



Faculty Perceptions of the Teaching and Learning Experience in Fundamental Mechanical Engineering Courses

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Abstract

Engineering curricula include fundamental courses, such as Statics and Dynamics, that serve as foundations for later courses. Unfortunately, these courses often have low success rates and are described as poor educational contexts. To gain a better understanding of the learning contexts in fundamental engineering courses, we focus on the perspective of faculty teaching fundamental engineering courses in mechanical engineering. Grounded in expectancy-value theory, we specifically examined faculty perspectives on how they facilitate learning (faculty behaviors) and faculty beliefs about students as learners. Within a sub-sample of a larger dataset, we found that no participants used the exact same strategies but they each used 3 or 4 of the following: facilitating group work, cognitive modeling, scaffolding, demonstrating practical applications, and use of reinforcers. We also found that participants had unique, shared, and differing beliefs about student learning. Participants' beliefs include the ideas that students are still figuring out how to learn engineering, looking for direction from instructors, and are distracted by competing demands on their time. We found differences with regard to perceptions of student motivation, student abilities, and student engagement. Our findings are both consistent with and expand current literature.

Introduction

Fundamental engineering courses serve as the foundation upon which advanced discipline-specific and professional courses are built. These courses are commonly required across multiple engineering disciplines and serve as pre-requisites to higher-level courses. Fundamental courses introduce and develop critically-needed concepts and skills [1], [2]. Students take several fundamental courses concurrently, often during the early years in engineering programs, which is also a period in their academic careers marked by personal, social, and academic challenges [3]–[5][3]–[5] [3]–[5][3]–[5]. Examples of fundamental courses in mechanical engineering curricula include Statics, Dynamics, Heat Transfer, and Thermodynamics. Because fundamental courses are prerequisites to advanced courses, student experiences in fundamental courses influence student learning in future courses and persistence in engineering.

Literature that explores fundamental courses often describes low rates of student success and educational environments that conflict with the types of learning experiences that students value and expect [6], [7]. Some courses have inadvertently earned such monikers as “gatekeeper” or “weed-out” courses, and have been identified as barriers to student persistence in engineering programs [5], [7]–[10]. Furthermore, these courses are often offered in large class environments in order to maximize teaching resources and manage costs associated with increasing engineering

student populations, a consequence of the push for more young people to pursue degrees and careers in science and engineering [11], [12]. Large class environments, however, can pose challenges for both students and faculty, such as diminished ability to engage in quality interaction between students and instructors [13]–[15].

In fact, a critical factor that shapes the student learning experience is interaction with instructors as socializers in the academic environment [16]–[19]. We focus on faculty-student interactions to provide context for the learning experience in fundamental engineering courses, an important step before designing strategies to facilitate effective learning environments. We explore faculty perspectives on facilitating learning in fundamental mechanical engineering courses and their role as socializers in the academic environment by asking: “How do instructors describe the teaching and learning experience in fundamental mechanical engineering courses?” Within these experiences and situated in Eccles’ expectancy value theory [16], we specifically ask: “*What behaviors and self-concepts (perceptions of roles) do instructors have as they facilitate learning in fundamental mechanical engineering courses? What beliefs do they have about students’ abilities and interests?*” Answering these questions, we argue, will provide the necessary data to enable improvements to student learning experiences in fundamental engineering courses.

Related Literature and Framework

The undergraduate student experience, and engineering student experiences in particular, have been explored in prior research (e.g., [7], [17], [20], [21]). Some of these studies characterize the early and middle years of the undergraduate experience as challenging times of transition for students, with a number of studies focusing on issues related to retention & persistence [7], [18], [22], [23] and strategies for improving student experience (e.g., first year experience programs, [24]). Of interest to our project are the findings regarding students’ expressions of frustration over fundamental courses and the role that instructors play in shaping the student learning experience [6]–[8].

Fundamental engineering courses and the undergraduate engineering student experience

Fundamental engineering courses are often students’ first encounter with the engineering disciplines. These courses serve as building blocks for more technical, discipline-specific course work in a student’s chosen engineering major, and are critical to student success in subsequent courses [2]. While these fundamental courses are considered foundational in the engineering disciplines, they require the application of knowledge and skills presumably developed in basic education courses, such as science and mathematics.

