Response Process Validity of the CBE Adaptability Instrument When Used with Engineering Instructors

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I. Introduction

There have been several calls of action to change undergraduate engineering education with one focus being on the adoption of research-based instructional practices [1]. Adoption of research-based instructional practices have been shown to contribute to attracting and retaining undergraduate STEM students [2]. This is particularly important given that more than 60% of students pursuing a major in a STEM degree in the US do not complete their degree [3].

At the national level, it is evident that there is a need to change STEM education in order to be more effective and accessible to all students [3]. A similar sentiment has been echoed by students who have indicated that their undergraduate engineering education experience could be improved by changing teaching styles and techniques [4]. There is some indication that higher education is beginning to implement a wide range of teaching practices and strategies (WATPS) [2]. Including a WATPS is not only beneficial for higher education in terms of attracting and retaining students but also for students and industry as a WATPS assists with preparing work-ready graduates [5].

However, despite extensive research about how to promote change in undergraduate STEM education, systematic change has been limited [6], [7]. Many change initiatives and models that have been utilized to study and promote change have failed to achieve the adoption of research-based instructional practices at universities [8], [9]. Similar trends in research have been identified within engineering education [10]. Thus, it is evident that alternative and more holistic ways to understand and support change are needed.

The COVID-19 pandemic created a real-world laboratory to explore what instructional practices and strategies were changed and sustained when instructors were forced to use new instructional methods under uncertain situations. However, some of the research conducted during the initial COVID-19 period (March – May 2020) was not theoretically grounded e.g. [11], [12]. Of the research conducted during this period, a few studies used the theory of adaptability to explore instructors' experiences during the period when they adopted new instructional practices [13]–[17].

The theory of adaptability grounds the research presented here and is defined as "a means of understanding individuals' capacity to constructively regulate psycho-behavioral functions in response to new, changing, and/or uncertain circumstances, conditions and situations" [18, p. 3]. This definition is the basis for the Cognitive, Behavioral, and Emotional (CBE) adaptability instrument developed by Martin *et al.* [18]. The CBE instrument was developed after evaluating a combination of personality and psycho-educational theories. The theories and models evaluated included cognition, affective and behavioral theories, models of change, lifespan theory of control, and theories on buoyancy, resilience, and coping. The CBE instrument consists of three dimensions: (1) cognitive (thinking process), (2) affective (emotional response tendencies), and (3) behavior (actions). Each dimension is represented by three items on the CBE instrument. A person demonstrates adaptability when they make modifications or adjustments to these three

dimensions in the face of a novel (new and changing) or uncertain situation [19]. The original Martin *et al.* [18] conceptualization of adaptability was modified where "new" and "changing" were replaced by "novel" [19].

Validity and reliability evidence for the CBE instrument was collected in previous work [18], [19]. Internal and external validity evidence was collected with a sample of 2,731 high school students. The results illustrated that the global construct of adaptability showed that the nine items of the instrument were relevant and related to the construct being measured. In the exploratory factor analysis, it was found that the nine items could be represented in a two-factor adaptability instrument (cognitive-behavioral (six items) and emotional (three items)), or as a single factor adaptability instrument (nine items). In addition, the adaptability score was compared to external variables which favorably provided validity evidence for external construct validity or relationship with other variables (Table 1). However, there is no research that has produced validity evidence for the use of the instrument by engineering instructors in the context of teaching. The purpose of this study was to collect cognitive response process validity evidence of the CBE adaptability instrument when used with engineering instructors in the context of the instructional environment.

II. Theoretical context of response process validity

Contemporary theories of validity are used today to collect and analyze validity evidence for an instrument. According to Hawkins *et al.* [20], contemporary validity theory is unlike traditional approaches that determine validity as a statistical property of a test. Kane [21, p. 1] states that (in the contemporary view) "the validity of a proposed interpretation and use [of the instruments results] depends on the plausibility of the claims being made, and validation involves the evaluation of these claims." Zumbo and Chan [22] further elaborate that contemporary views seek to not only collect and analyze validity evidence of the content, relationship to other variables, and internal structure like traditional views, but also provide evidence for response process and consequences. A summary of the five sources of validity evidence is presented in Table 1, which has been developed through synthesis and integration using the American Psychological Association (APA) et al. [23], Deng *et al.* [24] and Hubley and Zumbo [25].

