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Jennifer DeBoer
Purdue University

Maria J. Gerschutz
Trine University

David A. Evenhouse
Purdue University

Nimit Patel
National Science Foundation

Edward J. Berger
Purdue University

See next page for additional authors

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Authors
Jennifer DeBoer, Maria J. Gerschutz, David A. Evenhouse, Nimit Patel, Edward J. Berger, Nick Stites, Craig Zywicki, David B. Nelson, Charles Morton Krousgrill, and Jeffrey F. Rhoads

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Transforming a Dynamics Course to an Active, Blended, and Collaborative Format: Focus on the Faculty

Prof. Jennifer DeBoer, Purdue University, West Lafayette

Jennifer DeBoer is currently Assistant Professor of Engineering Education at Purdue University. Her research focuses on international education systems, individual and social development, technology use and STEM learning, and educational environments for diverse learners.

Dr. Maria J. Gerschutz, Trine University

After earning her doctorate from Wright State University, Dr. Gerschutz spent five years working for WillowWood, a lower-limb prosthetic company, leading efforts in research and assisting product development and testing. As part of her term at WillowWood, she was a two time recipient of the prestigious Thranhardt Award for Prosthetic Research Dr. Gerschutz passion for teaching has drawn her away from industry towards the academic setting, but has left her enthusiasm for bettering the lives of others. She is currently the Chair of the Biomedical Engineering Department at Trine University. Her focus areas of teaching include introduction to biomedical engineering, biomaterials, bioinstrumentation and dynamics.

David A. Evenhouse, Purdue University

David Evenhouse is a Graduate Student and Research Assistant in the Purdue School of Engineering Education. He graduated from Calvin College in the Spring of 2015 with a B.S.E. concentrating in Mechanical Engineering. Experiences during his undergraduate years included a semester in Spain, taking classes at the Universidad de Oviedo and the Escuela Politécnica de Ingenieria de Gijón, as well as multiple internships in Manufacturing and Quality Engineering. His current work primarily investigates the effects of select emergent pedagogies upon student and instructor performance and experience at the collegiate level. Other interests include engineering ethics, engineering philosophy, and the intersecting concerns of engineering industry and higher academia.

Nimit Patel, National Science Foundation

Research Assistant, Discover Learning Research Center (DLRC)

Dr. Edward J. Berger, Purdue University, West Lafayette

Edward Berger is an Associate Professor of Engineering Education and Mechanical Engineering at Purdue University, joining Purdue in August 2014. He has been teaching mechanics for nearly 20 years, and has worked extensively on the integration and assessment of specific technology interventions in mechanics classes. He was one of the co-leaders in 2013-2014 of the ASEE Virtual Community of Practice (VCP) for mechanics educators across the country.

Mr. Nick Stites, Purdue University, West Lafayette

Nick Stites is pursuing a PhD in Engineering Education at Purdue University. His research interests include the development of novel pedagogical methods to teach core engineering courses and leveraging technology to enhance learning experiences. Nick holds a BS and MS in Mechanical Engineering and has eight years of engineering experience. He also has four years of experience as an adjunct instructor at the community-college and research-university level.

Craig Zywicki

Craig is a Data and Assessment Analyst in the Office of Institutional Research, Assessment, and Effectiveness at Purdue University.

Dr. David B. Nelson, Purdue University, West Lafayette

David B. Nelson is Associate Director of the Center for Instructional Excellence at Purdue University. He received his Ph.D in World History from the University of California, Irvine in 2008.

David has been involved in many educational research projects at Purdue, including published worked in the programming education, student engagement and academic performance in dynamics engineering courses, and educational modalities in engineering, technology and economics.

Prof. Charles Morton Krousgrill, Purdue University, West Lafayette

Charles M. Krousgrill is a Professor in the School of Mechanical Engineering at Purdue University and is affiliated with the Ray W. Herrick Laboratories at the same institution. He received his B.S.M.E. from Purdue University and received his M.S. and Ph.D. degrees in Applied Mechanics from Caltech. Dr. Krousgrill's current research interests include the vibration, nonlinear dynamics, friction-induced oscillations, gear rattle vibrations, dynamics of clutch and brake systems and damage detection in rotor systems. Dr. Krousgrill is a member of the American Society for Engineering Education (ASEE). He has received the H.L. Solberg Teaching Award (Purdue ME) seven times, A.A. Potter Teaching Award (Purdue Engineering) three times, the Charles B. Murphy Teaching Award (Purdue University), Purdue's Help Students Learn Award, the Special Boilermaker Award (given here for contributions to undergraduate education) and is the 2011 recipient of the ASEE Mechanics Division's Archie Higdon Distinguished Educator Award.

Prof. Jeffrey F. Rhoads, Purdue University, West Lafayette

Jeffrey F. (Jeff) Rhoads is an Associate Professor in the School of Mechanical Engineering at Purdue University and is affiliated with both the Birck Nanotechnology Center and Ray W. Herrick Laboratories at the same institution. He received his B.S., M.S., and Ph.D. degrees, each in mechanical engineering, from Michigan State University in 2002, 2004, and 2007, respectively. Dr. Rhoads' current research interests include the predictive design, analysis, and implementation of resonant micro/nanoelectromechanical systems (MEMS/NEMS) for use in chemical and biological sensing, electromechanical signal processing, and computing; the dynamics of parametrically-excited systems and coupled oscillators; the behavior of electromechanical and thermomechanical systems, including energetic materials, operating in rich, multi-physics environments; and mechanics education. Dr. Rhoads is a member of the American Society for Engineering Education (ASEE) and the American Society of Mechanical Engineers (ASME), where he serves on the Design, Materials and Manufacturing Segment Leadership Team and the Design Engineering Division's Technical Committees on Micro/Nanosystems and Vibration and Sound. Dr. Rhoads is a recipient of the National Science Foundation's Faculty Early Career Development (CAREER) Award, the Purdue University School of Mechanical Engineering's Harry L. Solberg Best Teacher Award (twice), and the ASEE Mechanics Division's Ferdinand P. Beer and E. Russell Johnston, Jr. Outstanding New Mechanics Educator Award. In 2014, Dr. Rhoads was selected as the inaugural recipient of the ASME C. D. Mote Jr., Early Career Award and was featured in ASEE Prism Magazine's 20 Under 40.

