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Fundamental Engineering Course Test Beliefs and Behaviors: A Case Exploration of One Instructor

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Test Beliefs and Behaviors:
A Case Exploration of One Instructor of a Fundamental Engineering Course

Abstract

Tests tend to be the default assessment in fundamental engineering courses. Tests can be useful for learning such as retaining information, but not for all learning outcomes like conceptual change. In addition, tests can decrease student motivation to learn. Therefore, complementing tests with alternative assessments and being intentional in using and designing tests should be considered to address the problem test being the go-to form of assessments in fundamental courses. Instructor resistance to adopting teaching practices informed by research poses as another barrier toward addressing the problem. Thus, understanding engineering instructors' beliefs about why they use tests in their courses is an important first step toward addressing the problem. This research study begins addressing the gap by analyzing one case out of a larger multi-case study to provide hermeneutic insights for future analysis and studies on the beliefs of engineering instructors about using tests. Grounded in Situated Expectancy Value Theory (SEVT), this research paper analyzed one thermodynamics instructor, Charlie, who was a mechanical engineering associate professor in an R1 public, land-grant institution, and had taught for more than ten years. Analysis methods were inspired by the case study research methodology. Findings show slight conflicting beliefs within Charlie as they demonstrated strong beliefs in test benefits in helping students learn, but apologetic about using tests because of factors like inertia and peer pressure that compelled them to continue using tests in the course. Charlie was also apologetic about using tests due to their lack of ability to predict future student success. Charlie also expressed a lack of experience and knowledge in designing assessments in their courses. Future work will focus on understanding test usage beliefs at a broader scale and informing research to design alternative assessments that can be adapted to complement tests.

Keywords: Test, Exams, Assessment, Instructor, Beliefs

Introduction

Tests have been a default form of assessment in concept-heavy fundamental engineering courses (Lord & Chen, 2015; Sheppard et al., 2009). Situating tests in the expansive assessment literature, tests play important roles in the learning process, such as the "testing effect" in which students retain information after multiple testing (Roediger et al., 2011). However, tests also come with various disadvantages, such as being not appropriate for measuring conceptual change (Streveler et al., 2008) and decreasing motivation to learn (Tan, 1992; Vaessen et al., 2017). Thus, tests being the go-to assessments may not be an ideal way of assessing and helping with student learning in fundamental engineering courses. Considering alternative assessments as complements to tests and being intentional about test usage and design can be one way of addressing the problem of tests being the go-to method for assessment. Another dimension to this problem is the need to convince engineering education teachers, instructors, or faculty to inform their practices with scholarship and research. There have been documented research that show barriers among engineering instructors to adopt teaching practices based on research (Brownell & Tanner, 2012; Henderson & Dancy, 2007). Therefore, understanding why fundamental engineering course instructors use tests in their courses as test usage beliefs (Francis et al., 2015) is important to provide foundations for future research in addressing the problem of default test usage as this is a relatively understudied topic in engineering education.

This research paper strives to contribute to building that foundation by exploring one fundamental engineering instructor's beliefs and behaviors behind test usage to provide hermeneutic insights for future analysis on the topic. I leveraged the Situated Expectancy Value Theory (SEVT) as the anchoring framework to explore these beliefs and behaviors. Illumination of one individual case can provide meaningful insights that will inform future studies and analyses of test beliefs and behaviors. In this paper, I answered the research questions: *What are the test usage beliefs and behaviors of one fundamental engineering course instructor, who works in the mechanical engineering department in an R1 public, land-grant institution?*

Literature Review

Tests have been a common form of assessment in engineering classrooms, so much so that they tend to be seen as a default and go-to assessment (Lord & Chen, 2015; Sheppard et al., 2009). Debates on tests have been ongoing in the educational literature, with arguments supporting and against using tests in engineering classrooms. Proponents of tests argued that this form of assessment helps with certain learning outcomes, such as the "testing effect" where students can practice procedural knowledge and retain important information (Butler & Roediger, 2007; Roediger et al., 2011). However, opponents argued tests can discourage learning as students tend to go with pattern matching or memorization as a way to prepare for tests (Case & Marshall, 2004; Marton & Säljö, 1976). Frequent testing also led to students focusing on fear of failure as motivation for the course (Tan, 1992; Vaessen et al., 2017). These arguments should be considered while we discuss test usage in engineering classrooms as there could be other ways to complement tests to enrich the assessment design and experiences in fundamental engineering courses. Alternative assessments, such as projects, portfolios, concept inventory, and reflective practices, have potential in this regard (Johnson, 2006; Prince et al., 2012; Turns et al., 2014).

There have also been research and work that situate tests in high-level assessment frameworks. For instance, Suskie (2018) framed assessment philosophies in terms of student learning and provided various ways of creating an assessment toolbox. Suskie provided substantial information on how to construct objective tests that are consistent with the philosophy of deciding what students learn and making sure they are learning it. The information is encapsulated in a "test blueprint" that includes focusing on making students learn and how one plans for the learning to happen. For instance, Suskie argued that if a test is designed to focus on memorizing, even though it might be inadvertent, students would memorize to complete the tests and assume that was the learning experience. Thus, Suskie asserted the need for more intentional test designs. On the other hand, Russell and Airasian (2012) situated test design within the universal design of assessment philosophy in which tests should be designed with anticipation of the variety of backgrounds students bring into the classrooms in terms of accessibility. Tests should prepare for said varieties and allow students to engage with the tests successfully. These research, in general, situate tests within existing assessment philosophies and call for intentionality in test usage and design.