This work focused on the collection of response process validity evidence. Response process validity evidence can be collected using "think-aloud" techniques to assess the interpretation of instrument items [26]. Research has indicated that response processes are not well understood by researchers [22], [25]. Zumbo and Chan [22] described evidence for response processes referring to "the thinking processes involved when individuals give responses to items or tasks on selection procedures."

III. Research Question

The overarching research question for this study was: "How do participating engineering instructors interpret and make meaning of the items on the CBE adaptability instrument by Martin *et al.* [18]?"

Table 1. Five sources of evidence for validity argument adapted using the APA *et al*. [23], Deng *et al.* [24], and Hubley and Zumbo [25]

Validity Evidence	**Validity Evidence Description** based on APA *et al.* [23] and Hubley and Zumbo [25]	**Validation methods possibilities** adapted from Deng *et al.* [24]
Content	Relationship between the construct [concept/attribute being measured] of an instrument/test and the content [themes, components, wording and format of the items] of the instrument/test [23, p. 14].	Content analysis by panel of experts
Internal Structure	The degree to which the relationships among test items fit the construct (or construct components) [23, p. 16].	Factor analysis
Relationship with Other Variables	Relationship between the test/item score to other variables. This can assess relationships with external variables to the test construct or able to predict criterion scores [23, p. 16].	Correlation analysis
Response Process	"Explicit assumptions about the cognitive processes engaged in by test takers…concerning the fit between the construct and the detailed nature of performance or response actually engaged in by test takers" [23, p. 15]. This can be expanded to include affective (feelings and motivations) and behavioral dimensions of participant responses, and assess the influence of cultural, ecological and situational contexts [25].	Cognitive behavioral and /or affective (emotions and motivation) analysis of participant responses in situational, cultural, or ecological contexts [25]
Consequences	Positive and/or negative consequences based on intended and unintended interpretation and use of the test scores [23, p. 20-21].	Analysis of impacts of interpretation and use of test scores

IV. Methods

Setting & Participants

Cognitive interviews were used to explore the participants' interpretation of the CBE adaptability survey instrument. Participants were selected based on their participation in a larger study that utilized the CBE adaptability instrument. The participants were from an R1 university in the Midwest USA and had participated in the larger study for at least one year. The participants were identified and individually contacted to participate based on their engineering department, position, and gender. The participants were selected by the research team to ensure that a range of perspectives were included [27]. The participants selected represented tenured and tenure-track instructors and professors of practice across four engineering departments. A total of five instructors participated, of which three of the instructors were female which was an overrepresentation of females compared to the College of Engineering's overall demographics.

Data Collection

Data were collected during the Fall 2022 semester. Each instructor participated in a single interview. The interviews were conducted via Zoom video conferencing and lasted approximately one hour each. A think aloud protocol was used where participants were asked to verbalize their thinking while responding to the items on the CBE adaptability instrument. The interview protocol included semi-structured and open-ended questions related to the adaptability instrument. The semi-structured questions asked participants to describe their interpretation of each item, how they think they would respond to the item, and whether they found the item confusing. The open-ended questions asked participants to state their interpretations of "uncertain situations," "uncertainty," and "new situations." These open-ended questions were included because the research team found that these terms were difficult to interpret congruently amongst the researchers in their prior work. Therefore, it was anticipated a similar situation would arise with the participants. This was illustrated in a study by [14] where uncertain situations was clarified by the researchers as part of their analysis to mean "when a person faces an unexpected, unclear, or changing issue." Once the data were collected, the Zoom conferencing tool automatically transcribed the audio files into text. Then, each transcription was checked individually by a member of the research team for accuracy.