Transforming a Dynamics Course to an Active, Blended, and Collaborative Format: Focus on the Faculty

Introduction

Educational research has built a convincing consensus that interactive courses, courses that blend both online and in-class resources, and courses with peer collaboration elements are each respectively beneficial to undergraduate engineering students. However, these pedagogical practices are most commonly implemented in first- and final-year courses. Moreover, the processes of implementing these new practices, and of transferring reforms between institutions, merit further study. The existent body of literature regarding the facilitation of research-based pedagogical change has been described as "weak"[1], and researchers have frequently called for further study of STEM instructional reform and implementation fidelity[1–3]. As part of this broader effort, few have sought to study the lived experience of the specific faculty members who adopt and adapt to these new teaching practices in core engineering courses.

In 2008, faculty members at Purdue University designed a novel Dynamics curriculum with the intent of facilitating an active, blended, and collaborative learning environment. The learning environment, called *Freeform*, has since been executed and refined to the point that its developers are looking to expand its application, providing the environment to other institutions as part of an ongoing collaborative research endeavor. One such opportunity presented itself in the months leading up to Fall 2015, when Trine University expressed interest in adopting Freeform.

In this study, we follow the translation of Freeform from Purdue University to Trine University, expressly focusing on the lived experience of the instructor at Trine who implemented the course materials, scheduling, format, and pedagogical approach from the pre-established curriculum during the Fall of 2015. Few studies have amplified the voice of the instructors involved in curriculum development, and through this study we seek to do just that. Specifically, we address the following research questions: (1) What was the lived experience of a mechanical engineering instructor at a different institution as she adopted and adapted the provided materials and format? (2) How did the experience of this instructor evolve throughout the semester?

Background

The Freeform Environment

Though still the minority, interactive teaching methods that incorporate a variety of learning materials have become more prevalent in college and university settings across the United States. Recent studies, including a large meta-analysis, have pointed out that for college/university

science, technology, engineering, and math (STEM) courses, active learning outperforms lecturing on numerous student outcomes[4]. Another set of meta-analyses have demonstrated the benefits of blended learning in formal classroom settings (a mix of face-to-face and online materials and activities[5,6]). Finally, a variety of studies have demonstrated that collaborative, social learning has cognitive and non-cognitive benefits for students[7,8]. Few classrooms combine these three complex instructional approaches in one environment, and fewer still implement this approach in the challenging core second- and third-year engineering courses. Freeform employs what we call an active, blended, and collaborative (ABC) approach to a core mechanical engineering topic (Dynamics). Although Freeform Dynamics has reached a mature, steady-state, and effective implementation at its original institution, we need to carefully study the ways in which a beneficial but multifaceted course environment is adopted and navigated by faculty at a different institution.

The Freeform environment was developed in 2008 and first implemented in 2009, and may be viewed as a holistic pedagogical framework that embraces ABC principles while unifying both traditional and contemporary, research-based instructional practices. Freeform Dynamics, built for the core Dynamics course at Purdue University, incorporates multiple ABC learning elements: (i) class meetings including a wide range of active learning strategies, in particular, collaborative problem solving; (ii) a hybrid workbook that blends a traditional textbook and lecture notes in hard copy, including concise background and derivation, with fundamental and conceptual questions, relevant examples, and ample white space in which students take notes and solve problems; (iii) an extensive online video library with problem solution videos, animations, and live-action experiments focused on mechanics topics; (iv) a course blog housing videos and threaded discussions related to specific course content; and (v) refined student assessments, including collaborative group quizzes[9]. Freeform was developed and implemented over the last 6 years and, although a variety of instructors at the West Lafayette campus of Purdue University have implemented it in that time, this study documents the first time an instructor at a partner institution wholly adopted the Freeform learning environment.

The research reported here is one component of a larger study concerning the way in which students, instructors, and institutions engage with Freeform materials and the relationship the environment has with individual and group outcomes. Prior evidence suggests that the Freeform environment supports student conceptual learning and improves the class DFW rate[9]. However, no innovative course can be rigorously assessed using only a single metric. This on-going research seeks to utilize a diverse range of assessments and evaluations to study Freeform as a pedagogical framework. The entirety of this research project brings together more than 10 researchers of varying skill sets including expertise in mechanical engineering, engineering education, teaching and learning, data analytics, and teaching innovation, as well as input from the original developers of the Freeform environment.

Adoption and Implementation Literature

A prominent theme in literature regarding the spread and adoption of research-based practices in STEM education is that there is simply not enough of it. Despite invested resources and rigorous research, the spread of instructional innovations is slow[3,10]. Likewise, there has been too little study into the reasons behind these low rates of adoption; existing studies are fragmented across a range of contexts and perspectives[1]. Though few of these studies have focused on the lived experience of those instructors implementing said innovative practices, some publications can serve to inform our analysis here. For example, researchers have observed that communities of practice can help instructors to quickly adapt to a new environment[11,12]. However, the boundaries between these communities can also act as barriers to innovation, contributing to the low spread of innovations within a diverse institutional setting[13].

These communities, and the institutions in which they are situated, also act to define key aspects instructor identity, a theme that becomes evident in our later analysis. In this early analysis, we use the broad definition provided by Brownell and Tanner, that faculty professional identity comprises: "how they view themselves and their work in the context of their discipline and how they define their professional status"[14]. These authors noted how rarely the topic of pedagogical reform has been paired with the topic of professional identity[14]. Previous studies focused on instructor agency, addressing the ability of the instructor to enact personally-motivated changes within a given pedagogical environment without ever explicitly characterizing the personal and professional identities which act to drive these changes[15].

We continue to leverage a number of larger, more general frameworks and models to inform our continued analysis of the Freeform environment and its adoption[2,16,17]. However, an in-depth analysis of their nuances falls beyond the scope our current study.

Collaboration with Trine University (New Adopter)

Some aspects of this research require the collaborative effort of multiple institutions, and partnering with Trine University in the Fall of 2015 provided a unique opportunity to implement Freeform Dynamics in a different institutional context. Motivation for this partnership was both administrative and pedagogical. Traditionally, Dynamics at Trine is offered out of the Mechanical Engineering department, but serves students from civil engineering, electrical engineering, and biomedical engineering as well. The course was identified by colleagues at Trine as an essential, fundamental engineering course, which was unfortunately acting as a "barrier" to student retention. Simultaneous to these retention issues, administrative leaders at Trine had identified Freeform Dynamics as an intriguing means to broaden student engagement, while allowing for participation in a collaborative research endeavor with Purdue. The new chair of the biomedical engineering department, an experienced assistant professor, was slated to teach Dynamics in the Fall of 2015. She was subsequently recruited by university administration to

adopt the Freeform Dynamics platform for her Fall 2015 course. She had assumed the inaugural chair of the biomedical engineering department two years prior and had experience teaching Dynamics at Trine in the past.

