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Coming and Going: What Draws Students to Industrial Engineering and What Pushes Them Away*

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Seven undergraduate engineering students were interviewed regarding their experiences transferring into or out of industrial and systems engineering programs. An narrative research approach was used to highlight the individual behind the data and encourage exploration of the decision-making process at a personal level. Although the decision whether to change majors is one faced by many university students, it remains a deeply individualized choice, regardless of similarities in motivation or outcome. Through the medium of semi-structured interviews, these students' stories were told. Emergent themes included concerns about discipline rigor, responses of peers and family, and appreciation of available career opportunities. Although the sample size is small, the results suggest personal interest may play a larger role in student movement between engineering disciplines.

Keywords: industrial engineering; systems engineering; narrative; degree change; ethnography

1. Introduction

The decision to change majors – to transfer from one program, department, or college into another – is one that many college students face. One survey, supported by the US Department of Education, reported 30% of students, including engineering students, had changed their major at least once [1, 2]. As the world's needs for engineers grow [3], an increased understanding of why engineering students leave the field and what can be done to increase retention becomes increasingly critical in addressing this unmet demand [4, 5]. Because a student's likelihood to persist in their chosen major is a combination of factors attracting them to their major, factors repelling them from their major, and factors attracting them to other majors, expectancy-value theory can be used to inform and guide research [6] into what students are motivated by in their decisions to persist or transfer [7]. It is hoped that by gaining insight into how student motivation is affected by perceptions of the student's self and their environment, programs can improve efforts to increase retention. Ohland et al. expresses the end goal succinctly: "identify programming that retains the students who come to college committed to an engineering major and develop programming and policies that allow other students to migrate in" (8, p. 259).

However, the effect of lived experiences cannot be overstated. While statistics are a powerful tool in a researcher's arsenal, averages and significant differences only describe quantitative answers to a research question. Frameworks like expectancy-value theory may suggest an outline of the process, but individual differences in outcome prioritization, risk assessment, and experiential knowledge means that making a decision is a deeply personal and individualized affair. As Judy Jackson states, "social experiences tell the story behind the numbers" (9, p. 179).

In recognition of this and acknowledging the institutional differences which preclude generalizing students from different universities, this study instead proposes to construct narrative portraits of students who have changed majors. Rather than turning them into numbers to be analyzed, this narrative approach allows the students' stories to speak for themselves. Ultimately, this "allows us to see the larger social and cultural forces operating in the society through the eyes" [10, p. 104] of real individuals.

2. Background

2.1 Expectancy-value Theory

Expectancy-value theory connects "achievement performance, persistence, and choice . . . to individuals' expectancy-related and task-value beliefs" [11]. The model is appropriate for application to engineering student retainment because it focuses on personal or efficacy expectations rather than outcome expectations. In their review of literature on attrition from engineering programs, Geisinger and Raman found that outcome expectations such as financial stability and specific job titles were not commonly indicated as attrition factors. Conversely, factors corresponding to the elements of expectancy-value theory were more often connected to attrition (5, p. 919). Additionally, expec-

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tancy-value theory emphasizes the effects of perceptions and beliefs tied to performance and achievement [12]; studies have shown students who leave engineering programs are not necessarily underprepared or unmotivated [13, 14]. Thus, perceptions and expectations may be more important in decision making than objective facts. The two components of expectancy-value theory, ability beliefs and achievement values, are critical in the college major-to-career decision tree [15].

2.1.1 Ability Beliefs

Ability beliefs are defined as ''individuals' evaluations of their competence in different areas'', whether this be ''broad beliefs . . . in a given domain'' or ''expectancies for success on a specific upcoming task'' (11, p. 119). The emphasis here is on the individuals' subjective perceptions of their own abilities, rather than their objectively measured competence. Walden and Foor [6] found that GPA (Grade Point Average) was not a significant marker for whether a student is likely to transfer out of or between engineering. Instead, negative experiences with classes affected their belief in their ability to successfully complete their initially chosen engineering degree. Stereotypes can also contribute to the formation of ability beliefs. If, for example, a female student is repeatedly confronted with societal stereotypes that women are 'bad at math,' she might thence evaluate her competency in mathematics lower than she would have otherwise [16–18]. Similarly, a student struggling in a stereotypically 'difficult' major may seek to transfer into a stereotypically 'easier' major [19]. Additionally, inadequate high school preparation can negatively impact self-efficacy and self-confidence, leading to attrition because of low ability belief [5]. According to the expectancy-value theory, by raising a student's perception of their competency – their self-efficacy – in engineering or math, perhaps by providing positive feedback with the goal of improving self-confidence or self-esteem, their persistence will likewise increase [20, 21].