Most fundamental engineering courses, such as Statics and Thermodynamics, are taken by students during their second or third years in their academic programs, a period collectively called the *middle years* [3]. Studies focused on the middle years describe this period as characterized by self-doubt and vulnerability, with students dealing with such emotions as “feeling lost and invisible” [4], [25]. This experience of inner turmoil is accompanied by

challenges in their academic careers as their curricula become more discipline-specific [25]. Consequently, studies that focus on retention and persistence find that the period where attrition, failure, and withdrawal rates are at their highest coincide with enrolment in fundamental courses. Students who chose to leave engineering have expressed frustration over fundamental courses, feeling overwhelmed by the pace and academic workload of their program, and disappointment over their perceptions of the quality of teaching and advising [7], [23].

It is interesting to note that failure is not necessarily the main reason for leaving engineering; there are students who are otherwise successful but do not persist. The most common reason behind a student's decision to leave is the perception that a non-engineering, non-technical major will offer a "better educational experience" [7]. Those who choose to remain in engineering, on the other hand, often have low satisfaction levels for interaction with faculty, quality of instruction, and their college experience as a whole [17].

Instructors as socializers in the academic environment

While the literature discussed in the previous section focused on students, a common finding across most of those studies is the important role of the instructor in shaping the undergraduate student experience [17]–[19]. Student learning, like many other experiences in higher education, is sociocultural in nature, and the interpersonal interactions that students have in the academic environment contribute significantly to the learning process and the quality of their learning experience [26].

Socializers are the people that individuals interact with in a social context. In the academic environment, in the context of taking a course, students interact and establish significant relationships with their instructors and peers. Instructors, therefore, assume the role of socializers as presented in Eccles' expectancy value theory and model of achievement motivation [27], [28]. As students interact with instructors as socializers in the academic environment, their expectancies and values are influenced in part by their instructors' *behaviors & self-concepts* and *beliefs about student abilities and interests* [16], [27], [29].

Pascarella & Terenzini's [19] study on *how college affects students* linked student learning to effective teaching. The study positively associated the following instructor behaviors with learning: *rapport with students*, *interpersonal accessibility*, *instructor skill (especially clarity of presentation)*, and *efficiency in structuring the course*. They found that a "large part of the impact of college is determined by the extent and content of interactions with socializers: faculty and peers" [19]. Likewise, Tinto's [18] investigation into undergraduate student attrition found connections between successfully integrating into the college environment and "favorable interactions between instructors and students."

Although literature that suggests teaching strategies and techniques is extensive, there is considerably less research focused on how instructors understand the context in which they are expected to facilitate effective learning environments and foster positive student experiences

(e.g., [30]). The sharing of effective teaching practices is valuable; however, understanding context is key to ensuring the adoption of these practices, as it supports the ability to discern which strategies and tools are appropriate for ever-changing classroom situations and to promote systemic change [31].

Expectancy Value Theory of Achievement Motivation

Expectancy Value Theory of Achievement Motivation (EVT) [29] provides a useful framework for our study. Within EVT, socializers’ beliefs and behaviors are shown as influencers of student outcomes (see Figure 1). Students’ ability self-concepts, subjective task values, goals, activity choice & engagement, and performance are influenced by their perceptions of the attitudes and expectations of the socializers that they interact with and their interpretation of past events (e.g. grades and feedback received, recollections of past experiences) [27]. Student perceptions, in turn, are formed by the behaviors, beliefs, attitudes, and expectations displayed by socializers [16]. As a significant socializer in the academic environment [28], instructor behaviors and beliefs affect student outcomes.

