# AN ABSTRACT OF THE THESIS OF

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Traditional faculty development programs aimed at disseminating research-based pedagogy and innovations at potential adopters have helped increase awareness of these innovations; however, their adoption into engineering classrooms has been limited. This paper aims to present an alternative, pull-oriented approach to faculty development where faculty participants co-develop curricular innovations with engineering education researchers aimed at engaging engineering students in mechanics of materials. In this pull-oriented approach, faculty have greater influence, or pull, over the innovation development process, their adoption decision making, and the resources provided for them with the goal that this approach will lead to adoption of more engaging teaching practices in the engineering classroom. The purpose of this research is to describe how faculty participants interpret such an approach and how their contexts influence their adoption decision making. Multiple, descriptive-explanatory case studies were constructed from interviews with faculty during their adoption process and were evaluated using a constructivist framework. Findings from these case studies indicate that faculty development programs can be improved by empowering faculty in the innovation development and adoption process, engaging faculty throughout the entire adoption process, ensuring faculty have adequate resources for their adoption goals, and accommodating the unique contexts that faculty operate in. Additional findings seem to

indicate that course-specific faculty development and multi-year faculty development programs are also beneficial for initiating dissemination and sustaining adoption efforts.

# Pull-Oriented Faculty Development: A Multiple, Descriptive-Explanatory Case Study

by
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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Matthew S. Barner, Author

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# Chapter 1 - Introduction

Teachers are necessarily at the center of any educational reform and therefore their professional development is a critical component of improving education (Garet, Porter, Desimone, Birman, & Yoon, 2001; McKenna, Yalvac, & Light, 2009). Faculty development is a form of professional development geared towards teachers and often takes the form of workshops, seminars, and conferences during summers between academic years (Dancy, Brewe, & Henderson, 2007; Garet et al., 2001; Felder, Brent, & Prince, 2011). In science, technology, engineering, and mathematics (STEM) education, such faculty development programs typically focus on disseminating pedagogical innovations for prospective faculty to adopt and thereby improve their teaching and students' learning. These pedagogical innovations are often research based teaching strategies and curricular materials geared towards enhancing student engagement and learning. Common examples of such innovations include, but are not limited to: inductive learning, active learning, hands-on learning, and problem and project based learning (Biggs, 1996; Prince & Felder, 2006). In engineering education, these faculty teaching practices are thought to have a significant influence on engineering students' success, interest, and retention (Felder, 1993; National Research Council (NRC), 2012; Olson & Riordan, 2012).

While engineering faculty are often aware of these benefits, adoption of such pedagogical innovations has been less than desirable and lecturing remains the dominant method of teaching in many engineering classrooms (Borrego, Froyd, & Hall, 2010; Dancy & Henderson, 2008; Froyd, Borrego, Cutler, Henderson, & Prince, 2013; Jamieson & Lohman, 2012; Prince, Borrego, Cutler, Henderson, & Froyd, 2013). There are a multitude of contextual reasons that influence engineering faculty members' decisions to adopt pedagogical innovations, but some common barriers are: 1) faculty are not involved in the development of pedagogical innovations, 2) there is little to no engagement with faculty during the adoption process, and 3) faculty are not provided with adequate training, time, and resources to adopt across contexts (Dancy &

Henderson, 2008; Garet et al., 2001; Felder et al., 2011). Therefore, if faculty development is interested in improving engineering education through disseminating research based pedagogical innovations, these three barriers need to be addressed.

This study aims to present a unique faculty development program that is aimed to address these three issues with a pull-oriented faculty development workshop. By pull-oriented, the authors mean that the workshop is oriented around faculty needs, rather than any particular pedagogical innovation. This faculty development program took the form of a multiyear summer workshop over four years where engineering faculty co-developed curricular innovations with engineering education researchers. One of the main goals of the co-developed curricular innovations was to help increase student engagement and this led to many of the innovations taking the form of hands-on materials and demonstrations.

Following the third workshop, additional efforts were made to assist faculty with adoption during the academic year. These additional efforts included: 1) encouraging faculty to adapt—or pull—their co-developed curricular innovation in the manner they prefer, 2) providing each faculty participant with an aide to assist them during the academic year, and 3) ensuring faculty had enough curricular materials to engage all of their students. Therefore the purpose of this study is to investigate the participating faculties' interpretation of these three efforts and how their contexts influenced their adoption process through the following two research questions:

1. How do the participating engineering faculty interpret the researchers' faculty development efforts?
2. How does the participating engineering faculties' context influence their adoption decision making?

These two questions were answered through semi-structured interviews with the participating faculty and analyzed using multiple case studies. Semi-structured interviews enable the interviewer to learn about the interviewee's formulation of their perspectives within their own contexts; whereas rigidly structured interviews limit the range of experiences that can be shared amongst participants (Berg & Lune, 2012; Riessman,

2008). The case study is a valuable method for studying complex phenomena that are not easily distinguishable from their contexts (Baxter & Jack, 2008; Yin, 2003). The influence of faculty development programs on faculties' adoption of curricular innovations is a complex phenomenon that is not easily distinguishable from a wide variety of contexts. Therefore, case studies provide a powerful approach to constructively evaluate the faculty development program presented herein from the perspective of each participants' case, hence the need for multiple case studies. Both research questions are answered using their own types of case studies, descriptive and explanatory, respectively. Descriptive cases studies are used to describe an intervention and/or phenomenon (Yin, 2003), and are used in this study to answer the first research question by describing how the faculty participants interpret the additional intervention variables implemented after the third workshop. Explanatory case studies are used to explain contextual influences within a phenomena that are too complex to study via other means, such as surveys (Yin, 2003). This type of case study is used to answer the second research question by explaining each faculty participants' case through their unique contexts and the most influential contextual factors on their adoption decision making.

The findings of this investigation revealed all three additional efforts to be interpreted as overall positive influences on the participants' professional development and adoption decision making. While the how and why of such positive influences varied; common interpretations of these three additional efforts included enhanced empowerment, accountability, support, and engagement. Each participant's unique context also influenced how these three additional efforts supplemented one another and enabled faculty to pull and adopt their co-developed curricular innovations. The researchers' findings suggest that faculty development programs should aim to give teachers greater autonomy in the development, dissemination, and adoption of pedagogical innovations; all while making sure that teachers have the resources and support necessary for adoption to take place during the academic year.

Some limitations to the findings yielded from this case study approach are that not all aspects of the researchers' faculty development program and the participants' contextual influences can be studied with the same depth. Case studies need to be bounded within an appropriate scope to prevent them from compromising depth for breadth and from becoming unwieldy in the amount of data being collected and analyzed. This study focused on three specific additional intervention efforts made following the third workshop, but the researchers acknowledge that there are many more dimensions to their faculty development program and the participants' contexts that could have also been investigated in more depth. The Discussion chapter of this paper aims to highlight and discuss some of the additional salient interpretations that emerged as influential from the interviews with faculty participants, but were not initially bounded in the scope of their cases.

# Chapter 2 - Background

The following section aims to present the researchers' pull-oriented faculty development program and evaluation framework for the participant faculties' interpretations of said program. To do this, relevant literature pertaining to faculty development and innovation adoption models is first presented to justify the need for such a pull-oriented model. This is followed by a broad overview of the workshop and lessons learned after the first two workshops that guided the faculty development efforts being investigated in this study. Finally, the theoretical framework for evaluating these additional efforts is presented at the end of this section.

## 2.1 Relevant Literature

Traditional forms of faculty development in engineering education have focused on disseminating research-based pedagogical innovations to engineering faculty through a variety of means, such as: workshops, seminars, conference presentations, and publications (Dancy et al., 2007). These means have been largely successful in increasing engineering faculties' awareness of such innovations, but their actual adoption into the

classroom has been limited (Borrego et al., 2010; Dancy & Henderson, 2008; Jamieson & Lohmann, 2012). A survey study of U.S. engineering department chairs awareness and use of a variety of engineering education innovations yielded an awareness rate of 82%, but an adoption rate of only 47% (Borrego et al., 2010).

This gap in awareness and adoption is a difficult phenomenon to study and understand because of the variety of influential contexts on faculty behavior, ranging from institutional incentives to individual preferences. That being said, some common concerns expressed with traditional faculty development programs are that teachers are often not considered an important part of the development and dissemination of innovations and that there is little research effort devoted to interacting with faculty during the adoption process in order to improve professional development strategies (Dancy & Henderson, 2008; Felder et al., 2011). Also, many traditional faculty development programs do not provide teachers with sufficient time, training, and content-specific resources to make changes in their classroom practice (Garet et al., 2001; Loucks-Horsely, Hewson, Loves, & Stiles, 1998). Some additional reasons cited for lack of adoption inappropriately blame faculty, with little reflection on the limitations of an innovation or dissemination method. For example, personality factors, such as faculties' attitudes toward change is regularly cited as an opposing force to adoption (Borrego et al., 2010; Dancy & Henderson, 2008; Rogan & Anderson, 2011). While this certainly may be true for some faculty, the authors contend that the high awareness rate of pedagogical innovations amongst faculty suggests that they are attending faculty development workshops and seminars, and therefore are likely to be interested in and willing to adopt innovations. Thus, it is important to be more critical of faculty development and dissemination strategies, than of faculties' motivational behaviors.

By viewing faculty development programs as a means of disseminating pedagogical strategies, one can identify such programs as being either majority push or pull oriented. Push versus pull models of dissemination and adoption are frameworks for describing and analyzing any interaction between innovation developers and adopters

(Godin & Lane, 2013; Nemet, 2009). Briefly put, a push-oriented model of innovation dissemination is defined as one that originates from scientific or technological discovery; whereas a pull-oriented model is derived from customer or consumer demand (Godin & Lane, 2013; Langrish, Gibbons, Evans, & Jevons, 1972). In terms of faculty development, a push-oriented model can be described as linear, beginning with education researchers developing an innovation that is then disseminated to teachers through conferences, papers, workshops, seminars, etc. (Garet et al., 2001; Lee, Dancy, Brewe, & Henderson, 2012). This approach is often considered the most appropriate because, after all, it is education researchers' job to discover and develop pedagogical innovations. While faculty certainly have valuable input, they often have other work priorities that do not allow them to focus their time and resources towards conducting educational research (Borrego et al., 2010; Lee et al., 2012). However, many of the issues cited above with traditional faculty development programs are indicative of push-oriented models because they primarily focus on the innovation and not the adopters (Godin & Lane, 2013; Nemet, 2009).

A pull-oriented approach to faculty development would focus more on faculties' needs by giving them greater ownership in the innovation development process and control in their adoption decision making (Godin & Lane, 2014). Challenges with pull-oriented models are that adopters' needs are often considered unforeseeable and ever-changing, and therefore unpredictable and unlimited (Nemet, 2009). While this may be so, faculty should have, to some extent, a greater role in the development of research-based pedagogical innovations in order to bridge the gap between awareness and adoption. A valuable study in engineering education that can be used to support this contention is Borrego et al.'s (2013) survey of engineering faculty on their fidelity of implementation when adopting a variety of research-based pedagogical innovations. The results of this survey demonstrated a range of 11-80% fidelity of implementation for eleven different innovations (Borrego, Cutler, Prince, Henderson, & Froyd, 2013). Anything less than 100% fidelity would indicate a faculty member adapting an

innovation to some extent, and this survey shows that faculty do need to adapt, or pull, innovations in order to adopt them at some level. Another study proposes that faculty should play a role in the innovation process, because they can convey particular knowledge about their contextual classroom settings (Porter, Roessner, Oliver, & Johnson, 2006). These contextual classroom settings as well as other situational circumstances are likely what lead to lower fidelity of implementation percentages. Therefore, the authors contend that there is a need to investigate a pull-oriented model of faculty development where faculty are part of the pedagogical innovation development process. Such an investigation would provide a unique opportunity to describe and explore how faculty pull innovations and how their contexts influence their pulling.

## 2.2 The Pull-Oriented Workshop

The workshop began as a means of developing and disseminating research based curricular innovations aimed at addressing common student misconceptions in mechanics of materials. Mechanics of materials is a sophomore level engineering course usually taken by mechanical and civil engineering students after completing statics, and focuses on the behavior of solid objects subjected to stresses and strains. The course is also sometimes referred to as strength of materials or solid mechanics. Knowing that adoption of research based curricular innovations by engineering faculty is less than desirable (Borrego et al., 2010), the researchers decided to include future adopters—mechanics of materials instructors—in the development process of these curricular innovations. The goal here being that if engineering faculty are involved in the development process, then they would be more likely to adopt the curricular innovations they co-developed with other engineering faculty and education researchers. Each workshop has had 15 to 25 engineering faculty and 3 to 6 engineering education researchers in attendance. Thus, the workshop was oriented around the faculty participants and not around any particular set of pedagogical innovations. The workshop was set up over two days in the summer beginning with research being presented on common student misconceptions in mechanics of materials (Montfort, Brown, & Pollock, 2009). From there, the engineering

faculty collaborated with engineering education researchers to develop various curricular materials including, but not limited to, physical demonstrations and engaging classroom activities. While the research on student misconceptions provided direction for the development of certain curricular innovations, faculty were also encouraged to develop other innovations they thought necessary for their classrooms. Following the workshop, faculty were provided with the materials they co-developed so that they could adopt them during the academic year. In the following summer, the workshop is held again and in a round table discussion the faculty participants are encouraged to share their experiences with their curricular innovations during the academic year and then brainstorm ideas on how to improve moving forward. Then the remainder of the workshop is dedicated to developing additional curricular innovations or refine existing ones.