The implementation of Freeform Dynamics at Trine University was comprehensive, including near-identical material coverage, resource materials, homework and exam formulations, course textbooks, and ABC-inspired pedagogical style in comparison to Purdue. Researchers suspect that key differences in academic culture, size, faculty/student expectations, and other factors may affect the adopting instructor's experience, the implementation of Freeform, and the outcomes students achieve in the Freeform environment. Likewise, the research team wishes to document the factors that characterize the faculty experience of adopting and teaching within Freeform. This paper focuses primarily upon the faculty experience, but also represents an intersection of these two concerns, laying the foundation for future cross-institutional analysis while documenting and analyzing the complex experiential factors evidenced by an adopting instructor at Trine University.

Trine University is classified as a Baccalaureate College--Diverse Fields (Bac/Diverse) institution. It is a private university with approximately 2,700 undergraduate students. Administration at Trine has limited all courses to a maximum of 30 students in each class, and instructional experience and performance acts as an important part of the promotion process for faculty. In previous years, the instructor involved in this study included select teaching strategies that parallel ABC elements of the Freeform environment (e.g., in-class active learning). However, the comprehensive implementation of Freeform Dynamics in the Fall 2015 course constituted a major change in her instructional practice. To navigate and document this transformation process, the instructor implemented what shall be referred to here as reflective teaching practice, both on an individual basis and in concert with the research team.

Reflective Teaching and Learning

Literature regarding the dissemination of educational innovations has previously made direct ties between the dissemination of ideas and the development of reflective teaching practice[16]. Reflective teaching practice encourages a heightened awareness of the teaching and learning experience, with an eye towards appropriate adjustment for improvement. Theorists have variously characterized reflection as a process of experiencing, reflecting, generalizing, and planning[18], or as reflection-in-action and reflection-on-action[18]. Cowen[6] further suggests adding "reflection-for-action" to this second framework, creating a working model of constructive and productive reflective practice. It is this last descriptive framework that most aptly fits the way in which we (the instructor and the research team) reflected on and modified practice throughout the Fall 2015 semester. The impetus for employing reflective practice in teaching is entirely student-centered, democratizing pedagogical and curricular change through sensitivity to the

specific institutional, societal, or cultural environment. Indeed, the idea and practice of reflective teaching fits with the cross-institutional implementation of pedagogical reform, as:

> *"...if teachers can develop their own thinking about their own practice with the aim of changing it according to students' needs, educational transformations would not have to necessarily adhere to some linear predetermined scheme. They would open up to the very differences in learning that could proliferate in educational possibilities."*[19]*, p. 245).*

Following Galea's[19] warning against standardizing educational transformations, the Freeform environment allows for space in which the instructor can increase his/her interaction time with students and make adjustments to schedule, materials, and instruction based on his/her expertise.

In support of this reflective teaching practice, researchers sought to facilitate instructor reflection throughout the semester using weekly reflection prompts. In addition to this, weekly conversations between the instructor and research team promoted collective reflection, generating feedback and identifying areas where additional support was needed. Collective reflective practice has been shown to increase teacher self-efficacy and openness to external input[20].

Data

We used rich qualitative data from weekly reflection prompts to describe and characterize the inherently multi-faceted experience of the adopting instructor at Trine. This includes her experiences learning about the curriculum and online tools, implementing the Freeform Dynamics class, adjusting her instructional practice to reflect ABC learning, and assessing her students' levels engagement and comprehension throughout the course.

Our primary data source was the weekly reflection questions posed by the overall research team to the instructor. (Note that two weeks were missed or compressed on account of semester scheduling.) A few days after the semester week in question, the team sent a reflective prompt to the instructor. Responses were typically 300-400 words and could be general or, when necessary, could respond to specific questions. As the team constructed weekly reflection prompts, they built on previously published research findings for facilitating instructor reflection. These include probing past, present, and future experiences, including both cognitive and emotional experiences[21], and probing moments or experiences that stand out in the perception of the reflecting instructor[22].

Some questions evolved over the course of the semester to reflect semester milestones, such as exams, as well as to prompt further reflection on salient points brought up during weekly collaborative reflection. Others, however, remained consistent. Each week, the main reflection prompt was worded similar to the following text:

> Week 3: *What moments of experience stand out to you from your second week? These can be anomalies that necessitated immediate or distant reactions, patterns that you noted, or other experiences that stand out.*

Some additional or revised prompts were also included, such as the following set of secondary questions:

> Week 8: *How has the addition of quizzes gone for you? For your students? How has this conflicted with your usual practice, and how did you resolve those conflicts? We are interested in your own description of your experience, as well as both your decision-making process, and the actual actions you took in class.*

Methods

In characterizing the instructor's experience three of our researchers utilized a branch of phenomenology--Interpretive Phenomenological Analysis[23]--to understand the instructor's experience during this course transformation. These same three researchers conducted the analysis and member-checking procedures further detailed below. Interpretive Phenomenological Analysis allows not only for characterizing the instructor's experience, but also informs the subsequent interpretation of her experience. This acts to directly address the two research questions as stated in the introduction, which concern the expression and development of the instructor's lived experience. Please note that, while the overall research team includes developers of the Freeform environment, no Freeform developers or instructors participated in this IPA analysis process. However, all three researchers who were involved in the analysis were familiar with Freeform Dynamics, its content, and instructional practice in higher education on a more general basis.

We used Interpretive Phenomenological Analysis (IPA) to focus on the lived experience of the adopting instructor. To address our primary research questions ([1] the lived experience of the instructor as she adopts and adapts the environment, and [2] the evolution of her experience throughout the semester), we first conducted a whole-case analysis to explore the overall nature and lived understanding of her experience. We then analyzed the weekly reflection responses longitudinally, identifying patterns of meaning that developed or changed over the semester.

IPA practice is situated within a given context and frequently relies on first person accounts. In this case, the first person accounts are the direction reflections of the instructor implementing Freeform Dynamics in her Dynamics class. The analysis method attempts to identify "objects of concern", that is, anything that matters to the participant experience including events, values, relationships, experiential claims, or indications of the meaning of these "objects" to the respondent. Like many analytic methods, IPA also relies on an understanding of the researchers'

perspectives and how this may influence interpretation. Additionally, in order to check for consistent interpretation of the new instructor's experience, a round of member checking was also conducted. We presented results of the analysis to the instructor herself and asked her to validate and comment upon the themes we identified. By doing so, we hoped to mitigate error and to ensure an accurate interpretation and representation of our findings.

Our group of three researchers each employed IPA methods in analyzing the same set of data. After initial open coding, observations were compared in order to verify consistency across researchers and to inform the development of themes. The themes that emerged from this process constitute the principle academic contribution of this paper, as they characterize the experience of the instructor adopting the Freeform learning environment.