Another important argument that supports my work is the barriers among engineering education instructors in terms of adopting new ideas on pedagogy and assessments. Existing literature have demonstrated such barriers in terms of convincing engineering instructors to rethink how teaching works (Brownell & Tanner, 2012; Henderson & Dancy, 2007). Before researching how to address the barriers in terms of assessment design in fundamental engineering courses, it is important to understand the beliefs undergirding the resilience of test usage in these courses, which is a research gap this research begins to address.

There have been literature on understanding engineering instructors' beliefs on teaching practices, but research on beliefs behind test usage has been relatively understudied. In the larger education literature, there is scholarship that helps understand instructor beliefs in the form of course decisions. For instance, Stark (2000) created the Contextual Filters Model to help instructors of large classes design their courses. In this model, the instructor's backgrounds, views of the academic fields, and perceived purpose of education interact with contexts such as student characteristics and goals, external influences, and pedagogical literature to guide decisions on courses, like the subject matter, goals, and objectives, and learning activities. Feedback from these decisions forms a feedback loop that informs the perceived purpose of education. This model demonstrates the importance of various contexts in influencing an instructor's teaching decision-making. The creation of the Contextual Filters Model underlies the argument that instructor has a range of control over their course decisions, including assessment design. Assessment design, thus, can be more intentional as previously asserted. In addition, research have also shown that the shift to a more student-centered classroom calls for a more significant role of instructors in course design as there could be more unpredictability in classroom interactions, assessments included (Skott, 2015). These support the importance of scholarship in engineering instructor beliefs that guide assessment practices in classrooms.

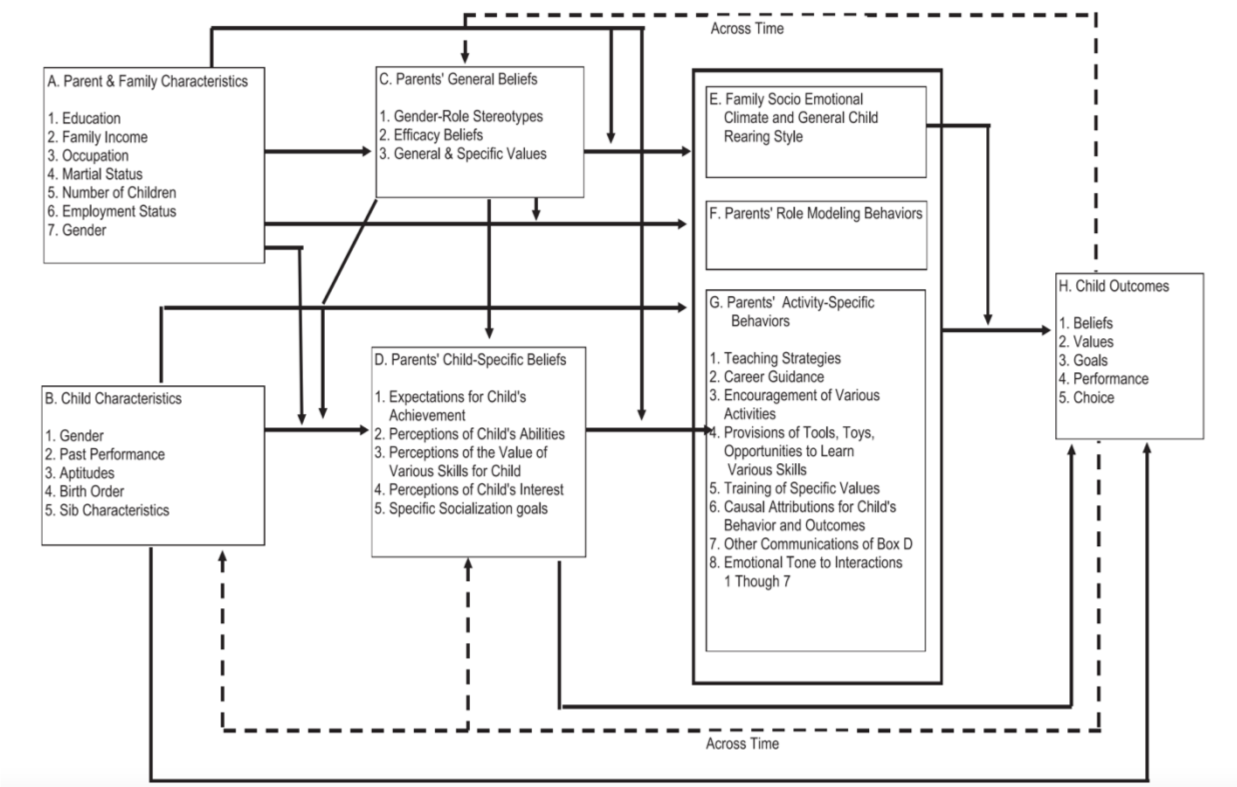
There have also been many studies that explore engineering instructors' teaching beliefs, and what factors and contexts influence their course decision-making. In a study that involved ten engineering instructors, Huang et al. (2007) found the importance of time as a factor that influences teaching decisions. These instructors used creative ways to address the teaching challenges, such as considering the students' needs and being selective in terms of curriculum content. A literature review explored instructor decisions to integrate laboratory components into engineering education, showing that instructor decisions were shaped by factors such as institutional context and policies, the role of society, and stakeholders such as students and accreditation (Coutinho et al., 2017). Another study by Reeping et al. (2018) explored instructors in an electrical and computing engineering department on their curricular decisions during a reform of the program. They found four themes (valuing system thinking, valuing adaptability, seeing students struggle between values of concrete and abstract, and noting students' low tolerance of ambiguity) that explain how instructors decide on teaching essential knowledge in the field. Many other studies explore the topic of teaching decision-making, with some focusing on having instructors adopt certain classroom approaches (Jarvie-Eggart et al., 2021; Moore et al., 2015). Many of these studies inherently lead to understanding of the beliefs behind these decisions. Another common thread resulting from reviewing these studies is that many of them focus on the instructional approaches, but not much on assessment approaches. Assessments are an essential element in course design, considering the intertwined nature of assessments with instructional approaches (Lattuca & Stark, 2011; Wiggins & McTighe, 2011). Therefore, my study strives to contribute toward filling this research gap in exploring instructor beliefs and decision-making behind assessment usage and design in engineering education, beginning with tests.