## 2.3 Lessons Learned

Following the second year of the workshop, participant faculty had developed a set of curricular innovations composed of several physical demonstrations and accompanying worksheet activities. The physical demonstrations were mostly highly deformable materials such as elastic exercise bands and foam swimming pool noodles that could easily illustrate stress and strain when deformed. These materials will be referred to as manipulatives throughout the rest of this paper. The worksheet activities were designed to guide students through using a manipulative or set of manipulatives while answering a series of conceptual questions often related to stress and/or strain. Each faculty participant was provided with a kit containing one of each physical demonstration and a binder including each activity and instructions on the intention and how to use each demonstration.

Faculty were interviewed after the academic year following the second workshop to understand their perception of their co-developed curricular innovations. The data collected from these interviews, as well as a round table discussion at the third workshop, indicated that faculty adoption of their curricular innovations was hindered by a wide variety of contexts across the participants. For the most part, however, faculty

participants felt that their designed activities took up too much class time, and that they were too constrained by the rigidity of the activities to adapt their innovations in a manner that would make them more suitable to their classroom needs. This is embodied in the following quotes from some of the participants:

> *"[W]hen I did [the activities] last year the wording was such that students spent time, but didn't accomplish anything."*
>
> *"I felt like I was to use what was provided and get feedback on that. And that was a little difficult because I didn't think that what was there on paper made sense. I didn't really feel like I should change it if it was being used for a study."*

These participants are referring to the kit made up of their co-developed curricular materials that was provided for them after the second workshop, and how they felt that the worksheet activities were time-consuming and confusing, respectively. While the participants had been encouraged to pull and adapt their curricular innovations to meet their needs, this was apparently not made explicit enough and some participants thought that they needed to maintain a high fidelity of implementation if they were to adopt. The faculty participants also expressed that they did not have the time or resources to create enough replicas of their manipulatives for each of their students to complete the activities.

For these reasons, it was decided at the third workshop that some additional efforts would be made to assist the participating faculty with adoption during the next academic year. These additional efforts consisted of: 1) being more explicit and intentional throughout the academic year with faculty about pulling their curricular innovations however they best see fit, 2) providing each faculty member with an aide to engage with throughout their term of instruction to help resolve any barriers to adoption as they emerge, and 3) providing each faculty member with enough manipulatives to put into each of their students hands. These three additional variables are described in more detail in the following subsections.

### 2.3.1 Pull

While in previous workshops faculty had the autonomy to develop their own curricular innovations and then implement them back at their institutions in the manner they best saw fit, this intention had not been made explicit enough amongst the faculty participants. Following the third workshop, faculty were more explicitly encouraged to implement the materials they developed in a manner that would be most conducive to them. Each aide had also been given explicit instructions to remind the faculty participants throughout their term of instruction that they could pull the materials to fit their curricular needs.

### 2.3.2 Aide

An aide is an assistant or helper to someone. Within this study, the aide assists the faculty participants with implementing their co-developed curricular innovations. The aide is not explicitly trying to influence the faculty participants' decision making; instead they simply assist faculty with whatever they need to adopt their innovations. In this way the faculty participants can contact their aide as frequently as they prefer and pull their aide to help them as necessary. For this study, there were two undergraduate research assistant's that performed the role of the aide, each responsible for half the participants. Both aides were seniors in engineering majors and had taken mechanics of materials in the past. They worked approximately 5-10 hours per week throughout each of their respective faculties' term of instruction. They were instructed to provide technical support and develop and deliver material requests as necessary for their faculty participants.

### 2.3.3. Student Kits

In previous years of the workshop, faculty would be provided a kit containing one of each demonstration and activity they had developed. Following the third workshop, a student kit was assembled that contained similar manipulatives to these demonstrations so that students would be able to conduct the activities on their own and follow along

with their instructor's demonstrations. Each student kit contained five manipulatives meant to demonstrate multiple mechanics of materials concepts. Over 600 student kits were created and sent out to engineering faculty across the United States. Faculty that received the student kits were either workshop participants or colleagues of workshop participants. This relieved the faculty participants of the time and resources necessary to have replicated their curricular innovations for all their students.

## 2.4 Supporting Literature

The motivation for these additional efforts is not only supported by the participating faculties' expressed needs, but also by findings from two similar pull-oriented faculty development efforts. The first example of a similar faculty development program was a multiyear study of engineering faculty adoption of research-based pedagogical innovations, wherein the faculty were given the autonomy to pick and choose which innovations to adopt and how they wanted to adopt them (Nelson & Hjalmarson, 2015). This aligns closely to the pull-oriented model mentioned earlier by allowing faculty to pull which innovations they prefer, even though the faculty in this specific program are not part of the innovation development process. Nelson and Hjalmarson (2015) found that the innovations selected and fidelity of implementation by faculty participants varied greatly across contexts. This highlights the importance for being intentional in enabling faculty autonomy to pull innovations towards their needs and within their individual contexts, as opposed to pushing a one size fits all type model of innovation and adoption.

Another similar faculty development effort to the one presented herein was a multiyear collaborative effort amongst biomedical engineering faculty and learning scientists to develop educational materials (McKenna et al., 2009). Participating engineering faculty in this study also collaboratively reflected with learning scientists during their adoption process. McKenna et al. (2009) claim that the engagement through collaborative development and reflection were a significant influence on changing faculty

approaches to teaching. In this way, the reflective engagement process with learning scientists during adoption offered the participants support on how to pull their co-developed materials to fit their needs.

While there are some other similar faculty development programs, the two programs previously discussed align the most with the pull-oriented faculty development characteristic of the program presented in this paper. The findings from these types of faculty development programs closely align with the lessons learned following the second workshop in the authors' faculty development program. Therefore, the purpose of this study is to investigate the additional three efforts—aide, student kits, and pull—that were provided following the third workshop because these were explicit requests that the faculty participants thought would improve their adoption of their co-developed curricular innovations. The two research questions aim to describe how faculty interpreted these three efforts and explain how their contexts influenced their adoption efforts. This is done within a guiding theoretical framework chosen based on its appropriateness for answering these types of research questions with qualitative data.

## 2.5 Theoretical Framework

Since the end-goal of faculty development is improved student learning through faculty adoption of pedagogical innovations, most evaluation efforts focus on collecting data from students' grades and their evaluations of their teachers (Felder et al., 2011). Evaluating student performance and their perspective of their instructors inevitably makes the assumption that better grades and/or positive student evaluations mean successful adoption of pedagogical innovations. This form of evaluation may be efficient for push-oriented faculty development programs where the pedagogical innovation being disseminated is already considered effective and its impact on student learning is purely a matter of faculties' fidelity of implementation. However, evaluating student perspectives and performance does not provide adequate information of faculties' interpretations and decisions while attempting to adopt curricular innovations.

In a pull-oriented faculty development program, such as the one examined in this paper, faculty are at the center of all innovation decisions. Therefore, it is important to understand their interpretation and the programs influence on their teaching before evaluating impact on students. Unfortunately, most faculty development program evaluations aimed at faculties' perceptions are participant satisfaction surveys with little to no effort to understand whether the program was valuable for faculty in their actual classroom practice (Felder et al., 2011).

With one of the main premises of a pull-oriented model being faculty autonomy during the adoption process, evaluation of such a model should focus on understanding faculties' perspectives during their term of instruction when they are actually making adoption decisions. This requires an evaluation framework that enables a more holistic consideration of the myriad of contexts that can influence faculty in their adoption of curricular innovations. Guba & Lincoln (1989) propose a constructivist approach to evaluation that they refer to as fourth generation evaluation. It is beyond the scope of this paper to discuss the preceding three generations of evaluation, but Guba & Lincoln (1989) contend that there are three major flaws associated with the rigid positivist nature inherent in the first three generations. These flaws are as follows: 1) evaluators stand outside of evaluation, 2) a failure to accommodate value pluralism, and 3) an over commitment to the positivist paradigm of inquiry (Guba & Lincoln, 1989). Such approaches miss opportunities to be more pragmatic for program evaluation and improvement because they deemphasize the role of evaluands' contexts and values. Evaluands are who and/or what is being evaluated (Guba & Lincoln, 1989). In the case of faculty development and this study, evaluands would therefore be the faculty participants and the pedagogical innovations that they are attempting to adopt. Therefore, the previous three generations would be inappropriate for evaluating the faculty development presented herein since this study seeks to describe and explore the faculty participants' interpretation and context. Also, the pull-based model to faculty development is a pragmatic approach built on continuous improvement to meet faculty needs as they

emerge, which means continuously evolving variables that are nearly impossible to evaluate adequately with a positivist approach.

Guba and Lincoln's (1989) fourth generation evaluation framework emerged as an alternative, constructivist framework, in response to the previous three generations inadequate accommodation of all stakeholders, specifically evaluands, in program evaluations. Fourth generation evaluation can be described as a constructivist framework because it has a relativist ontology, subjectivist epistemology, and a hermeneutic methodology (El Dessouky, 2016). Guba & Lincoln (1989) contend that fourth generation evaluation is a constructivist framework because: 1) ontologically, evaluators are subjective partners with evaluands in the creation of data, 2) epistemologically, phenomena can only be understood within the context with which they are studied, and 3) methodologically, fourth generation evaluation produces data in which facts and their interpretations are inextricably linked.

Such a constructivist framework aligns well with the research questions being interested in each participant's interpretation and context, and—perhaps more importantly—also aligns with the inherent collaborative nature of the workshop because the researchers and faculty are co-developing their curricular innovations together. For these reasons, Guba & Lincoln's (1989) fourth generation evaluation was chosen as the most appropriate theoretical framework for this study as it holistically encompasses the goals of this study and the faculty development program it seeks to evaluate.

To illustrate this theoretical framework of evaluation between participants and researchers, an example excerpt from one of the interviews is presented here:

> **Researcher:** You'd say, overall, the most helpful things that [your aide] did for you was having somebody to talk with weekly and keep everything in the forefront of your mind?
>
> **Participant:** Yeah, absolutely. It did. …I'm pretty sure I would not have spent as much time tweaking the activities as I did and getting to the point where I felt

> they were useful If I didn't have, almost feel like I had a responsibility, or I had…that I was…Oh, I can't think of the word I'm looking for.
>
> **Researcher**: Some sort of *accountability* there?
>
> **Participant:** Yeah, *accountability*. There we go. I felt *accountable.*

By the time this interview had occurred, the researcher had already heard from other participants that they interpreted their aide as instilling accountability. Because of this, the researcher was able to make a guess at the word the participant was looking for. In this way, past participants' interviews had influenced the researcher, which then led to the researcher influencing the participant in this illustrated instance. The participant describing their interpretation of their aide as holding them accountable was constructed in this instance by the researcher and participant, but also by the researcher's interactions with other participants and this participant's interactions with their aide.

This shared construction, allowed the researcher then to pursue this interpretation of *accountability* further, which led to a better mutual understanding of their constructed reality:

> **Researcher:** It's an interesting thing that it's been perceived that [your aide] helped hold you accountable. It's funny because had you not used the [manipulatives] or whatever, it wouldn't have been a big deal. You would have just had probably less to chat about with [your aide]…
>
> **Participant:** No, it would have been…a *missed opportunity* to interact with other people that teach this class. It's a *missed opportunity* for me to learn and try something.

From this further inquiry, the participant elaborates how not interacting with their aide would have been a *missed opportunity* to interact with the other faculty that that aid also communicated with regularly. This "*missed opportunity"* interpretation is further influenced by the participant's interaction with their aide and their aide's interactions with other faculty, but also illuminates a more personal interpretation of this participant's reality that is less influenced by the researcher than the "*accountability"* interpretation. These additional lines of inquiry create a thicker, more in-depth description of the

constructed reality which enhances the reliability and trustworthiness of the interpretation (Borrego, Douglas, Amelink, 2009; Creswell, 1998).

This inquiry led to one particular version of this participant's social reality being constructed and while multiple alternative interpretations could have emerged, that does not detract from the value and reliability of this finding (Guba & Lincoln, 1989; Walther, Sochacka, & Kellam 2013). Attempting to eliminate or reduce researcher bias or subjectivity by waiting for an entirely authentic response from the participant here may have resulted in a missed opportunity to extract a meaningful and reliable interpretation. According to Berg & Lune (2012), "pure objectivity is not a meaningful concept if the goal is to measure intangibles such as meanings, reasons, and understandings. These concepts only exist because we can interpret them." Furthermore, Hammersley and Atkinson (1995) contend that attempting to fully eliminate the *actual* influence of the researcher is impossible. "[T]he goal in a qualitative study is not to eliminate this influence, but to understand it and to use it productively" (Maxwell, 2013). Thus, the authors' goal with this illustration is to make transparent the reflexivity of their investigative and interpretive process in order to increase trustworthiness and reliability of the methods and results (Borrego et al., 2009; Maxwell, 2013; Walther et al., 2013). Fourth generation evaluation, therefore provided the most appropriate theoretical framework for evaluating the researchers' professional development efforts—the aide in this previous illustration—as influential variables within each case study that could be holistically interpreted in regards to each participant's context.