Emergent Themes

In total, we had twelve separate reflections, in which were identified between 300 and 400 nodes during open coding (about 30 open codes or "nuggets" of information from each reflection). As a crude picture of the central emphasis of the instructor's experience, we charted the word frequency across all of the reflections and found that "students" (and words related to the "student" stem) were by far the most frequently mentioned subject, encompassing a weighted 4.07% of the instructor's words. Exams were also frequently mentioned, as were the terms "weeks" and "time" or "timing". The nodes elicited from the twelve reflections, as well as the word frequency analysis, contributed to the identification and refinement of a number of themes characterizing the instructor's experience.

RQ1 - Lived Experience of a Mechanical Engineering Instructor Adopting New Format: Key Dimensions are Student Perception and Course Constraints/Flexibility

Experience Driven by Student Perception and Reaction

First, we identify those emergent themes globally important to the instructor in her experience transforming the Dynamics course. (See Table 1 for summary.) One of the most prevalent and pervasive themes is that of the *experience being driven by student perception and reaction.* In the complex process of implementing new materials, activities, and structures, it is the student's perception, or the instructor's perception thereof, which dominates the instructor's experience. At times, this perception was a source of unease or discomfort, e.g., *"...I felt resistance from the students...I felt a disconnect from students."* (Week 1). Perceived student reaction shapes the instructor's experience by encouraging self-judgment and contributing to a sense of inadequacy:

> *"...typically teach using ppt slides. Using solely the textbook, I feel like the students are not getting a clear message or that there is disconnect between the notes (their textbook) and my lecture. All of these things make me feel uneasy, less confident in my lecture*

presentation, apprehensive and stressed….I feel like it is hindering my performance in the class because some of the feelings are being projected in my teaching." (Week 9).

Conversely, an increase in student comfort is often accompanied by an increase in instructor comfort. An example of this comes from when the instructor refined her teaching methods towards the end of week one saying, *"I think this new approach lessen [sic] student apprehension and relieved some tension I was feeling with lecturing solely from the pdf."* (Week 1).

At other times, the instructor's decision-making is shaped by interpretation of, or an effort to preempt, student reaction, e.g., *"I took a different approach for the review this time...I wanted to eliminate any confusion."* (Week 10) or *"Some suggestions came forth [from mid-semester survey]...I have made adjustments towards these concepts."* (Week 8). This is the case even though the instructor acknowledged that students in her class have no comparative classroom experience for learning dynamics (i.e., exposure to another pedagogy or course environment), so they could not say which approach they preferred.

There are several other instances where the reaction, or potential reaction, of the students seems to have considerable impact on her perception of the course and her own instruction, for example: *"...I felt a disconnect with the students which is odd."* (Week 1), *"I felt bad for the students"* (Week 9), and *"I feel my relationship with these particular students is very amiable"* (Week 13,14,15). This theme persisted strongly throughout the semester.

Experience Driven by Student Performance

Similar to the first theme, the instructor's *experience is often driven by student performance*. From analysis of her reflections, we gather that the phenomenon is driven by the instructor's feeling of a distinct sense of responsibility regarding the performance of the students, as well as their comfort with the course structure and material. She mentions this on multiple occasions, for example, *"I think this approach lessen [sic] student apprehension"* (Week 1), *"I worry about my students when I could visibly see the students stressing..."* (Week 9), and *"I would like to see all the students succeed in passing the course without decreasing my standard (or rigor) of evaluation. This is a goal I have for all of my classes."* (Week 11). All this demonstrates a personal commitment to student performance and success within the course, despite the curriculum having been developed by someone else.

The instructor employs multiple means, from direct conversation to the use of assessments, to gauge how well the students comprehend content and perform in the class. In this context, the use of assessments is particularly important. Statements like *"I concluded this by observation of their homework"* (Week 2), *"I do feel [the quiz] is a good check and balance of the level of material comprehension for the students…"* (Week 8), and *"I would probably assign more homework than what is given in the new material. I think practice at varying levels of difficulty*

would be helpful… It allows me to get a sense of their grasp of the material." (Week 10), give a sense for how the instructor consistently concerns herself with the employment of assessments to gauge student comprehension and performance.

This concern regarding assessments is especially prominent when the instructor discusses the design and implementation of exams. The three exams during the semester created spikes in stress and dimensions of experience for the instructor. From the development of the exam, to the review of content prior to the exam, to the exam questions themselves, the transformation to the new course seemed especially stressful around exam time:

> *"The process of developing the exam this time was different."* (Week 4);
> *"The biggest difference in my process was the review...It is hard to tell which method the students would prefer, because these students have only experienced the latter review sheet [here, the new review sheet format with Freeform-style questions]."* (Week 5)
> *"This year I did not use any previous exam questions [to come up with questions for this year's exams. The instructor normally reuses some questions to gauge alignment.]. Compared to previous years, I am only slightly behind on the exam writing process."* (Week 15)

Imposition or External Determination

The instructor's experience is also characterized by *imposition or external determination*, as the instructor felt limited or less autonomous in a number of ways. Most notably, she makes frequent mention of how things felt "unnatural" or were not "typical" to how she usually conducts classes. This sense of tension between the natural and the unnatural seems to imply that the imposition of a foreign curriculum was in some way forcing her to compromise her professional identity as an instructor. The habits, tools, and theories she typically employed when teaching were now mitigated by an external power. *"I am very much a planner. So this goes against my nature."* (Week 9).

This mitigating effect extended not only to the instructor's professional identity, but also to the ability and knowledge gained from her prior professional experience. When teaching within the Freeform framework, the instructor found herself unable to predict the amount of time necessary for specific lectures, activities, or assessments. *"The pace is slightly different from previous years so I do not have a good feeling how long (referring to time) material and examples will take in class."* (Week 10). Likewise, it became difficult to gauge how the students might perform in a given assessment or activity. All these judgments are based upon past instructional experience, but the prior experience she had come to depend on proved to be inadequate when transitioning to an entirely new instructional environment.

We noted a sense of tension and uncertainty around exams, as mentioned earlier, but also around quizzes: *"Since I typically do not give quizzes in my courses, I am working through this issue to find a balance."* (Week 8), again emphasizing the instructor's concern over assessment. This imposition seems to have led to feelings of uncertainty about what areas or aspects of the course she had the freedom to modify. However, it should be acknowledged that this lack of autonomy may have been exacerbated by the presence of this research study, as the instructor may have felt additional pressure to adhere to the Freeform framework in order to avoid compromising the usefulness of a cross-institutional project.

