended workshops offered prior to or near the start of remote instruction. On average nine out of 161 (5.6%) faculty teaching engineering attended a workshop on a given topic [Director of Engineering & Computing Education Core, 2022, email message to author, December 20, 2022]. Twenty-three percent of Period 1 respondents self-reported attending workshops of any kind (Fig. 3(a)).

For the community-based activity types, Fig. 3(b) confirms the pattern seen in Fig. 2(b); instructors engaged in all activities the most during Period 1. The decrease in participation in these activities was mixed in Periods 2 and 3. Instructors' engagement in casual conversations with colleagues was consistently high, relative to other types of community-based activities, across all three periods. In Period 1, instructors also indicated that they directed their colleagues to resources, but to a lesser extent helped colleagues with specific things. The instructors got help from staff and colleagues in Period 1, relied on colleagues somewhat more in Period 2 though with fewer instances, and sought more help from staff than colleagues in Period 3.

Table 7 shows instructors' level of agreement that the activities they engaged in were similar to those in a pre-COVID semester. The mixed response indicates that instructors agreed on one survey and disagreed on the other survey within a period. As can be seen in Table 7, there was a general increase in agreement across the three periods.

3.2 Emotional Dimension of Adaptability

Figs. 4 and 5 summarize the number of emotions selected by each instructor at least once in each survey and the number of categories from which they selected those emotions, respectively. Across the remaining weeks of Spring 2020, participating instructors selected a greater number of positive emotions in a greater number of categories than negative emotions. Generally, Fig. 4 shows that the average and median number of positive and negative emotions selected decreased slightly from week 12 to the grading week. The range in the total

Table 7. Instructor agreement that activities engaged in were similar to those in a typical week prior to the COVID-19 mandate for remote instruction

Similar to pre-COVID	**Period 1 Weeks 12–13 (n = 32)**	**Period 2 Weeks 14–15 (n = 27)**	**Period 3 Finals & Grading (n = 32)**
Agreed	16%	48%	59%
Mixed	28%	33%	28%
Disagreed	56%	19%	13%

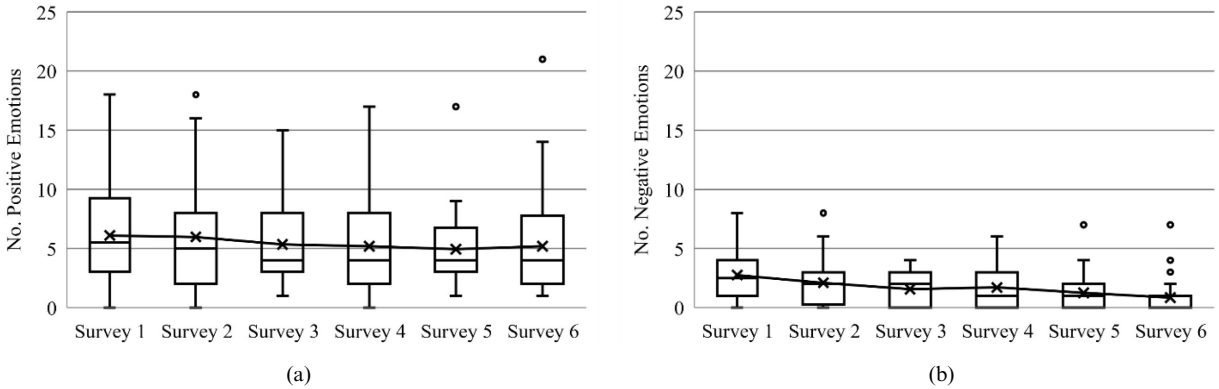


Fig. 4. Number of (a) positive emotions (out of 24) and (b) negative emotions (out of 24) selected at least once per instructor per survey.

number of emotions that an instructor selected was large. For instance, on Survey 1, one instructor selected no positive emotions and another selected 18 out of 24 possible positive emotions. The distribution of the number of positive and negative emotions per participant was very consistently skewed to the right, the exceptions being for negative emotions in week 14 and the grading week.