## Chapter 3 - Methods

Based on the theoretical framework described above, a qualitative, multiple, descriptive-explanatory case study methodology (Yin, 2009) was implemented to analyze seven workshop participants' interview data. According to two prominent case study researchers, Robert Yin (2003) and Robert Stake (1995), the case study approach is philosophically based on the constructivist paradigm, and this paradigm also guides Guba

and Lincoln's (1989) fourth generation evaluation. A case study methodology is considered to be one of the more useful approaches for analyzing and reporting information about an individual, setting, event, or group that can then be presented and experienced vicariously (Berg & Lune, 2012; Guba & Lincoln, 1989; Stake, 1995; Zeller, 1995).

One of the advantages of the case study approach and why it aligns so well with fourth generation, constructivist evaluation is the close collaboration between the researcher and participant, which enables the participant to tell their stories and construct reality through a dialectical discourse with the researcher (Baxter & Jack, 2008; Crabtree & Miller, 1999). Such a methodology guided in-depth data collection through multiple interviews and analysis into the seven participants' cases and their relation with the three variables of interest for this study. These three variables were the additional efforts implemented after the third workshop: 1) the pull, 2) the aide, and 3) the student kits.

Descriptive case studies are used to describe how each participant interpreted these three variables and answer the first research question:

1. How do the participating engineering faculty interpret the researchers' faculty development efforts?

Explanatory case studies are used to explain how each participant's context influenced their adoption decision making and answer the second research question:

2. How does the participating engineering faculties' context influence their adoption decision making?

Multiple case studies were used to represent each of the seven participants as their own unique case. This allows for similarities and differences to be drawn across each case, making findings more compelling and robust (Yin, 2003; Berg & Lune, 2012). How and why seven participants were selected is discussed in the following subsection.

## 3.1 Participant Selection

The researchers selected participants from the group of instructors that attended the third summer workshop. Instructors were recruited to attend the workshop through emails, conference networking, and snowball sampling through previous workshop participants inviting their colleagues to attend future workshops (Patton, 1990). Sixteen instructors attended the third workshop. Seven of these instructors ended up teaching mechanics of materials in the following academic year; while the other nine shared their co-developed materials with colleagues at their respective institutions that were teaching mechanics of materials that year. This led to a total of thirteen instructors that were implementing the materials developed at the workshop in some capacity. While all thirteen were interviewed, only the seven that had attended the third workshop were chosen for analysis because their cases represented the only instructors that participated in the development and implementation of the new curricular materials. In this way, these seven participants were purposefully selected based on them being the most relevant cases for the research questions and purpose of this study (Maxwell, 2013).

Of the seven participants, five were community college instructors and two were university instructors. Teaching experience ranged from 6-18 years, while experience teaching mechanics of materials ranged from 2-17 years. One faculty participant taught a semester (15-week) long course, while the other six taught quarter (10-week) long course. Class size ranged from 20-35 students, in class hours per week ranged from 3 to 6 hours, and lab hours per week ranged from 0-3 hours across the participants. This sample size of seven instructors was considered appropriate for this study because it was large enough to represent a range of diverse experiences, but small enough to allow for deeper inquiry into each instructor's unique contexts (Patton, 1990). Focusing on these seven instructors allowed for the researchers to study in detail the three variables within each case, thereby creating more depth to each case (Campbell & Ahrens, 1998).

## 3.2 Data Collection

In-depth, semi-structured, open-ended interviews were conducted with each instructor at the beginning and end of their term of instruction. Interviews were chosen as an appropriate means for data collection as they allow for interpretations and experiences to be made explicit and therefore knowable and meaningful (Patton, 1990). Furthermore, in a constructivist framework, meaning and interpretation of responses is negotiated amongst the researcher and participants and the open-ended interviews enable this negotiation to take place (Guba & Lincoln, 1989). While both interviews were open-ended, there were protocols developed for each to maintain some structure and a manageable scope (Campbell, Quincy, Osserman, & Pederson, 2013), as well as to help guide the interviewer. Table 1 shows example questions from each protocol.

*Table 1: Sample Interview Protocol Questions*

| 1st Interview Protocol | 2nd Interview Protocol |
|---|---|
| • Have you implemented similar curricular materials in your previous courses?<br>• What are your plans with the demonstration materials we sent you? Which activities do you plan on using and how?<br>• Do you think your aide will help in in allowing you to meet your goals from the workshop?<br>• How do you plan on using the student kits? | • What was your favorite and/or least favorite part about your involvement with this project?<br>• Is there anything you wish we could have helped you with more or any recommendations for us moving forward?<br>• Please explain how your interactions with your aide helped or did not help you implement your curricular activities?<br>• Will you continue to use these materials in future mechanics of materials courses? |

Conducting two interviews with each instructor at the beginning and end of their term of instruction provided a means to renegotiate meaning, identify changes in perspective, and further validate findings (Patton, 1990; Maxwell, 2013; Creswell, 1998). Furthermore, the interviewer had developed a rapport with each participant through collaborations at the third workshop and through additional email communication throughout the academic

year. In fourth generation evaluation, having rapport with the participants is considered to increase trustworthiness between stakeholders and therefore the credibility of the data constructed between the researchers and participants (Guba & Lincoln, 1989; Berg & Lune, 2012). Each interview lasted anywhere from 30 to 90 minutes in length and were recorded and transcribed for later analysis. Transcriptions were either done by the interviewer or a third party transcriber resulting in the text data used for analysis.

## 3.3 Data Analysis

Analysis of the text data began with coding the interview transcripts with the goal of iteratively constructing codes from the raw text towards answering the research questions (Auerbach & Silverstein, 2003). The coding method employed contained multiple iterations that can be loosely grouped into three major cycles. The first cycle consisted of inductive coding, followed by a second cycle of deductive coding, and finally a third cycle of deductive coding again, but with an external reviewer to enhance reliability of the codes generated (Campbell et al. 2013, Miles, Huberman, & Saldana, 2014). The first cycle is described in the following paragraph.

Interview transcripts were initially printed and coded inductively by hand using multiple colored highlighters. This process was iterative, meaning that as codes changed and/or new codes emerged in later transcripts, earlier transcripts were re-read so that each new iteration of codes were applied to each transcript. Once a final iteration code set had been applied to each transcript, the transcripts were loaded into Dedoose (version 7.6.6) qualitative data analysis software, which was used to apply the final, inductively generated coding-scheme. This was done to manage the coded transcripts and to unitize coded excerpts from non-coded excerpts for further analysis (Campbell et al., 2013). These coded excerpts were then coded again, but deductively based on their relevance to the three variables of interest and the research questions. While the researchers were specifically interested in the interpretations and influence of the three variables, the interview transcripts were coded inductively initially to prevent any bias towards these established variables and allow for other perceived influential variables to emerge in the

participants' interpretations (Miles et al., 2014). Some of these emergent variables are discussed later in the Discussion chapter of this paper.

The second cycle of coding was deductive because it was guided by the patterns that emerged in the first cycle of coding and applied to excerpts about the three variables: the pull, the aide, and student kits (Miles et al., 2014; Auerbach & Silverstein, 2003). This was done for two reasons: first, to reduce the number of excerpts down to a more manageable and relevant amount and second, to begin identifying the most important findings within each variable and across each case (Auerbach & Silverstein, 2003). In this way, the unit of analysis is the relevant excerpts defined in the first cycle of coding, and then the second cycle of coding is working to identify the most relevant units for constructing each case around each variable.

Finally, the third cycle of coding was deductive as well, but conducted with an engineering education researcher not involved in the project. This was done to assess the reliability of the previously established codes and to negotiate any possible different interpretations (Campbell et al., 2013). Any disagreements on the previously established codes were negotiated until a more appropriately operationalized code could be mutually agreed up with the external researcher.

Each participant's case study then represents the final unit of analysis. Since there are seven cases coded across three variables, the researchers were able to explore and analyze 21 potential differences and similarities within and across the contexts of each case, increasing the robustness and reliability of the codes found (Baxter & Jack, 2008). Each case, therefore, is bounded within each participant's own context and is its own unit of analysis (Miles et al., 2014; Baxter & Jack, 2008). The goal for each unit of analysis then is to provide a comprehensive, description of the participants' interpretation of the three variables to answer the first research question and then to be able to explain how each case's context influenced the interrelation between these three variables to answer the second research question. Figure 1 illustrates the scope of each case in regards to the

three variables and the participants' contexts. The contextual influences highlighted in Figure 1 illustrate some of the most salient contextual influences across the cases, and does not mean to represent the only contextual influences for each case.

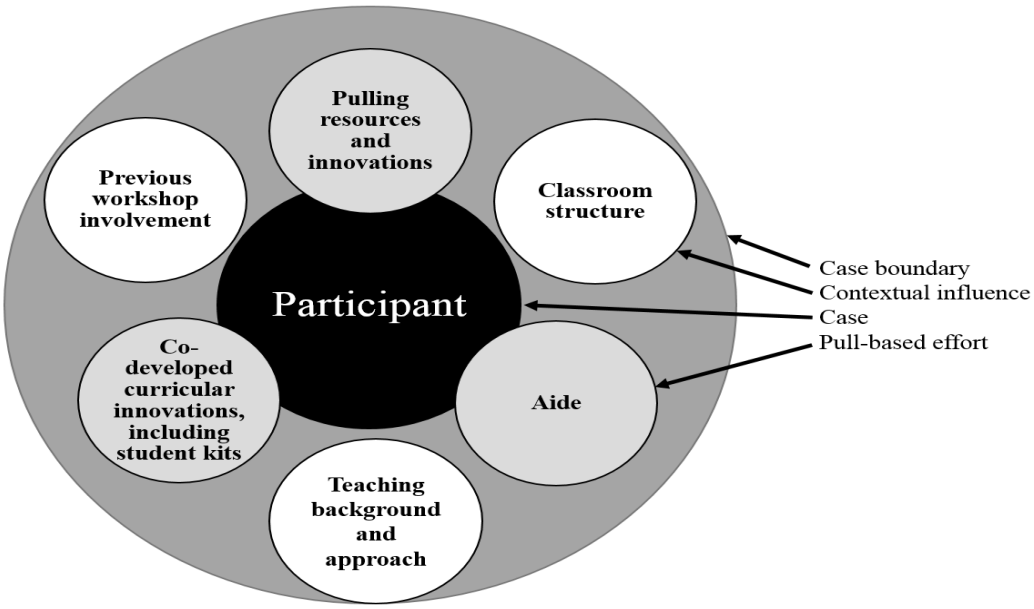


*Figure 1: Case Boundary*

## Chapter 4 - Findings

The purpose of the following chapter is to present the most salient findings relevant to the research questions and therefore this chapter is organized into two parts with one part dedicated to each research question. The first part focuses on answering the first research question by presenting the codes that were determined from each case to describe the participants' interpretations of the three variables. The second part then focuses on answering the second research question by explaining the major contextual influences in each case and the interrelation of those three variables. It should be noted that other findings emerged throughout the data collection and analysis that were not within the scope of this project. These other findings are presented and discussed in the Discussion chapter that follows this chapter.

Before presenting the findings, relevant background information for the participant faculty is presented in Table 2 to provide the reader with some insight into each faculty member's experience.

*Table 2: Faculty Participants' Background Information*

| Case | Institution Type | Term Length (Weeks) | Class Size (# of students) | Class (Lab) Hours/ Week | Teaching Experience (Mechanics Experience) in Years | Workshops attended | Other Classes Taught |
|---|---|---|---|---|---|---|---|
| Mark Twain | Large CC | 10 | 30 | 5 (0) | 6 (6) | 3 | Intro physics, intro to engineering, statics, dynamics, graphics |
| Ayn Rand | Medium CC | 10 | 30 | 5 (0) | 18 (17) | 2 | Intro to engineering, statics, dynamics, thermodynamics, circuits, graphics |
| Anne Rice | Small private university | 15 | 35 | 3 (0) | 17 (12) | 2 | Intro to engineering, statics, dynamics, fluid mechanics, surveying, civil engr. capstone |
| Clive Hamilton | Large CC | 10 | 25 | 4 (0) | 6 (3) | 1 | Intro chemistry, intro to engineering, statics, dynamics, hydraulics, circuits, graphics, bioengineering. |
| George Orwell | Small public university | 10 | 30 | 3 (3) | 8 (8) | 2 | Intro to engineering, statics, dynamics, structural design, civil engr. capstone |
| Lewis Carroll | Large CC | 10 | 30 | 5 (0) | 15 (2) | 2 | Intro physics, intro to engineering, statics, circuits |
| Toni Morrison | Large CC | 10 | 20 | 6 (2) | 9 (4) | 2 | Intro physics, mathematics, intro to engineering, graphics, thermodynamics |

## 4.1 Coded Interpretations of the Three Variables

This section focuses on answering the first research question by presenting the codes developed to operationalize the participants' interpretations of the three variables—pull, aide, and student kits. Table 3 presents the codes developed for each variable with their operational definitions.