2.1.2 Achievement Values

In contrast to the 'Can I do this task?' question explained by ability beliefs, the second, potentially more important question [22], that expectancy-value theory attempts to provide rational for is 'Do I want to do this task?' [23]. Achievement value comprises four elements. Attainment value is the ''importance of doing well'' on a task as it relates to ''[demonstrating] aspects of one's actual or ideal self-schema'' (24, p. 280). If an individual sees themselves as an engineer, they may have a higher attainment value for success at tasks that confirm their sense of engineering identity [22, 25]. This premise can be further expanded to subsets or categories of engineering based on gender [26–28] or discipline [29–31]. Intrinsic value is the ''enjoyment the individual gets from performing [an] activity'' [24]. A student is less likely to persist in a field if they expect to get limited enjoyment from completing the necessary courses [32] or from their future career [33]. Likewise, intrinsically instigated motivations may have a larger impact on choice satisfaction than other forms of motivation (such as parental pressure) [34]. This element of expectancy-value theory is more difficult to directly influence but can be addressed by ensuring curriculum appropriately exposes students to the many facets of the field they are pursuing [29, 35, 36]. Utility value informs the '''extrinsic' reasons for engaging in a task'' [24]. This could entail large-scale effects such as future salary and prestige or smaller-scale requirements to reach a desired end state like taking required math courses [37–40]. The final element of achievement value is that of cost, conceptualized as all the negative aspects inherent in engaging in a task. Applied to engineering students, costs may include negative emotional states [41], levels of effort required [42, 43], or the lost opportunities to pursue other fields [44]. This may manifest as a financial barrier to entry erected by the investment required to pursue an engineering degree [45], expected or perceived negative stereotypes by others (''nerdy'', ''imaginary engineering'' [45], ''un-feminine'' [46]), or any number of other influences [29].

2.2 Narrative Portraits through Ethnography

An ethnographic approach to research explores cultural phenomena from the point of view of the subject of the study [47]. It is the science of the anecdote. While quantitative methods seek to answer questions like ''what?'' and ''how much?'', the qualitative methods employed in ethnography help researchers gain a deeper understanding of the answers to ''why?'' [48, 49]. This approach connects global and local cultures by addressing how personal context pressures interpretations of generalizable theories.

Ethnography was first pioneered in anthropology research and emphasizes first-hand experiences of a particular social setting through participant observation and interaction [50]. While traditional ethnography encourages entirely impartial and non-interactive observation [51], more recent trends in this type of research have expanded the approach to comprehend the perceptions, feelings, and experiences of participants over just their behavior [50]. Hammersley [75] discusses how definitions of ethnography have diverged over time but does high-

light some commonalities: direct involvement of the researcher, high status given to participants' perspectives and understandings, and a focus on particular cases as the basis for theoretical generalization. Thus, the terms 'ethnographic' and 'narrative' are both used to describe the approach used in the current work.

Holland and Eisenhart [52] explain the value of this type of individual-focused research in higher education specifically. Universities are cultural microcosms; despite sharing many societal and environmental similarities between them, each institution creates a unique experiential context that distinguishes one from another [53, 54]. Thus, how students perceive their own or other degree programs is specifically influenced by the context in which those perceptions were formed [55, 56]. This means the ethnographic approach and narrative-style of reporting is well-suited to understanding student perceptions [57].

Further, this process is flexible, allowing patterns and explanations to arise naturally through exploration [10, 58, 59]. Standardized questionnaires are valuable for many types of research, but in exploring subjective experiences such as perceptions, such questionnaires inevitably involve researcher-caused biases [60, 61]. Ethnography does not seek generalizability – it is participant-focused and highly subjective [62]. Despite this, stories realized through narrative research can inform and enlighten researchers for future work as well as offer insight into rare or difficult to capture experiences [63].

Thought rare, this narrative approach is not completely novel to the field of engineering education. The authors drew on the experiences and results of prior research, including [23, 36, 45, 73, 74] to guide the design and implementation of this study's methodology.

3. Research Objectives

For this study, the question became not whether a student transferred between disciplines, but why the student transferred between disciplines. For instance, although engineering is a difficult career path [41], studies have shown that GPA is not necessarily a significant factor in initiating or directing student migration [7, 64, 65]. According to expectancy-value theory, a combination of achievement values and ability beliefs strongly influence this type of decision.

Therefore, this study sought to understand how individualized perceptions about engineering disciplines instigate or influence a student's decision to transfer into or out of industrial and systems engineering [66]. Using a disaggregated approach to develop narrative portraits of individual students in disparate environments serves to highlight how circumstances and experiences influence students differently despite being in ostensibly similar situations.

3.1 Contributions

The present work hopes to contribute two primary findings. First, the use of narrative portraits to tell the story of individuals provides a lens through which broader trends in STEM culture and education can be observed [10, 67]. Second, it aims to support the value of this research method within engineering education literature [9, 10, 48, 53, 74]. The narrative approach connects elements of expectancy-value theory to student-reported experiences and influences, increasing the understanding of both.

4. Methods

4.1 Study Design

Interviewees were recruited through a follow-up to another study by the authors. Individuals were eligible for inclusion if they had ever changed majors into or out of an Industrial and Systems Engineering program. Industrial and Systems Engineering was chosen as the focus of this study because of its unique position compared to other engineer disciplines (cf. "Industrial engineering is an enigma among engineering majors" [66, p. 1] and "IE's focus on people and systems is simply different than other engineering disciplines" [73]). All students except one (Alex) were from the author's institution, a public, land-grant university in the south-east US; Alex was from a public university in the south-west US. Both universities have large, well-developed engineering programs.

4.2 Instrument

This study used semi-structured interviews to guide participant discussion into how their individualized experiences in their university degree programs influenced their decisions to transfer into or out of industrial and systems engineering. Semi-structured interviews provided more flexibility than standardized, closed-ended survey questions while minimizing the participant-on-participant biases present in focus groups [68–70]. Although an interview guide was used, participants were free to elaborate on specific aspects of their experiences as desired, supplemented by additional questions from the interviewer. This meant that not all questions in the guide were explicitly asked and answered by each participant, though efforts to visit each primary topic were made.