Scheduling and Schedule Requirements

The curricular changes that the instructor experienced in the transformed course are primarily embodied by the *schedule and scheduling requirements,* with key touchpoints being topic coverage and order. In our analysis, we see the imposition of this schedule quickly give rise to a feeling described consistently as "treading water". There is a constant pressure to plan classes and learn content which is amplified by the instructor's preference for having course content planned far in advance. Statements like *"I feel like I am treading water because most days I am only one step ahead of the students"* (Week 9) and *"I am currently only one step or less ahead of the lectures"* (Week 11) show how the schedule impacts the instructor's experience, imposing a perpetual perception of rushing.

The Freeform Dynamics schedule also appeared to afford or support flexibility in the Dynamics class. For example, the instructor noted that *"...the nice thing about the Freeform was that the students were able to work until the end of class without me having to stop to provide the solution because the solution is available online."* (Week 1). She perceived some of the shifts in activities and topic coverage as supportive of student engagement and freeing of her time: *"...[I] noticed that students focused more on the assignment and gained a deeper understanding of the topic. As the professor, it provided me an opportunity to interact with the students and gave me an understanding of their comprehensive level."* (Week 2). She also perceived that, in future years, the scheduling and content of classes could be altered in order to better align with her preferences. She states that *"...I think I would separate each topic by devoting a day to each one"* (Week 7) and *"...planning on breaking up homework assignments"* (Week 7), which shows that the instructor experience includes a feeling of room for improvement in the course content, scheduling, and materials. Despite the challenges to adoption she was experiencing, the instructor also felt the environment was portable for substitute instructors: *"...the Freeform style class allowed me to cover additional information in the class meeting prior to my absence. As a result, I was able to generate a quiz and have the remaining time as problem work day in my absence. This minimized the burden placed on the substitute."* (Week 4).

Concerns with Timing and Time Requirements

In addition to concerns regarding scheduling requirements, concern over *timing and time constraints* were also prevalent throughout the semester. The external determination of the course environment and materials contributed to a feeling of strangeness with the resource materials, causing the instructor to devote large amounts of time to simply familiarizing herself with the content. A major "object of concern" for the instructor was the feeling that the problems, for example, were not ones for which she knew all the nuances, strengths, and weaknesses yet:

> *"I feel like I am developing a new course because I am spending a lot of time working problems. I am working all the problems in the workbook plus all the problems in the homework."* (Week 8).
> *"In a course, I like to logically think how one step will lead to another. In this course I have a hard time accomplishing this because I have not had the time to look at the material for future lectures or lay out a plan of action. This issue predominately affects the homework."* (Week 9).

Through these quotes, we can again see the instructor's concern over assessments and assessment design, a concern that was reflected in the amount of time she dedicated to these aspects of the course. She says, *"I spend a considerable amount of time organizing the information I plan to cover in class and assign for homework."* (Week 10), and this is corroborated by the sheer number of reflections that directly reference assessments such as homework, quizzes, and exams.

Reconciliation of the Old and the New Course

Finally, the theme of *reconciliation of the old and the new course* (in terms of approaches and material) was prevalent in the instructor's experience. Throughout the semester, incorporation of practices and content that resembled the instructor's past experience led to an increase in her comfort with the course. For example, she traditionally taught using an interactive PowerPoint (ppt), and Week 1 was largely characterized by her attempts to find an instructional method that was comfortable for both her and the students. She writes about day 2 of instruction: *"I decided to use the pdf of the workbook as my notes. In doing this, I felt a disconnect with the students which is odd because I typically teach with ppt...With the pdf, I think there was too much information in front of them"* (Week 1). Then, when discussing day 3: *"I decided to teach on the board more and use the pdf only for image support. I increased the size of the pdf in order to limit the clutter on the screen and to focus on key concepts,"* (Week 1), a practice which seems to better approximate her use of PowerPoint in the past. This change in practice was immediately followed by a release in tension.

Her experience plugging material and methods from her previous courses into the Freeform structure was not always a simple task. Including old material often required that she take an

entire day to cover a topic not considered in the typical Freeform Dynamics schedule. Old practices were often incorporated reactively and gradually, as was the case in her exam review sessions. Regarding the first exam review, she writes, *"I typically create a review sheet with problems that cover the basic concepts for each topic that could potentially be on the exam. However, this time I only provided a previous exam for the students to study from."* (Week 5). Later, we see this more "typical" practice being employed*, "I took a different approach for the review this time. Instead of posting a previous Purdue Exam, I created a review sheet of six problems that covered the basic concepts of 4.A and 4.B."* (Week 10)

RQ2 – Evolving Experience of this Instructor Throughout the Semester: Eventual Balance

Shifting Balance of Reconciliation

Next, we turn to themes that evolved as the instructor's experiences grew and changed over the semester. The theme of reconciliation again emerged as a key longitudinal characteristic of the instructor's experience, as the *balance of reconciliation* shifted for the instructor over the course of the semester (see Table 2). That is to say, her experience reconciling her previous and current practice shifted from near-complete implementation of the new practice to more integration of her previous instructional practices by the end of the semester. For example, in Week 3, she begins adjusting topic coverage: *"This week I decided to introduce a topic that is not covered in the textbook. I spent a day talking about projectile motion...I strongly feel this will be beneficial for the students when we proceed to chapter 4 and need the kinematic relationships to fill-in missing elements within problems."* (Week 3). By Week 10, she notes, *"At the beginning of the semester, I used mostly 'new' material. I have recently incorporated 'old' material."* (Week 10).

In addition to a greater presence of old practices and content, the application and use of these elements became more strategic in nature. Often, they were incorporated into the course in order to serve a specific purpose. Content from the new Freeform Dynamics curriculum was perceived as being more conceptual in nature and as good in promoting innovative thinking. Older content, which the instructor was more familiar with, was perceived as being more useful in gauging student comprehension and problem solving ability. For example, she says regarding her second exam, *"My Exam 2 only covered 4.A and 4.B. For the first two problems, I used old material to test their comprehension. For the concept problems, I still utilized "new" material."* (Week 10).

Evasive Return to Normalcy

The semester was characterized by the aforementioned sense of rushing, accompanied by a slow familiarization with the course's content and instructional practice, a theme we refer to as the *evasive return to normalcy.* However, the beginning and end of the semester were experientially distinct from the main body of the semester. The reflection during the first week is unique in that its paragraphs are broken up by day, implying that there were distinct "moments of experience"

Table 1. Emergent themes and subthemes characterizing the instructor's experience transforming the Dynamics course (RQ1).