*Table 3: Developed Codes and Operational Definitions for Each Variable*

| Variable | Code | Operational Definition |
|---|---|---|
| Pull | 1. Empowerment | Empowerment includes awareness of one's own autonomy and ability to pull their adoption process. It also encompasses the self-recognition of being an expert in one's own adoption process. |
| | 2. Preference | Preference is a way of expressing empowerment through choice. This includes making the decision to adopt or not adopt something, or to utilize or not utilize a resource that was provided for them. |
| | 3. Personalization | Personalization is a way of expressing empowerment that often manifests after a preference is made. Therefore personalization includes adapting the curricular innovations and resources that the faculty participant preferentially chose in any way. |
| Aide | 1. Accountability | Accountability represents action that was taken due to the intervention of the aide that might not have been taken had that intervention not occurred. Accountability includes increasing one's own awareness of their own goals, so that change and adoption efforts are sustained. |
| | 2. Support | Support represented assistance being provided in resolving barriers of any size. It also represents the comfort of having a designated resource readily available to help. |
| | 3. Reflection | Reflection includes extended engagement with one's own adoption process. This includes thinking about their decisions and ways to improve their curricular innovations and teaching strategies as a result of communicating with their aide. |
| Student Kits | 1. Enthusiasm | Enthusiasm includes the faculty participants' excitement to use the kits and try new methods of teaching as a result. It also encompasses their perception of the kits increasing their own students' enthusiasm. |
| | 2. Accommodating for teachers' time and resources | Accommodating includes interpretations of the student kits saving the faculty participants' time and resources by not having to assemble dozens of student kits on their own. It also included how this resource saving effort allowed for faculty to focus their resources on other areas of their adoption. |
| | 3. Accommodating for teachers' engaging their students | Accommodating in this code includes interpretations of the student kits helping faculty participants engage their students. This included enabling the ability to facilitate more engaging discussions and exploring the technical content of the course in new ways. |

The following subsections explore each of these codes in more detail while providing additional examples quotes from the interviews to support each codes operationalization of the participants' interpretations. It should be noted that each example does not always exemplify one code and that there often is overlap of the applied codes to each excerpt. The selected quotes for each code were chosen to provide the reader with the most appropriate illustration of each code's operationalization.

### 4.1.1 Empowerment

While increasing faculty autonomy in the innovation development and adoption process was one of the initial goals of the workshop, if faculty are not aware of this goal then they may not express their autonomy. One of the main goals of the pull variable was to be more explicit and intentional towards the faculty participants about their autonomy and ability to pull their co-developed curricular innovations towards their needs. Some of the faculty participants interpreted this pull variable as increasing their awareness of their autonomy and thereby empowering them to pull their co-developed curricular innovations however they best saw fit. While many of their co-developed curricular innovations had a specific intent or method of use; faculty were encouraged to adapt and pull their innovations toward different classroom needs in order to at least initiate the adoption process.

In her second interview, Rice expresses how being able to pull empowered her to take ownership over their co-developed curricular materials:

> **Rice (2):** I felt like I had more license to change. […] I had more of a…a little more of a license to just go ahead and tweak this for my class and share back and that made me feel much better about using the material. I did, I took to things and I changed them and I've made it my own style […] so that was really…helped me use it more.

In this excerpt, Rice says she felt she had "more license to change" and pull their co-developed curricular innovations towards her own style and how that helped with her

adoption. This license to change, or pull, was empowering for Rice because it gave her greater ownership over their co-developed curricular materials and her adoption process.

Another example of the pull variable being interpreted as empowering through increased ownership came from Carroll's first interview:

> **Carroll (1):** I want to teach [mechanics of materials] next year because I'm still…these [innovations] are still evolving. I still want to continue.

Here, Carroll expresses that being able to pull their co-developed curricular innovations has continued their evolution and this empowers him to want to continue with his adoption process and continue improving his mechanics of materials teaching and their co-developed curricular innovations.

In addition to increased ownership, the pull variable was also interpreted as empowering by acknowledging that the faculty participants were the experts of their classrooms. Orwell exemplifies this in the following excerpt from his second interview:

> **Orwell (2):** It's nice to just be recognized as experts, all of us, on whatever level and to come in and try to advance.

For Orwell, being recognized as an expert of one's own classroom, regardless to what degree, empowered him to continue pulling with his adoption decisions and advance through his adoption process.

These excerpts illustrate some of the different ways in which the faculty participants interpreted the pull variable as being empowering. The ways in which this empowerment interpretation of the pull variable manifested in their adoption decision making also varied, but was commonly interpreted as empowering them to preferentially select and/or personalize their co-developed curricular innovations, and also influenced how they chose to pull their aide.

### 4.1.2 Preference

One of the ways the faculty participants interpreted pulling was through their preferential selection of which co-developed curricular innovations they chose to adopt and how they preferred to utilize their aide. This preference interpretation manifested in a variety of different ways across the participants, and this is not necessarily surprising since each participant pulls towards their own unique contextual and classroom needs. For Rice, she expresses in her second interview how she was more confident in pulling the co-developed curricular innovations that she preferred for her classroom:

> **Rice (2):** I definitely probably trusted [activities] that were based off things that I'd been doing before anyway because I also didn't feel like I had to throw something out to bring that in. It was a tweak of something that I was already doing that I felt was valuable. I guess I understood the, I had more confidence because I'd seen what they were.

Here, Rice expresses how she preferred to pull the co-developed curricular innovations that were more aligned with the way she had been operating her class in the past. While this example may represent a limited form of adoption, it does illustrate the value of being able to pull in this case so that Rice could improve upon her existing approach. This example also highlights that radical changes to curriculum through full-fledged adoption may be so intimidating and overwhelming for faculty that they abandon adoption. Therefore, allowing faculty to pull the changes that they prefer allows for, at a minimum, incremental improvement.

While faculty sometimes expressed their preference for one of their co-developed innovations over another, faculty participants also expressed their preferences when pulling their aide. Each aide was encouraged to offer assistance in developing additional curricular materials for their faculty as needed, but some faculty expressed a preference to not use their aide in this way. In his second interview, Twain expresses why he preferred to not pull his aide towards the development of additional worksheet activities:

> **Twain (2):** It's hard to say, "Can you create some worksheets that will really work, that will get to the bottom of the confusion for students […]?" That ain't

> going to happen until I do it a few times […]. Those are the things that I'm still figuring out.

In this excerpt, Twain expresses that he would prefer to create the worksheet activities himself, at least initially; rather than ask his aide to do it. This is because Twain sees it as a problem that is best suited for him to resolve since he is more in tune with his own students' confusion. Twain prefers to not pull his aide in this way because of his preference to create his own curricular materials; not necessarily because he views his aide as unqualified for the task. He simply prefers to go through the iterative process of trial and error before asking someone else to go through this process for him.

In Orwell's second interview, he expresses a similar preference to not pull his aide towards developing additional curricular materials:

> **Orwell (2):** I think given the distance and…I wouldn't say there was much of a delay because he was pretty timely getting things back to me, but I don't know if it's necessarily a model for the teacher. I would probably prefer working with my lab tech here at the school […].

Orwell initially expresses here that his aide was timely in providing him with additional materials, even though he and his aide operated in remote locations from each other. Still, Orwell expresses that he would prefer to work with his lab technician that is located at the campus he teaches at. In this case, Orwell shows that he is comfortable asking someone else to develop materials for his classroom, but that he would prefer to not have to work remotely with them. This illustrates that while Twain and Orwell expressed similar preferences of not pulling their aide towards developing additional materials, they did prefer distinct ways of developing additional materials based on their contexts. It is difficult to say for sure, but perhaps if Twain had his own lab tech located at his institution, he might be more willing to let someone else develop worksheets for him if they have more localized knowledge of his context.

While preference was one way the participants interpreted their ability to pull, preferentially selecting not to do or utilize something is actively abandoning adoption.

Some of the participants did attempt adoption and then for a variety of reasons made the preference to stop adopting that innovation or resource in their own particular way. For instance, Orwell did utilize his aide and have him send additional materials, but then decided that it would be better for him to utilize his lab tech for such roles because they provide more localized support. This shows how engaging in the adoption process allowed some of the participants to become more aware of their preferences so that they can begin the adaptation and personalization process.

### 4.1.3 Personalization

Personalization embodies the initial intention of the pull-oriented model for faculty development. The idea being that if faculty can pull innovations and their adoption process, then they will personalize and adapt innovations in a way that makes the adoption process less likely to be abandoned. Once this intention was made more explicit after the third workshop, the faculty participants interpreted this variable as allowing them to make all sorts of personalization decisions with their co-developed curricular innovations. For example, in her first interview Morrison expressed how she personalized her student kits:

> **Morrison (1):** […] so I've repackaged the [student kits], and I have now just a box of foam beams and a box of the [foam] noodles, and so I just bring out what we're going to use that day.

Similar to Morrison, another faculty participant expressed that the student kits brought too many manipulatives into the classroom at one time. This excerpt illustrates how Morrison personalized her student kits to deal with this challenge by repackaging the manipulatives into multiple boxes containing just one type of each manipulative. In this way, she pulled her student kits into several separate manipulatives that she could bring in one at a time to avoid any distractions caused by the other manipulatives in the student kits. Such a personalization might seem obvious and one that a faculty member would make regardless of the additional effort of make pulling explicit, but not every faculty member ended up making this personalization. This shows that the faculty participants'

perceived different challenges and barriers to implementing their innovations and that by encouraging them to pull they can come up with their own unique, personalized solutions for their needs.

Another way this personalization interpretation was represented amongst the participants was in their adaptations of their worksheet activities associated with the manipulatives. Rice exemplifies this in the following excerpt from her first interview:

> **Rice (1):** I'm trying to use what we developed in the workshop and I think it works for me because I'm an engineering teacher with my own preferences about how to do things. That means taking those worksheets and making changes or editing them.

Here, Rice expresses how her preferences guided her personalization of the worksheets so that she can pull their co-developed curricular innovations developed at the workshop towards her style. This excerpt shows that for Rice, being able to pull and personalize the worksheet activities was a critical variable in her adoption efforts, and without such empowerment, she may have abandoned adopting some of their innovations.

Other faculty participants preferred not to use the designated worksheet activities for each manipulative at all, and instead personalized their use of the manipulatives towards their own style of operating their classroom. In her second interview, Rand expresses such an interpretation of being able to pull and personalize her use of their co-developed innovations towards her style:

> **Rand (2):** […] for myself, I felt it was more effective to use [the manipulatives] multiple times for very short things rather than one activity because then they could keep building on those ideas. […] the nice thing about that approach is that I think everybody's style is different and it was more we were able to give things that you could then adapt to your style as you need them.

While Rand expresses in this excerpt that she preferred not to use the manipulatives with their designated activities, she was still able to pull her adoption of the manipulatives by adapting them and personalizing her adoption towards her style. This excerpt holistically exemplifies how the pull variable empowered Rand to preferentially select which aspects

of their co-developed curricular innovations she chose to adopt and then further personalize towards her own unique context.

For other faculty participants, being able to personalize was not always a necessity for adoption, but allowed them to progressively improve their innovations. In Carroll's second interview he expresses such a personalization.

> **Carroll (2):** It's a nice little activity, but I think it was originally done by one of the members of the group and then I just snazzed it up a little bit.

In this excerpt, Carroll demonstrates how personalization does not always mean a significant change in the worksheet activities or student kit structure, but can sometimes be a simple and minor pull to fit one's own preferences. This shows that personalization is indeed contextual because faculty have their own existing preferences for curricular materials that can lead to even minor personalization efforts.

Adoption does not need to have one correct way that works for everyone, which is why the pull-oriented model is beneficial. These findings demonstrate that a pull-oriented model empowers faculty to preferentially choose and personalize innovations and resources to cater towards their unique needs. Being able to pull enables the adoption process to continue and improve, sometimes in small increments, but sustained nonetheless. One of the ways in which this pull variable was made more explicit was through the faculty participants' interactions with their aides. These interactions were interpreted as providing increased accountability, continuous support, and an opportunity for reflection.

### 4.1.4 Accountability

The original intention for the aide was to provide the faculty participants with assistance during adoption and to encourage them to pull their innovations. While the aides did fulfill these roles, the most common interpretation of the aide was that they provided a source of accountability for the faculty participants. In Rand's second interview, she expresses such an interpretation:

> **Rand (2):** Part of the reason why I was incorporating it was because I knew I was going to talk to [my aide]. […] There's accountability there. It's like a workout partner.

Rand chose to communicate with her aide over the phone on a weekly basis and in this excerpt is saying that such regular engagement with her aide made her feel accountable to her goals of incorporating the innovations developed at the workshop, like a workout partner keeping someone accountable to their fitness goals. A similar interpretation of the aide providing a source of accountability towards one's own goals was provided by Twain in his second interview:

> **Twain (2):** For me then, [my aide] was just a reminder that, "Oh, right. I said I wanted to try something new. I should stay on top of that."

Here, Twain expresses that his aide provided him with a reminder to stay on top of his adoption efforts and trying something new in his classroom. Twain also chose to communicate with his aide via weekly phone calls; which from these two excerpts seems to indicate that the accountability interpretation emerged from frequent engagement with their aides.

These excerpts from Twain and Rand illustrate an interesting finding where some of the faculty participants interpreted their aide as a source of accountability. This is interesting because the aide variable was not implemented with the intention of holding the faculty participants accountable to anything. In fact, the faculty participants were not even required to communicate with their aide on a regular basis. They were encouraged to reach out to their aides when they needed assistance, but all of the faculty participants ended up choosing to communicate with their aides over the phone on a weekly or bi-weekly basis. This seems to indicate that the faculty participants pulled their aides to provide themselves with their own source of accountability.

The following exchange with Morrison during her first interview provides some further insight into this interpretation and how it manifested:

> **Morrison (1):** I think the biggest thing is just the accountability of checking in every week […].
>
> **Researcher (1):** […] how is it that [your aide] is making you feel more accountable about this stuff?
>
> **Morrison (1):** […] there's accountability because I'm concerned of the repercussions of that falling through. I think it's more about not wasting a resource that here's an opportunity to improve the quality of what I'm doing and that's cool, and why not take advantage of it?