Data Analysis

The analysis provided response process validity evidence which is one of the five sources of validity evidence defined in Table 1. First, the interviews were analyzed to determine if participants found the item confusing when they initially read the item (pre) and after providing their interpretation of the item (post). The interview transcripts were thematically analyzed through an inductive coding process [28]. Codes were grouped and themes were developed. Themes focused on participants' across-item interpretations and within-item interpretations. When an item was found to be confusing or vague, the researchers further analyzed the participants' responses to interpret reasons why the confusion or vagueness occurred. Based on the rationale interpreted, recommendations to change the wording of items are presented.

V. Results and Discussion

A summary of participants' interpretation of the CBE adaptability instrument by Martin *et al.* [18] is found in Table 2. Participants found some instrument items to be initially confusing when reading the item for the first time (pre). Certain items (e.g., item 1 and item 5) became more clear for a participant at the end of their interpretation process (post). Only items 4 and 6 were not confusing for all the participants at any point in time. The other items had mixed responses. At the end of the interpretation process, 80% of the participants found item 2 confusing, 60% for item 7, 40% for item 5, and 20% for items 1, 3, 8, and 9. Table 2 also indicates the number of participants who responded differently to each item when thinking about a different context (research or personal life) when compared to the teaching context. Participant responses did not change when they thought about different contexts for items 2, 3, 6, and 9 (Table 2). All participants indicated that they did not feel pressured in general or by the presence of the interviewer when they provided a response to specific items. However, one participant did indicate generally that it would be less stressful if the survey was taken online. The following

sections present across-item and within-item confusions and make recommendations for changes.

Table 2. Summary of participants' interpretation of adaptability instrument items from Martin *et al.* [18]

No.	Item	Agreement pre (confusing) (out of 5)	Agreement post (confusing) (out of 5)	Response change when context changed (out of 5)	
				Research	Personal
1	I am able to think through a number of possible options to assist me in a new situation	2	1	2	0
2	I am able to revise the way I think about a new situation to help me through it	4	4	0	0
3	I am able to adjust my thinking or expectations to assist me in a new situation if necessary.	1	1	0	0
4	I am able to seek out new information, helpful people, or useful resources to effectively deal with new situations.	0	0	2	2
5	In uncertain situations, I am able to develop new ways of going about things (e.g., a different way of asking questions or finding information) to help me through.	3	2	1	0
6	To assist me in a new situation, I am able to change the way I do things if necessary.	0	0	0	0
7	I am able to reduce negative emotions (e.g., fear) to help me deal with uncertain situations.	3	3	1	2
8	When uncertainty arises, I am able to minimize frustration or irritation so I can deal with it best.	1	1	1	1
`9	To help me through new situations, I am able to draw on positive feelings and emotions (e.g., enjoyment, satisfaction).	1	1	0	0

Across item concerns

The use of the words “uncertain situations,” “uncertainty,” and “new situations” in the item prompts created confusion for participants across items. One example of how a participant struggled to interpret a prompt with “new situation” is found below:

> *I wouldn't call this a confusing prompt, but it's a little bit vague, just because what a new situation refers to is, you know, … like it's going to mean a different thing to each person.* (Participant A)

Similarly, trying to interpret “uncertainty” or “uncertain situations” created confusion. In an attempt to make sense of “uncertain,” participants tried to reword what “uncertain situations” meant when responding to an item. A participant elaborated:

> *It is a little bit confusing that it says in uncertain situations, because I have to think about what that really is. I believe this is asking me in situations with which I don't immediately know what I'm going to do.* (Participant B)

As part of the interview protocol, after the participants completed responding to the nine items, they were asked to state their interpretations of “uncertain situations,” “uncertainty,” and “new situations.” Variations in how participants responded included some participants describing “uncertain situation” in a similar manner to how other participants described "a new situation” indicating an unclear distinction between the two.

Upon delving further into participants’ responses, it was found that three out of five participants described uncertain situations as a situation where they do not know something (either about what is happening or going to happen). One participant indicated that an “uncertain situation” was a situation where they did not know what to do immediately. Another participant described an “uncertain situation” as an unexpected situation and indicated that they were unsure of whether an uncertain situation can be a new situation. Another participant described an uncertain situation can be a new situation, but not all new situations can be uncertain.