Theme	Sub-theme	Indicative Quote
experience driven by student perception and reaction	unease or discomfort of students reflected on to instructor	"...students stared at me with big eyes trying to digest everything. I think it was a shock because dynamics is a more traditional course…" (Week 1)
	increased student comfort a precursor to increased instructor comfort	"…I felt the review session went smoother. I had less 'silent time' where the students did not know what to ask." (Week 10)
	impact on instructor planning and decisions	"The students and I had a discussion about resources and the benefit of those resources...I...anticipate that the usage of videos will increase right before the first exam. I plan [to] restress the importance of the resources periodically throughout the semester." (Week 3)
	sense of judgment	"…I feel like the students are not getting a clear message or that there is disconnect between the notes (their textbook) and my lecture… A sense of rushing is always present. I feel like it is hindering my performance in the class…" (Week 9)
experience driven by student performance	use and usefulness of assessments	"I would probably assign more homework then what is given in the new material. I think practice at varying levels of difficulty would be helpful… It allows me to get a sense of their grasp of the material." (Week 10)
	special concern regarding exams	"Typically at this point I am starting to make preparations for the end of the semester – writing the last exam and thinking about the final." (Week 11)
	sense of responsibility	"I would like to see all the students succeed in passing the course without decreasing my standard (or rigor) of evaluation. This is a goal I have for all of my classes." (Week 11)

imposition or external determination	mitigation of professional identity	"I am very much a planner. So this goes against my nature." (Week 9)
	mitigation of instructional experience	"The pace is slightly different from previous years so I do not have a good feeling how long (referring to time) material and examples will take in class." (Week 10)
	lack of autonomy	"In addition, there is a section of the book that we do not typically cover. The prep work for that section was much greater than normal." (Week 8)
scheduling and schedule requirements	primacy of the schedule	"In approximately 4 day timeframe, I will have to work all the examples in the textbook for 4.C, all the homework, develop lectures, and finalize details. In addition during that time period, I will have to grade homework and exams." (Week 9)
	sense of rushing, or treading water	"I feel like I am treading water because most days because I am only one step ahead of the students." (Week 9)
	perceived potential for flexibility in class content	"The second day of class contained a lot of material to cover. If I was to teach it again, I would push some of the information to the third class." (Week 1)
	affordance for flexibility in class structure	"ended the class with an active assignment in which the students worked on their own utilizing resources around them. This seemed to work well for both the students and I." (Week 2)
	informed by concept scaffolding	"The transition to kinetics was smooth for me...For the students, I think it brought a degree of familiarity…[but], I felt that students are still uncomfortable with applying kinematics relationships to assist with solving the kinetic problems. This is a newer issue I have experienced." (Week 7)

concerns with timing and time requirements	familiarization with content	"…I am spending a lot of time working problems. I am working all the problems in the workbook plus all the problems in the homework. When selecting problems to work in class, I spend a lot of time working out a problem and double checking the problem for errors." (Week 8)
	assessment design	"I have had trouble segmenting the given homework problems into smaller assignments of two problems each night. I have mixed up the order of some of the problems to better coincide with the material covered in class. I spend a considerable amount of time organizing the information I plan to cover in class and assign for homework." (Week 10)
reconciliation of the old and the new course	increased comfort when new practice reflects old course	"There is a comfort level related to the old material and an expectation of student performance." (Week 10)
	plugging in, misalignment	"This week I decided to introduce a topic that is not covered in the textbook." (Week 3)

(to use the wording in the prompt) that stood out to the instructor on a day-to-day basis. The implication here is that there was period of drastic change and realignment during the first week, as students and instructor adjusted to the new learning environment. This structure is lacking in later reflections, where moments of experience are called out, but the week is evaluated as a whole, not a collection of days.

It is also notable that over the course of the semester, as the instructor perceived an increase in student comfort with Freeform Dynamics, her own experience and description of comfort correspondingly increased. Additionally, as mentioned above, subsequent weeks were characterized by a ubiquitous sense of rushing:

> *"One major difference is that I typically have exams finalized a little less than a week prior to the exam…"* (Week 4);
> *"A sense of rushing is always present*." (Week 9);
> *"I want to finish chapter 5 without rushing through material."* (Week 11).

However, in the 15th week of the course the instructor experience changed drastically: *"I finally feel like I have my feet on the ground because I just finished the prep information necessary to complete the course."* (Week 15). It was not until the penultimate week that the instructor finally lost the sense of treading water, replaced with an evidenced release of tension. She writes, *"Compared to previous years, I am only slightly behind on the exam writing process. But considering all, I am not stressed out about the final*." (Week 15).

Probing Multiple Avenues for Student Feedback

The evolution of the instructor's course experience embodies the development of *multiple avenues for student feedback* with which the instructor could engage. Given the impact of student perception and performance on the instructor's experience (see RQ1), it is informative that the evolution of the instructor's experience included adding new and different ways of gathering information on, and from, students. This included formal formative assessments in the form of quizzes—a form of assessment, which was not typically employed by the instructor, but is strongly emphasized by the Freeform framework:

> *"I took the approach from the very beginning that quizzes will be given during class and the students have, in my mind, accepted it as an element of the course. I do feel it is a good check and balance of the level of material comprehension for the students and the professor."* (Week 8).

The instructor's experience also expanded to add formal feedback on the course via a midterm survey: *"I have never conducted a mid-semester survey before so this was new to me."* (Week

8). These formal instruments were added throughout the semester to supplement the instructor's informal conversations with the students, e.g., *"The students and I had a discussion about resources and the benefit of those resources."* (Week 3). The instructor may have felt the need to add these formal channels for feedback because of the quieter nature of this group of students: *"In general, this particular group of students are very quiet and reserved...As [the] semester has progressed, the relationship with the students has opened up."* (Weeks 13/14).

Though quizzes and mid-term evaluations may be common in other educational settings, this instructor had not used them in prior practice. In her reflections and informal feedback to the research team she pointed out that in prior classes, she was able to gauge student academic performance and emotional states through her close relationship with them and through other formative assessment tools (e.g., homework). However, as she continued to adopt and adapt to new practices, she incorporated new assessment tools within the Freeform environment and reflected on the increase in her understanding of student learning and student perspective.

Increasing Ownership and Confidence

The *increasing ownership and confidence* briefly mentioned earlier also merits some further discussion and incorporates aspects from the surveys and assessments used by the instructor to garner student feedback. First, it should be noted that throughout the semester, the instructor gave explicit justifications for her incorporation of old content and practices into her curriculum. Towards the beginning of the course, this often took the form of either a direct contrast between Purdue and Trine Universities, or a characterization of Trine's unique curricular context. For example, *"This week I decided to introduce a topic that is not covered in the textbook.... The topic is covered in our physic courses however the derivation of the kinematic equations, I feel, is not stressed in the course. I strongly feel this will be beneficial for the students when we proceed to chapter 4..."* (Week 3). However, this need for justification gradually disappeared over the course of the semester, with the personal judgment of the instructor serving as sufficient justification for changes to the curriculum by the end of the year. As quoted earlier, *"I used old material to test their comprehension. For the concept problems, I still utilized "new" material."* (Week 10).