In this exchange, Morrison elaborates on how she saw her weekly communication with her aide as an opportunity to improve her adoption and teaching. Morrison expresses that her concern of not taking advantage of such an opportunity led her to interpret her aide as helping hold her accountable to her goals of improving her teaching. This accountability interpretation emerging from a concern of missing out on an opportunity to interact with their aide is similar to the example interview exchange provided in the Theoretical Framework section of Chapter 2.

While the aide was intended as a source of engagement with faculty throughout the academic year to provide support in real time, each faculty participant chose to engage with their aide on weekly or bi-weekly basis regardless of whether they needed support or not. Such continuous engagement appears to be an influential source of accountability in sustaining their efforts towards meeting their goals of implementing their co-developed curricular innovations. This continuous engagement provided more than just accountability, however, and did indeed provide the real time support that the aide was intended for.

### 4.1.5 Support

In addition to accountability, faculty participants also interpreted their aide as a source of support for when they had questions about how to implement their co-developed curricular materials. One might think that the faculty participants should have a sound idea and plan for implementing their innovations since they contributed to their development and therefore not require much support, but most of the faculty participants

taught mechanics of materials more than six months after the workshop. This time lag would cause participants to forget some of the finer details of their co-developed curricular innovations. Also, unforeseeable challenges can emerge when making any type of change and these challenges can cause significant barriers to adoption if not met with adequate support in a timely manner. In Orwell's second interview, he expresses how his aide was supportive in working out all the details of his adoption process:

> **Orwell (2):** All of those details of implementing something like that was new and then how to do it most effectively, [my aide and I] would talk a little bit about that, and that was helpful […].

Here, Orwell expresses how he interpreted his aide as providing him with support on how to implement their co-developed curricular innovations most effectively. Orwell was able to obtain this support through his continuous engagement with his aide via their weekly phone calls.

Even when some faculty did not have questions or concerns, they still interpreted their aide as being a supportive resource throughout their adoption process. Hamilton expresses this best in the following excerpt from his second interview:

> **Hamilton (2):** I think knowing that [my aide] was there was also helpful […] because I feel like any little, tiny barrier can be enough to have people not implement changes. Just making sure that there aren't any barriers available, you're basically saying, "I have this person and this person will ensure that any assembly blocks are removed," so I think those are all positive.

While Hamilton did not feel he needed to ask his aide for any specific support, he recognized that having an aide available for support was comforting in case he did encounter challenges. Other faculty members expressed similar interpretations in regards to the value of having a resource dedicated entirely to assisting them, so that when they had challenges they had a specific person to go to for support. Carroll expresses this interpretation in his second interview.

> **Carroll (2):** Just having somebody, knowing I can contact [my aide] and I'm not getting on anybody's nerves. That was very helpful.

Here Carroll expresses not wanting to get on anybody's nerves when asking for help, so having the aide as a designated resource for support made him more comfortable reaching out for help when needed. For Carroll, this concern emerged from his previous years of involvement and perceiving that he might be intrusive when asking for assistance. Adding the aide resource following the third workshop helped ensure that Carroll did not abandon adoption due to not having a readily accessible resource for support.

Another interesting way that the aide was interpreted as providing support was by connecting and facilitating the sharing of ideas and resources amongst the faculty participants. In Morrison's second interview, she expresses how her aide supported her in this way.

> **Morrison (2):** [My aide] was sort of a liaison between myself and…like, if I had an idea and she passed that on to other people. […] what [my aide] had done ahead of time was talk to her other instructors and see if there'd be any interest in doing that so I wasn't just making work.

This was an interesting interpretation because the faculty could always email the other faculty participants to share ideas without going through their aides. Since each aide was communicating with multiple faculty throughout the academic year, they became well aware of common concerns that faculty had and the strategies they were using to resolve these concerns. In this way, Morrison and other faculty saw their aide as a knowledge basin they could tap to gain insight into what other faculty were doing or needed. Thus, the aides were able to provide additional support to their respective faculty by being able to facilitate knowledge and dispense ideas and successful tips they learned from their interactions with other faculty. In addition to accountability and support, another interpretation that faculty participants' had of their aide was that their interactions created an opportunity to be more reflective about their adoption process.

### 4.1.6 Reflection

Continuous engagement with their aides provided a unique opportunity for the faculty to reflect upon their adoption process and keep lessons learned in the forefront of their minds so that they could continuously improve and adapt their innovations and adoption process. This interpretation is expressed by Hamilton in his second interview when discussing the value he found in communicating with his aide on a regular basis:

> **Hamilton (2):** I thought it was still a nice reflection time as well so I could reflect on…it allowed me to reflect on what happened and then maybe make some notes and think about how I could improve the way that I present the material as well as ways that we could improve the activities themselves.

Hamilton had discussed earlier in this interview how he did not need his aide as much for accountability and support, but illustrates in this excerpt how he still found value in their continuous engagement as an opportunity to be more reflective about his adoption process. Similarly, Morrison expressed in her first interview how her weekly phone calls with her aide provided her with feedback and kept her adoption efforts at the forefront of her mind:

> **Morrison (1):** One of biggest things is just by having that weekly telephone conversation; it keeps this in the front of my mind and current. […] That was helpful. That kept the feedback there.

In this excerpt, Morrison is referring to one of the biggest things her aide helped her with, in this case reflection. Continuous engagement with her aide through weekly phone conversations provided Morrison the opportunity to reflect and receive feedback from her aide so that she could maintain her focus on her adoption efforts throughout the term.

Having the opportunity to reflect with someone on a regular basis seemed to also influence some participants' enthusiasm towards their adoption process. Rand expresses this enthusiasm in the following excerpt from her second interview:

> **Rand (2):** Having [my aide] to bounce ideas around […] literally having somebody to say, "Hey, I tried this and I thought it worked or it didn't work,"

> was…got me enthusiastic about trying new things just because of having that person there.

Here, Rand expresses that by simply having somebody to engage with and reflect upon her adoption process made her more excited to try new things and make changes in her classroom. Reflection is not something that requires communication with an aide, but such communication does allow for personal reflection to become more explicit and influential. The enthusiasm generated amongst the faculty participants through their reflections with their aides may also be influenced by the enthusiasm that the student kits generated amongst the participants.

### 4.1.7 Enthusiasm

The student kits were provided to the faculty participants a week before they began their term teaching mechanics of materials. These student kits were an explicit request from the participants at the third workshop as an additional resource that would help them engage their students by providing them with their own set of manipulatives to follow along with demonstrations and to use when doing the worksheet activities. Faculty participants overall had positive interpretations of the student kits they were provided with and one of the common positive interpretations was the enthusiasm they expressed towards adopting the student kits in their classrooms. In Orwell's first interview, he talks about his excitement to use the student kits.

> **Orwell (1):** I'm pretty excited to use the new [student] kits now with each individual student having those. I think it'll generate more enthusiasm.

Here, Orwell expresses his own excitement for implementing the student kits, and that he thinks it will generate more enthusiasm amongst his students. In Orwell's case, he is already an enthusiastic instructor about the topics that he teaches, and having the student kits appear to be a way for him to extend his ability to share his enthusiasm with his students.

While Orwell had already been using manipulatives in his previous mechanics of materials courses and the student kits provided a nice extension of his existing approaches, some other faculty were less experienced with adopting manipulatives into their classrooms. For example, Hamilton had been teaching his mechanics of materials course from a more traditional abstract and theoretical concepts approach, but acknowledged that there were better ways of teaching and engaging his students. Hamilton expressed that the student kits could help motivate him towards adopting more tangible models of teaching engineering concepts, which in turn made him excited about using the student kits. This is demonstrated in the following excerpt from Hamilton's first interview:

> **Hamilton (1):** The big goal is to have students become capable engineers. In order for them to do that, there are certain concepts they need to learn, but more than that it is also about teaching them how to learn […] I think that anything that we do that's related to that is a success in my mind. […] I think [manipulatives] are a way to encourage me as an instructor to change course contents towards that model.

Hamilton went on to add:

> **Hamilton (1):** I'm excited about using [the student kits] that you've sent. […] Whenever you're developing something new, you never really know what's going to come until you're in the middle of it. That's part of the fun of it.

In the first excerpt, Hamilton expresses how the manipulatives in the student kits have encouraged him towards a model of teaching that focuses more on the big picture of becoming a capable engineer, and then he goes on in the second excerpt to talk about his excitement towards using the student kits and trying something new. This demonstrates Hamilton's enthusiasm towards the student kits because they have enabled him to try a new model of teaching that he believes in and is excited about.

Not all interpretations of the student kits were as rapturous as the previous excerpts exemplify. Some faculty expressed concerns over the student kits being a distraction at times during class, but overall even the faculty participants that had some

issues with the student kits were enthusiastic about adopting them and continuing to improve them. Carroll expresses these sentiments best in the following excerpt from his second interview:

> **Carroll (2):** My overall feeling, there's still […] this [student] kit was really good. I still have issues, but I feel that we have been on a journey and we have actually gotten somewhere. I actually feel quite excited I must say.

Some of the issues Carroll is referring to in this quote were the significant amount of class time that he would use on days when using the student kits and not being sure which concepts or topics he should and should not use his student kits for. Still, he acknowledges that the student kits were an initial effort to improve the engagement potential of some of the demonstrations and worksheet activities developed at previous workshops, and that they have provided a noticeable improvement on their previous efforts. In this way, the student kits generated enthusiasm for Carroll to continue progressing through and improving his adoption process. All that being said, another way in which the student kits made the faculty participants excited was that they saved them significant time and resources by not having to create these kits on their own.

### 4.1.8 Accommodating of Faculty Resources

Faculty are often significantly pressed for their time and sometimes do not have the adequate resources to create all the materials they would like for their classroom. When faculty expressed interest in having student kits for all of their students at the third workshop, the goal became to create enough student kits and ship them to each instructor before their term of teaching mechanics of materials. Morrison expresses the impact this effort had in the following excerpt from her second interview:

> **Morrison (2):** Having the [student] kits and not having to make all that stuff myself. It's huge.

Morrison had developed multiple manipulatives for all of her students to have in her past mechanics of materials course and is therefore aware of the time and effort such a process

takes. For this reason, she interpreted the student kits as being a huge convenience on her time by not having to make all the manipulatives on her own.

Another faculty participant that had spent the time and effort developing manipulatives for all her students in the past was Rice. In Rice's first interview, she expresses a similar interpretation of the huge impact the student kits had in their time saving value:

> **Rice (1):** Having more manipulatives is definitely something, like setting yoga bands in every student's hands. I don't have time to sit there and cut pool noodles into pieces and put grids on them. I've done that in the past, I've found the time for it, but it's…you do some of that and then you're diminishing mental and time ability to do more. It's having these whole manipulative student kits are fantastic. Every student I have, I care [about], but I can't put those together. It's huge.

This excerpt shows how Rice interpreted the student kits as accommodating to her time constraints, and subsequently enabled her to allocate her time towards other adoption efforts, like pulling the worksheets and activities towards her preferences. Rice also talks about how she cares about all her students and has tried making enough manipulatives for each student in the past. Similar sentiments were expressed by other faculty participants, and shows that limited time and resources can be a significant barrier to adoption of innovations for even the most caring instructors.

Finally, Rand expressed her sentiments towards the student kits being accommodating towards her available resources in the following excerpt from her second interview:

> **Rand (2):** […] there's absolutely no way that I could have put together this [student kit] like what you guys have done and had all the resources that you've had […]

While the student kits were the faculty participants' idea and they helped develop the manipulatives that went into each one, Rand's excerpt here expresses how this desire for each student to have their own set of manipulatives was unfeasible for her to implement on her own, even though she had been involved in the development process. This

illustrates how faculty's wants and desires may exceed their time and resource capabilities to implement on their own, and that faculty development, especially in a pull-oriented model, needs to consider these challenges.

Not having to spend their own time and resources mass producing their co-developed innovations enabled the faculty participants to move forward immediately with the adoption process and begin to try and engage their students with the innovations they co-developed. In this way, the student kits also were accommodating to the faculty participants because they allowed for greater engagement with and from their students.

### 4.1.9 Accommodating for Engaging Students

While many faculty participants interpreted their student kits as increasing their enthusiasm and accommodating to their resources, perhaps the most valuable interpretation was that the student kits helped the faculty participants engage their students. In Orwell's second interview, he expresses how having manipulatives in each of his students' hands helped facilitate more engaging discussions that he might not have had without the kits:

> **Orwell (2):** Just being able to hand out the foam stress element and then the block that represented the loaded element and having the two of those things in everyone's hands this last week was awesome because I could wander around every table and say, "So what's the state of stress?" And they could hold it up and we could talk about it from different perspectives […].

This excerpt shows how Orwell has interpreted the student kits enabling him to have an inductive and exploratory discussion with all of his students as they engaged with their manipulatives. Such an accommodation might not be feasible with a solo demonstration presented in front of the class or even passed around the classroom.

For Rand, the student kits were accommodating for the specific reason of being able to further engage her students with her demonstrations. This interpretation is exemplified in the following excerpt from Rand's first interview:

> **Rand (1):** […] having a kit for everybody is fantastic. […] I think that has made it much more …they're following along with the demonstrations […] and they really seem to enjoy it, and find it much more engaging. They were actually answering the questions I think more confidently, then if I was doing it separately.