4.3 Procedure

Eligible and willing participants were invited to schedule their approximately 1-hour long interview using an online scheduling tool during September and October 2022. Interviews were conducted using Microsoft Teams or a similar web-conferencing platform and audio was recorded. All participants were provided with an overview of the study and its goals prior to beginning the recording. Participants were also informed of measures taken to protect their identities in the final work. No participant expressed concerns regarding the anonymity of their responses; however, efforts have been made to deidentify any material reported here.

4.4 Analysis

The audio recordings were transcribed using a web-based transcription software, Otter (Otter.ai, 2016), to produce text documents for analysis. The transcriptions were compared to the audio files to review for accuracy and any inaccuracies were corrected. Additionally, all personally identifying information was removed or replaced with pseudonyms to ensure confidentiality. Once edited, each transcript was imported to MaxQDA (VERBI Software, 2022) for coding. Because the coding system was not intended to be used to guide quantitative analysis, participant statements were broadly grouped into three main categories and further labeled with affect within each category. These categories emerged following a review of the themes and topics of the corpus as a whole [71, 72]. Affect was subjectively determined based on word choice and tone of voice. For example, ''loved'', ''seemed reasonable'', and ''a lot of stress'' were phrases found in statements coded positively, neutrally, and negatively, respectively. Emphasis was placed on participant responses to the events described rather than value judgements on the positive or negative connotations of the events themselves. All coding was done by the primary researcher who also conducted the interviews. The transcripts were reviewed multiple times to ensure thorough categorization of relevant statements. This coding scheme is presented in Table 1. In total, seven students were interviewed.

Table 1. Coding system

Original Major
Original – Negative Affect
Original – Neutral Affect
Original – Positive Affect
New Major
New – Negative Affect
New – Neutral Affect
New – Positive Affect
Changing
Changing – Reasons
Changing – Responses

4.5 Terminology Usage

Throughout the following discussion, the term 'industrial engineering' is used to refer to the field of industrial and systems engineering because it was the primary term which interviewees used to describe their discipline. However, participants were not screened on their view of the delineation of those two terms, industrial versus systems, nor was attention given to the technical name of any university departments or degree program titles. It is this author's opinion (though justification for such an opinion is outside the scope of this work) that industrial engineering and systems engineering, even if theoretically distinct, have such overlap that the terms can acceptably be interchanged in common usage. When a participant chose one term over another, their word choice has been retained.

5. Results

Each student's story was unique. The choices they made during their educational journey were deeply personal decisions made in consideration of their likes and dislikes, their experiences and expectations, their hopes for the future and their desires for now. For the purposes of this study, each students' educational journey was divided into three primary sections: the time spent in the original major, the process of deciding to change majors, and the time spent in the new major.

Each conversation began with a retelling of their entire journey, to allow the researcher a chance to tailor questions and conversation topics appropriately. These retellings are summarized here. For references' sake, Table 2 presents the origin and destination majors for each student as well as a broad description of their primary reason for changing degree programs.

Arya transferred from Biomedical Engineering into Industrial early in her academic career: before classes even started for her first semester. Since then, she's supplemented her studies with an additional major in Business Administration through a program offered by her department. Merida began college as an education major, but soon chose to drop out to focus on being a parent. Now, with her children grown, she finally embraced the opportunity to complete her education – starting in Business Information Systems before changing to Industrial Engineering and adding a Business Administration degree under the same program as Arya. Alex also found himself having to put his education on pause, to care for his siblings after his mother passed away.

Table 2. Interviewed Students

Name*	Original Degree Program**	Current Degree Program**	Reason for Transfer
Arya	Biomedical Engineering	Industrial Engineering	Personal interest
Merida	Business Information Systems	Industrial Engineering	Personal interest
Alex	Chemical Engineering	Industrial Engineering	Personal interest
Paris	Communications	Industrial Engineering	Personal interest
Chris	Psychology	Industrial Engineering	Career opportunities
Brian	Mechanical Engineering	Industrial Engineering	Personal interest
Henry	Industrial Engineering	Mechanical Engineering	Career opportunities

* All names and other identifying details are fictitious.
** Program names are generic and do not reflect department titles.

Despite initially planning on studying Chemical Engineering, positive experiences during his university's First-Year Engineering program introduced him to Industrial Engineering, a discipline he pursued upon returning to college. Paris started as an engineering student at community college before an injury led her to change to a less demanding program, Communications. Now recovered and unwilling to settle for something she is not passionate about, Paris discovered Industrial Engineering and has not looked back. Chris always enjoyed Psychology, but after having lackluster experiences during COVID-19 and reevaluating his interest in attending medical school, Chris made the jump into Industrial Engineering for the surety of finding a job. Brian knew he wanted to be an engineer, so he chose Mechanical Engineering. Two years later, he realized he could not see himself doing the kinds of things he was learning that mechanical engineers did and, with the support of his coworkers of all disciplines, transferred into Industrial Engineering. Unlike the others, Henry started in Industrial Engineering, because he was interested in the combination of engineering and business. Despite enjoying his coursework, Henry felt Industrial Engineering was not broad enough for the industry he hopes to work in and made the change to Mechanical Engineering.

These students are not all from the same university or even from the same country. They cover a wide range of ages and socio-economic backgrounds. Despite these differences, their experiences in Industrial Engineering and what led each of them to make the decision to change into or out of the field share common themes that transcend age and geography.

