2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
Paper ID #37111

A Measure of Engineering Instructors' Adaptability Based on Cognitive, Behavioral, and Emotional Dimensions

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Abstract

This Research paper considers an adaptability framework for providing insight into faculty development in the face of engineering being slow to adopt best practices in teaching. As traditional change models (e.g., Diffusion of Innovations) have not produced the results that are hoped for, a look through a lens of adaptability has the potential to help identify how to assist instructors implement and sustain a wide array of teaching practices and strategies (WATPS) during and after times of change. The purpose of this study was to quantify the variability of adaptability of engineering instructors at a United States R1 Midwest university using the Cognitive-Behavioral-Emotional adaptability model instrument. Females' Cognitive/Behavioral and Total Adaptability scores were found to be statistically higher than males. These differences had a medium or large effect size as indicated by Cohen's *d*. No statistically significant differences were found for academic position or rank. Differences found may be attributed to work culture; lack of differences may be attributed to individuals with a certain adaptability profile being drawn to a career in academia. Accounting for adaptability when considering the extent to which WATPS are used can enable more individualized support for instructors during periods of change.

I. Introduction

Instructors are challenged to implement and sustain a wide array of teaching practices and strategies (WATPS) in undergraduate courses because WATPS have been shown to improve students' conceptual understanding, appeal to a diverse set of students, and increase persistence in engineering, especially among underrepresented groups [1], [2], [3], [4]. The adoption of a WATPS can produce more workforce ready engineers that innovate in creative ways. Engineers graduating from universities that utilize a WATPS are more competitive in the global workforce [3], [5], [6]. However, there is reluctance to adopt a WATPS due to a lack of class time, time to prepare, and incentives; student resistance; and the faculty researcher/teacher identity tension [7], [8], [9], [10].

A forced change requires instructors to adapt their teaching practices. Forced changes come about as a result of pandemics and natural and humanitarian disasters as well as accreditation modifications and department and university unilateral academic policy decisions. In all of these examples of forced change, the motivation for change is external and may be time sensitive. One example of a forced change was the COVID-19 pandemic; it provided an external reason for instructors to engage in the use of different teaching practices than their norm to meet the demands of delivering courses remotely. This was a crisis-induced change.

The question is, how adaptable are instructors? What can adaptability frameworks tell us about the ways in which instructors are or are not adaptable? The purpose of this study was to begin to understand instructor adaptability by quantifying the adaptability of engineering instructors at a

United States R1 Midwest university. To investigate the adaptability of instructors, an existing adaptability instrument was utilized. Demographic groups and subgroups that are often used to study instructors were explored: sex, position, and rank status. This work is part of a larger research endeavor to employ adaptability as a lens for designing novel support strategies that enable instructors to better use a WATPS.

II. Background

In engineering education, change in teaching practices that is sought through professional development is typically investigated through change models such as the transtheoretical model (TTM) [11], [12], Diffusion of Innovation [13], and the Concerns Based Adoption Model (CBAM) [14]. Such models track individual change through stages. For the TTM, the stages include preconception, contemplation, preparation, action, and maintenance. For the Diffusion of Innovations model, these stages include awareness, interest, evaluation, trial, and adoption [13]. The CBAM stages of concern are awareness, informational, personal, management, consequences, collaboration, and refocusing [14]. In engineering education research, these models are most typically used to understand supports and barriers to change (movement between stages) [15].

Adaptability models focus on an individual's *capacity* for change. Theories of adaptability have different foundations. One theory was explored in this study. This theory is from counseling, psychology, and educational psychology [16] which states that adaptability can be defined as an "individual's capacity to constructively regulate psycho-behavioral functions in response to new, changing, and/or uncertain circumstances, conditions and situations" [16, p. 58]. Martin and colleagues' adaptability framework includes three elements: cognitive (thinking), behavioral (actions), and emotional (affective) adaptability [16]. This adaptability framework is referred to in this paper as the Cognitive, Behavioral, and Emotional Adaptability Model (CBEAM).