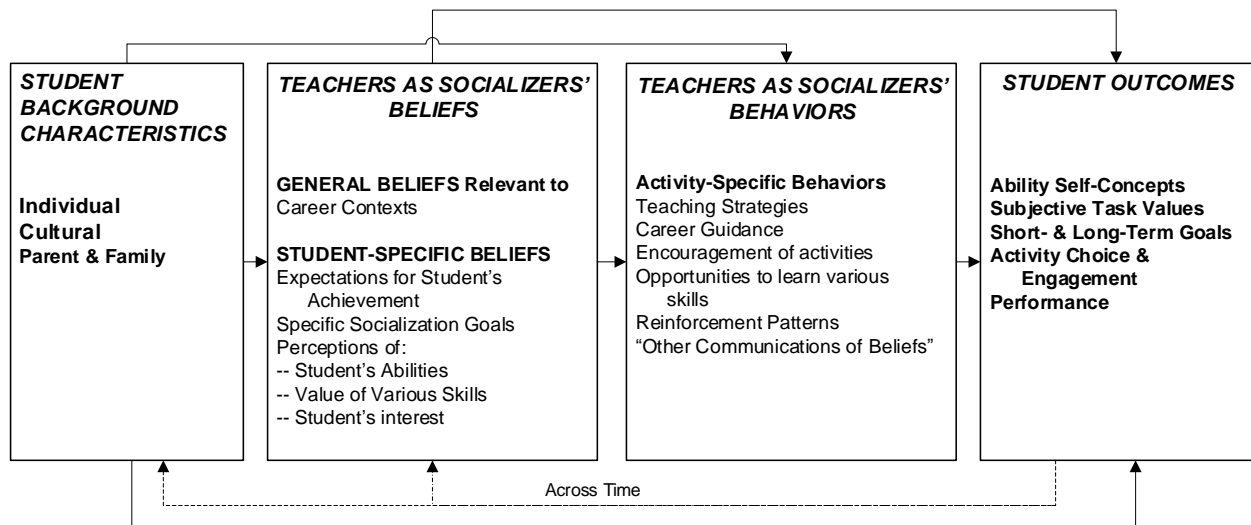


Fig. 1. Modified Expectancy Value Theory of Achievement Motivation [29]

Methods

Using qualitative methods for data collection and analysis [32] we analyzed three purposefully-selected transcripts chosen from a dataset containing 41 semi-structured interview transcripts with instructors of concept-heavy engineering courses. The sampling frame consisted of instructors who have taught the following concept-heavy engineering courses: Statics, Dynamics, Mechanics of Deformable Bodies, Thermodynamics, Heat Transfer, Circuits, and Programming. Participants from this existing dataset represent multiple engineering disciplines and institutions across the United States. The data was collected as part of a larger NSF-funded project that explores the link between motivation and conceptual change.

The project participants self-selected by responding to an invitation disseminated to instructors of the identified courses in a partner institution. Requests for participation were also sent to the following ASEE divisions: Biological & Agricultural Engineering, Chemical Engineering, Civil Engineering, Educational Research & Methods, Electrical & Computer Engineering, Engineering Physics, Mechanical Engineering, Mechanics, Minorities in Engineering, and Women in Engineering. Recruitment sites were purposefully selected to ensure that instructors from a variety of institutions, and, consequently, teaching and learning experiences, were represented in the dataset. We chose ASEE divisions based on the likelihood that its members taught courses that we were interested in, and that we will be able to get multiple perspectives from a variety of participants.

Participants

Preliminary analysis on the larger dataset included attribute coding throughout the time of data collection. Attribute coding consists of documenting information about the qualitative data and the demographic characteristics of the participants for dataset management and reference purposes [33]. Sources of data for attribute coding were the interview transcripts, field notes, and pre-interview survey responses. Attribute coding generated participant profiles that served as a basis for the selection of the sample analyzed in this paper. After an examination of participant profiles, we chose to use a confirming and disconfirming sampling strategy [33], [34]. We focused on mechanical engineering professors, who represented the majority (44%) of the participants in the larger study. To account for variability of experiences within the discipline, we chose one professor each from the two most commonly taught courses by participants (Thermodynamics, 29%; Heat Transfer, 24%) and the course taught by the least number of participants (Dynamics, 8%). We also ensured variability in class size and institution type; participants included in the analysis taught in R1 (doctoral universities with highest research activity), R2 (doctoral universities with higher research activity) and Baccalaureate College (arts and sciences focus) institutions, based on Carnegie Classifications. Table 1 shows information regarding the participants whose interview transcripts were included in this analysis. Pseudonyms are used in order to ensure confidentiality and participants' anonymity.

Table 1. Participant Demographics

Participant	Course Taught	Number of terms teaching the course	Class Size	Institution Type
Peter	Thermodynamics	10 to 20	65 to 75	R1
Faye	Dynamics	5	20 to 30	Baccalaureate College
Foster	Heat Transfer	7	24 to 30	R2

Data Collection

All 41 participants filled out a pre-interview demographic survey that included items for course/s taught, length of teaching experience, and gender, among others. The participants were given the option to do an in-person or phone interview and were compensated with a \$25 gift card. The interview protocol included questions meant to draw beliefs and experiences about student

motivation, facilitating learning & conceptual change, and the instructors’ roles as socializers in the learning environment. Examples of interview prompts are provided in Table 2.