Some of these changes took the form of the development of instructional practices or habits, such as the inclusion of problem work at the end of class or changes to the exam reviews, both of which have been mentioned previously. Others came as the direct result of action informed by student or outside input, *"Some suggestions came forth like try to write bigger and the homework problems can be a lot of work and difficult. I have made adjustments towards these concepts."* (Week 8). In either case, they constituted moments when the instructor was able to take direct control over her instruction, despite the imposition of the adopted curriculum.

Possible Influence of Research Study

Of note to this particular study is the possibility that, through writing weekly reflections for this study, the instructor's experience was directly altered as a result. This is to be expected to some extent. As stated earlier, reflective teaching practice has been shown facilitate instructor self-perception, thus encouraging the informed development of a course. There is some evidence of just such a phenomenon occurring in the instructor's reflections. There are instances were a topic or term will come up in a specific reflection, only to be repeated in multiple subsequent reflections, implying that its advent has fundamentally altered how the instructor is perceiving and interpreting her experience.

For example, the notion that the instructor was not able to accurately gauge how long a specific topic would take to teach was not explicitly stated until Week 10, despite numerous times where the topic could have arisen. It is not mentioned in Week 1, *"The second day of class contained a lot of material to cover. If I was to teach it again, I would push some of the information to the third class."* (Week 1), nor Week 7 *"If I was to teach that section again I think I would separate each topic by devoting a day to each one."* (Week 7). Here we see her comment on how long specific content takes to cover, but she makes no comment on her ability to gauge content length. However, after mentioning it in Week 10 *"The pace is slightly different from previous years so I do not have a good feeling how long (referring to time) material and examples will take in class."* (Week 10), the topic immediately returns in Week 11, *"…As a result, I am still guessing the amount of time required to cover each topic."* (Week 11). This is important to note, as the *direct influence of the research study*, specifically due to elicitation of data via reflection prompts, could mitigate the generalizability of this study's findings.

Subject Reaction and Member Checking

We conducted a round of member checking by presenting the instructor with the emergent themes and having a conversation to confirm the set of the analyses presented here. In addition to corroborating and slightly revising the wording of the emergent themes, she summarized her overall experience, presented here.

> *The adoption of new approaches comes with uncertainty, uneasiness, and significant time commitment. This particular experience did not lack in any of these areas; however, the student comprehension and success, the driving factor for the adoption, outweighed the drawbacks. My previous teaching style included student in-class collaborative work, which was not a significant difference from the new Freeform style being adopted. On the other hand, the Freeform approach required the acceptance of new formats, restructure of material, and novel resources. The limited time before the start of the semester for course preparation intensified the stress, discomfort, and confidence in the*

Table 2. Emergent themes and subthemes evolving over the course of the semester of the instructor's experience transforming the Dynamics course (RQ2).

Theme	Sub-theme	Indicative Quote
shifting balance of reconciliation	greater incorporation of old practice or content	"At the beginning of the semester, I used mostly 'new' material. I have recently incorporated 'old' material." (Week 10)
	strategic incorporation of old practice or content	"My Exam 2 only covered 4.A and 4.B. For the first two problems, I used old material to test their comprehension. For the concept problems, I still utilized "new" material." (Week 10)
evasive return to normalcy	initial period of flux	"The first day I felt resistance from the students. They were unsure of the change especially when it involved an exam." (Week 1)
	growing familiarity accompanied by sense of rushing	"Typically at this point I am starting to make preparations for the end of the semester – writing the last exam and thinking about the final. I am hoping I am to that point by week 15." (Week 11)
	back to normal the penultimate week	"...finally feel like I have my feet on the ground…" (Week 15)
probing multiple avenues for student feedback	evolving assessments for multiple purposes (testing comprehension, interim course feedback)	"...biggest conflict I have is the timing for the quiz...Since I typically do not give quizzes in my courses, I am working through this issue to find a balance…" (Week 8)
	eliciting feedback from a quiet group	"glad I conducted a mid-semester review mostly because the students in this class are not talkative like my typical students so it is hard to understand the needs of the students." (Week 8)
increasing ownership and confidence	less concern for justifying inclusion of old content or changes to schedule	"I think I might truncate the last day of Newton/Euler Rigid body to include a review problem over central impact. Previous experience has shown me that student can mess up equations very easily on this topic." (Week 11)

	development of instructional practices and habits	The second week in class mimicked the teaching style towards the end of the first week of class... This seemed to work well for both the students and I." (Week 2)
	direct action responding to input or observations	"Some suggestions came forth like try to write bigger and the homework problems can be a lot of work and difficult. I have made adjustments towards these concepts." (Week 8)
possible influence of research study	lasting effects of reflection on experience	"…so I do not have a good feeling how long (referring to time) material and examples will take in class." (Week 10) "… As a result, I am still guessing the amount of time required to cover each topic." (Week 11)

class. In addition, the reordering of the material required strategic planning of the presentation and the delivery pace of the material. In contrast, the supplemental resources available to the student allowed for additional class time for one-on-one interaction.

The particular students in the class were naturally introverts, necessitating the use of various assessment methods for student comprehension and student learning techniques. In response to these assessments, slight adjustments and integration of some old resources were incorporated to meet student needs. Over the course of the semester, the comfort level associated with the Freeform style improved.

In her own words, she corroborates and adds depth to the analytic themes that emerged from her ongoing reflections. Ongoing analyses of her reflections and corresponding student data may help to further triangulate the points of experience she highlights.

In her weekly reflections as well as her member-checking response, the instructor articulated ways in which her future, second implementation of Freeform Dynamics would be informed by her first experience with the environment. We acknowledge that the essence of her experience will likely shift the second time around, and we hope in future work to be able to capture the experience of such "second time around" implementers. In our ongoing work, we also explore the experiences of two new adopters at the same university who have been provided with the notes, feedback, and personal recommendations from the instructor we study here. We hypothesize that the experience of the new instructors will be notably informed by the experience of this instructor. Our future work may help us to distinguish the experiential factors more closely related to the complex active, blended, and collaborative environment of Freeform, the factors most closely related to the process of adopting a new course framework, and the factors most closely related to the routine practice and characteristics of a given institution.