The average number of categories from which the positive emotions were drawn was four in week 12, then two in week 13, and between three and two in the remaining weeks. The average number of negative emotions categories decreased from two in week 12 to one in the week 13 to final exams week and to zero in the grading week.

The categories of emotions from which instructors selected at least one emotion within each period are shown in Fig. 6. Again, it can be seen, that there were more positive emotions (Fig. 6(a)) than negative emotions (Fig. 6(b)) expressed by the instructors across the periods. Generally, positive emotion category selections were similar from Period 1 to 2, though there was a drop in the number of instructors selecting emotions in the Caring and Committed categories. As the semester came to a close in Period 3, the percentage of participants selecting emotions in the positive emotions categories were at their minimums for all except the categories of Happy and Accomplished which jumped to their maximum.

Regarding negative emotions, the most frequently selected emotions in Period 1 were those associated with the categories of Inadequate, Fearful, and Confused. However, the selection of emotions in these categories, as for all the negative emotions categories, decreased across the semester. The number of instructors selecting emotions associated with the Angry and Lonely categories remained constant for the first two periods but decreased in Period 3. Instructors only rarely selected emotions in the Hurt category.

Instructors both agreed and disagreed about whether the emotions they felt were similar to those felt at a similar time in a non-COVID-19 semester (Table 8). The mixed response indicates that instructors agreed on one survey and disagreed on the other survey within a period. The general trend across the periods was towards greater agreement that the emotions felt were similar to a non-COVID semester.

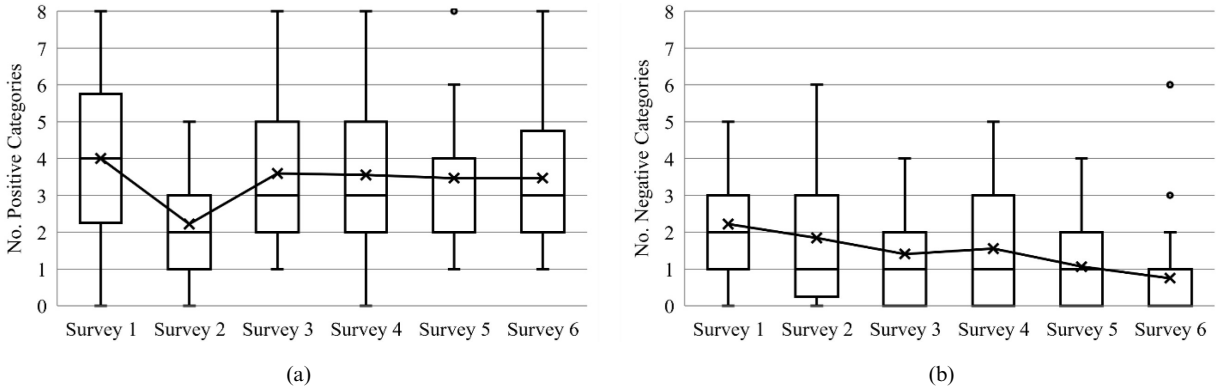
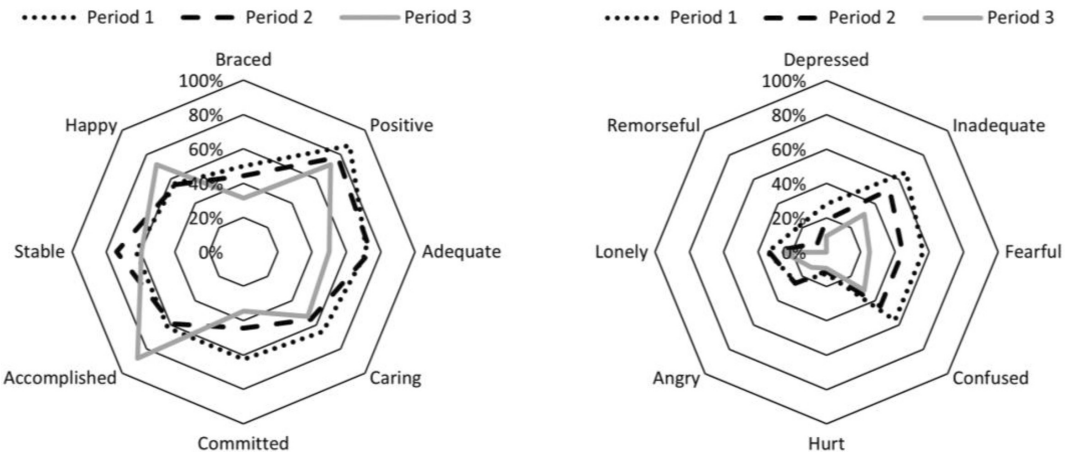