5.1 Emergent Themes

Although not explicitly coded for, several themes emerged throughout analysis of the transcripts. While the comments are presented *in situ* in the following narrative, Table 3 presents a brief summary of how many of the seven interviewed students mentioned various topics during their interviews. The list is not exhaustive but may serve to indicate which topics were of particular importance to the students in terms of their decision to change degree programs and their experiences while doing so.

Though covered in more detail below, some insights can immediately be drawn from this breakdown. For example, although grades or course difficulty has been reported as a contributing factor to students' decisions to leave engineering, when rigor was mentioned by those interviewed here (who were, admittedly, all changing into an engineering major), it was in terms of the original program not being difficult (Chris), not being difficult enough (Paris), or being difficult in the wrong way (Alex). Those that mentioned their new degree program's difficulty described it in terms of an acceptable or enjoyable level of rigor. Two students described a lack of career opportunities in their original degree program while four discussed the availability of jobs in their new degree program. A recurring theme amongst the students was the emphasis, not on the negatives of their original degree programs, but on the positives of their new degree program. As Arya put it, "it just really looks like this is really what I want to do."

5.2 The Beginning

Each student had a reason they chose the degree program they initially started in. For some, the intrinsic value placed on the subject matter was the important element. About why he chose Psychology, Chris said "I loved reading about the

Table 3. Emergent themes related to the decision to change degree programs

Theme	Mentioned by (of 7)
Consultation with Family	6
Flexibility of New Major	4
Rigor of Original Major	3
Rigor of New Major	4
Career Opportunities	5
Peer Opinions of ISE	4
Lack of Knowledge of ISE	5
Specific Courses	3

brain . . . [I] wonder what's going on in his brain right now . . . that was really interesting to me." When it came time to declare a major, Chris picked a field he knew he would gain personal enjoyment from learning more about. Brian made his decision in the same way; he knew he wanted to do engineering and Mechanical Engineering seemed like the one that most aligned with his interests. Others decided what to study for a much more pragmatic reason – maximizing the utility of their time spent in school. Merida saw her degree choice as the logical extension of the work she was already doing in her career. Business Information Systems tied into her job function and would supplement her already established skills. Meanwhile, Arya's choice of Biomedical Engineering was based on her perceived utility of the field: confronted with a family member with an autoimmune disorder, she "wanted to do something that could help him in the future." To justify going to university outside his home country, Alex knew he needed to choose a major with a high return on investment. That, paired with his country's large petrochemical industry, led him to choose Chemical Engineering. In other words, Alex's initial choice of discipline was heavily influenced by his future potential earnings and job opportunities. This is not to say that individuals make decisions exclusively on one or another of the values espoused by expectancy-value theory. Henry's response acknowledged the influence of a combination of values leading him to initially declare as Industrial Engineering: not only would the degree set him up well to take over his father's construction firm, but he was also "really interested in the way engineering principles went together with business practices." Henry realized both the intrinsic value the field would have as well as its utility in his future plans.

Besides Henry's comments about the family construction business, only Alex mentioned salary expectations as a deciding factor in the initial choice of discipline. Even when students described the utility of their chosen field, that utility was expressed in terms of achieving objectives (helping family members or progressing a career, for example) more so than money. In a sense, even Alex did not choose engineering because of the salary potential, but because it was his preferred option of the three choices he had available to him. In his own words:

> "[I]f you want to come outside the country, or to the [United] States to study, you have to either want to be a doctor or lawyer or engineer . . . I didn't want to be a lawyer. . .Becoming a doctor here in the States is remarkably difficult . . . engineering, in addition to having really good pay, I can actually get an engineering degree in four years which would reduce the cost to my mom."

Paris' choice of Communications was similarly constrained. In her case, it was not her enjoyment of the subject matter or her expectations of the utility of a degree in the field that led her to Communications. Rather, it was the high cost of pursuing her preferred field of engineering while recovering from a severe shoulder injury which pushed her into a degree program with a lower physical and mental workload than the one she actually valued. She did not make the choice completely at random, of course. She "knew that communication was a very broad major" and "that's what [her] sister was in" so it seemed a reasonable option at surface level.

In several instances, students did reflect on an element that partially factored into their decision of their original major: whether they thought they would be able to succeed in that discipline. For example, Alex knew he "was good enough at math, physics, and science to tackle an engineering curriculum" and that he "was really good at chemistry"; Henry "was always good at math and science"; Brian has "always been pretty good at math". Merida, when considering her pre-parenting educational experiences, noted that "the science made sense to me". Perhaps unsurprisingly, it was primarily the students who started in STEM disciplines that felt the need to justify their ability to perform successfully in those disciplines.