When requested to interpret “new situations,” one participant indicated this is when something unexpected happens or when one does not know what is going to happen. This description was similar to another participant’s description of an “uncertain situation.” Two out of five participants described “new situations” as situations never encountered before. Participants’ responses indicate differing interpretations of the phrase “new situations.”

Recommendation: Based on the variations in interpretation of the aforementioned terms, it is advised that these terms be defined in the introduction of the survey instrument as follows: A new situation is a situation that has never been encountered before. An uncertain situation is a situation which is unclear or unexpected [14] which could also mean that there is missing information to fully interpret what is happening or going to happen. It is possible that a new situation could be an uncertain situation, but an uncertain situation does not necessarily have to be a new situation.

Within item concerns

Specific issues and concerns related to an item are discussed in this section. Items that three or more participants were initially confused with are discussed and recommendations presented. In addition, item nine is presented, even though it was found confusing to only one participant. This was included because the researchers believed that a wording change (based on the analysis) could reduce participant confusion of the item.

Item 2: I am able to revise the way I think about a new situation to help me through it.

Four out of the five participants indicated that the prompt was confusing. One participant chose a neutral answer after struggling to interpret the prompt. An area that was confusing was interpreting "revising the way I think." One participant indicated that this is only possible with external input:

> *I wouldn't start out revising the way I think about a new situation. I would be thinking about how I normally think about it. …with additional data, or input from outside of myself, I can replace the thing about it.* (Participant D)

The use of the word "revise" could create confusion, as this could mean that the participant thinks of one way of solving a problem when faced with a new situation and is then required to revise that way. A new situation may require a revision in thinking from what one has used before to address an older issue. One participant indicated that you can only revise the way you think if you have options or think about options. This participant thought of an example to make sense of the item.

Recommendation: Based on the confusion, it is recommended that the question be reworded to: "I am able to reframe the way I initially interpret a new situation." The word "reframe" was used to in place of the phrase "revise the way I think" as it better captures the idea of being cognitively flexible when interpreting a new situation.

Item 5: In uncertain situations, I am able to develop new ways of going about things (e.g., a different way of asking questions or finding information) to help me through.

Three out of five participants found this item initially confusing. One participant required some reflection time to interpret the prompt:

> *Well, initially, yes, a little bit confusing. New ways of going about things...when I get to the point of reading "things", like okay, what things. But then the example a different way of asking questions or finding information clarifies it for me, and if I remember that we're talking about classroom teaching, then this helps. So, it took a little bit of reflection to get past the middle of the question, but then it wasn't, confusing anymore to assist me in a new situation.* (Participant A)

Participants thought about what the question was asking in different ways. One participant reverted to using the example in the item to guide their interpretation of the item:

> *Can I change what I've been doing in order to find out more information? Can I take the process that would go about doing things in order to help me?* (Participant D)

The participant below explained that this item is about problem solving which is more related to a cognitive process. However, this item is intended to ask a behavioral based question.

> *Can I problem solve with regards to undergraduate teaching in situations with which I don't immediately know what I'm going to do…Am I able to develop new ways?...basically this is asking me if you don't know what to do, can you figure out a way to do it?* (Participant B)

The middle part of the question "new ways of going about things" can be confusing. Participants would think about what type or variety of "things" (which could include cognitive elements) or focus only on the example illustrated in the item prompt which is "different way of asking questions or finding information."

Recommendation: To address the confusion, the question can be changed to: "In uncertain situations, I am able to change the way I go about doing things." This wording directs the participant to focus on behaviors by utilizing the word "doing" versus "develop", as the wording "develop new ways of going about things" could lead to the participant thinking about their cognitive processes such as problem solving, which is not the intent of this item.

Item 7: I am able to reduce negative emotions (e.g., fear) to help me deal with uncertain situations.