Fig. 5. Number of (a) positive emotion categories (out of 8) and (b) negative emotion categories (out of 8) selected at least once per instructor per survey.



(a) (b)

Fig. 6. Percent of instructors selecting (a) positive and (b) negative emotions in each category at least once in each of the three periods. (Period 1 – Weeks 12–13, Period 2 – Weeks 14–15, Period 3 – Final Exams and Grading).

3.3 Cognitive Dimension of Adaptability

The cognitive dimension of adaptability as expressed by participants is summarized in Table 9 and Fig. 7. The total number of applied codes for Successes, Challenges, and Solutions to Challenges in each period can be found in Table 9 with the range of the number of codes per participant in parentheses. The range of codes per participant stayed relatively consistent for both Challenges (1–6) and Solutions (1–4) across all periods. For Successes, the range of the number of codes per participant was greatest during Period 1 (2–13) before becoming more similar in Periods 2 and 3 (1–8). When removing outliers, coded Successes were similar across all periods (1–8).

Table 8. Instructor agreement that feelings indicated were similar to those felt in a typical week prior to the COVID-19 mandate for remote instruction

Similar to pre-COVID	**Period 1 Weeks 12–13 (*n* = 32)**	**Period 2 Weeks 14–15 (*n* = 27)**	**Period 3 Finals & Grading (*n* =32)**
Agreed	19%	33%	59%
Mixed	31%	26%	25%
Disagreed	50%	41%	16%

Table 9. Variability in the number of coded Successes, Challenges, and Solutions responses

	No. Codes (Range of Codes per Participant)		
	Period 1 Weeks 12–13	**Period 2 Weeks 14–15**	**Period 3 Finals & Grading**
Successes	137 (2–13)[1]	97 (1–7)	106 (1–8)
Challenges	81 (2–6)	79 (1–6)	64 (1–5)
Solutions	94 (1–4)	73 (1–5)[2]	66 (1–4)

[1] Two participants were outliers with 11 and 13 coded responses spread across the different codes. When removed, the high was 7.
[2] One participant was an outlier with five responses spread across four different codes.

Fig. 7 shows the Successes ((a), top left), Challenges ((b), top right), and Solutions to Challenges ((c), bottom) cited during each period. The radar plots indicate the percentage of each theme cited within the total of all instances during that period. Across all periods, Course Related and Student Experience were the most frequently cited themes within Successes and Challenges, and Changing/Modifying Course Elements was the most frequently cited theme for Solutions to Challenges.

The Course Related theme relates to all items that pertain to a course including academic integrity, course design and content delivery, exams/quizzes, grading, and instructors completing tasks associated with delivering the course content. Course Related Successes increased across the three periods (27%–46%). Challenges followed a similar trend but with a more significant increase (23%–59%). Period 1 challenges focused on course design and content delivery and exams/quizzes, while Period 3 challenges largely focused on delivering exams, addressing academic integrity, and grading.