As time went on, some students began to identify negative aspects of their chosen field they had not fully realized when choosing initially. Arya was misinformed that, to pursue a career in Biomedical Engineering, she would have to move across the country. She also had to grapple with the idea of going to medical school and spending a "terribly long" time in school. Chris' disillusion also involved the requirement of medical school for his eventual career goal of psychiatry. He found himself comparing the amount of school required and the cost of that school with the job security and salary potential he could expect. In Chris's words, "there was a lot of school . . . eight to ten years. . .it's a lot of stress, especially going to med school. . .and then the money aspect . . . you put all that time in, and then . . . you don't know if you can have a secure job." There was more at play for Chris, however. He first started at his university in the fall of 2020 and was immediately confronted with an environment which differed wildly from his expectations. Having all his courses taught asynchronously online lowered the difficulty of the classes because he could approach the material on his own time, but it also meant he never formed any strong bonds with his classmates. While not necessarily a factor that pushed him away from psychology, the lack of personal ties to other students in his

department made his eventual decision to change majors much easier. No other student mentioned the social consequences of changing majors in this way, perhaps because it was not a concern for them. For Brian, it was not the length of time he would be in school that gave him pause but the work he would be doing after graduation. He explained that a mechanical engineer from a prominent company came to speak to one of his classes and described the kinds of things mechanical engineers did at that company. Brian recalls:

> "And one of the ones that struck me was that mechanical engineers spend at least 70% to 80% of their day behind the computer, typing, drawing blueprints, things like that. And I just, I don't like, I can't sit still for that long of a time."

His words convey the shock he felt at the sudden realization that the degree he had spent two years pursuing was leading him down a career path he was not excited to continue following. Paris echoed the same sentiment regarding her realization that Communications was not for her: "I'm doing something that I don't want to do. And if I'm going to be in school, it might as well be worth it."

Not all students interviewed expressed such harsh opinions about their starting major, however. Henry was perfectly content in Industrial Engineering until he learned the industries in his desired geographic location tended to hire considerably more mechanical engineers than they did industrial. Even less negative was the response Merida and Alex had: it was not until a new option was presented that the idea of changing degree programs was even considered.

5.3 Making the Change

Each student described the moment they learned about the discipline they would come to call home. Arya had never heard about industrial engineering until she attended a new student convocation and received some brochures from the industrial engineering table. For her, the decision to change was easy: "my dad and I looked at [the brochures] in the hotel that night and . . . 'industrial engineering seems really cool'. And so that's what happened." She realized that through industrial engineering, she "could still help people, which is . . . why [she] wanted to do biomedical". The first exposure Paris had to the term 'industrial engineering', meanwhile, came while she was working at a restaurant as part of the Disney College Program. A fellow intern mentioned how some of the processes they employed, like FIFO (first-in, first-out), were related to his major, industrial engineering. That same night, Paris called her father, who worked as an engineer, and asked about industrial engineering. They quickly realized how well the field suited her and by the end of Paris' time at Disney, she had decided to change majors.

While Arya and Paris made their decisions very quickly, Brian spent much longer considering his options. He explained that, after realizing what life as a mechanical engineering would entail, he spent nearly a month reading about various engineering fields online to learn what each discipline did. Industrial engineering appealed to him because "you're not stuck in one spot. You can work on machines or you could do blueprints or you could design this; it's not one specific field." It is interesting to note that Brian's descriptions of what he did not like about mechanical engineering and what he did like about industrial engineering have significant overlap. However, it was the perceived flexibility of the field that truly appealed to him. Not all students had that single moment of learning about the field: Chris's brother was already enrolled in industrial engineering, but he had not considered industrial engineering as relevant to himself until he was faced with negative experiences in psychology. Henry had a similar experience. Although he was content in industrial engineering, through an internship in the project engineering department at a manufacturing facility, he came to understand the roles that different engineers played in his desired industry. Henry realized that "having a more technical hands-on background with the mechanical side would [make him] a better project engineer". Despite acknowledging the value of industrial engineering – Henry stated that if he ever pursued a graduate degree, it would be in industrial engineering – he "wanted to have a foundation" in mechanical engineering. But it was not just the technical aspects of the new discipline that led Henry to make the decision to change after two years in his original program. An extremely goal-oriented individual, Henry realized that the types of places he wanted to work, in the rural area of the country he wanted to work in, tended to be smaller companies that would not necessarily have the budget to invest in a large industrial engineering department. He said, "when you're dealing with smaller manufacturing companies . . . they need people who have a much broader set of skills . . . they just want to get a mechanical engineer who has experience working on the equipment or understanding how things run". Since Brian and Henry followed opposite paths, some thought-provoking parallels can be drawn between them. For example, Henry left industrial engineering because it was not technical or hands-on enough. Contrariwise, Brian left mechanical engineering because he liked "being hands-on . . . and [he] didn't see that happening in mechanical." What's more, these two students are

from the same university, which means they both experienced the same industrial engineering department and the same mechanical engineering department; yet each evaluated those experiences in different ways according to their values and life goals.

Unlike the other students interviewed, Alex attended a university which requires incoming freshmen engineering students to participate in a First-Year Engineering (FYE) course before declaring for a specific discipline. It was through this experience that Alex was introduced to industrial engineering, alongside presentations from each other discipline offered at his university. Upon learning what industrial engineering entailed, Alex realized the interest he had in pursuing a job in chemical engineering was not sufficient to justify the lack of enjoyment he would experience on the way to graduation. He framed it in terms of relating a task to its payoff:

> "[I]ndustrial engineering . . . there's a lot of practical applications where I can see . . . what I'm doing actually has an application, as opposed to chemical engineering where you're studying organic chemistry in this abstract way. And then later on you get to chemical processes that will bring your thermodynamics in. . .your organic chemistry in and tie it all together. . .the prospect of a year and a half of taking very intellectually challenging classes without any real payoff or any real insight into how I will be applying this. . .it just didn't [make] sense to do anything other than industrial engineering."

Although Alex tied his decision directly to his previous degree program, multiple students described the flexibility and broadness of industrial engineering as a particularly attractive feature.

