Instructor Concerns and Use of Resources in the Development of Course Materials

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Introduction

A national push to reform engineering education has been in effect to enable the United States to stay globally competitive. In doing so, the field of engineering education has grown rapidly which has led to the development of new research-based innovations. An innovation “represents whatever change or reform is being implemented.” Therefore, for our research, using an exercise for the first time would be considered an innovation. Previous research has found that instructors are generally aware of new innovations but few have been widely implemented in classrooms. This “implementation gap” has led to fewer instructors using innovations that can result in a positive impact on students.

In order to better understand this implementation gap, it has been suggested to involve those who will use the innovation in the creation process. While doing so, the Concerns Based Adoption Model (CBAM) will be applied to provide a theoretical framework. CBAM describes innovation changes in the educational environment as a progression through sequential “Levels of Use” describing how the users’ efficacy and efficiency with the innovation increase as they adopt it. Past work in CBAM has shown that instructors’ Levels of Use rise (and therefore the positive impacts of the innovation increase) as they develop and address concerns. In CBAM a concern is “any thought or feeling that affects evaluation or planning of curricula materials.” Similarly to Levels of Use, concerns typically progress through the corresponding Stages of Concern as instructors’ use of the innovation develops. In short, research based in the CBAM framework has shown that strategically targeting interventions to address new adopters’ concerns is effective in increasing their Level of Use and Stage of Concern, and thereby improving educational outcomes.

Before utilizing CBAM, we must take into account that it was developed and primarily applied in the context of public, K-12 schools. This differs from a typical university setting as there is less administrative control over curricular and pedagogical choices. In turn, university professors are given the liberty and often encouraged to develop or personalize educational materials. Consequently, CBAM will be somewhat different in this application and it is unclear if the framework’s constructs of “administrator,” “instructor,” and “change facilitator” apply directly. As will be discussed in more detail in the sections to follow, we have therefore modified our application of CBAM to the particular context of university-level engineering education.

Background

CBAM was developed in the 1970’s and 1980’s by researchers at the University of Texas at Austin. Over this timeframe, three main components were created; Levels of Use (how individuals interact with the innovation), Stages of Concern (the feelings of individuals), and Innovation Configurations (how the innovation is adapted to a particular setting). When used in conjunction, these components aid in assessing and guiding the adoption of innovations in an educational setting. Explaining the full complexity of CBAM is beyond the scope of this paper but this body of research can be further explored in the included references.
One vantage point in which adoption can be viewed from is that of the instructor. Specifically, CBAM’s Stages of Concern (SoC) can be utilized as it focuses on how instructors’ beliefs and attitudes change as they progress through the implementation process. Concerns are the elements that construct the different SoC’s as summarized in Table 1.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Concerns</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 0</td>
<td>Awareness</td>
<td>Participant is not concerned or involved with the innovation</td>
</tr>
<tr>
<td>Stage 1</td>
<td>Informational</td>
<td>Participant is generally aware of the innovation but has not considered the demands or requirements of its use.</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Personal</td>
<td>Participant is unsure about their ability to meet the demands of the innovation. Barriers to implementation are considered in the realm of personal impacts.</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Management</td>
<td>Participant is focused on using the innovation in a routine, by-the-instructions manner. Concerns are focused on efficiency, organizing, managing and scheduling.</td>
</tr>
<tr>
<td>Stage 4</td>
<td>Consequence</td>
<td>Participant’s main concern is how the innovation will impact student understanding.</td>
</tr>
<tr>
<td>Stage 5 - Collaboration</td>
<td></td>
<td>Participant concentrates on working with others who use the innovation.</td>
</tr>
<tr>
<td>Stage 6 - Refocusing</td>
<td></td>
<td>Participant is actively engaged in how to improve the innovation or utilizing what they see as a better alternative.</td>
</tr>
</tbody>
</table>

Table 1. Summary of CBAM’s Stages of Concern

The concerns of instructors correspond to specific stages within the model with higher SoC associated with higher Levels of Use and therefore an increased potential for adoption. To progress to higher stages, resolutions of concerns must occur. For instance, if management concerns persist without a resolution for an extended amount of time, an instructor could revert back to personal concerns. To prevent this regression, appropriate resources should be made available to instructors to assist in resolving concerns in a timely manner and thereby supporting increased rates of adoption.