The Student Experience theme relates to how students experience instruction including their performance in terms of the instructors' assessment, obstacles faced by students that are both academic and personal, completion of work, student engagement in course activities, and students' reactions, feedback, or emotions. Across the three periods, Student Experience Successes were consistent (28%) and Challenges decreased (~40%–10%). Student engagement was often both a success and challenge across the three periods.

Among the Solutions to Challenges, Changing/

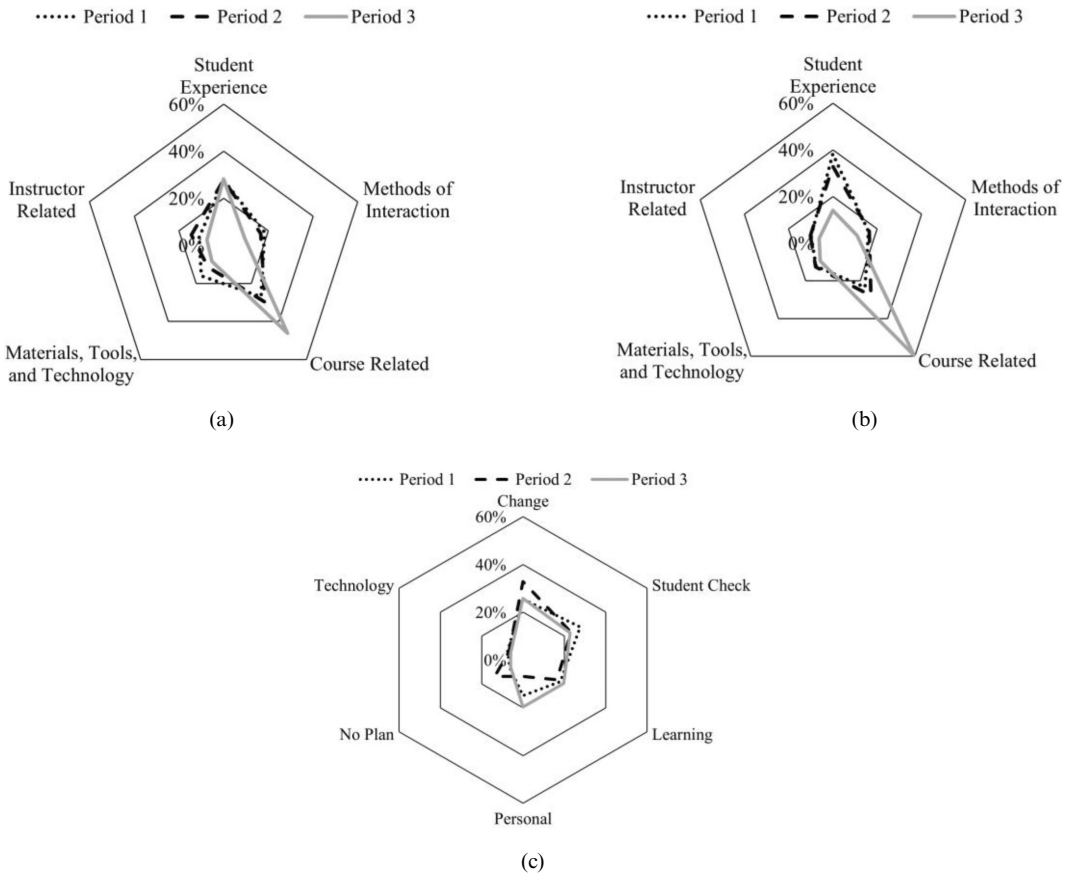


Fig. 7. Percent of codes related to (a) Successes, (b) Challenges, and (c) Solutions to Challenges themes in each of the three periods (Period 1 – Weeks 12–13, Period 2 – Weeks 14–15, Period 3 – Final Exams and Grading)

Modifying Course Elements was the most frequently cited across all three periods reaching a max during Period 2 (33%). During Periods 1 and 2, the most common topic within the theme was related to changing something in the course. Changing the format of the assessments was also a common topic during Periods 2 and 3.