In summary, this research begins to address the research gap in beliefs behind test usage among engineering instructors of fundamental engineering courses. This is important to fill as the engineering education community should embrace more alternative assessments to complement tests and more intentionality behind test usage and design. To achieve this, understanding the current beliefs of fundamental engineering course instructors can provide knowledge to address the barriers to adopting scholarship-based teaching practices.

Conceptual Framework

I adapted the Situated Expectancy Value Theory (SEVT) to frame the instructors' beliefs and behaviors on classroom tests. SEVT is a motivation theory that focuses on explaining how one makes achievement-related choices through two constructs: Expectancy and subjective task values (Eccles, 1983; Eccles & Wigfield, 2002, 2020; Wigfield & Eccles, 2000). In general, SEVT posits that one's confidence in achieving and completing these choices (expectation of success) and the subjective task values they place on the choices (whether they are interested in the choices, whether it is important for them to achieve the choices, and whether the achievement of those choices is useful to them) can explain why they end up making such choices. SEVT has been documented to guide studies of engineering education topics, especially on understanding engineering student pathways (Matusovich et al., 2010; Peters & Daly, 2013) or faculty motivation to engage in the research and practice cycle (Matusovich et al., 2014).

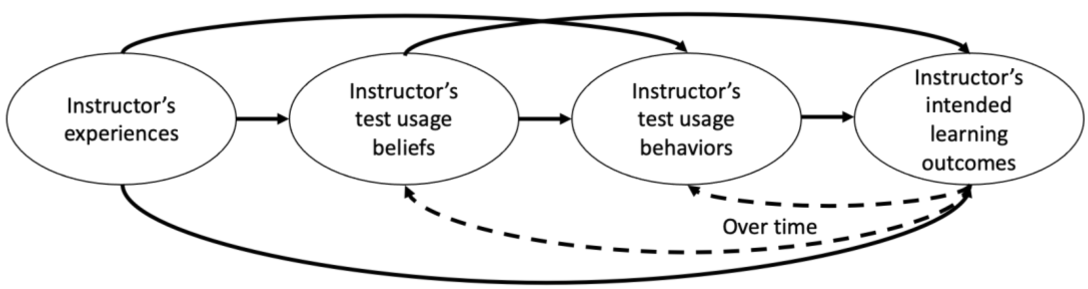
Figure 1: Socialization perspective of SEVT (Eccles & Wigfield, 2020)



The framing of this study, however, focuses on the socializers (Figure 1) that eventually influence these constructs of expectancy and subjective task values. In SEVT, socializers of the person making the choices have effects on that person's choices through influencing their expectation of success or subjective task values, as illustrated in Figure 1 (Eccles, 2007). This means the instructors are socializers who socialize students into engineering in their courses, and tests are one of the tools of socialization. Eccles (1983) argued that instructors' expectations of students' performances, such as perceived expectations of their students' test performances, can influence their students' achievement expectancies and behaviors. These students' expectancies and behaviors include making decisions on what to prioritize in engineering courses, and in the bigger picture, whether to continue to pursue an engineering degree.

In addition, Eccles asserted that the learning experiences the instructor provides can influence the students' achievement choices, and tests form part of that learning experience. For example, a thermodynamics course instructor's test usage beliefs influence how tests are implemented in the course, like format, questions, time given to the students, etc. Socialization happens when the students experience the tests, and the student performances on multiples tests may influence their achievement choices in the engineering course, or even engineering in general. Students who perceive their test performances as expected by their instructor may continue, while students who do not may decide to not continue with the engineering course, and possibly in engineering. I argue here that student test performances are not completely based on the students' ability. Other factors, such as test anxiety stemming from time constraints, may influence the student test performances, and these factors can be manifestations of the socializer or instructor's beliefs about tests. Some crucial questions that can be raised in this situation include: Could other forms of assessments instead of tests be used to assess students, considering some of the documented test disadvantages? How did the instructor's beliefs manifest in the test implemented? and could the tests be implemented differently, which may lead to different student experiences? These are some of the important questions that could be asked when tests are framed as a form of socialization based on SEVT.

Figure 2: Conceptual framework adapted from the socialization perspective of SEVT illustrated in Figure 1.