Here, Rand expresses how she observed the kits increasing her students' engagement through their ability to follow along when she was using a demonstration. This appears to have influenced her interpretation of the kits being fantastic, and such a finding seems to indicate that if an innovation can create greater engagement amongst students in an easily observable manner, then instructors are more likely to have a positive interpretation of the innovation and continue moving forward with adoption. Twain exemplifies how the student kits allowed him to adopt new classroom practices in the following excerpt from his first interview:

> **Twain (1):** […] holding the pool noodle and being able to draw that angle of gamma on the actual pool noodle right there we're doing the math, but we're doing it with our hands. Rather than just an equation and diagrams, which is what I used to do in the past.

In this example, the pool noodle Twain is referring to is one of the manipulatives provided in the student kit that can be used to represent a column or a beam deforming due to certain types of applied loads, like torsion. Twain expresses in this excerpt how having this manipulative from the student kits in each of his students hands has allowed him to teach some mechanics of materials concepts in a more tangible way than the more abstract way of equations and diagrams that he used in the past. In this way, Twain interpreted the student kits as accommodating for him to engage his students in new ways and allowed him to adopt new approaches in his classroom.

The manipulatives that had been developed at previous workshops were meant to engage students, but were limited in their impact to reach more students because faculty were only provided one of each manipulative and expected to use them as demonstrations or produce more on their own if they wanted to put them in more students hands. Providing the faculty participants with the student kits helped accommodate their goals of

engaging their students by enabling their students to engage with the manipulatives on their own.

## 4.2 Summary of Coded Interpretations

These nine codes represent the three most salient interpretations to the three additional variables implemented following the third workshop. As evident by the previous excerpts, many of these codes overlap to some extent indicating that the three variables are inextricably linked and difficult to assess the influence that each had on their own for each individual participant. That being said, it is quite clear from these excerpts and their codes, that all three variables were overall interpreted by the faculty participants as having a positive impact on their adoption efforts. Not every faculty interpreted each variable in the exact same way though, and their interpretations did not always manifest in the same way either. Their interpretations and subsequent adoption decision making was greatly influenced by their individual contexts and how they utilized these three variables together. The following section aims to present each faculty participant with greater individual focus on their case to illustrate their contextual influences and answer the second research question.

## 4.3 Contexts within Each Case

The following section aims to answer the second research question through individual case reports for each faculty participant. Therefore, these reports illustrate the most salient contextual influences on their adoption decision making and how they utilized the three variables of pulling, the aide, and the student kits. It is impossible to encapsulate all the contexts that influence any type of decision making, which is why the scope of these reports is bounded to the most salient contextual influences in regards to the three variables being focused on in this study. Other salient contextual influences that emerged throughout the data collection and analysis process are presented and discussed in the Discussion chapter that follows this chapter.

### 4.3.1 Case 1: Mark Twain

Mark Twain is a community college instructor that teaches fundamental physics and engineering courses. His experience as a physics instructor has influenced the way in which he teachers engineering in that he tries to approach engineering concepts from an underlying theoretical physics perspective. He is interested in fully understanding how and why certain assumptions are made in engineering and how these assumptions sometimes differ from underlying concepts in physics. This is exemplified in the following excerpt from Twain's first interview:

> **Twain (1):** I don't remember taking [this] kind of [mechanics of materials] in my classes, so a lot of the stuff that I was learning was as I'm teaching it. From a physics background, when you look at a strain curve, it's not what's really happening. But we love that fact that we don't talk much about the actual stress-strain curve […]. But I wanted to really be confident in my division of what is truth, and what we assume to be truth.

In this excerpt, Twain is referring to a mechanics of materials phenomenon often represented with a graphed curve that engineers use, but the curve does not accurately represent the underlying physics of the phenomenon. For this reason, he sometimes has concerns adopting curricular innovations in his engineering classes compared to his physics classes because he is less certain about the assumptions engineers make when applying physics. Specifically when it comes to adopting manipulatives, Twain wants to be certain about whether the innovation accurately demonstrates a physical phenomenon or whether it's an analogous representation engineers use to approximately demonstrate a phenomenon and how to accurately explain these nuances to his students.

Twain recognizes the value of manipulatives on student engagement and has wanted to add more into his engineering classrooms, but has not been able to as much as he would like, partially because of the concerns mentioned above. Attending the workshop for three years has provided Twain an opportunity to connect with other engineering faculty and flesh out some of these nuances between physics and engineering

which has made him to move forward with adopting more manipulatives into his classroom. This is demonstrated in the following excerpt from his first interview:

> **Twain (1):** I think then what I got out of this group is […] for me to be able to bounce ideas off with people. It's been very helpful about how I approach the class. That's been supportive. I've really liked how last year we just listened to one another, and created what it is we're creating. I think what it does for me then is like, "I'm looking at it from this way, and if you're looking at it from this way, and we're both going to the same point." Now […] you can look at an idea in multiple fashions. One way that it's changed my teaching, just the conversations we're having […] so that's helpful.

Twain expresses here how his dialogue with other faculty, mostly engineering faculty, at the previous workshops he has attended has allowed him to share his physics perspective and learn about different engineering perspectives that represent the same point, and how this dialogue has been helpful for him to move forward in adopting the innovations they co-develop. Beyond the workshop and into the academic year, Twain's aide, the student kits, and explicitly reminding him to pull their innovations have all contributed to him making a change towards a flipped classroom approach following the third workshop.

Twain had wanted to move from a more traditional lecture approach where he occasionally used demonstrations to a flipped classroom where he could spend more time in class using manipulatives. His flipped classroom approach consisted of providing his students lecture slides and readings to go over before class, and then in class he would guide his students through the lecture slides and reading material using their manipulatives and accompanying activity worksheets to explore and engage with the material. The student kits provided him with the resources he needed to provide each of his students with manipulatives in class to follow along with the activities. The flipped classroom approach had been something Twain had wanted to do before, but had not adopted yet. This seems to indicate that being more explicit about pulling the curricular innovations and providing him with the student kits helped nudge Twain in the direction of adoption that best aligned with changes he was already hoping to make.

Perhaps the most important variable for Twain was his aid holding him accountable to actually making these changes. Twain did not ask his aide for much in terms of support or additional resources, but did credit his aide for reminding him to stay on top of the changes he wanted to make. Therefore, Twain's context of wanting to implement more manipulatives in his engineering classroom and adopting a flipped classroom approach influenced the way in which he adopted their co-developed innovations and how he utilized the three additional variables.

### 4.3.2 Case 2: Ayn Rand

Ayn Rand is a community college instructor that teaches a wide variety of fundamental engineering courses and has 17 years of experience teaching mechanics of materials. While Rand has extensive teaching experience, she claims to be always looking for ways to improve and values her involvement in the workshop as an opportunity to learn better ways to engage her students. That being said, Rand admits that she had been implementing more of their co-developed innovations following the third workshop compared to her involvement the previous year as a result of all three additional variables implemented following the third workshop.

Rand acknowledges that her aid not only made her feel more accountable to her goals, but also made her more enthusiastic about trying new things. Rand's initial approach to teaching mechanics of materials was to primarily lecture and then do some interactive problem solving. Following the second workshop, she tried bringing in some of the co-developed manipulatives, but thought that the accompanying worksheet activities they had developed confused students and took too much time.

After the third workshop and being provided with the student kits and encouraged to pull their innovations, Rand felt that she was able to adopt their co-developed innovations in a manner more conducive to her style. Instead of using worksheets and designed activities, Rand implemented the manipulatives at least once a week in her class to allow students to follow along with her demonstrations and help facilitate discussions

while interactively solving problems. In this way, Rand was able to keep a very similar approach to her existing lecture style with interactive problem solving, but was able to adopt the manipulatives and engage her students more in this existing approach by implementing the manipulatives how she wanted to. The following excerpt from Rand's second interview illustrates her adoption and pulling of the student kits:

> **Rand (2):** The kits were a huge success. I did not use them in the way that we talked about in the workshops where we had the activities […]. Instead, it was more like they were there and when we were talking about things, we pulled them out and used them then and we used them with problem solving. I think the kits were a big thing.

Here, Rand demonstrates how she pulled the student kits and adopted them into her existing approach. This illustrates her context of being an experienced instructor with an established approach, but also being interested in adopting better ways to engage her students. The following excerpt from her first interview further demonstrates this context and how her involvement in the program has allowed her to adopt more manipulatives into her mechanics of materials class than in other courses she teaches:

> **Rand (1):** I think I'm very collaborative in my other classes as well, in terms of how we do the lectures and problem-solving. But I don't have the same physical, hands-on things happening in my dynamics classes, and in some of the other courses. I think it would be wonderful if this model went out to other engineering fundamental courses. I could see myself implementing those types of things in other classes.

In addition to Rand's classroom and teaching approach, her experience from her involvement in previous workshops was another contextual influence on her adoption process and the way in which she interacted with her aide. Following the second workshop, Rand did not adopt their co-developed innovations as much as she had hoped for, which led her to utilize her aide as a source of accountability and reflection to help her sustain her adoption efforts. Having the student kits and being able to pull them within her existing approach allowed her to be more enthusiastic about adopting more manipulatives into her classroom and further engaging her students.

### 4.3.3 Case 3: Anne Rice

Anne Rice is a university instructor that teaches a wide variety of fundamental engineering courses and higher level civil engineering courses. She has 12 years of experience teaching mechanics of materials and has been utilizing similar manipulatives in an active learning environment prior to her involvement in the workshop. Following the second workshop, she abandoned adopting most of the co-developed innovations because she did not feel she should use the manipulatives without their accompanying worksheet activities and she felt that the worksheet activities were confusing and took too much time. While Rand does teach a 15-week long semester course, her class only meets three hours per week and therefore the time she has for active learning and using manipulatives is limited.

While Rice would not say that she has made any major changes in how she teaches the class from before to after her involvement in the workshop, she did adopt more of their co-developed innovations following the third workshop as a combined result of the three additional variables. Rice had attempted to make enough manipulatives for all her students in the past and acknowledged that having the student kits provided for her saved her a great deal of time, but that the kits sometimes cause too much of a distraction and mess in the class. Ultimately, since Rice had been using similar manipulatives in her class before, her aide and ability to pull seem to have been the most influential on her adoption decision making.

Rice did ask her aide for some additional worksheets and materials, but mostly credits her aide with holding her accountable to spending the time necessary to adapt the worksheets and activities to align with her preferences so that she is more likely to adopt their curricular innovations and not abandon adoption like she did the previous year. This is exemplified in the following excerpt from Rice's second interview:

> **Rice (2):** I'll just reinforce that my main takeaway was that accountability piece that [my aide] provided. It was very helpful for me. In fact, for the first couple of weeks when there was a phone call, it would stress me out a little bit. I was like,

> "I don't have anything to talk about. I don't have time to think about this. I don't even have time to get these kits handed out." Once I relaxed, gave myself an out and said, "Okay this is about providing that reminder that I thought I didn't have last year, that's how I'm going to use it." Then it was really helpful.

This excerpt shows that even for an experienced instructor like Rice who already uses manipulatives in an active learning environment, having a source of accountability was necessary for her to continue adopting new innovations into her classroom. It should also be mentioned that even though Rice interpreted her aide as being primarily a source of accountability, she also utilized her aide to provide her additional student kits to overcome what was for her a major barrier to adoption:

> **Rice (1):** One of the reasons that I haven't gotten to [using the student kits] is because we didn't have enough for all students across all sections. Especially with a new instructor teaching one of those sessions, I didn't want to give [the student kits] to my students and not give them to his students. I didn't want his students perceiving that there was a difference. That's already hard for a new instructor and the students question things about that. I didn't want to undermine his class style and so it's one of the reasons that I have just held off on it. Let's just wait until we can get them out to everybody.

Here, Rice is referring to another instructor at her institution teaching a different section of mechanics of materials in parallel to her own section. Rice was initially only provided with enough kits for the students in her section, but by having the aide available to her, she was able to put in a request for more kits for the other section so that she could move forward and feel comfortable with her own adoption without undermining the other instructors approach to teaching.

Therefore, Rice's case demonstrates her context of being an experienced instructor with an established active learning approach and how she wanted to adopt the co-developed innovations from the workshop into her classroom. In this context, Rice's aide was a significant influence by providing her with the necessary materials to move forward with her adoption and helped hold her accountable to pulling the innovations so that she continued improving on her existing approaches.

### 4.3.4 Case 4: Clive Hamilton

Clive Hamilton is a community college instructor with 6 years of teaching experience in introductory chemistry and fundamental engineering and bioengineering courses. He has three years of teaching experience in mechanics of materials and the third workshop was the first one he attended. Hamilton admits that he rather enjoys the traditional model of engineering education that he characterizes as being more math and theory focused than engineering actually is in practice. While he does prefer this model, he acknowledges that providing more engaging and interactive ways of teaching is more beneficial from the student's perspective and that any faculty development programs and resources that push him towards a more engaging way of teaching is good. For this reason, Hamilton was quite open-minded to adopting their co-developed innovations and thought that the student kits were helpful in engaging his students and helping them visualize some of the underlying mathematics and physics.