Merida's introduction to the field of industrial engineering is perhaps the most interesting of those presented here. She was an administrative assistant in an industrial engineering department at a university. However, when she made the decision to return to school to complete her education, she chose business information systems. She said, that choice "made sense with my professional career that I've had and my own interests . . . And so I was drawn to that because I knew that for my work." Even as Merida began to investigate jobs she would want to engage with through the degree she was pursuing, she realized she was interested in more than just pure business information systems. However, Merida faced a large stumbling block that nearly prevented her from changing to industrial engineering; in her words, "because of my background, I couldn't imagine myself as an engineer." It took reading her favorite book, *Zen and the Art of Motorcycle Maintenance*, by Robert M. Pirsig, for her to realize that not only *could* she be an industrial engineer, but that she *should* be an industrial engineer. Merida explained:

> "When I learned about systems engineering, it was like, 'I have wanted to be a systems engineer since I read that book.' Even though I didn't know that's what he was, in the book. And so, it just made sense. I'm like, 'that's exactly what, that's the types of problems I like to solve. That's what I like to do. That's what I should do.'"

The decision to change majors was not without reservations, however. Chris mentioned being afraid of the increased difficulty between psychology and industrial engineering, specifically referencing the reputation engineering at his university has for being "tougher". Regarding that feared difficulty increase, he commented, "it can get kind of rough. I don't make high A's in there, but I enjoy what we're doing so I study . . . I don't like studying but I don't hate it because I enjoy what's going on." Alex, meanwhile, predicted that industrial engineering would be easier than chemical engineering because he connected perceived difficulty with personal interest. In other words, chemical engineering classes "seemed like more of a chore" while industrial engineering was something he was "able to feel more engaged with." Regardless of the objective difficulty of the courses, Alex felt that being invested in the material would reduce their subjective difficulty. For Paris, the increase in challenge was part of what drew her to industrial engineering. For her, communications was not challenging "in the ways that [she] wanted it to be." She continued, "it didn't really push me as a student." When asked about how industrial engineering compared, Paris replied, "the work that I'm doing for this major is definitely harder. . .I know that it's going to push me academically. But I also think that solving problems is the way that I really want to be challenged. And in communications, I didn't really have to . . . solve any problems." She further related these expectations of harder coursework to her drive for good grades – while in the communications program, she felt that earning poor grades let down her parents; now in industrial engineering, she feels that earning poor grades is letting down herself. Through this, Paris highlights the importance of intentionality in her decision-making and in achievement of her goals. It also reflects the contribution of Paris' beliefs in her own competencies: because of her perceptions of her ability to succeed at harder coursework, her expectations adapted to reflect success as the default outcome.

5.4 Responses to the Change

A common concern echoed by several students revolved around how those around them would react to the news they were changing majors.

Chris simply remarked that he thinks his current group of friends would tease him if he was still a psychology major. Both Arya and Alex explained that at their universities, industrial engineering is perceived as the engineering major "you pick when you decide that you can't hack mechanical engineering or chemical engineering . . . so this is the easier engineering" (Alex) or as "baby engineers or not real engineers . . . the easy way out, the easy engineering" (Arya). Arya expressed frustration at these comments and defended industrial engineering by offering a rebuttal: "I have to take all the calculus, I have to take all the physics, just like you do . . . I take just as hard classes and maybe even harder." Rather than being upset by these comments, Alex attributes it to a lack of understanding on the part of students of other disciplines of what industrial engineering actually entails. He described the general perception of industrial engineering as "it's viewed as not being quite engineering, more like this funny thing that's in here, and they also do a professional engineering exam." In other words, Alex feels that other students are confused by industrial engineering because it does not necessarily match the 'traditional' definition of engineering – he specifically referenced business courses and engineering economics as examples of courses that "to a mechanical engineer [don't] make any sense". Really, Alex emphasized the flexibility that industrial engineering has compared to other fields:

> "If you're a mechanical engineer, that's cool. But it's just 3-D drawings, right? If you're a civil engineer . . . it's always the same concrete, different kinds of dirt. Same deal. It's the same thing forever . . . It's like ice cream. It's always going to be chocolate today, or vanilla. Bro, I just want some frozen yogurt."

For Alex, industrial engineering allows him to break the molds of structure and tradition in a way other disciplines cannot.

On the more positive side of responses, Brian reported that all his coworkers supported what he wanted to do. Even the facility director told him "It was a good switch". Knowing that his coworkers were behind him and were proud of him had further reaching effects than just reaffirming his choice of major and minimizing the perceived costs of switching. Brian says, "they're the reason I'm still in college". Considering the scenario where his coworkers had responded with ridicule or other negative reactions regarding industrial engineering paints a dire picture for the possible future of Brian's education. Henry experienced similar encouragement from his coworkers when it came to switching into mechanical engineering. Despite having been occasionally teased for being "imaginary", Henry understood that his coworkers genuinely cared when "one of them asked [him] if [he] was just changing because somebody was trying to influence what [he] decided to do. . .he didn't want [Henry] to be pushed to have any kind of peer pressure about it." In Henry's view, the engineering disciplines "all have their advantages, and all have their disadvantages or what they specialize in and what they don't." Regarding the perspective that industrial engineering is somehow inferior to other types of engineering, he said "[industrial engineers] are just as smart. They're just as effective at helping a company achieve their goals. I find they're just as much an engineer as anybody else." In his case, it was simply that "mechanical engineering was a better fit for what [he] wanted to do."