Table 2. Selected interview prompts

Interview Prompt	EVT Linkage
What happens in a typical class period? (Participants were asked to describe activities that the class usually engage in and the kind of interactions that happen in the classroom)	Activity specific teacher behaviors; teacher strategies Student engagement & performance; student ability
Please describe how you plan and make decisions for class. What role do your students’ beliefs play in these decisions?	Activity specific teacher behaviors; teacher strategies Students’ beliefs
What are the things that you care about the most when you are teaching a class? Do you feel that you have the resources to allow you to do the things that you care about in class? (Participants were asked about the things that they get to do and/or have difficulty doing given the structure/context of the class that they are teaching)	If student success, student ability, subjective task values are expressed
Do you think that all students are given enough opportunity to be the best learners they can be? If yes, how is this accomplished? If not, what do you feel are the barriers preventing students from achieving this?	Beliefs about students’ abilities and interests
I would like to ask you again to think about your students. As you interact with them in the context of your class, what are the things that you think they value about being in your class?	Beliefs about students’ abilities and interests
Why do you think they are there? What do you think drives them to come to class? What drives them to do the work they are asked to do? What, from your perspective, do they want to get out of your class?	Beliefs about students’ abilities, subjective task values, and performance

Our interviews ranged from 30 minutes to one hour, were completed during the Spring and Summer 2017 academic terms by three researchers, were audio-recorded, and transcribed verbatim. We also took field notes during the interviews. All research activities adhered to approved human subjects research protocols.

Analysis

Descriptive and *in vivo* coding techniques were used to allow faculty beliefs and experiences to emerge from the data [33]. Analysis was conducted using qualitative analysis software (www.dedoose.com). While no *a priori* codes were used, we explored faculty perspectives on facilitating learning in concept-heavy mechanical engineering courses guided by Eccles’ expectancy value model of achievement motivation [16]. Specifically, we examined the data through the role of instructors as socializers as embedded within Eccles’ model. Although the purposeful interview protocol was developed with EVT as a framework, the entire transcript was coded for each participant to ensure salient points were not omitted from our analysis.

The decision to focus on a purposefully-selected subset of the participant population was to develop a data-informed, inductive “start list” [32] of codes and labels to help guide succeeding coding cycles and analysis. Codes and labels are words or phrases that describe and ascribe meaning to interesting excerpts in the data. We used a case study approach with the goal of

achieving “a comprehensive understanding of the groups under study” and providing “a rich, thick description of the phenomenon under study” [35]. A case for this paper is defined as instructors teaching concept-heavy mechanical engineering courses [32].

Participants were asked to provide a snapshot of a typical class. They responded to this prompt by providing examples of the strategies that they employed to facilitate learning. Through their descriptions of these strategies, participants’ behaviors as socializers in the academic environment emerged through excerpts about the activities that they engage in as instructors, the activities that they facilitate for students, and the interactions that they have with their students. Self-concepts (e.g. their perceptions about their role in the learning process) also emerged from these narratives. In this context, we operationalized participants’ behaviors as socializers in the academic environment to be specific actions within strategies used to facilitate the learning process. These behaviors displayed within teaching strategies include *facilitating group work*, *cognitive modeling*, *scaffolding*, *demonstrating practical applications*, and *use of reinforcers* (Table 3) and were the labels used to describe excerpts. Participants’ self-reported behaviors were consequently associated with the student learning experience through literature-based evidence about the strategies for facilitating learning that trigger these behaviors [26].

Table 3. Selected Codes – Participants’ behaviors

Code/Label	Description
Facilitating group work	Having students engage in learning activities in the group setting
Cognitive Modeling	Provide students with the structure/thought process, e.g. providing steps in solving a problem, working sample problems
Scaffolding	Participant shares teaching strategies that include: breaking down complex concepts, providing guidance on what concepts and techniques to focus on and watch out for, providing utilities and resources to support the learning process, trying to capture and keep students' attention, ask questions that get students thinking about the task/topic/problem in productive ways, give frequent feedback on how the student is progressing
Demonstrating practical applications	Provide opportunities to apply concepts to practical real-world activities (projects, in-class demonstrations using physical objects, experiments, relating topics to what is being used in industry/the workplace)
Use of reinforcers	Participant shared using tangible (food, prizes) or performance-impacting rewards (bonus points) to encourage engagement with the course material (encourage attendance, submission of homework, taking exams)

With regard to beliefs about students, the interview protocol included prompts that asked participants to describe their students (e.g., *Do you think that all students are given enough opportunities to be the best learners they can be?*). These prompts led participants to articulate their beliefs about students, student learning, student abilities, and student interests. The codes assigned to excerpts related to participants’ beliefs about students are shown in Table 4.