Prior to his involvement in the workshop, Hamilton had not used many manipulatives in his classroom and thought that what they co-developed at the third workshop was beneficial to him to use without much pulling during the academic year. His reasoning for this was that he needed to try and implement their co-developed materials as is and see how they went before making changes. Hamilton also felt that he did not need his aide to assist him or help develop additional materials before he tried to implement them on his own. This is demonstrated in the following excerpt from Hamilton's second interview:

> **Hamilton (2):** I guess for me, I'm quite willing to just try something out for the first time without worrying about meddling with the details too much until later. For me, I was not trying to change things before I even tried them once because I think the other…the thing that [my aide] kept on mentioning was that she would be happy to develop different activities or things like that and I was like, "Well I'm not even sure how these activities will go the first time, so I'll just try these," the ones that have been developed through the workshops.

While this excerpt may seem to show Hamilton not having much of a need for his aide, he did find his aide to be beneficial to him because their interactions provided him a nice time to reflect on his adoption process and ways that he could improve their innovations and his adoption process for next year. One reason he found this reflection time particularly beneficial was because he felt as a community college instructor that he did not have many other engineering faculty to talk with and discuss teaching, so he found his aide to be a nice source of reflection about his experiences in the classroom, as demonstrated in the following excerpt:

> **Hamilton (2):** […] specifically to a community college instructor…we don't have other faculty to talk to, generally. I don't know if that's true with everybody, but I'm the only engineering faculty here. It's nice to discuss ideas with somebody that understands what you're talking about. That's maybe something that a university professor doesn't have quite the same issue with…they do actually have other faculty to understand the material and to talk to about [it]. So I found that to be beneficial […].

Hamilton's case is particularly unique compared to the rest because he is the only participant that did not attend more than one workshop. Also since he has only attended the third workshop, he has only attempted to adopt their co-developed curricular innovations with the additional three variables provided. These three variables had been added to help faculty improve their adoption efforts based on experiences from past years that Hamilton did not have. It is hard to say how Hamilton's case might differ if he had been a participant at the workshop in previous years. His current context of being a new workshop participant seems to have influenced his adoption decisions by implementing their co-developed curricular innovations as is before deciding to do any pulling or asking for additional resources from his aide. His context as a community college professor without other engineering faculty to communicate with led him to utilize his aide as an opportunity to reflect upon his classroom experiences with someone in a way that he could not with the other faculty at his institution.

### 4.3.5 Case 5: George Orwell

George Orwell is a university instructor that has been teaching mechanics of materials for 8 years. He also teaches several other fundamental engineering courses and higher level civil and structural engineering courses. Orwell's mechanics of materials class meets over a ten week term with three hours of class time per week and three hours of lab time per week. His class and labs were recently re-configured and set up for the students to sit in groups at large tables and he has been trying to implement several changes in his curriculum to accommodate this new structure. Some of these changes are discussed in the following excerpt from Orwell's first interview:

> **Orwell (1):** Last year, when I started working in that classroom, I decided I was going to make really good use of the fact that the students were in groups. I did want to incorporate what we had developed in the workshop, but I was also interested in developing more online teaching tools. I'm using MecMovies[1] online platform. It's all web based. I've been using that a lot. I guess what I'm saying is that all of the products of the workshops ended up being implemented with a bunch of other changes that I've been looking to make […] but prior to that, it was pretty straight forward, kind of chalk and talk approach for the classroom.

Orwell greatly valued the student kits for providing him with manipulatives for his students to do in conjecture with the MecMovies that he was also adopting in his classroom. This is exemplified in the following excerpt from Orwell's second interview when asked what his students thought of their student kits:

> **Orwell (2):** Well, I know [my students] love [the student kits]. They say that they enjoy working with something physical. I've also been using Timothy Philpot's MecMovies website, and his visualizations are really good on that website. To be able to couple something physical that [my students] can manipulate with the visualization on a screen […]. I think it puts us all in the same head space.

Here, Orwell expresses how he was able to use another innovation coupled with the student kits to keep all his students in a group seating environment focused on the same

[1] For reference, "MecMovies" (by Timothy A. Philpot) are interactive dynamic simulations of statics and mechanics of materials concepts and available to use for free at https://web.mst.edu/~mecmovie/

thing. This demonstrates how Orwell was able to pull his student kits to accommodate his classroom structure and his approach to experimental learning.

Initially, Orwell thought that he would also pull his aide to help him develop additional activities for the student kits, but as the term progressed he preferred working with a lab tech at his institution. Orwell did acknowledge, however, that his aide was supportive in providing him with tips and details for implementing the student kits in his classroom. Therefore, Orwell's context of having a lab tech and a group seating classroom, while also wanting to implement other changes in tandem with their co-developed curricular innovations influenced the ways in which he pulled his adoption.

### 4.3.6 Case 6: Lewis Carroll

Lewis Carroll is a community college instructor that teaches fundamental physics and engineering courses. Majority of his teaching and professional experience is in physics and while he has been teaching for 15 years, he has only been teaching mechanics of materials for the past two years. Lewis' limited experience teaching mechanics of materials influences his adoption decision making as he often expressed concerns with how much time he should spend implementing an innovation around one mechanics of materials topic at the expense of another. Carrol expressed that he is often comfortable bringing manipulatives into his physics classroom and spending more time engaging his students around fundamental concepts, even if that means not having the time later in the term to cover more advanced or nuanced concepts because he knows what are the most important concepts in physics. However, since Carroll is not an engineer, he is less certain about these types of decisions when it comes to mechanics of materials and his other engineering courses. This uncertainty is expressed in the following exchange from Carroll's first interview:

> **Carroll (1):** I have a hard time cutting back stuff because I feel that if some engineer decided that that should be in the textbook…I got a lot of information from the workshop folks. I try to kind of stick with what they do roughly. If they say, "You do Chapter 12, or you don't, it's not a big deal." Then I might say,

> "Okay, okay. Good, good. Then, I'll to that. Mohr's circle[2] for example is something that I could drop and save some time. Then you talk to some other engineer and they say, "Oh, you must do Mohr's circle." That's where I'm not an engineer and I have that insecurity.

This insecurity sometimes leads Carroll to not adopt innovations he perceives as being too time consuming because he is unsure about dropping later content in the term. Such a decision not to adopt based on time management and content coverage concerns occurred for Carroll following the second workshop because he perceived the worksheet activities associated with their co-developed curricular innovations as taking up too much class time.

For these contextual reasons, Carroll implemented his co-developed curricular innovations in a way that addressed his concerns. Carrol brought the student kits into class every day, but only for demonstration purposes during lecture and for his students to follow along with their own manipulatives. He decided to make the worksheet activities associated with their co-developed innovations take home assignments so that he did not have worry about them taking up too much of his class time. While this might seem like Carroll is missing the intention of their innovations to increase classroom engagement, he is still bringing manipulatives into the classroom for each of his students to engage with his demonstrations in lecture, while also facilitating engagement outside of the classroom by assigning the worksheet activities as take home assignments. This is demonstrated in the following excerpt from Carroll's second interview:

> **Carroll (2)**: I think the doing [the activities] at home part, I think I'll continue with that next year. This is the last activity…I think there's too much opportunity to get confused. If some of the legwork can be done at home, then the class can run a little more smoothly.
>
> Carroll went on to add:

[2] Mohr's circle is a graphical representation of stress transformations usually covered in later chapters of mechanics of materials textbooks

> **Carroll (2):** I have still used the equipment throughout. I would say I've had the [manipulatives] in the classroom every other day.

In this way, Carroll's contextual concerns influenced the way in which he pulled his adoption of their co-developed curricular materials by having the worksheet activities be take home assignments, while still being able to use the manipulatives to some extent in the classroom as well.

Carroll was also able to utilize his aide for support when concerned about what engineering concepts he should be spending more or less time on in the classroom and with the manipulatives. Through his aide, Carroll was able to tap into what the other engineering faculty participants were doing with their innovations, and therefore feel more comfortable with his adoption decision making if he knew other engineering instructors were making similar decisions. For Carroll, all three additional variables were influential within the context of his adoption efforts and he noted considerable improvement in his ability to implement and gain experience with their co-developed innovations compared to the previous year.

### 4.3.7 Case 7: Toni Morrison

Toni Morrison is a community college instructor that teaches fundamental mathematics, physics, and engineering courses. She has 9 years of teaching experience, and 4 years of experience teaching mechanics of materials. Morrison had been implementing similar manipulatives in her previous mechanics of materials classes and had made enough of some of her manipulatives to put in to each of her students hands. This experience led her to greatly appreciate the student kits being provided to her because she did not have to dedicate her time and resources to make all those herself. She also then went on to modify the student kits by separating out each individual manipulative and only bringing in the manipulative(s) relevant to what she would be lecturing on any given day so that her students would not be distracted by the other manipulatives in their kits. This allowed Morrison to engage her students by having them follow along with her lecture demonstrations using their appropriate manipulative.

Morrison's mechanics of materials course met over a span of 10 weeks with 6 hours of in class time per week and 2 hours of lab time per week. Therefore Morrison had more combined class and lab time than any of the other faculty participants. Her lab time allowed her to implement her student kits in a unique way where she had her students model their manipulatives in SolidWorks[3] to combine virtual and physical exploration of the concepts her students learn during class, all while gaining modeling experience. Morrison discusses what this adoption pull looks like in the following excerpt from her first interview:

> **Morrison (1):** […] we're going to go back into SolidWorks and model combined loading and I'm going to take those [manipulatives] down to the lab and [my students will] be able to actually physically load them, analytically load them, and model them in SolidWorks. [The student kits will] be used in lab for that.

Morrison had been using SolidWorks in her lab component before, but she has now adopted her student kits within this context to allow her students to physically experiment with an object in the real-world that they also model and experiment with simultaneously in a virtual environment. So even though the context of Morrison's class structure and time may seem to allow her an easier path to adopting their co-developed curricular materials, she still had to pull the student kits and accompanying worksheet activities in a unique way to fit within her existing lab structure.

In addition to this, Morrison also perceived her aide as providing her a sense of accountability to make sure she was aware of her adoption efforts and making an effort to improve the quality of their co-developed innovations. Again, this shows that even with the benefits of Morrison's classroom context and her experience using manipulatives, she still found the continuous engagement with her aide as being beneficial by keeping her adoption process in the forefront of her mind. Morrison also utilized her aide as an opportunity to share additional resources she developed and tips and strategies she

[3] SolidWorks is a computer aided drafting (CAD) program used to model and analyze solid objects.

learned in her adoption process with the other faculty that her aide interacted with. This is demonstrated in the following excerpt from Morrison's second interview:

> **Morrison (2):** I wanted to share my syllabus and exam files and [my aide] checked and then came back and said, "Hey, why don't you actually initiate that?" And, so I did […]. [My aide] found out that there was interest, so I was able to upload some of those and a couple other instructors have added theirs as well, so it's a start.

Here, Morrison is illustrating how she utilized her aide to see if any of the other faculty participants would be interested in her sharing some of her curricular materials. Such an interaction for Morrison encouraged her to pull and make modifications to the worksheet activities and manipulatives because she was able to find out through her aide that there were other participants that would be interested in her adaptations.

Therefore, in Morrison's case, her context of being an instructor experienced with using similar manipulatives and having more class time to experiment with new ways of implementing their curricular innovations allowed her to engage with her aide as a liaison to share her adapted resources and lessons learned with other interested faculty participants. This interaction did indeed lead to other participants adopting what Morrison had done. For example, Rice divided her student kits up by each individual manipulative and Carroll adopted some of the worksheets that Morrison had modified.

## 4.4 Summary of Findings from Each Case's Context

Each of the previous cases presented unique and similar contexts that influenced the participants' adoption decision making. For example, a common similar contextual influence was a concern about class time when adopting their co-developed curricular innovations. On the same token, many instructors' contexts influenced how they resolved this concern. Some altered the worksheet activities so that they took less time, others made the worksheet activities take home assignments, and others decided to implement their manipulatives without the worksheet activities at all. This illustrates why it is important to not only describe the commonly coded interpretations that answer the first

research question, but to also analyze each case with additional focus on each individuals' contexts and explain how these contexts influence their interpretations and adoption decision making.

# Chapter 5 - Discussion

In the following section, the findings presented above are discussed in more detail along with their implications. This is then followed by a discussion of other variables and contexts that emerged as influential during the data collection and analysis process. Finally, this section is concluded with a discussion of recommended future research efforts on pull-oriented faculty development programs and their evaluation.

## 5.1 Implications of Findings

The faculty participants interpretations of the three additional variables having a positive influence on their professional development and adoption of curricular innovations confirms some of the recommendations for improving faculty development in the literature. For example, each faculty's aide provided a form of continuous engagement with the faculty throughout the academic year, which has been recommended by Dancy & Henderson (2008) as a way of resolving barriers to adoption of curricular innovations. Furthermore, providing faculty with enough student kits ensured they had adequate material resources for adoption, which Garet et al. (2001) and Loucks-Horsely et al. (1998) have cited as a common shortcoming in many faculty development programs. Finally, increasing faculty autonomy in the innovation development and adoption process has been cited as ways for improving faculty development efforts (Dancy & Henderson, 2008; Felder et al., 2001; Nelson & Hjalmarson, 2015); which was the goal of explicitly encouraging the faculty participants to pull the development and adoption of their innovations towards their needs.

While the positive influence of the three additional variables examined in this study do support these existing recommendations in the literature, it is important to

understand the ways in which these variables were positive influences on the faculty participants' development and adoption processes. Continuous engagement via the aide variable manifested in a variety of different ways for different faculty, but most commonly as a source of accountability, support, and reflection. This seems to indicate that not any one form of continuous engagement will work for all faculty, and that faculty may need different sources of accountability, support, and opportunities to reflect depending on their context.