For Paris, external reactions to her decision to change to industrial engineering were similarly positive. Overall, her family was very supportive; she describes her father as encouraging and her sister, who works in public relations, as having never pressured her to stay in communications. Further, she said, "all the people that are close to me knew and they can all tell now that I'm so much better off now that I did switch." Having a supportive network enabled Paris to appropriately process her desires to succeed. Internally, however, the decision came with heavier consequences. Paris had been involved in cheerleading her entire life; in fact, it was due to cheer that she suffered the injury that led her to become a communications major in the first place. During her time in the Disney College Program, she realized she did not miss cheerleading as much as she had thought she would. After changing her major, she was faced with a summer of calculus and chemistry in addition to workouts to prepare for the upcoming football season. She recalls thinking, "I can't even find time to do this. How am I going to have time to go to practice?". Paris joked:

> "I remembered [engineering students] were always talking about 'oh my gosh, can they let us out of practice? They're keeping us 30 minutes over. I have a project to do' and I thought 'my gosh, must suck to be y'all'. And then now here I am. One of my roommates is a cheerleader and when she's going into practice, I'm still doing homework and not even almost done."

Despite that, Paris is confident in her decision to change to industrial engineering. As she put it, "I definitely don't regret [quitting cheerleading]. And that shows me that I made the right choice."

Unlike the others, Merida experienced significant negative responses, not just to her decision to change from business information systems to industrial engineering, but, in some cases, to her decision to return to university at all. Beyond her personal struggles about her ability to succeed and with "all these ideas about what it means to be someone at [her] age in life, going back to school for anything,

let alone to be an engineer'', she faced external pressure from those she thought would support her. Merida explained:

> ''the fact that I'm a woman who's raised her children, and now wants to go to school is just a weird idea for them to embrace at all. I don't even know if it's about engineering as much as I'm a woman who just had her 50th birthday, I should be wanting to go play with my grandchildren and not want to go back to school . . . and develop a career.''

Even after she moved past the naysayers that decried her right to be in college at all, Merida was faced with nearly overwhelming pressure to remain within the field of business. According to her, the most common educational experience promoted to non-traditional students is ''go back to school to be better at what you already do.'' While business had the most obvious utility for her future, Merida looked beyond the short-term to see that industrial engineering provided equal or more utility. She said a frequent response she received was ''kind of a smile and nod and . . . you can tell from their smiles 'okay, that's nice of you. Let me know how that turns out','' which is a particularly patronizing way of showing ridicule and disdain at her ability to achieve her goals. In other circumstances, she was pressured by those with ostensibly good intentions to consider how staying in business would be an easier path than engineering, that she would be able to finish sooner, that she did not realize how difficult her classes would be if she became an industrial engineering student. Merida described feeling disappointed that even those who were educators and advisors professionally were encouraging her to abandon her dreams in favor of the easy way out or the lowest cost route. This societal pressure was overcome as she encountered more and more instances of positive representation in engineering. This representation enabled her to build the confidence needed to answer ''Can I do this task?'' with a resounding 'Yes!' Merida conveyed the experience thusly:

> ''As I learned about systems engineering and as I saw other women who were engaged in becoming and being an engineer, it made it seem like I don't have to be as afraid of where I fit in the grand scheme of things because there are women engineers, there are women systems engineers, and it just made sense.''

5.5 Where They Are Now

All the interviewed students, including Henry who transferred out of industrial engineering, had positive things to say about the field, whether just reaffirming their decision to change degree programs or elucidating why they feel industrial engineering is the ideal discipline for them. Arya's response was simple: industrial engineering, with the addition of a second degree in business administration, will perfectly equip her to create her own engineering consulting business. Brian's closing thoughts were equally succinct: ''I like it. I enjoy what I do now and I hope to continue enjoying it.'' Chris found that ''industrial engineering isn't just about one major, about one little thing. It's about a whole area of aspects. It's really cool to me.'' Alex chose to highlight the importance of the connection industrial engineering has with business:

> ''I really think it's where those two circles meet. I think that's what industrial engineering is all about. Because, the Venn diagram. You've got engineering, got business, and then we've got us that kind of straddle both. And that's what I enjoy most about it . . . the fact that industrial engineering is not pure engineering.''

Henry, despite having left industrial engineering, felt his time in the field was important to getting him ''on the path to where [he's] supposed to be.'' He specifically acknowledged industrial engineering's emphasis on strong communication skills as an important contribution to his success in both his new field of mechanical engineering and in his work. Merida concluded her thoughts with reaffirming the encouragement provided by seeing positive representation. Based on her own experiences, she declared:

> ''Representation. People seeing others like themselves. I think of some of my friends . . . and I want to hold them up on billboards and say 'Look! This person did it. This person is an industrial engineer. You could do this too, if you wanted to.' . . . whatever they see themselves as, I can point to them and say 'I know someone who is like that and who is doing what you want to do. It's possible for you to reach your goal.''

Finally, Paris reflected upon her experiences as a communications major and realized how lost she was in that field. Her parting comment conveys so much that was left unsaid by the tone and expressions used by the students introduced here as they each spoke about their new home of industrial engineering (or old home, for Henry). Her words embody the potential of a field like industrial engineering. Paris explained:

> ''I just am really glad that I was able to switch and found something that I was very passionate about, because I was always scared that I would not ever find that out, never know what I want to do. And I would have a job that I didn't care about. But now I get it. When they say, 'if you love it, it won't be a job. You won't feel like you're going to work.'''