Overall, adaptability frameworks allow researchers to look at an individual's potential response to changing and uncertain situations [16]. A study of instructor adaptability, and how adaptability may vary depending on sex, position, and rank status, may provide insight into how instructors may react to a forced change. This study took place during the COVID-19 pandemic, with its unprecedented presentation of changing guidelines (e.g., recommendation for asynchronous or synchronous course delivery, social distancing) and numerous unknowns (e.g., students' access to remote learning, duration of pandemic).

While the pandemic was certainly one example of a forced change, adaptability does not only pertain to situations as severe as the COVID-19 pandemic. The intention here is to think of the applicability of an adaptability lens more broadly. Course instruction is affected by a variety of changes, such as new requirements or technology, different students with different preparation, backgrounds, and motivations each semester, or physical classroom changes [17]. Without researching the adaptability of instructors, it is difficult to know how they will react to change and how best to support them when change occurs.

III. Research Question

The research questions addressed in this study were "What is the adaptability of engineering instructors based on the CBEAM?" and "Do differences exist in adaptability of engineering instructors based on sex, position, or rank status based on the CBEAM?"

IV. Methods

A. Setting and Participations

In the Fall of 2021, all engineering instructors from engineering departments who contributed to the teaching of undergraduates at an R1 United States Midwest university were invited to participate in the study. Out of approximately 250 instructors, 77 responses were received. Only data from tenured or tenure-track professors and professors of practice (with standard faculty position ranks) were included, leaving 75 responses. Contracted (non- ranked) lecturers and adjunct professors were not included because they often have different duties and motivations with regards to teaching. To ensure quality data, any participant that selected the same Likert response for all items was removed from the analysis. As a result, the number of participants retained was 59 (Table 1). With respect to the demographics of the college of engineering, females were overrepresented (32% vs 19%), and assistant professors were overrepresented (42% versus 35%). Professors of practice were also overrepresented.

Table 1. Engineering instructors' demographics for inclusion in study (*n* = 59)

Demographic	Subgroup	*n*	%
Sex	Male	40	68
	Female	19	32
Position	Professor of Practice (Teaching Only)	10	17
	Professor (Teaching & Research)	49	82
Rank	Assistant	25	42
	Associate & Full	34	58

B. Data Collection

The link to an online one-time survey, including two measures of adaptability, was emailed to every instructor in the college of engineering in October of 2021. The instructors provided consent as per the IRB protocol for the project and were compensated with a $10 e-gift card for completion. The survey included 48 closed-ended items in which participants were asked to consider a series of statements in the context of teaching undergraduate courses. Participants were asked to mark the degree to which they agreed with each statement using a 5-point Likert scale (i.e., strongly disagree (1), disagree (2), neither agree or disagree (3), agree (4), and strongly agree (5)).

Nine of the items were from a translation of CBEAM framework into an instrument, three items corresponded to each of the three dimensions of adaptability: cognitive, behavioral, and emotional [16]. Example items are "I am able to revise the way I think about a new situation to help me through it"(cognitive), "To assist me in a new situation, I am able to change the way I do things if necessary" (behavioral), and "When uncertainty arises, I am able to minimize frustration or irritation so I can deal with it best" (emotional). The results of an exploratory factor analysis (EFA) conducted on this instrument, when tested with 2,731 high school students, suggested a 1-factor model with an item loading mean of 0.70. A 2-factor model, cognitive-behavioral and emotional, had item loading means of 0.68 and 0.65, respectively. The confirmatory factor analysis (CFA) yielded a good fit for the 2-factor model ($\chi 2 = 231.46$, $df = 26$, NNFI = 0.99, CFI = 0.99, RMSEA = 0.05) with correlation between the two factors at $r = 0.88$. A domain-specific version of this instrument was proposed for use with other audiences [18] and showed adequate reliability with K-12 teachers [19].

C. Data Analysis

For the CBEAM instrument, since Martin et al. [16] concluded that a 1-factor model and a 2-factor model were good fits, three scores were calculated: cognitive/behavioral, emotional, and total adaptability. A mean score was determined by summing all responses corresponding to a factor and dividing the number of items included in the factor. The 1-factor model corresponded to the total adaptability score, and the 2-factor model corresponded to the cognitive/behavioral and emotional scores. A confirmatory factor analysis (CFA) was performed to test whether the hypothesized models fit the data collected in this study.