Table 4. Selected Codes – Participants’ beliefs about students

Code/Label	Description
“still figuring out how to learn engineering”	Instructor belief that the student has not established a strategy for learning; student is still putting together a method for learning that works for them
“intellectually capable”	Beliefs about the ability of students to meet the intellectual demands of the course
Perceived lack of utility value	Students perception that the course/class/activity is not useful to future goals
Distractions	Items/objects/activities that affect student ability to focus on course-related learning activities
"lack of time"	Participant shared a generic belief that students do not have enough time to accomplish course-related tasks or engage with course material, but statement does not specifically attribute lack of time to an activity
Varying levels of motivation, (-): less motivated	<i>in vivo</i> description of students with high levels of interest and intent to engage in the course material
Varying levels of motivation, (+): highly motivated	Participant shared that students are not or have low levels of intent to engage with the course material, both inside and outside of the classroom
“hardworking”	Instructor belief that students are willing to put in a significant amount of effort to accomplish a task

Research Quality

Walther et al [36] talk about quality of research in terms of quality in “*making the data and handling the data*” (p. 638). In making the data, quality of data collection included both interview protocol and interview quality. Both interview protocol and interview quality were maintained by training additional interviewers regarding the desired type of data collected (i.e., the project’s research objectives) and having two interviewers present during some of the 41 interviews. When two interviewers were present for an interview, they discussed the effectiveness of the interview questions, prompts, and data immediately following the interview, and all suggested changes were noted on the interview protocol. In addition, the second interviewer acted as an observer of the primary interviewer, which allowed for consistency of interview approaches.

In handling the data, the first author conducted a detailed examination of the three interview transcripts included in this analysis and developed an initial set of codes and labels. Inter-coder reliability was ensured by having a secondary coder review code definitions made by the primary coder, review coding decisions, and discuss codes, code descriptions, and emergent themes until agreement was reached [37]. This generated the list of codes to be applied in the analysis of the remaining interview transcripts.

Results and Discussion

Participants were prompted to share their experiences with facilitating learning in the context of the mechanical engineering courses that they taught. During analysis, we paid attention to articulated behaviors, self-concepts, and beliefs about their students. These generated emergent themes that include our participants' aspirations and strategies (their behaviors) that they employ to facilitate learning in fundamental engineering courses. Specific to our research question on beliefs about students' abilities and interests, participants shared beliefs about student interests, attitudes, values, and barriers that prevent students from making the most out of the learning process. In our sample, we found similarities in strategies (e.g., use of group work) across participants. There were differences, however, in perceptions about student values and motivation between the participant who taught a larger class in a larger institution and the participant who taught in a smaller, specialized institution.

Participants' behaviors and self-concepts

All participants in this sample shared the use of group work as a strategy to facilitate the learning process in their courses. They all talked about the goal of encouraging students to interact with their peers and the belief that working with their peers helps students learn better, a belief that aligns with the concept of *distributed cognition* [26]. In concept-heavy courses, where students encounter complex tasks, there is value in creating environments where students can share the learning task with their peers and be exposed to multiple perspectives and ideas [38]. They also shared similar techniques for peer collaboration (*facilitating group work*), namely having students group themselves into small groups, giving them a problem or set of problems to work on, and spending time interacting with the groups to provide feedback. Faye, for example, shared: "We do it in groups of two or four, I answer certain types of questions to help them along."

Group work, as used by our participants, facilitates meaningful interaction between students, and between the instructor and students. Both interactions are considered valuable to the learning process. Interactions with peers, which expose students to multiple perspectives that may not necessarily align with their own, may create productive sociocultural conflicts that promote conceptual change [26]. Interaction with a more competent and experienced socializer (the instructor), on the other hand, is beneficial to the learning of new skills [26]. Other strategy-based behaviors shared by the participants are shown in Table 5, all of which are in keeping with sociocultural perspectives about learning [26].