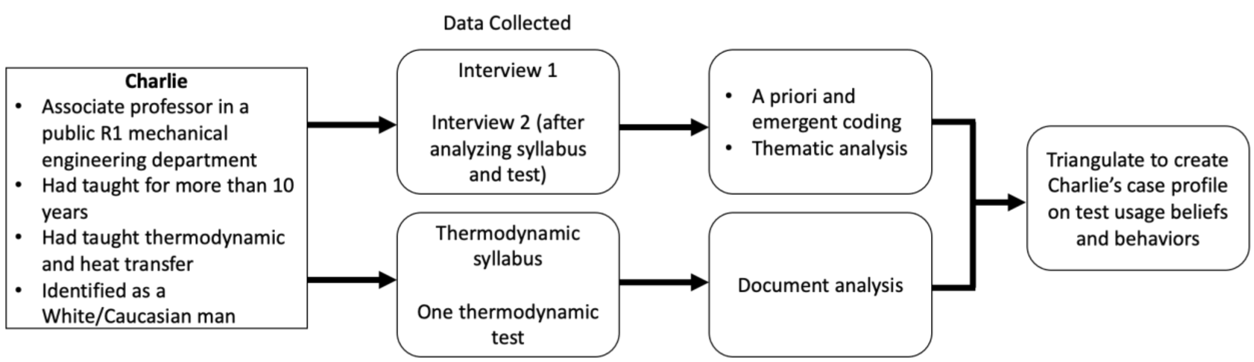


Thus, I framed tests as a form of socialization process into engineering, and SEVT in Figure 1 is simplified into the conceptual framework that guided my study (Figure 2). As illustrated in Figure 1, student performance is one of the many outcomes, along with subjective task values, expectancy, choice, and others. The intended learning outcome can be perceived as an expected performance from the students as perceived by the instructors. The instructors' experiences, such as their personal backgrounds and experiences with the course and department contexts, can influence their test beliefs and behaviors. The instructors' test beliefs and behaviors can influence the instructors' intended learning outcomes. The intended learning outcomes ultimately can also influence the instructors' beliefs and behaviors over time. For this study, I defined beliefs based on the idea of instructor's beliefs in that they are 1) a set of concepts that contain one's knowledge of how they perceive judge their realities, 2) substantial influences on their teaching behaviors, and 3) not necessarily coherently structured and can be contradicting when these beliefs do not cross-examine with each other (Hermans et al., 2008).

Methods

This paper documents a research effort that is part of a larger multi-case study that focuses on exploring classroom test beliefs and behaviors of seven participants, with each participant being an individual case. Specifically, this research analyzed one specific case, Charlie, from said multi-case study. Arguments on analyzing and documenting one case exist in educational literature. Robinson (2014) supported their argument of an N=1 study with Yin's assertion that case study research methodology is "distinct" and "separable" from typical qualitative methods (pg. 29). Robinson (2014) documented six functions of N=1 case study research. This research followed the idea of hermeneutic insight in which a research study attempts to gain insights or findings from an intensive exploration of one case for future validation in other cases or samples. Adapting this idea, this paper strives to explore Charlie's test beliefs and behaviors deeply to gain insights about test beliefs and behaviors manifesting within a fundamental engineering course instructor. These insights can serve as foundations for 1) analysis of other cases in the larger study and 2) the beginning of addressing the research gaps that emerged from the literature review. Research of beliefs with one participant has also been documented in the education literature, supporting the value of such study design in engineering education (Bryan, 2003).

Figure 3: Charlie's background and data analysis process



As part of the larger study, data collection involved two types of data form (Figure 3). First, the participants provided their course syllabus and a test they used. The course document data pool only had a course syllabus and a test for each participant because some participants were not comfortable sharing more than one test. To ensure consistency across the seven cases, the course document data pool is limited to one syllabus and one test. For Charlie, the syllabus and a test from his thermodynamics course became part of the data analyzed for this paper. The participants were also involved in two interviews, including Charlie. Interview 1 asked questions such as "why do you use tests in this course," "how do you design your tests," "how did your past experiences as an engineering student influence your thoughts about exams," and "how do you think tests help your students learn" to help understand the participants' beliefs and behaviors on tests. Interview 2, following the course document analysis (detailed in the next paragraph), focused on having the participants discuss their syllabus and test they shared, with questions such as "how is the course grade weighting decided," and "please walk me through your thought process and decisions while designing and implementing this test/exam?" Essentially, Interview 2 focused on discussing the specific syllabus and test shared by the instructors.

The analysis process for Charlie's case was inspired by Yin's (2018) perspectives on case study research methodology. Yin asserted that a case study should focus on exploring a contextualized phenomenon deeply. This research framed the test usage beliefs and behaviors of engineering instructors who teach fundamental engineering courses as phenomena that are highly contextualized within an institution and engineering departments. These beliefs and behaviors can be influenced substantially by the contexts as part of the instructor's experiences (Figure 2). For this paper, the analysis focused on these data forms to exemplify Charlie's test usage beliefs and behaviors for hermeneutic insights (Figure 3). After Interview 1, a priori and emergent coding schemes informed the iterative coding analysis of Charlie's first interview transcript, resulting in codes and excerpts categorized into different topics, such as "beliefs," "behaviors," and "test connections to learning outcomes." (Miles et al., 2014) Subsequently, this research analyzed Charlie's syllabus and test to understand his test behaviors, in addition to the behaviors that he described during Interview 1 related to the coded topics (Bowen, 2009). Analysis outcomes from Charlie's Interview 1 and course documents informed how Interview 2 was conducted with Charlie. Analysis of Interview 2 involved another iterative a priori and emergent coding of the Interview 2 transcripts, and thematic analysis of both Interviews 1 and 2 transcripts and documents to consolidate findings into high-level themes and create Charlie's case profile detailing their test usage beliefs and behaviors (Braun & Clarke, 2012; Yin, 2018).