4. Discussion

The data revealed cognitive, behavioral, and emotional expressions of adaptability among engineering instructors during the pandemic. While Martin et al. [15] initially made a clear distinction between the cognitive and behavioral dimensions of adaptability; results from their adaptability survey instrument ultimately indicated that these two dimensions are not separate factors. An interwovenness of these two dimensions was also found within the results of this study. As such, the evidence of engineering instructors' adaptability is discussed first from the cognitive and behavioral dimensions followed by the emotional dimension.

4.1 Cognitive and Behavioral Dimensions

In terms of the cognitive domain, Martin et al. [15] considered evidence of adaptability to be related to revising one's thinking about a new or uncertain situation, thinking through options, and adjusting expectations. In terms of the behavioral domain, evidence centers on one's ability to seek information, help, and resources; develop new approaches; and make changes in what one does. These themes are discussed in light of the study results.

4.1.1 Think about Options, Revise, and Adjust

The initial transition of course materials to a remote format during the beginning of ERT (Period 1) required instructors to *revise their way of thinking* about course delivery, *think about options* for remote instruction, and *adjust* their expectations so that instruction could proceed. Evidence of this cognitive activity may be inferred from instructors' elevated behaviors associated with self-directed activities and the nature of their successes and challenges.

While information about instructors' prior experience with teaching online was not collected, other research has indicated that instructors at research-intensive institutions (where the current study was conducted) had the least amount of experience with online teaching compared to other

institution types [30]. This lack of experience suggests a need for instructors to think (cognitive) and take action (behavioral) very quickly in order to be prepared for remote teaching. Furthermore, online teaching for the purposes of teaching during ERT more closely resembled a flipped classroom, which is a teaching method unfamiliar to most and used by few engineering instructors. Thus more effort (cognitive and behavioral) was required to make the transition from traditional lecturing methods to the remote instruction, as both online and a flipped pedagogy needed to be adopted for ERT for those instructors choosing synchronous delivery. Evidence that instructors engaged in quick action is demonstrated in the high level of self-directed activity in Period 1.

The sustained level of successes and challenges on the topic of student engagement (Student Experiences) cited across all three periods is another indicator of cognitive adaptability. The number of challenges indicate that many instructors were continually revising their thinking about remote student interactions, thinking about options to improve engagement, and adjusting their expectations, though they may not of had the tools or training necessary to adequately engage students in learning remotely. Difficulties with student engagement in higher education was echoed by other researchers during this time period [31, 32] and is a well-known challenge within online teaching [33].

4.1.2 Helpful People or Useful Resources

Instructors did seek out people and useful resources to help them navigate the pandemic situation. They seemed inclined to communicate with their peers about their instruction during the change period (Period 1), both giving and receiving help. However, working remotely due to shuttering of campus in Period 2 seemed to curtail the initial level of peer-to-peer activity, limiting instructors' ability to communicate face-to-face. Interactions among colleagues became constrained to pre-arranged, web-conferencing meetings. Instructors also sought help from professional teaching and learning staff during Period 1 (corresponding to moving to ERT) and Period 3 (corresponding to administration of final course assessments). While instructors agreed to a greater extent that their activities were becoming more like a pre-COVID semester as the semester progressed, the bump in communication with professional staff during Period 3 might have been distributed to colleagues if access to colleagues had been available.

Instructors did seek out information and useful resources, though the balance of information seeking behaviors was slightly curious. Across all three periods, instructors were more engaged in teaching themselves what they needed to know and using a variety of their own university's online resources and other non-university resources to support their teaching needs. The lower reliance on workshops was surprising particularly in light of the minimal undergraduate engineering course utilization of the university's learning management system (LMS). Perhaps the low utility of workshops was a reflection of engineering's persistent culture that devalues workshops [18]. Still, even under the conditions of COVID, others have found that engineering instructors were less likely to attend university-wide workshops than instructors of other disciplines, though more attended engineering-specific workshops [34].