Table 5. Selected participants' strategy-based behaviors for facilitating learning

Strategy-based behaviors	Peter	Faye	Foster
Facilitating group work	X	X	X
Cognitive modeling	X		X
Scaffolding	X		X
Demonstrating practical applications	X	X	
Use of reinforcers		X	

In addition to strategy-based behaviors, the participants also talked about the various ways that they interacted with their students (behaviors in EVT terminology) in the context of the courses that they taught. The interactions range from in-class discussions to non-academic conversations, but by far the most common across responses in this sample is instructor-facilitated discussion in the classroom, where the instructor will pose a question to the class in general in order to stimulate conversation, such as:

“I try to do that is in class when I ask questions, especially if a student gets the question wrong, I try to tactfully say, ‘Why is it wrong?’ And where do they need to go to move towards the right answer?” – FOSTER

Peter also shared a non-verbal trigger that leads to an interaction:

“Sometimes corrections, because I’m doing everything on the board. Sometimes I occasionally make a mistake on purpose. Usually I don’t make a mistake on purpose. It will be a mistake, and somebody will stop me, which is very good.” – PETER

Both instances may be considered as environmentally-triggered, context-specific situations that may stimulate interest and promote engagement in the classroom [39]. Sometimes, the interaction is initiated by students, either by approaching the instructor after class to ask a question or posing a question while a problem is being presented or a discussion is going on. Participant behaviors that emerged from these excerpts include *cognitive modeling* and *scaffolding*.

Self-reported behaviors indicate that participants consider themselves responsible for providing academic support and guidance (e.g., *cognitive modeling*, *scaffolding*) and ensuring that learning outcomes are met through productive learning activities (e.g., *facilitating group work*). Emergent self-concepts from the data include being the *more experienced socializer in the academic environment* [26] (e.g. provider of academic support and guidance) and assuming the role of *facilitator of learning* [40] (e.g. provider of learning activities). Both self-concepts are in keeping with contemporary descriptions of the role of an instructor in the learning process [26], [40].

We found that the participants are using theoretically-supported approaches to facilitating learning. There are, however, situations that may prevent the expected gains from these strategies

from being maximized. One of the perceived barriers shared by participants, and one that they all aspire for, is student ownership and accountability in the learning process:

“The challenge is to make sure that they're doing their part. After you've taught a course a few times, you know what you need to give them. The question is, are they doing their part?” – FOSTER

These statements indicate that designing effective learning environments go beyond the implementation of best practices and theory-based strategies; potential gains may be affected by students' response to learning opportunities. What this may suggest is the need to complement good instructional strategies with the development of a culture of ownership and active participation in the learning process among students. Figuring out ways to motivate students to be self-directed and active learners is more about pedagogy than engineering, something that instructors in engineering programs may not have been trained for or have direct access to helpful resources [41] – an observation that may merit further exploration.

Participants' beliefs about students

Participants expressed various beliefs about students and student learning. Unique, similar and conflicting beliefs emerged from the sample data. All participants shared the similar belief that students are distracted by competing demands on their time. We also found differences in perceptions about student motivation, student abilities, and willingness to engage in the course.

Faye, a participant teaching Dynamics in a Baccalaureate college, shared the following belief about her students:

“My students, my perception of them is that they are *still figuring out how to learn engineering*. This is only their second class within an engineering major. I feel that they are looking for a great deal of direction.” – FAYE

The belief that students in a fundamental engineering class are “*still figuring out how to learn engineering*” because of where they are in their academic careers is in keeping with findings from literature on the sophomore experience [e.g., 4]. Students at this stage are still in transition and find themselves navigating their academic journey on their own for the first time [3]. On the other hand, the belief that students at this stage in their academic career are “*looking for a great deal of direction*” aligns with literature highlighting the importance of faculty to student success [41]. It suggests that an instructor's role covers both facilitating learning in engineering and providing guidance on how to engage in the learning process.