Limitations

Research in this paper has three limitations. First, although exploring one case can generate meaningful findings as argued by Robinson (2014), generalization of findings to the larger population of engineering instructors is strictly not recommended. Instead, this paper focuses on the transferability of findings, arguing for providing rich and thick descriptions to provide readers sufficient information to transfer findings from Charlie's case to their contexts and backgrounds (Geertz, 1973; Guba & Lincoln, 1994). Second, the data collected were the snapshots of Charlie's test beliefs and behaviors within a semester during the Covid-19 pandemic. They are not meant to be a complete picture of Charlie's test beliefs and behaviors because of the limitations in terms of course documents collected (as explained previously due to the inconsistent number of documents shared by different participants in the larger study). The study design acknowledged these limitations while also providing meaningful and useful findings to the community. Third, the study design may have limited further interpretations of some of the findings. Although the data collected and analyzed were sufficient to present a robust view of beliefs and behaviors, they may not fully eliminate some rival plausible explanations. These limitations present as future work to further understand engineering instructors' test beliefs and behaviors.

Research Quality

The research followed some of the guidelines by Walther et al. (2013) and Tracy (2010) in ensuring research quality. First, several strategies were used to address potential threats to the fit of the findings to the reality. These include triangulations of different data types to affirm some of Charlie's test beliefs and behaviors and constant acknowledgment of my positionality throughout the research process, including study design, data collection, and data analysis. Second, to establish the trustworthiness and credibility of the findings, member checks were conducted with the participants to ensure the interpretations and portrayal of the interviews and course documents stay true to what the participants meant. In addition, analysis of the data involved constant engagement with the data to ensure interpretations were consistent with participants' accounts. Lastly, this paper documents thick descriptions and concrete details to show, instead of telling, Charlie's test beliefs and behaviors, allowing the readers to have agency in transferring and interpreting the findings for their contexts.

Positionality

As a former mechanical engineering student and an active engineering education researcher, I have had personal experiences with tests that might have been unpleasant or stressful, forming certain connotations and preconceived notions when "tests" are discussed. I also have a strong affinity toward the diverse assessment philosophy, arguing for the reduction use of tests due to their effects on student learning, such as motivation to learn. However, as previously described, I constantly checked my preconceived notions about tests to acknowledge their effects on the overall research process. For example, I strive to understand deeply the participants' justifications of test usage in their courses, and not immediately judge such justifications based on my positionality. In addition, I identify as an Asian man who was born and raised in Malaysia, and I have experienced certain forms of privilege as an engineering student because of my identity. I constantly acknowledged the privilege that shaped my experiences with tests, such as high school learning experiences that have prepared me as a good test taker, during the research process. These positionalities shape how I see tests, and as a reflexive researcher, I reflect and acknowledge them in my research.

Results

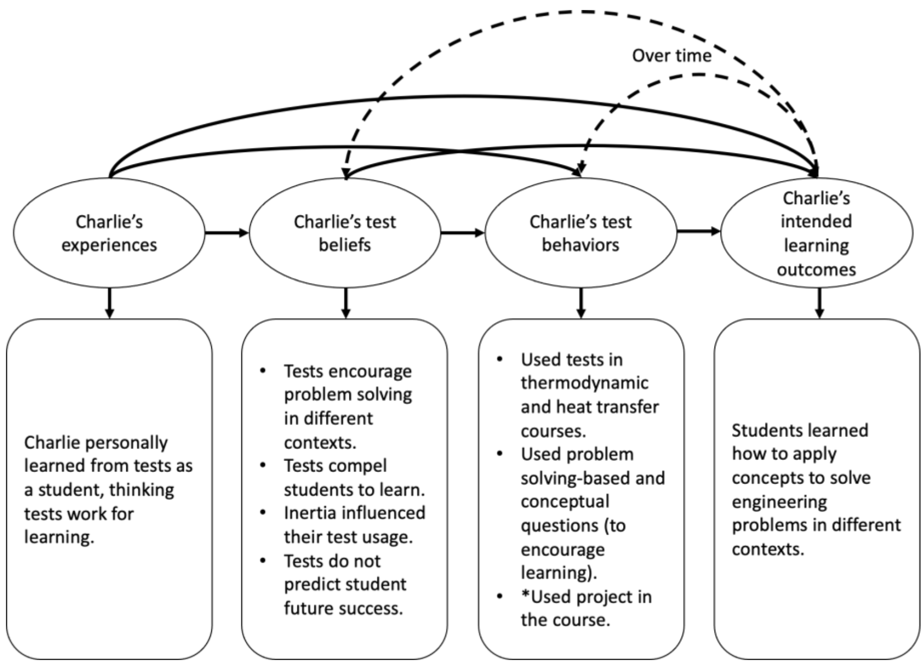
This paper illuminates Charlie's case to answer the research question of exploring what Charlie's test usage beliefs and behaviors are. While presenting these beliefs and behaviors, I also explored how the beliefs and behaviors align with each other, Charlie's experiences, and perceived student outcomes.

Figure 4: Charlie's thermodynamics course grade weighting.

Exams	45%
Final Exam	30%
Project	10%
Homework and Quizzes	15%
	100%

Charlie had specifically expressed strong beliefs about using tests in their courses. Before discussing Charlie's beliefs on why they used tests in their thermodynamics course, I present here Charlie's behavior of using tests with Charlie's syllabus, showing how tests are organized in their course. For Charlie's thermodynamics course, tests constituted the majority (75%) of the student course grades (Figure 4). The 45% exams were split into two exams as midterms. The final exam was two hours long total while the midterms were during class time (50 minutes) except during the pandemic when students had a whole day to complete the exams. This did not include quizzes, which are also a form of test according to Charlie. For the quizzes, they could be administered with or without prior announcements (implying no predetermined number of quizzes), with no make-up opportunity given. It must be noted that Charlie used a project in their course that constituted 10% of the course grade, and homework were counted along with quizzes to form 15% of the grades. Overall, tests formed a big part of the student assessment experiences as students need to work on the three big tests to a obtain substantial portion of their grades in Charlie's thermodynamics course.