Despite instructors' low attendance at workshops offered by the college's professional teaching and learning staff, they did turn to one-on-one professional teaching and learning staff interactions for just-in-time, individualized help when the challenge was high, as with academic integrity concerns and administration of exams (in Period 3), or there was limited access to peers, or peers were not perceived as having the knowledge to help.

4.1.3 New Ways of Going about Things

As the semester progressed and course materials were transitioned, instructors' focus shifted to administering exams and maintaining academic integrity in Period 3 and identifying new ways of going about summative assessment. Evidence of this is found within the theme of Course Related successes and challenges (cognitive) and the high level of community-based activities related to seeking help from professional teaching and learning staff (behavioral). A considerable concern as the semester drew to a close was the maintenance of academic integrity during exams. Similarly, other research found that STEM instructors were more concerned with secure assessment of learning during Spring 2020 than instructors from other disciplines [10]. Gamage et al. [35] described the many strategies used around the world for safeguarding against dishonest acts during the pandemic (e.g., redistribution of assessment weights, more frequent formative assessments, making exams pass/fail, open-ended take-home exams, time constrained exams, alternatives to exams such as projects, written reports, oral presentations). Many of these assessment strategies were adopted in the present context and required learning of new instructional techniques to implement.

4.2 Emotional Dimension

In terms of regulating or managing emotions during uncertain situations, Martin and colleagues [15]

point to drawing on positive emotions and reducing negative emotions, particularly minimizing frustration and irritation. The balance of positive versus negative emotions and the nature of the negative emotions expressed by the engineering instructors in this study are unpacked below.

4.2.1 Drawing on Positive Emotions

The fact that the engineering instructors self-reported more positive than negative emotions across Periods 1 to 3 could mean that, on average, the engineering instructors in this study demonstrated emotional adaptability. Similar results were found by other researchers. For example, Meishar-Tal and Levenberg [13], in a study of emotional intensity in response to teaching synchronously online, also found that higher education lecturers expressed greater positive (success and opportunity) than negative emotions (threat and failure). Also, in a study of volunteered stories of engineering instructors' COVID-19 experiences, the emotional tone skewed towards positive [36]. Another indication of emotional adaptability was seen across surveys 2 and 3. When the campus was shuttered in Week 13, instructors reported fewer positive emotions. But a week later, the number rebounded.

One explanation for instructors' positivity may be rooted in a sense of responsibility or organizational commitment [37]. Instructors had to proceed with instruction to meet the needs of their students, and when they experienced success, positive emotions were elevated. Baba [38] also found above average emotional intelligence among higher education faculty in India, particularly for what they defined as "value orientation" and "integrity" factors. These two factors are described as one's beliefs about how interpersonal relationships should be (value orientation) and one's sense of being part of a greater whole (integrity), respectively. In the instructional environment during COVID-19, these factors may relate to the instructors' concern for their students' continued learning and well-being.

4.2.2 Managing Negative Emotions

Maintaining some sense of normalcy in the face of uncertainty requires adaptability on the part of instructors to manage their own negative feelings. Few negative emotions were expressed by the engineering instructors in this study and these feelings diminished over the three periods. This finding is unique as other studies tended to only capture instructors' experiences at one or two time points during ERT, and typically some weeks into ERT (e.g., [37]).