Although CBAM has not been widely implemented in engineering education, research from other approaches clearly indicate the presence of this “implementation gap.” Most engineering students are not benefiting from proven effective pedagogies and materials because there is an implementation gap between their creation and application.

**Purpose**

This work is part of a larger effort to understand and further close the implementation gap present in engineering education. Specifically, we attempt to directly observe this gap in action by studying individuals in their roles as developers and future implementers.
Methods

We observed and recorded a one-and-a-half day materials development workshop consisting of 17 instructors from 14 institutions working in small groups to develop new, research-based course materials for a sophomore level Mechanics of Materials course. Participants were given informational packets that contained previously researched misconceptions specific to their assigned content area. Groups were given the freedom to create any type of material such as demonstrations, homework problems or lectures but groups chose to focus on creating hands-on materials that were accompanied by a worksheet to guide students through the inquiry process. For example, the torsion group created an activity in which students manipulate a foam pool noodle and make observations on how a square grid deforms as a torsional load is applied. Audio and video recordings from each group at the workshop were then transcribed and analyzed by a single researcher using constant comparative coding and CBAM. Due to the differences in structures that influence the use of an innovation in K-12 versus university settings, CBAM’s SoC will be applied in a modified manner. Examples of the form concerns would take in a university setting can be found in Table 2.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Excerpt of Concern Cited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal</td>
<td>• I am not good at writing assessment questions.</td>
</tr>
<tr>
<td>Management</td>
<td>• How will we get the materials needed for the manipulative?</td>
</tr>
<tr>
<td></td>
<td>• Who will construct enough manipulatives for an entire class?</td>
</tr>
<tr>
<td></td>
<td>• How to best create a worksheet that follows along with the manipulative.</td>
</tr>
<tr>
<td>Consequence</td>
<td>• Will the exercise be confusing to students? Will they be able to see what we want them to see?</td>
</tr>
<tr>
<td></td>
<td>• How will we assess students? How will we know if they learned anything?</td>
</tr>
<tr>
<td></td>
<td>• How will the goal of the activity improve student understanding?</td>
</tr>
<tr>
<td>Refocusing</td>
<td>• Improving a previously created exercise that more directly addresses students’ misconceptions</td>
</tr>
</tbody>
</table>

Table 2. Modified CBAM’s SoC

We additionally coded the participants’ references to resources that would be needed or desired in the design and implementation of the course materials.

Codes were assigned based on the stage of concern or resource indicated followed by a brief summary of the topic being discussed. The code Concern – Unclear was assigned to statements that did not clearly reference one of the defined Stages of Concern. Table 3 provides an example of the code given to particular audio excerpts and the justification of the code based on CBAM.
“Do each of your students have one of those [manipulative]?”  
Concern – Unclear – number of manipulatives per student  
The participant did not reference if they were concerned about the impact on students or the management or cost of creating manipulatives.

“Our lab time is like a bonus and it means they [students] get a little extra time.”  
Concern – Consequence – lab time a bonus, gives students extra time  
The participant referenced how lab time impacts students by giving them extra time.

<table>
<thead>
<tr>
<th>Excerpt</th>
<th>Code</th>
<th>Reasoning</th>
</tr>
</thead>
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<td>“Do each of your students have one of those [manipulative]?”</td>
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<td>The participant referenced how lab time impacts students by giving them extra time.</td>
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Table 3. Example Coded Quotes

Each code was then grouped by its stage of concern to measure its frequency and to allow for the determination of the most prevalent stage of concern that participants’ held. Unclear codes were not further analyzed due to their inability to provide clear insight about the concern of a participant.

**Results**

Four of the six possible types of concerns were identifiable in our data. As shown in Table 4, Management and Consequence concerns were the most common. No Awareness and Informational concerns were identified. This is due to the participants developing their own materials and would therefore have no challenges or interest in “learning about” or “understanding” the innovations.