Figure 5: Charlie's test usage beliefs and behaviors conceptualized with SEVT.



Charlie also had an intended learning outcome for their students, which was to apply concepts to solve engineering problems in different contexts. I interpreted this as a form of transfer in terms of transferring thermodynamics concepts to solve different problems in the course. They argued that "*once you get good at those basic concepts [thermodynamics] like you can solve anything...*" This will be crucial in understanding Charlie's beliefs about why using tests in their course.

In terms of why Charlie used tests in their thermodynamics course as illustrated in Figure 5, Charlie justified test usage through the described intended learning outcome. First, Charlie believed that tests encouraged students to apply the concepts to solve engineering problems in different contexts. Charlie specifically explained tests were appropriate for the learning outcome.

"*Giving students [in tests] something that they maybe haven't seen exactly before, but should be able to solve by applying the basic concepts that they've learned*…"

To Charlie, tests were ways to introduce students to different problems in terms of getting them to apply the basic concepts to solve the different types of problems, especially those that students had not seen previous before the tests. He elaborated with a "building a house" metaphor:

"…*Like building a new house, we've learned how to build a bathroom and living room and a kitchen and but now they've we're going to set it up a little bit differently so could you build a new house to the new type of house or analyze it*."

Here, Charlie described building a new house with the skill sets of building each component of the house (bathroom, living room). They extended the explanations that tests serve as ways to get students to organize and put the basic concepts together to solve different types of thermodynamics problems, showing test usefulness in helping students achieve the learning outcome.

Second, Charlie asserted that tests encouraged their students to learn to achieve the learning outcome:

"*The students respond to incentives… if there wasn't any test done or…any way of assessing some of the material outside of the labs then it'll just get ignored.*"

This quote specifically shows that Charlie believed that students most likely would not put effort into learning the materials without tests. Charlie believed that tests were a form of accountability that motivated their students to study. This was another way tests helped students learn as Charlie believed their students would study and learn while preparing for tests. Combining this with the first belief, Charlie argued that their students would prepare and learn how to apply concepts to different problems because of tests, which were to 1) encourage students to study and 2) expose students to different problems and have them think of how to use those basic concepts to solve the problems.

It must be noted that Charlie made the connections between these beliefs with their personal learning experience when they were an engineering student. Charlie specifically mentioned that tests were helpful to them when they were learning in engineering courses.

"*I could kind of make my way through, and what the test to be, I really wanted to try to learn the concepts beyond just recognizing the format of the problems and what I had seen before to solve the questions*."

For Charlie, they specifically discussed the need to learn for the tests, which resulted in having been able to successfully go through the tests. Here, Charlie explained that they wanted to learn the concepts beyond just pattern matching with the problem formats. Tests became the place to use those concepts they learned. Charlie implied that their learning experiences as a student informed their beliefs about test usage.

When it comes to the test questions, Charlie used both problem-solving-based and conceptual questions in their tests. In the test shared with me for the research, Charlie's questions had a brief context for the students with variables and numbers attached to those variables. Students were then expected to solve the problems by identifying the appropriate concepts and principles of thermodynamics and solving mathematical manipulations to obtain the final numerical answers. These problem-solving questions align with Charlie's intended learning outcome of having their students learn how to solve problems using the basic thermodynamics concepts using tests.

In addition to problem-solving questions, Charlie used conceptual-based questions to assess their students' understanding of the concepts. In the test shared, Charlie had various formats of these conceptual questions. For example, they had students predict how different variables vary based on a thermodynamics context. In this case, the context was removing heat from a container that contained superheated water vapor. Charlie wanted their students to predict whether variables like temperature and volumes increase or decrease in this context. Charlie also included true/false and multiple-choice conceptual questions. These questions support my interpretation that Charlie believed students must understand the concepts first before applying them. Although Charlie did not list understanding of the basic thermodynamics concepts as a learning outcome, they implied that with the inclusion of conceptual questions in tests, in addition to problem-solving-based questions.

Charlie also expressed beliefs about using tests that were not learning outcome related. Charlie mentioned that inertia was also a large part of the reason they used tests:

"*I mean the real answer is just, that's one of the worst answers for almost anything, is because that's the way everybody's always known it pretty much. I think when I first started, I tried to make sure I sort of conform to what the usual or the typical ones were, and then, I guess, since then, I haven't put a put a ton of thought into it.*"

Charlie here admitted that the idea of "everyone is doing it" was one explanation for why they continued to use tests. Specifically, Charlie talked about conforming to the typical assessment habits his peers were doing and ended up getting comfortable with those habits, leading to Charlie continuing to use tests after teaching for more than ten years. They ultimately said "*most of it is inertia*" when elaborating, labeling this idea. Furthermore, Charlie talked about the lack of creativity on their part as one main reason why they did not break the inertia cycle personally.

"*I'm not creative enough. To be honest, I haven't thought that much about alternate ways of doing things*."

Here. Charlie explained that they were not creative enough to think about alternative ways of assessing student learning in thermodynamics. The "creative" argument constantly surfaced throughout the interview. Charlie also used an apologetic tone to express these beliefs during the interview, sounding slightly guilty about conforming to the inertia to continue using tests.

Although Charlie justified test usage with learning outcomes and invoked inertia as another reason why they continued to use tests, Charlie also mentioned and discussed a shortcoming with tests. They specifically mentioned that they did not think tests help predict students' future successes.