Descriptive statistics (mean and standard deviation) were computed for the CBEAM factors using all included responses. In addition, kurtosis ("tailed-ness") and skew (degree of asymmetry) of the distribution were computed. Further, Cronbach's alpha was computed as a measure of reliability or internal consistency (i.e., how closely the items in a factor relate).

Descriptive statistics (mean and standard deviation) for the factors were also computed for the demographic subgroups. Statistical tests were performed to determine whether there were significant differences between the subgroups of three demographics: sex (male versus female), position (professors versus professors of practice), and rank status (assistant versus associate and full). An independent t-test assuming unequal variance (Welch's t-test) was executed for looking at differences between two subgroups. Note that the degrees of freedom for this test is an approximation. For these tests, the null hypothesis was that there is no difference in the mean of the (dimension) adaptability score between the subgroups. The alternative hypothesis was that there is a difference in the mean of the (dimension) adaptability score between the subgroups. A significance level of 0.05 was used to accept or reject the null hypothesis.

For the statistically significant findings, an effect size was calculated. Cohen's d was used to determine if the difference is meaningful and not just due to the sample size. A small effect size is considered to be 0.2, a medium effect size is 0.5 and a large effect size is 0.8 [20]. A large effect size means that there is a difference between the two groups, and it has practical significance.

A k-means cluster analysis was also conducted on the CBEAM responses to reveal groups of instructors that responded to the instrument in a similar fashion. Frequency of instructors in each cluster were examined and comparisons were made between subgroups within each demographic group.

V. Results

The descriptive statistics for CBEAM responses according to the 1-factor model and 2-factor model are shown in Table 2. For 2-factor model, the mean score for the Cognitive/Behavioral factor was significantly different (higher) than that of the Emotional factor ($t(97) = 5.36$, $p < 0.001$). The Cronbach's alpha measures indicate that the items within a factor are reasonably related as they are greater than 0.70 [21].

Table 2. CBEAM descriptive statistics, Cronbach's alphas, and CFA factor loadings

	M	***SD***	**Kurtosis**	**Skew**	**Cronbach's α**
1-Factor Model					
Total Adaptability	4.16	0.45	0.65	-0.28	0.85
2-Factor Model					
Cognitive/Behavioral	4.34	0.43	0.87	0.02	0.84
Emotional	3.78	0.69	1.16	-0.44	0.78

Table 3 shows the group mean scores and *p*-value statistics for the CBEAM [16]. For *p*-values less than the significance level of 0.05, the *p*-value is bolded and the Cohen's *d* is presented. Across all three demographics, participants' mean scores for the Emotional dimension was lower than for the Cognitive/Behavioral dimension.

Table 3. CBEAM [16] results (*n*= 59).
Mean scores are between 1 (low adaptability) and 5 (high adaptability).

Demographic	**Cognitive/ Behavioral**			**Emotional**			**Total Adaptability**		
	M	*SD*	*p*	*M*	*SD*	*p*	*M*	*SD*	*p*
Sex									
Male	4.23	0.15	**0.003** *	3.75	0.55	0.61	4.07	0.20	**0.025** **
Female	4.59	0.17		3.84	0.34		4.34	0.16	
Position									
Professor of Practice	4.55	0.15	0.10	3.67	0.79	0.65	4.26	0.21	0.46
Professor	4.30	0.17		3.80	0.42		4.13	0.20	
Rank									
Assistant	4.40	0.18	0.40	3.77	0.57	0.95	4.19	0.20	0.61
Associate & Full	4.30	0.18		3.78	0.42		4.13	0.21	

Note. *M* = mean, *SD* = standard deviation, *p* = *p*-value
*Cohen's *d* = 0.90, **Cohen's *d* = 0.64

Two differences were found to be statistically significant; both were between the two sexes. The first difference was that females scored higher than males on the cognitive/behavioral adaptability dimension ($t(33) = 3.18$, $p = 0.003$). This difference had the most practical significance due to an effect size of $d = 0.90$. Females also had a significantly different (higher) total adaptability score than males ($t(39) = 2.33$, $p = 0.025$). This difference also has meaningful significance due to an effect size of d = 0.64. No other statistically significant differences were found for any of the other CBEAM adaptability dimensions for sex, position, or rank status.