The types of negative feelings most frequently expressed by the engineering instructors in this study were less about being isolated, angry, and depressed and more about being inadequate, fearful, and confused. These latter negative emotion categories align with the negative feelings of being stressed and overwhelmed that other researchers have reported higher education faculty expressing. Two larger studies have reported that faculty (across institutions and disciplines) experienced elevated levels of stress and feelings of being overwhelmed, frustrated, and anxious during COVID-19 [9, 39]. The sources for these negative feelings have also been identified. Cheirichetti and Backer [12] reported that engineering faculty at a large public U.S. university were overwhelmed by work related to their courses and not being in control of classes as well as more generally by deadlines, a need to rush, and work piling up. Conversely, Meishar-Tal and Levenberg [13] found that negative emotions were more related to general anxiety about the COVID outbreak and other situational parameters (e.g., working at home with children present) than the remote instruction itself.

The degree to which the engineering instructors in this study reported experiencing negative emotions appears lower than that of higher education instructors at large [39, 12]. Differences may be attributed to data collection methods and context. With regards to data collection, others were often seeking evidence of stress levels, and survey prompts bluntly asked about stress and feelings of being overwhelmed. The current study took a more neutral stance to asking about participants' emotions. This may have also led to instructors divulging only what they felt were appropriate emotions for their role in the unfolding situation and downplaying negative emotions. Regarding context, certainly, different geographical locations experienced the impact of COVID-19 differently. In turn, different kinds of institutions and units within institutions supported instructors to different degrees and in different ways. Instructors' perceptions of autonomy and support directly relate to their adaptability [37]. In the context of this study, engineering instructors may have perceived sufficient autonomy and support for their teaching to manage their negative emotions.

4.3 Implications and Limitations

The CBEAM Framework provided a multi-dimensional take on engineering instructors' experiences during the pandemic from which implications for practice and research can be derived. The sections to follow discuss these implications. Limitations of the study and future research are also discussed.

4.3.1 Implications for Practice

The fact that engineering instructors were often

learning on their own and giving and receiving help from colleagues to adapt to the sudden change indicates engagement in a work-place learning type of faculty development as opposed to a training or workshop-based type of faculty development [40]. Given engineering instructors' high utility of independent learning as a means for facilitating adaptation to a sudden change, the implication for practice is that high-quality resources for independent learning need to be available as a change commences. For example, workshops need to be converted to self-taught and self-paced online training and more peers or faculty developers need to be available for on-demand conversations and individualized assistance. Addressing this need requires forethought to put in place resources targeted to the types of knowledge and skills instructors will need to successfully adapt to change.

Furthermore, instructors need to ensure course materials are designed and developed in a way that they are suitable for multiple delivery methods and include a greater variety of assessment types (e.g., projects, papers) or more frequent (lower stakes) formative exams [35]. In order to design and develop materials, some level of workplace learning about remote education delivery is needed. This learning would also assist instructors with tackling engagement challenges in remote settings.

While there are many benefits of remote meetings in terms of limiting the spread of infectious disease, accessibility, convenience, and collaboration, maintaining face-to-face connectivity needs to be prioritized. Often, the culture of standing meetings is that they tend to start quickly and focus solely on scheduled business. Large (e.g., department level) and small (e.g., committee) online meetings need to include space for informal conversations about teaching and learning so that instructors maintain connections with peers.

4.3.2 Implications for Research

Adaptability among engineering instructors has not previously been studied. The research presented here gave a snapshot of faculty adaptability during a time when instructors had to adapt quickly and with limited preparation to do so. The results can be used in future research to compare to business-as-usual semesters to better understand the ebb and flow of instructor adaptability. More importantly, the adaptability framework as a lens to study change was found to provide useful insights about the experiences of instructors. The adaptability framework is universally applicable regardless of the type of change (crisis, climate change, institutional, accreditation, etc.) and could be used for purposes beyond research including "just-in-time" adjustment to faculty development resources.