<table>
<thead>
<tr>
<th>Stage of Concern</th>
<th>Number of Times Cited</th>
<th>Percent of Total Concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Informational</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Personal</td>
<td>21</td>
<td>1.7</td>
</tr>
<tr>
<td>Management</td>
<td>227</td>
<td>18.5</td>
</tr>
<tr>
<td>Consequence</td>
<td>406</td>
<td>33.1</td>
</tr>
<tr>
<td>Refocusing</td>
<td>1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Unclear</td>
<td>571</td>
<td>46.7</td>
</tr>
</tbody>
</table>

Table 4. Concerns Cited

Due to their abundance, we have chosen to focus on Management and Consequence concerns. Consequence concerns were the most common type of concern, accounting for about half of all of the clear statements of concern made. Though Management concerns were cited only half as often in comparison to Consequence concerns, it remained the second most common concern referenced.

**Management Concerns**

The Management concerns identified generally fell into two broad categories: logistics surrounding the invented manipulative and classroom dynamics (The allotment of classroom time or utilization of space for example.).
Manipulative concerns referenced cost, needed materials, and the preparation time required to create the manipulatives. In the excerpt below, we see the participant was concerned about the amount of preparation time required for construction of the manipulative:

“Would you hire someone to prepare those? It looks like a lot of work to put all those grids and cutting and all that stuff?”

The “grids and cutting” refers to cutting exercise bands into one-foot lengths and marking them with an even grid to clearly demonstrate deformations and strains. The participant had already clearly indicated their belief in the value of the idea, but here they voice their concerns about its specific application in their classroom.

Another common concern was in regards to classroom management which varied from group size concerns to the amount of class time the new activity would take. Participants, especially those with fewer credit hours, seemed more hesitant to create and implement new activities that took longer amounts of time. When discussing the amount of time each participant had to implement a new activity one participant said:

“I think in my case and it is probably the same for you, I am aiming for things that take 10 minutes or so. That is really what I can afford."

The participant’s concern is clearly indicated in the use of the word “afford,” indicating that the primary constraint at that time was the allotment and use of class time. Again, the phrasing clearly indicates the potential value of the innovation – that is not an issue. The concern being expressed relates to the logistical allotment of class time.

**Consequence Concerns**

The Consequence concerns frequently aggregated into two categories: clarity of activity (For example, correct use of vocabulary, logical progression through the worksheet, or clear expectations.) and how to assess student learning.

Clarity of the activity often presented itself in the form of the use of vocabulary and wording but also in the ability of students to visualize a concept. Participants were concerned about addressing previous courses’ application of terminology and how this affects students in Mechanics of Materials. In the excerpt below, we see how terminology was a concern of the participants.

Participant A: “..sometimes some of the students even have a hard time understanding bending moment and torque. They are taking Physics at the same time and the terminology doesn’t always match. The Physics’ instructor uses torque a lot. I don’t know if anyone else..”

Participant B: “Yeah my students have come with the same thing. They use torque and moment is a new term for them. So they want to know what the difference between moment and torque is.”
In Physics (often taken before or concurrently with Mechanics of Materials), students are taught that the words torque and moment can be used interchangeably but this is not true when used in the context of an engineering course. Recognizing “terminology doesn’t always match” caused participants to be concerned about students’ understanding of terminology. Clearly, participants are concerned about the impact their choice of wording will have on students when they use the innovation.

Participants were also concerned about creating a worksheet that led students through the exercise to the intended outcome which can be seen in the examples below.

“I think instead of being general describe the strain here, I think I would give them a prompt, describe the strain, are you observing normal [referring to “normal strain,” the concept under study]? That would give them the words and let them know what we are wanting them to identify.”

This participant is refuting the way in which another group member had suggested phrasing the worksheet that correlates with the designed manipulative. Here, the participant is not worried about the logistics of implementing the activity but instead is focused on the impact their phrasing will have on student outcomes.

Additionally,

“Do you want to prompt them anymore? Like is it different from one end to the middle to the other end?”

This is a continuation of the previous excerpt where a different participant is suggesting further questions that will get students thinking about how the strain varies from one end of the pool noodle to the other when a torsional load is applied. Clearly, the participant is concerned about students gaining a better understanding of the phenomena.