"*…they're [tests] not good predictors of future success necessarily, I read and listen to a few podcasts and some books about, like the SAT or like the LSAT right, and how those are so different and difficult…*"

It must be noted that, in this case, when asked about test shortcomings, Charlie immediately used the context of standardized testing to raise the shortcoming of tests not being predictive of student future successes, even though the contexts for the tests (Charlie's test and standardized tests like SAT) are different. However, Charlie acknowledged the differences and furthered their point about the shortcoming of tests in their courses with the language "*like even for our tests*…" showing Charlie believing the test shortcoming applied to their thermodynamics tests and standardized tests. Charlie then continued to elaborate by juxtaposing engineers with trauma surgeons and their different contexts.

"…like even for our tests, real engineering student, I mean one thing you have as an engineer, [un]like trauma surgeon is, you have time to look something up to run a model, talk to somebody else, ask them double-check something and you'll never get a piece of paper shoved in front of your face and say you have you know 30 minutes figure this out."

Here, Charlie explained that testing environments were typically not the environments engineering students most likely would experience when they work in the future, unlike trauma surgeons who may need to make quick decisions during their job. Thus, combining ideas about standardized testing and comparison with trauma surgeons, Charlie argued that tests did not predict whether their students would be successful as engineers in the future. Considering Charlie's intended learning outcome of students learning to apply concepts to different problems, this shortcoming is highly relevant as Charlie did imply students would need to use these concepts to solve engineering problems in the future. The non-predictive nature of tests might have limited what students could learn with this outcome. One note about the shortcoming is that Charlie had a similar apologetic tone like the one when they discussed inertia as a reason to continue to use tests.

One relevant observation is that Charlie might be open to using other forms of assessments, evident in Figure 5 as the course grade weighting shows a project used in their course. However, when asked about the project, Charlie did not make any explicit connections between the project and test usage. Instead, they included the project because it was an outcome of a collaboration with an engineering education researcher, and Charlie decided to keep it because they found it different for their students in a thermodynamics course and the students liked it.

"*The credit for the project all goes to [engineering education researcher]. She had the idea for a project that we did as part of an NSF project, and I did like it … and the feedback from the students was quite good overall. I think they enjoy doing it, and it was something a little bit different…*"

Although Charlie did not make explicit connections, Charlie did seem to be open to other forms of assessments in their fundamental engineering courses based on this piece of evidence.

Based on Charlie's test usage beliefs and behaviors, there are several key findings. First, Charlie strongly believed that tests were helpful to get students to understand and apply basic thermodynamics concepts to different problems. In addition, Charlie also believed that having tests could act as milestones to encourage students to study to learn the concepts before taking the tests. Second, Charlie apologetically discussed inertia and their lack of creativity as reasons to keep using tests. Third, Charlie also sounded apologetic when discussing the lack of predictive ability of tests on student success being a shortcoming of tests.

Fourth, Charlie did not further explain their rationale behind using three tests and other types of assessments in their courses. While explaining test usage, Charlie seemed to focus a lot more on student learning, which is honorable. However, Charlie did not further explicate why there should be three tests, and how each test helped their student learn other than they would learn how to apply concepts to different problems. For instance, Charlie might have considered the final exam as a summative assessment, and the two midterms as formative, but did not think of articulating this. Another evidence to support this assertion is that Charlie did not consider deeply the rationale behind using the project, other than that it was created through collaboration, and they found it different for students without explaining how the project was situated within the larger course design to help students learn. Throughout the interview, Charlie did not explain their justifications for their assessment design in their course.

Overall, Charlie presented slightly conflicting beliefs due to the strong beliefs on test helpfulness with learning outcomes, but the constant apologetic sense in using tests due to inertia. On the test shortcoming, although one can argue that helping students learn and predicting student success are not contradictory with each other, Charlie gave the impression that this shortcoming acted as a conflicting belief with this test usage. They implied that tests could not predict student success in terms of practicing engineering, and Charlie seemed to want that as part of their intended learning outcome in their thermodynamics course. Charlie's continuous test usage for more than ten years of teaching in this institution implies that Charlie may believe more strongly about test benefits and have no strong intention to go against the inertia, and to a certain extent, the shortcoming. In addition, Charlie also did not explain their justifications behind assessment design, centering their assessment usage, especially tests, mostly on them being helpful to student learning without explaining how all the assessments complement each other to help with learning.

Examining SEVT as the conceptual framework for my analysis, the framework provides some explanatory functions in examining Charlie's test usage beliefs. Findings from Charlie's case demonstrated that Charlie's test usage beliefs and behaviors do show alignment like how SEVT posited. For instance, Charlie made several connections between tests helping students achieve the intended learning outcomes and their usage of problem-solving-based and conceptual-based questions in their tests. In short, Charlie believed that using tests helped their students learn about applying basic thermodynamics concepts to solve different problems by using problem-based and conceptual-based questions in their tests. This is one example of how SEVT explains Charlie's test usage belief and behavior. Charlie also implied that their personal experiences of learning from tests informed their beliefs and behaviors of using tests in their courses, another connection SEVT posits. Overall, SEVT provides an adequate framework to understand Charlie's test usage beliefs and behaviors. As this research specifically focuses on gaining hermeneutic insights for future investigations and validations, Charlie's case has presented insightful findings that will inform the analysis of other cases in the larger multi-case study to examine test usage beliefs and behaviors and provide knowledge to generate discussions about test usage beliefs among engineering instructors.