The adaptability framework provided a holistic view of the experiences of instructors during a change which was not present in many other studies. When comparing the results of this study with that of others, three differences in the nature of data collection were noted. First, some researchers collected data within a limited subset of the individual dimensions of adaptability (e.g., emotions [38]). These studies were somewhat likely to have theoretical underpinnings (e.g., emotional intelligence [38]). Second, other researchers tried to collect data on many aspects of the pandemic experience, spanning issues of work and home, sometimes without distinction [e.g., 12]. These studies tended to have no theoretical foundation. Third, other researchers queried their participants from a standpoint of seeking problems only, such as challenges and negative emotions [e.g., 9, 41]. The nature of these methods failed to provide a holistic and neutral understanding of the experiences of instructors. The research presented here demonstrated that a combination of the use of an adaptability framework and weekly data collection is feasible and can provide a nuanced understanding of the experiences of instructors during a teaching change.

4.3.3 Limitations

Several limitations of the current study exist. First, this study was conducted at a single university with its unique response to the COVID-19 pandemic. Results are not intended to be generalizable but rather are intended to demonstrate the experiences of engineering faculty and the use of the CBEAM Framework for exploring faculty adaptability in response to a change.

Second, the number of participants was small as participation in the research was voluntary. Instructors who self-selected to participate may or may not represent the full spectrum of experiences; this may have contributed to bias in the results. One indicator of missing experiences can be deduced from the misalignment between the number of technology successes, challenges, and solutions (low) and previous use of the LMS (less than half). This misalignment could possibly indicate that those who were technologically adept were more likely to participate in this study. Additional information about participants' previous online teaching experience could also shed light on determining who did and did not self-select to participate. There was also a drop in the number of survey participants from 32 to 27 during Period 2. The drop in participation may indicate that stress increased for these individuals during Period 2, as this is when instructors no longer had access to

campus and had to balance teaching, research, and personal lives all remotely. Their level of stress was then not captured during this period.

Third, the timing of ERT could have also of had an impact on the results. ERT began towards the end of the Spring 2020 semester which makes it difficult at times to distinguish between the ERT response and typical end-of-semester activities, successes, challenges, and emotions. Comparing the results found during this ERT period to future full-length semesters of COVID-impacted teaching could provide insight about instructor adaptability over the entirety of a disrupted semester.

Fourth, the greater tendency for instructors to report positive emotions needs to be taken into account when interpreting results. This tendency may be due to the neutral approach taken in the design of the survey questions which offered participants the choice of reporting both positive and negative experiences and emotions. A neutral approach may or may not have led to participants to filter their negative experiences and emotions. Conversely, other studies used prompts that were negatively worded (e.g., "how often have you felt you were under pressure from deadlines?" [39]) which could have invited more negative experiences and emotions.

Fifth, additional validity and reliability evidence needs to be collected for the emotions instrument. The expert panel raised some concerns about the alignment of some emotions to the categories in which they were placed. For others to use this instrument, a revisit of the emotions in each category and the category names would be necessary.

Finally, the wording of the survey prompts about successes and challenges appeared to have resulted in more details about instructors' behaviors than their cognition. The lack of explicit instructor data on their thinking about their experiences resulted in the researchers using behaviors to make inferences about their cognition. Martin et al. [15] also had a difficult time differentiating these items on a closed-ended survey. Re-wording of the prompts is necessary to elicit instructors' thinking (cognition).

5. Conclusions

An adaptability lens was used to capture a holistic view of instructors' experiences of ERT during the initial phase of the COVID-19 academic lockdown. Instructors' cognitive, behavioral, and emotional adaptability were examined. As per the adaptability lens, instructors included in this study demonstrated aspects of adaptability; they quickly took action, pursued learning new things, and managed their behaviors and emotions. This lens revealed that instructors generally engaged in teaching themselves the things they needed to learn to execute ERT to a greater extent than attending formal training; they interacted with their peers less after it became difficult to do so remotely; and they reported feeling more positive than negative emotions. The findings provide insight into the support that instructors may need to facilitate change during future disruptions. Overall, there are indications that the application of an adaptability lens to understand instructor adaptability in the face of change has the potential to generate results that can fuel the transformation of higher education systems.

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