Though participants were noticeably concerned about how the materials they developed affected students, they were also concerned about how they were going to assess this impact. This often included discussions about when to assess students (e.g. pre, post or both), how to track assessments, and what types of questions to ask. In one case, a participant did not think it was important to track student pre-assessments as seen in the following excerpt:

“I generally don’t. I am using them [pre-assessments] as a way into the discussion and as a way for them to self-assess where they have come from. I leave it on the students. But I don’t feel like I have to track everything and every assessment I give them. It is formative and not point based. If I am doing research, then I would need to track it.”

This excerpt is part of a larger group discussion about how each participant tracks pre and post student assessments. The use of the word “formative” indicates the participant is more concerned about students’ being able to gauge where they are in relationship to the content being covered than assigning grades.
Discussion

The preponderance of Consequence concerns could be expected from a group developing curricular materials, especially a group of experienced teachers all oriented to a particular learning framework (as is studied here). We noted, however, that one reason Consequence concerns were so common is that they often followed discussions where Management concerns were resolved. For example, when designing an activity, participants first had to decide on the amount of time they could devote to it before they could consider the impact on students. Since participants were well aware of their individual constraints in regards to time, they were able to resolve this concern and focus on their Consequence concerns. Examples of Management concerns and their resolutions are presented in the following section.

To resolve manipulative management concerns in regards to preparation time, a participant drew upon the resource of the availability of lab technicians which is cited below:

“We have lab techs, I would only fiddle around with one set and eventually I would say to the lab techs, can you make more?”

This participant was able to focus on the impact the innovation would have on students and held little to no concern in regards to the amount of preparation time required to make the manipulatives. He was able to alleviate this management concern since he had a resource of lab technicians available. Those without lab technicians had preparation time concerns but utilized students as a resource as follows:

“We could actually pre do that, oh wait that is a lot of toothpicks to do, we can let students do that.”

“So the pre-work is, have the students draw those squares?”

Part of the designed innovation required drawing squares on pool noodles and sticking a multitude of toothpicks on Rubik’s cubes with putty to demonstrate a phenomena not easily visualized by students. Though participants agreed this exercise would be beneficial to student understanding, they quickly recognized the amount of time it would consume to construct the manipulatives. Without the use of lab technicians, they were able to resolve this management concern through the utilization of students and continue to focus on the impact the activity would have on students.

The resolution of Management concerns often came from the utilization of available resources such as lab technicians or students. Some Management concerns were left without a resolution as they were beyond the control of the participant. For example, those who taught a four credit hour course desired the resource of having five credit hours which is demonstrated in the discussion to follow:

Participant A: “You know, we have a 4 credit hours. The way we have the schedule set up, we have 2 hour blocks.”

Participant B: “So you have 2, 2 hour classes? I have 5 classes a week, 4 which are lecture and 1 which is a 2 hour lab.”
Participant A: “That would be nice to have all that time.”
Participant B: “So this stuff [activities] I normally push off to the 2 hour lab.”

From this exchange we see how Participant B had a dedicated time where they could implement new activities while Participant A was limited by the lack of this “extra” resource and would have to incorporate activities into the given lecture time. Though Participant A acknowledged the importance of incorporating these new innovations into his classroom, he had to balance his Management concerns in regard to time.

Conclusion

The prevalence of Management concerns in response to Consequence concerns shows the importance of their interconnectedness. Though participants were often more concerned about how the materials were going to impact students, they were still aware of the logistical concerns in making the exercise feasible when it comes time to implement it in a classroom. Therefore, providing resources and structures within the academic setting that support the resolution of Management concerns may help assist instructors during the implementation process and aid in decreasing the implementation gap.

Future research will track the same cohort during the implementation process to inform additional ways in which the implementation gap can be bridged. Furthermore, the current study and future research can help guide further development of CBAM to more accurately depict the adoption of innovations in university settings.

Addressing the implementation gap is vital in getting research-based instructional materials into the hands of instructors. These research-based materials can directly benefit students and in turn, assist in creating globally competitive engineers.

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References