Three out of five participants found the item confusing. One participant believed that the prompt could be reworded, as it may not be possible to reduce emotions:

> *…but I think it can be reworded. Instead of reducing, I would say, overcome or move forward in spite of negative emotions, because I would not reduce the negative emotions. But I would say the skill is to acknowledge the negative emotions and have coping mechanisms that even though you feel stressed or fear, how can you continue to move forward with it.* (Participant D)

Another participant elaborated on this point further and explained that the word "fear" may be too strong of a word to use in the context of teaching:

> *But I don't think I can actually reduce those emotions. I just put them into the box for later… I don't associate the feeling of fear with teaching. So that's a little worrisome to me. I think of fear as like real fear. So, I think that might just be a little bit strong, it made me have to sit there and think about what the question is asking a little bit more. (*Participant B)

Recommendation: Examples of emotions such as fear can be removed and replaced with other words like anxiety or stress, as they are more closely aligned to the teaching context. The item can be reworded to avoid the words "reduce emotions" and be adjusted to read: "When dealing with uncertain situations, I am able to manage or control my negative emotions to help me get through."

Item 9: To help me through new situations, I am able to draw on positive feelings and emotions (e.g., enjoyment, satisfaction).

Only one out of five participants found the item confusing and interpreted the prompt in two possible ways with two potentially different answers to each interpretation.

> *I think it is confusing, because I'm not sure exactly what "draw on positive feelings" mean. I'm kind of going two ways with this. Does it mean looking at the bright side or does it actually mean looking back in my memories to happy teaching moments and saying, I can get through this new situation because if that's the case, I'd probably say neither agree or disagree. But if it just means looking at the bright side, then I strongly agree. So, I wouldn't agree to split the difference to accommodate my confusion.* (Participant B)

One participant interpreted the prompt as asking whether one is a pessimist or optimist in reacting to new situations. The participant further elaborated that a response to this item would be dependent on the situation.

> *The situation can be quite broad, I guess if I knew if I could pinpoint a situation, I think I would respond differently* (Participant C)

Recommendation: To limit the additional participant analysis of the words in the item, it is advised that this prompt be changed to: "To help me through new situations, I am able to draw on or generate positive feelings and emotions".

VI. Limitations

Despite the small sample size, the study did reveal important findings that could be used to improve the wording of the instrument indicating that the sample size was sufficient for the intended purpose. However, to further investigate how participant responses are affected by contextual environments, both within and beyond the teaching context of engineering education, studies with larger sample sizes would be necessary.

A second limitation exists in terms of the methods used in this research. Sometimes participants indicated that they were not confused and that the item was vague but they did not always provide a reason for why the item was vague. Additional probing questions could be used to explore "vagueness" beyond the probing questions used for "confusion."

VII. Conclusion

The aim of the paper was to assess the response process validity of the CBE instrument by analyzing engineering instructors' cognitive responses to the items on the CBE instrument. It was found that participants experienced difficulties in interpreting and making meaning of certain items on the CBE adaptability scale by Martin *et al.* [18]. Confusion in participant interpretation can lead to "misplaced" responses that can affect the cognitive response validity of the instrument.

To improve the wordings of the CBE instrument, participant responses to items were assessed and recommendations to the wording of four items were suggested. Only a single item (item five) had an interpretation that was misaligned to the intended CBE dimension. This misalignment was determined based on the use of the theoretical framework. In addition to the recommendations made to improve the wording of the four items, definitions of the words "uncertain situations" and "new situations" are recommended to be provided to the participants at the beginning of the instrument to assist them with interpretation of items.

Instructor adaptability is an alternative way to understand change within the teaching context. Understanding the individual adaptability of instructors can guide processes to support instructors to adopt research-based instructional practices. Adoption of research-based instructional practices can assist with improving learning and increasing retention of students enrolled in engineering programs.

VIII. Future Work

Based on the recommended changes, further work is required to assess reliability and develop a validity argument for the instrument in the context of undergraduate teaching and beyond. It is suggested that a similar process as illustrated in this paper be extended to a broader group of participants beyond either engineering or other R1 university settings. Additional contexts are suggested as findings indicated that responses on certain items are affected by contextual settings or environments. This finding re-emphasizes the importance of considering context when administering the adaptability instrument as it may yield different results when administered in different contexts or if participants are asked to think of different contexts. Expanding participant recruitment can assist in assessing the recommended changes to the instrument and can further improve the response validity argument.

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