The participants have a shared belief that students' academic behavior is adversely impacted by competing demands on their time:

“One of them is, I understand engineering is a tough major. So they have a lot of stuff to be done. So sometimes, it's just *lack of time*. And I don't try to judge them that they're lazy or that they're not doing it. It may just be that they've prioritized

what they have due, and reading the textbook isn't high enough on the list, and they don't have time to do it.” – FOSTER

“I think a lot of it is occasionally they're overworked, depending on how exams are going for the other classes and their other classes in general.” – PETER

“But their time is not their own. So it is, to me, I find it is limited in that even the really good students can only ... they've gotta prioritize their time.” - FAYE

This perception aligns with the inclusion of cost – “what will I need to give up to accomplish this task?” – as a factor that students consider when engaging in a task, embedded in the expectancy value model of achievement motivation [29].

We observed a difference in participants' beliefs about student abilities and behaviors, particularly between Peter, who teaches a large class in a R1 institution, and Faye, who teaches in a Baccalaureate College. Peter expressed varying beliefs about students' abilities, pointing out differences based on major. It is worth noting that Peter's class consisted of students from two engineering disciplines, while Faye's class consisted exclusively of mechanical engineering students:

“The ME students... want to learn how to apply various tools and various principles and concepts to real situations. They want to add a practical tool to their toolkit, which is thermodynamics, and it will allow them to analyze a broad range of problems... The ME students are maybe slightly *less capable*... (but) usually *highly motivated*.” – PETER

In contrast, Peter shared the following observation of the non-mechanical engineering students:

“The (engineering major) students are *quite smart* and *quite capable*... but they grumble a little bit more... (and) they're *less motivated*... ‘This course is down there on my list of priorities.’” – PETER

These observations are related to the utility value construct in Eccles' expectancy value theory [29]. Mechanical engineering students seem to find more usefulness in the course material as they feel that it is critical for their future careers, while there is a *perceived lack of utility value* among students in the class who are pursuing a different engineering major. This heterogeneity of students in the class poses challenges to the instructor in terms of promoting student engagement in the course.

Faye, on the other hand, shared a different experience, describing students in the class as “*hard working* in general” and “*motivated*.” She also shared the following perception: “They have a lot of *distractions*, but I think in general they have good faith about coming to class and learning something.”

In Summary

Data analysis generated faculty experiences and perceptions as they facilitated the learning process in fundamental mechanical engineering courses. We allowed behaviors, self-concepts, and beliefs in the context of the participants' role as significant socializers in the academic environment to emerge and noted patterns that clustered excerpts around emergent themes. Our first sub-question – “*what behaviors and self-concepts do instructors have as they facilitate learning in fundamental mechanical engineering courses?*” – prompted our participants to recount strategies they used to facilitate learning, and what they cared about (e.g., student accountability in learning). We were also able to document participants' perceptions about student attitudes and the barriers that prevent students from making the most out of the learning process from our second sub-question, “*what beliefs do instructors have about students' abilities and interests?*”

Our research contributes to literature by providing faculty perspectives and experiences in the context of fundamental mechanical engineering courses. More broadly, the results of the analysis of our entire dataset may be used as evidence-based input to curricular decisions and the design of effective learning environments in concept-heavy fundamental engineering courses, as well as understanding the learning experience in these courses.

Limitations

The data and results discussed in this paper are limited to the perceptions of three respondents, each sharing experiences from contexts different from the other. We are constrained to taking note of interesting experiences and beliefs that emerge from the data, and intentionally refrain from drawing general conclusions at this time. An analysis of a subset of the dataset, however, is an important step in the qualitative analysis process [32]. It prepares the researchers to engage in a more detailed and intentional analysis of the remaining data.

Implications and Future Work

Labels and emergent themes generated by the analysis conducted for this paper will serve as the start list for coding the remaining interview transcripts in the dataset. The list of codes and labels, however, will continue to evolve as new experiences and beliefs emerge from the data.

Our descriptions of variations in the teaching experience according to class size and institution type may inform analysis of remaining interview transcript data using case study as research design. The codes and themes define the boundaries of teaching fundamental engineering courses for a class size and institution type, representing a case. The case descriptions for other contexts generated by this future work may identify barriers to effective learning environments and inform the design of strategies to overcome challenges faced by instructors of fundamental engineering courses.

The analysis of data from instructors will ultimately generate information on *behaviors*, *self-concepts*, and *beliefs about students* of instructors as socializers in the context of concept-heavy

engineering courses. This information may be examined alongside data on students' expectancies and values in order to foster a deeper understanding of the learning experience in fundamental engineering courses.

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