Figure 1 shows the results of the k-mean cluster analysis for the CBEAM 2-factor model responses. With $k = 2$, the clusters explained 55.1% of the variance and produced clusters that could be interpreted. The two clusters may be described in the following manner:

- Cluster 0 includes instructors with relatively high Cognitive/Behavioral and Emotional scores with a center at Cognitive/Behavior = 4.55, and Emotional = 4.25
- Cluster 1includes instructors with relatively lower Cognitive/Behavioral Emotional scores with a center at Cognitive/Behavior = 4.06, and Emotional = 3.15

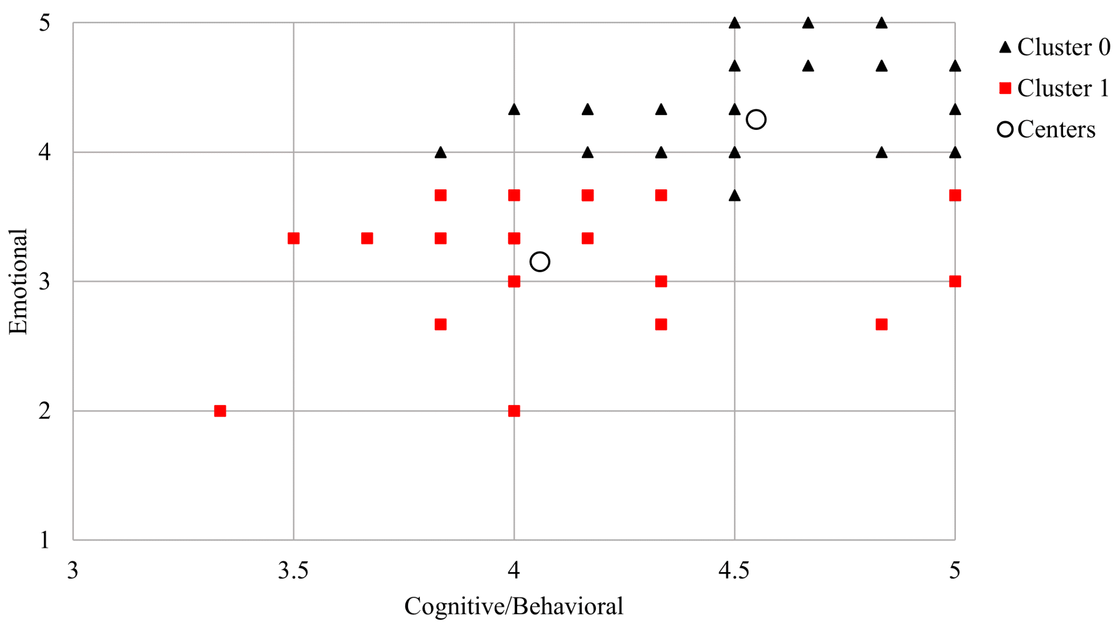

Figure 1. Clusters for *k* = 2

Table 4 shows the percentage of each demographic subgroup accounted for in each cluster. While it appears that female and assistant rank instructors appear less frequently in Cluster 1, differences in clustering between subgroups were not significant at a level of 0.05.

Table 4. Percent of demographic subgroup in each cluster

Demographic	Cluster 0		Cluster 1	
	n	%	*n*	%
Total	34	-	25	-
Sex				
Male	21	52.5	19	47.5
Female	13	68.4	6	31.6
Position				
Professor of Practice	6	60.0	4	40.0
Professor	28	57.1	21	42.9
Rank				
Assistant	16	64.0	9	36.0
Associate & Full	18	52.9	16	47.0

VI. Discussion

The instructors included in this study had, on average, high scores on the CBEAM factors. The mean score for these instructors was higher than that found for secondary school teachers [19]. The secondary school teachers' Total Adaptability mean score was 5.36 (SD = 0.78) on a 7-point Likert scale, or 3.84 on a 5-point Likert scale. High adaptability among university instructors is not surprising. A positive relationship has been found between education level and personal adaptability [22]. This means that individuals with advanced degrees, as are expected among university instructors, are likely to be more adaptable than those with lower degree attainment.