In regard to the student kits variable providing faculty with adequate resources, that was only one of the three salient interpretations that were found. The faculty participants also perceived this variable as a source of enthusiasm for them and their students and as a way to further engage their students in the classroom. This would imply that if there are other ways of increasing faculty enthusiasm towards adoption and/or student engagement in the classroom without manipulatives, that similar positive influences could be observed without the extensive resources and effort required to provide faculty with a significant supply of resources.

Finally, while faculty autonomy had been one of the intentions behind the pull-oriented faculty development workshop presented in this paper, such autonomy had to be made far more intentional and explicit throughout the academic year for the faculty participants to act out their autonomy by preferentially selecting what innovations they choose to adopt and how they personalized those innovations to cater their needs. This seems to indicate that faculty autonomy can be limited in its influence if faculty are not empowered to act out their autonomy during the academic year.

In addition to describing how these three variables were positive influences within their multiple interpretations, it is also important to explain the variety of contexts that influenced these interpretations and the ways in which faculty made adoption decisions. For example, some faculty participants had similar contexts that influenced them in different ways; while others had different contexts that influenced them in similar ways.

One common observation amongst all participants was that they did not mention how their institutional or departmental contexts influenced their adoption or lack thereof. This supports Lattuca, Berom, and Knight's (2014) investigation into departmental contexts' influence on engineering faculty development and adoption of innovations, in which they did not find a strong correlation between departmental environments and teaching practices.

The only institutional context that initially seemed influential was two of the community college faculty participants mentioning that having their aide to reflect with was beneficial to them because they did not have other engineering faculty to communicate with at their institutions. However, this contextual influence was not mentioned by any of the other community college faculty participants in the study and is likely not indicative of all community colleges, nor are all university departments guaranteed to have multiple engineering faculty to communicate and reflect with. This then suggests that regardless of institution type, faculty that feel more isolated from their colleagues may need more support during the adoption process.

Perhaps the most common influential context was the faculty participants' concern of managing their class time when adopting their co-developed curricular innovation and allocating enough time for other course content as a result of their adoption decisions. At least amongst these participants, this finding seems to counter the idea that university faculty have more constraints on their time when it comes to faculty development than community college faculty do (Porter et al., 2006). This finding and the ones discussed above also illustrate the case studies' value in supporting or challenging the existing literature (Flyvbjerg, 2006).

Ultimately, the authors contend that while certain variables and contexts may have common influences on faculty development and adoption decisions making, no one variable acts in isolation from one's context or without influence from other variables. Therefore, it is important to understand faculty cases in-depth in order to understand how

these variables may be leveraged in a wider variety of contexts to improve faculty development programs geared towards adoption. As Montfort, Brown, & Shinew (2014) put it, generalized descriptions of individual faculties' instruction development and adoption processes through traditional forms of faculty development and adoption theories fail to capture the critically important details and contexts of these individuals' realities.

## 5.2 Other Emergent Findings

It should be noted and discussed that while this study primarily focused on the three additional variables implemented after the third workshop, other variables did emerge in the data collection and analysis process that were commonly expressed as influential by many of the faculty participants. The two most influential variables that emerged outside the scope of this project were the course specific nature of the workshop and the multiyear nature of the workshop.

### 5.2.1 Course Specific Nature of the Workshop

Having the workshop focus specifically on developing innovations for mechanics of materials was done initially with the intention of disseminating research on common misconceptions students have with fundamental concepts in mechanics of materials. Throughout the interview process, participants were asked what they enjoyed most about the workshop and a common response was having a workshop that focused on one course. Twain embodies this sentiment in the following excerpt from his second interview.

> **Twain (2):** I'm so comfortable in mechanics and materials now, more so than dynamics. […] If you guys want to write another grant for dynamics, please. I'll sign my name to any piece of paper you want.

Other faculty participants expressed similar interpretations, stating that the course specific nature allowed them to focus on a well bounded problem and improve their

teaching one course at a time. Furthermore, such a bounded approach seemed to work well in this pull-oriented model as it focuses adopters' development efforts towards addressing a specific concept or topic; which enables adopters to more clearly define their needs and wants from the innovation. Another valuable aspect of the workshop that was expressed by the participants was its multiyear approach that is discussed in the next subsection.

### 5.2.2 Multiyear Nature of Workshop

The multiyear variable refers to the annual summer occurrence of the workshop. While this study focuses on events that occurred following the third workshop, many of the faculty participants attended at least one previous year of the workshop and valued this sustained approached. Rand expresses this interpretation in the following excerpt from her second interview.

> **Rand (2):** I think that one of the great benefits of this has been that it's been a multiyear thing. […] I think that the design process of seeing what works and then go back and change it has been really important.

It is indeed the multiyear, iterative approach that led to the implementation of the three additional variables examined in this study. Such an approach is almost necessary for a pull-oriented model to faculty development because it is difficult for adopters to develop exactly what they want unless the go through the trial and error process of designing and testing what they develop. These emergent variables and the findings from the three variables focused on in this study provide additional insight into future research endeavors on faculty development and adoption.

## 5.3 Future Research

First off, there has been a multitude of studies on push-oriented models of professional development and adoption frameworks, but far fewer on pull-oriented models (Godin & Lane, 2013), and therefore there is a need to further study and research

the nature and influence of other pull-oriented models. Future research could also examine the faculty development model presented in this paper implemented for different engineering courses and see if similar or different interpretations emerge. Another valuable study would be to examine different forms of continuous engagement and/or instructional consultation. While the aide variable in this study had been intended to provide support and assistance, the findings related to accountability and reflection were not expected. Many of the faculty participants in this study expressed that in the future they could be paired up with another faculty member from the workshop to communicate with on a similar basis as they did with their aide and receive similar benefits from such an interaction. The authors think that this could be a sustainable and affordable way to provide continuous engagement and faculty support throughout the academic year, rather than employing instructional consultants, and would be worth investigating further.

## Chapter 6 – Conclusion

The purpose of this paper was to present and evaluate a pull-oriented approach to faculty development where faculty and education researchers collaboratively developed curricular innovations to be adopted by faculty in their mechanics of materials classrooms. A constructivist framework was used for the evaluation and focused on faculty interpretations of specific variables within this pull-oriented approach, as well as faculty participants' context and the influence it had on their adoption decision making. While the faculty development presented in this paper was a multiyear workshop, three additional variables, or efforts, were implemented following the third workshop based on lessons learned for the first two workshops. These variables were: 1) being more intentional and explicit with the faculty participants' ability to pull, 2) providing the faculty participants with an aide to assist them in their adoption process, and 3) providing each faculty participants with student kits for all of their students. To that end, the authors had two research questions that they aimed to answer by constructing multiple descriptive-explanatory case studies for the participants through interview data collected

throughout their adoption process during the academic year. These research questions are answered as follows:

1. How do the participating engineering faculty interpret the researchers' faculty development efforts?

Faculty participants overall interpreted the researchers additional three efforts of the pull, the aide, and the student kits as being a positive influence on their adoption process. The pull variable empowered the faculty participants to preferentially select the co-developed curricular innovations that best suited their classroom needs and to further personalize these innovations to enhance their likelihood of adoption.

Faculty participants utilized their aide in a variety of different ways, but each chose to communicate with their aide over the phone on a weekly or bi-weekly basis. This continuous engagement with their aide was interpreted by the faculty participants as providing them with a sense of accountability and an opportunity for reflection on their adoption process, while also providing necessary support in sustaining their adoption process throughout their terms of instruction.

Finally, the student kits provided faculty with enough manipulatives to put into all of their students' hands. This effort was interpreted as saving the faculty participants considerable time and resources that they could then dedicate to other areas in their adoption process. The student kits also generated more enthusiasm towards adoption amongst the instructors because they could engage their students in more ways than their previous co-developed curricular innovations were able to do.

While these interpretations were common amongst the faculty participants, they also operated within their own unique contexts that influenced their adoption decision making, and the second research question aimed to explain these contextual influences in more depth.

2. How does the participating engineering faculties' context influence their adoption decision making?

The faculty participants most salient contextual influences on their adoption decision making were there: involvement in previous workshops, classroom structure, and teaching experience. All but one participant had attended the first and/or second workshop. These participants' experiences from the first two workshops were what guided the implementation of the three efforts described in the previous research question. Therefore, many of the participants expressed that the addition of these three efforts marked a significant improvement on their adoption efforts compared to previous years, because they were all aimed at addressing specific lessons learned from the previous workshops. The one participant who was a new workshop attendee at the third workshop appreciated the three additional efforts, but did not have the context of knowing the intention of these efforts from past experience and therefore did not always see them as being as influential as the other participants. This seems to indicate that adoption in a pull-oriented model should be an iterative process to innovation development and adoption so that adopters can discover any additional support or needs they have in their adoption process.

Faculty participants also adopted in unique classroom environments with differing amounts of allocated class and lab time and seating arrangements. Regardless of the time each faculty had allocated for their course or their class structure, they all still adopted their co-developed curricular innovations in unique ways. This seems to indicate that innovations need to be adaptable to a wide variety of classroom contexts and that more rigid innovations can be challenging to implement for faculty in even the most optimal of classroom environments.

The last major contextual influence identified was teaching experience. Teaching experience is not necessarily just the number of years that a faculty member has been teaching, but also their experience with different pedagogical approaches and the alignment between their professional expertise and teaching background. Faculty participants that came from a physics background had concerns with adopting innovations into their engineering classrooms due to concerns over content coverage and

dissecting theoretical physics from pragmatic engineering assumptions. While these concerns were expressed by the participants with physics backgrounds, they are not necessarily uncommon concerns for instructors with engineering backgrounds. Other faculty participants with experience implementing manipulatives and using research-based pedagogical approaches still encountered challenges in adopting their co-developed curricular innovations. These variety of experiences influenced the faculty participant's adoption decision making in multiple ways, further indicating that a pull-oriented model may be best suited for faculty development as it allows faculty to address these myriads of contexts in their own unique way.

The authors do not mean to contend that their faculty development program is better than traditional push-oriented models or even other pull-oriented models. This study rather aims to put forth an adequate alternative to faculty development and provide useful lessons learned for future pull-oriented faculty development programs. In this way, comparison with a control case, or cases, in order to prove one approach as being better than another is irrelevant to the goals and questions of this research. Furthermore the idea of proving one approach is better than another even with a control group suggests that people—specifically instructors in their classrooms—can be controlled as carefully as inanimate objects (Borrego et al., 2009; Wankat, Felder, Smith, & Oreovics, 2002). Therefore, it is the authors' hopes that this study will inspire more pull-oriented approaches to faculty development and innovative new ways of evaluating faculty development programs to continue improving engineering education and improve the adoption of research-based pedagogy in the engineering classroom.

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# APPENDICES

## Appendix A – First Interview Protocol

| | |
|---|---|
| 1. Please explain your overall teaching experience and your experience teaching mechanics of materials | • Does your style of teaching differ from subject to subject or stay the same?<br>• Have you implemented similar curricular materials in your previous courses? |
| 2. Describe how and why you got involved in this project? | • Do you think your involvement will change the way you teach?<br>• What do you want to get out of your involvement with this project?<br>• Have you discussed your involvement in this project with any of your peers and how so? |
| 3. Describe your current or previous mechanics of materials course (or any other courses) | • What does a typical class look like? Lectures, group work..?<br>• Are you doing anything different with your class since being involved in this project?<br>• Is there anything you wish you could change about your course that hasn't seemed possible to date? |
| 4. Please describe how you see your future (or current) mechanics of materials course working | • What are your plans with the demonstration materials we sent you? Which activities do you plan on using and how?<br>• How do you plan on using the student kits? |
| 5. The whole goal of this project has been to implement a "pull-model" for changing the mechanics of materials class. Meaning that you provide us with what you want to change in your classroom rather than the other way around. To that end, we have provided what we are calling an aide to help meet your needs. Do you think your aide will help in allowing you to meet your goals from the workshop? | • What are your expectations/desires from us throughout the term?<br>• Do you think we can realistically provide you with what you need in a timely and continuous manner?<br>• How do you plan on communicating your needs to us and how frequently? |

## Appendix B – Second Interview Protocol

| | |
|---|---|
| 1. How frequently did you communicate with your aide and in what ways? | • Do you think more or less frequent communication was needed?<br>• How often did you reach out to your aide? Or was it more your aide reaching out to you? |
| 2. Please explain how your interactions with your aide helped or did not help you implement your curricular activities? | • What was the most helpful thing your aide did for you?<br>• Why was this helpful for you specifically?<br>• Least helpful? |
| 3. Was there anything you felt like your aide could not help you with? | • How might we be able to help with this in the future? |
| 4. How helpful was the Canvas site for you during the term? | • Did you communicate with any other instructors on there?<br>• If you used any of the worksheets on there, how much did you have to alter them to fit your class?<br>• Did you find the videos helpful? |
| 5. Is there anything you wish we could have helped you with more or any recommendations for us moving forward? | • How do you think we can improve our efforts or the materials? |
| 6. Will you continue to use these materials in future mechanics of materials courses? | • Will you use them in other engineering courses?<br>• Has this inspired you to try and develop similar materials more suited for other engineering courses? |
| 7. Is there any last things that you want to say or express that we did not cover in this interview? | • What was your favorite and/or least favorite part about your involvement with this project?<br>• What do you want to accomplish at this summer's workshop? |