Discussion and Implications

Through this analysis, we saw distinct ways in which Freeform Dynamics adoption was, and was not, like other significant course modifications. Here, for illustration, we have chosen compare and contrast the adoption of Freeform to adopting a new textbook based upon themes emerging from instructor reflections. The adoption of Freeform is like textbook adoption in that the Freeform Dynamics lecturebook is effectively a new textbook (albeit a slightly unconventional one). New instructors have to adapt to new notation choices, figure aesthetics, material organization, and a new philosophical approach to material presentation—one of the sub-themes that the instructor felt her students reacted to. For instance, the Freeform Dynamics lecturebook somewhat de-emphasizes long, expository materials in favor of tight derivations with a focus on conceptual understanding. While adapting to each of these changes requires effort, they are also the same kinds of adaptations required when adopting any other new textbook. In addition,

conventional textbooks are often packaged with certain instructional supports such as sets of PowerPoint lecture slides, which can be used and adapted by the instructor. The absence of such lecture support resources in Freeform may subsequently require more effort on the part of the adopting instructor than other textbook choices. The implication here is that adopting a new textbook is a significant amount of work for any instructor, who must become familiar with a new organization and philosophy for the material, as well as new problems for homework, quizzes, or exams. Adopting Freeform, from this standpoint, looks a lot like adopting any other new textbook. The instructor acknowledges the overhead associated with adopting the new learning environment in ways that reflect what we would expect from someone adopting a new textbook, e.g., "I feel like I am developing a new course because I am spending a lot of time working problems." (Week 8). Moreover, instructors must negotiate the boundary between the familiar prior experience and the new experience of teaching with a new textbook. The instructor routinely mentioned analogous issues in her weekly reflections, with emphasis areas ranging from addition/deletion of material that has been covered in the past, the pace of the material coverage, the organization of the topics, and so forth. All of this again is consistent with any effort to adopt a new textbook.

However, Freeform is a complete "course environment," and it does present other affordances that conventional textbooks do not. The Freeform Dynamics lecturebook is calibrated for active learning environments, and the Freeform system likely operates best when active learning pedagogies are used in class. For example, the massive library of worked example videos provides student support, but also expands instructional possibilities in the classroom: lecture time can be minimized, and collaborative problem solving time can be maximized, because the worked example videos are an ever-present free resource for students. In the case of this study, instructor quickly adopted a new, more active pedagogical style to engage students in collaborative learning supported by all of the available Freeform Dynamics resources: "I started off with a brief lecture regarding the material and governing concepts followed by in-class problems that I worked on the board. I ended the class with an active assignment in which the students worked on their own utilizing resources around them." (Week 2). The lecturebook, with its ample white space for students to take notes and complete example problems, is calibrated for exactly this kind of in-class pedagogy, and the online worked examples are available for students to help scaffold their development as problem solvers.

The wholesale adoption of the system—the lecturebook, course blog, online content, and in-class active pedagogies—and the reconciliation of the new system with the instructor's previous approach yields a rich narrative about faculty experience, adaptation of a teaching framework to a new environment, and decision making in the face of inevitable time and resource constraints. Our findings suggest further areas of inquiry for studies of faculty practices in curriculum adoption, including probing opportunities for cross-institutional collaboration, interrogating

variation in mechanical engineering department and student cultures, and studying sources of faculty development and support throughout the course transformation process.

Specifically, we see that clarity regarding what dimensions of an adopted instructional framework can and cannot be changed during implementation is crucial for both the source institution and the adopting instructor. In Freeform, the developers initially defined topic coverage, ordering, and scheduling to reflect a foundation in students' knowledge of gateway concepts (e.g., various applications of calculus), coverage of their common misconceptions (e.g., equations for central impact), and the scaffolding of a coherent concept narrative. At the same time, these concept narratives were structured to be modular. Clarity regarding the dimensions of Freeform Dynamics that can and cannot change, as well as the way in which concepts are scaffolded, may aid in a more cohesive and comprehensive reconciliation of an instructor's old format with the new environment. Additionally, student perception was a key driver of the instructor experience, and a key motivator behind her choices to make pedagogical and curricular chances. The importance of, and expansion in, avenues for the student voice to be heard (through assessments, conversations, or surveys) may point to the need for such development to be a more formalized aspect of the Freeform adoption process.

Further, we note that the research process itself was an important part of the instructor's experience. This is an important caveat for future Freeform Dynamics implementations; as the environment changes, the presence (or lack thereof) of the research team may mediate future instructors' understanding of the environment and how they need to implement it.

It also seems that the process of adopting and adapting to the new environment involved the mitigation and reassertion of the instructor's professional identity, a phenomenon which has been noted before and merits further study[14]. The instructor is central as facilitator of the students' Dynamics learning experience, and the evolution of her professional identity likely plays a role in the students' experience as well. A conceptual understanding of the Freeform environment, therefore, must recognizably include not only the learning materials and pedagogical structure, but also affordances for the instructor's own identity and self-conceptualization. We hope to explore this topic more extensively in further studies.

Limitations and Future Work

We recognize a number of limitations with this study, some of which will be addressed by follow-up work. First, the close involvement of the research team likely played a role in shaping the instructor's experience and her feelings of freedom or constraint within the Freeform environment. This was mentioned previously, but we would like to again emphasize it as a potential limitation of this study. Indeed, the research team's analysis should also be contextualized with the recognition that the Freeform developers and lead implementers are a part of the broader research group. Further, the specific nature of the institution to which the

environment was scaled likely played a role in the adopting instructor's experience. This is not inherently a limitation, as the goal of the study was to study and characterize the experience of the adopting instructor as authentically as possible. However, it does affect the generalizability of the study's findings. As we utilize a qualitative approach in this study, we do not endeavor to make broad generalizations from our findings. They are not representative of diverse types of institutions or indeed of all similar, baccalaureate-focused universities. The work is also not generalizable to the experience of all practiced junior faculty. Rather, we intend for this qualitative lens to illuminate ways in which instructors adopt this new environment and to highlight experiences that may improve instructional support to adopters and suggest improvements to the structure of the environment itself.

Future phenomenological and phenomenographic work will investigate whether the nature of the instructor experience adopting this new course is consistent across institutions, instructors, and even other content areas in mechanical engineering. The type of institution to which Freeform Dynamics is being scaled may distinctly shape the instructor's experience in transforming their course. In this case, the small classroom, student-focused nature of the adopting institution aligned well with the student-centered values of the active-blended-collaborative environment. Moreover, the standard conscientious practices and values espoused by this particular instructor aligned closely with the engaging and student-centered nature of the Freeform environment. In her words, "I feel a responsibility towards the students to help them succeed." (Weeks 13/14).

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