The most significant differences found in this study were between the sex subgroups, where females were found to score higher than males on the CBEAM Cognitive/Behavioral and Total Adaptability dimensions. Findings from other research agree with this result. Sex has been found to be significantly related to personal adaptability where females were more adaptable than males [22]. Literature suggests that a difference in adaptability exists due to women being better at dealing with emotions and less afraid to express fear or anger [22], [23]. However, in the present study there was no significant difference in female and male scores on the CBEAM Emotional dimension. The significant difference was in the Cognitive/Behavioral dimension, suggesting that the difference found is not emotionally dependent.

The lack of differences in adaptability based on position may support the idea that a certain type of person is attracted to a career in academia more generally, whether their appointment involves teaching only or teaching and research. That is, "personality might affect the job choices that people make . . . [and the] jobs for which people are hired" [24, p. 9-10]. From the perspective of recently hired assistant professors, personal adaptability is one of the four dimensions of academic employability [25]. Further, there are certain stressors associated with different careers. People with similar levels of adaptability may seek out and be hired into particular career paths. This means that the instructors studied here may be very similar as a result of a self-selection process in their career choice.

It is perhaps surprising that there was no significant difference between those with assistant rank versus associate or full rank. Since often an instructor at the associate or full rank has been teaching for longer than an instructor at the assistant rank, it was anticipated that they be less adaptable as similar studies have identified that the length of time at a single work site is negatively related to personal adaptability [22].

There were no significant differences in the demographics of the clusters. This is not surprising given the general lack of significant differences among the demographic subgroups' scores. This finding, particularly if it were to hold for the larger engineering instructor population, does make it difficult for those providing instructional support (e.g., professional developers, administrators) to assume that traditional ways of classifying instructors, by position and rank status, will have bearing on who is likely to be adaptable during a change. Perhaps other demographics (e.g., level of professional development with teaching and learning) might shed additional light on the potential adaptability of instructors.

It is possible that the CBEAM is not sufficiently differentiating instructors of low and high adaptability. This could be due to misinterpretation of items. This issue was explored in parallel in [26]. It may also be due to participants tending to rate items only as agree or strongly agree, rather than using the full scale. Another model of adaptability may provide more insight.

Limitations

This study had several limitations that may impact generalizability of results. First, this study took place at a single engineering college in a single university where the cultural differences impacting adaptability (e.g., hiring practices, teaching assignments) may or may not compare to other universities. Second, while the sample size of this study overall is sufficient, when parsed by demographic subgroups, the sample size is small. Small sample sizes may increase the likelihood of Type II errors, resulting in finding there is no difference between subgroups when there is. Third, the data is self-reported. While there was no direct pressure to respond to items in a certain manner, there was the possibility for social desirability bias. This bias entails participants responding to items in ways they think they should. Fourth, the participants self-selected to participate. There is a possibility that instructors with low adaptability chose not to participate, perhaps due to work stress. Therefore, the data may not capture the entire landscape of engineering instructor adaptability in the study setting.

Conclusion

This study investigated the adaptability of engineering instructors and whether adaptability varies by sex, position, and rank status. The aim was to explore the use one adaptability framework, the CBEAM, for its potential to provide insight into instructors' adaptability as it pertains to adapting to change in the instructional environment. Females were found to have higher Cognitive/Behavioral and Total Adaptability scores than males. No other differences were found. Future work entails exploring another adaptability framework and relating instructors' adaptability scores to changes in the WATPS they employ before, during, and after a forced change.

Acknowledgements

This work was made possible by grants from the National Science Foundation (NSF 2027471 and 2105156). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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