Discussion and Implication

The first takeaway from this analysis is that test beliefs and behaviors can be complicated. Findings in this paper have shown that decisions to use tests may be complex with potential conflicts. Charlie's case has demonstrated that their test usage beliefs show affirmation and slight conflicts with each other. Charlie essentially argued for the need for tests in their thermodynamics course because they believed tests help their students achieve the intended learning outcomes. However, Charlie apologetically acknowledged that inertia and peer pressure played a substantial part in them using tests. Furthermore, Charlie then admitted the test shortcoming of not being able to predict future student success, also apologetically. The apologetic tone seemed to imply Charlie was frustrated with test usage, but the frustration was insufficient to push Charlie to rethink test usage in thermodynamics. Thus, this presents Charlie showed slightly conflicting beliefs in their test usage. However, Charlie's behaviors in using the different question types show that Charlie ultimately weighed the benefits of tests as more important than the shortcoming. In addition, Charlie may have also implied that the inertia and peer pressure might be something they would not be able to address individually as an instructor. This interpretation can explain why Charlie continued to use tests in thermodynamics for more than a decade of teaching.

This takeaway is consistent with existing literature instructors' belief research. Findings have shown that beliefs drive instructor's practices (Francis et al., 2015). In research on instructor's beliefs, it has been widely accepted that instructor's practices typically are influenced by their beliefs about teaching. Charlie has shown to articulate well why they used tests in their courses with helping students attain the intended learning outcome. However, existing research has also shown that unless these beliefs are cross-examined with each other, contradicting and conflicting beliefs can exist within an instructor's belief (Gill & Fives, 2015; Hermans et al., 2008; Richardson, 2003). Research has shown that instructors can have contradicting beliefs that guide their practice, such as a study by Bryan (2003) that shows nestedness (multiple nests of beliefs that may or may not overlap with each other) and contradicting guiding beliefs of an elementary teacher's beliefs on science teaching and learning. This teacher had two different beliefs that guided the teacher's practice (belief of lifelong learner) and vision of practice (hands-on approach). Specifically, this teacher used a more transmission-based philosophy in teaching their students science in practice, which conflicted with their education vision of focusing more on activity and exploration in learning science. Bryan found that this teacher's lack of experience to conduct hands-on learning became a part of why the conflicting beliefs and behaviors happened. Charlie demonstrated this as they continually mentioned their lack of creativity to use alternative assessments in their thermodynamics course. Overall, Charlie had shown consistent belief conflicts that have been documented in existing literature.

This analysis has shown that teaching belief conflicts exist in engineering education, especially in the context of assessment usage. As I have found that research on assessment is scarce in engineering education, findings of this one-case exploration can begin to address the research gap of understanding instructors' beliefs in assessment usage. In this context, I present findings that show the belief conflicts, which can support future research on the topic. It must be noted that this analysis did not intend to document "best practices" of test or assessment usage in engineering classrooms. Instead, this research strives to focus on uncovering how one engineering instructor's beliefs align with their test usage in their course in the hope to further research on the topic in our community.

The second takeaway is the lack of consideration of the roles of the different types of assessment in Charlie's case. Charlie believed their tests help their students learn, which is consistent with the idea of classroom assessment in which assessments are not just to find out whether students have learned, but also designed to provide learning values to the student (Pellegrino et al., 2001; Shepard, 2000). In addition, this is consistent with the idea illuminated by Suskie (2018) in that assessments are to frame what instructors want their students to learn and how to ensure they are learning the knowledge. However, my analysis has found that Charlie did not further explicate how the overall assessment design in their thermodynamics course helped their students learn. Literature have shown that assessments can serve various roles, such as the formative and summative paradigms, within a course (Pellegrino et al., 2001; Suskie, 2018). It is possible that Charlie did not think of raising it, but their explanations on using a project in a course support my observation that Charlie might not consider the overall assessment design while implementing it. This is further supported by Charlie's own assertion that they did not think they were creative enough to use alternative assessments, underlying a lack of assessment experience Charlie had. This takeaway can be a manifestation of engineering instructors, especially those who are not well-versed in engineering education literature, teaching their courses based on their personal experiences, instead of documented and researched practices (Brownell & Tanner, 2012; Henderson & Dancy, 2007; Jamieson & Lohmann, 2009). Findings from Charlie support this, as Charlie described their personal student experiences, inertia, and peer pressure as some factors that compelled them to continue using tests. In addition, these findings emphasize the need for more intentional design in terms of assessments, especially under existing assessment philosophies and guidelines (Russell & Airasian, 2012; Suskie, 2018). It must be noted that the study design did not fully address this takeaway as additional data like Charlie's teaching philosophies might contribute to a deeper understanding of Charlie's beliefs regarding the roles of different types of assessments. Nonetheless, this takeaway is notable throughout Charlie's data and should be considered an important future element in understanding test beliefs and behaviors of engineering instructors. Ultimately, these takeaways and findings from Charlie have begun to address some of the research gaps in terms of understanding engineering education instructors' beliefs and behaviors on test usage in fundamental engineering courses, paving the way to start understanding the underlying beliefs that can explain test usage among engineering instructors.

An important implication of this work is the overall analysis of the remainder of the cases in the larger study. Charlie's case has provided the hermeneutic insights as a baseline for analysis of the rest of the cases. The future analysis will discern high-level themes and categories that explain the beliefs and behaviors on tests of multiple engineering instructors of fundamental engineering courses. Another implication is that some findings of these beliefs and behaviors can begin to inform practice on how to promote alternative assessment approaches in engineering classrooms. For instance, one can potentially research how existing and newfound alternative assessments can align with the test usage beliefs. However, this implication is limited to only engineering instructors who can relate to Charlie as an instructor as the findings would be transferable to these engineering instructors.

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