6. Conclusion

Ethnographic research methods are not commonly used in engineering education applications, but in some instances, this narrative-driven approach is the most appropriate. In this study, semi-structured

interviews were conducted with seven engineering undergraduate students who had either transferred into or out of industrial and systems engineering. Through the conversations, each student discussed what led them, individually, to make the decision to change from one degree program to another and how that decision has since affected them. Perhaps, the overall sentiment can best be summarized by these two quotes: ''If only I had known'' (Paris) and ''they just don't really know'' (Alex). Each student repeatedly returned to a lack of understanding, both on their own part and in greater society, of what industrial engineering is. Though some valued their time in other disciplines, there was a general regret at the wasted time and wasted money spent pursuing majors they changed out of which could have been avoided if each had been aware of industrial engineering from the beginning. These stories are not statistics – they do not represent the engineering undergraduate population of the United States. But nor do they attempt to. There is value in observing the small details, the nuanced responses, the voice of the individual. In doing so, insight into the bigger picture is gained. The emotional struggle of facing naysayers, the internal debate over pursuing one's passions, even the realization that a better path lies elsewhere – for educators, these elements are vital in understanding the student as a person and not just as a statistic. For example, Brian's trajectory change was initiated by one industry speaker's comments. It is obvious to many, including likely Brian himself, that not all mechanical engineering jobs operate in the same way or have the same responsibilities. But in that moment, Brian's perceptions of mechanical engineering were narrowed to reflect the mechanical experience at one specific company. Brian's story thus serves as a cautionary tale to educators about the importance of contextualizing information and of providing broad career exposure to students. Similar lessons can be learned from Alex's perceptions of the value or drudgery of various prerequisite courses. Allowing curriculum to encourage and emphasize the interconnectivity of topics and themes across courses enables students and educators to highlight the value of each course as a valuable building block in the student's education. Finally, educators can use the pervasive sentiment of a lack of knowledge of what industrial engineering entails to foster conversations about increasing awareness of the field and its opportunities. In so doing, perhaps more students will realize that, beyond chocolate and vanilla ice cream, frozen yogurt is what's right for them.

References

1. K. Leu, NCES Data point: Beginning college students who change their majors within 3 years of enrollment, *Psychiatric Times*, **31**(3), 2017.
2. ASEE, ''Engineering By The Numbers: ASEE Retention and Time-to-Graduation Benchmarks for Undergraduate Engineering Schools, Departments, and Programs,'' ASEE, Washington, DC, 2016.
3. National Academy of Engineering, ''NAE Grand Challenges,'' 2015.
4. J. J. Ferrare and Y.-G. Lee, ''Should We Still Be Talking about Leaving? A Comparative Examination of Social Inequality in Undergraduate Patterns of Switching Majors. WCER Working Paper No. 2014–5,'' 2014.
5. B. N. Geisinger and D. R. Raman, Why they leave: Understanding student attrition from engineering majors, *International Journal of Engineering Education*, **29**(4), pp. 914–925, 2013.
6. S. E. Walden and C. E. Foor, 'What's to keep you from dropping out?' Student Immigration into and within engineering, *Journal of Engineering Education*, **97**(2), pp. 191–205, 2008.
7. L. Fleming, K. Engerman and D. Williams, Why students leave engineering: The unexpected bond, *ASEE Annual Conference & Exposition*, 2006.
8. M. W. Ohland, S. D. Sheppard, G. Lichtenstein, O. Eris, D. Chachra and R. A. Layton, Persistence, engagement, and migration in engineering programs, *Journal of Engineering Education*, **97**(3), pp. 259–278, 2008.
9. J. Jackson, The Story Is Not in the Numbers: Academic Socialization and Diversifying the Faculty, *NWSA Journal – (Re)Gendering Science Fields*, **16**(1), pp. 172–185, 2004.
10. C. E. Foor, S. E. Walden and D. A. Trytten, 'I Wish that I Belonged More in this Whole Engineering Group:' Achieving Individual Diversity, *Journal of Engineering Education*, **96**(2), pp. 103–115, 2007.
11. J. Eccles and A. Wigfield, Motivational Beliefs, Values, and Goals, *Annu Rev Psychol*, **53**, pp. 109–132, 2002, [Online].
12. P. Herriot and R. Ecob, Occupational choice and expectancy-value theory: Testing some modifications, *Journal of Occupational Psychology*, **52**(4), pp. 311–324, 1979.
13. M. Besterfield-Sacre, C. J. Atman and L. J. Shuman, Cross institutional comparison of freshman engineering attitudes, *Proceedings – Frontiers in Education Conference, FIE*, 2, p. 786, 1997.
14. S. J. Correll, E. Seymour and N. M. Hewitt, Talking about Leaving: Why Undergraduates Leave the Sciences, *Contemp Sociol*, **26**(5), p. 644, Sep. 1997.
15. I. J. Park, M. Kim, S. Kwon and H. G. Lee, The relationships of self-esteem, future time perspective, positive affect, social support, and career decision: A longitudinal multilevel study, *Front Psychol*, **9**(APR), p. 514, 2018.
16. P. Bordalo, K. Coffman, N. Gennaioli and A. Shleifer, Beliefs about Gender, *Harvard Business School*, pp. 1–60, 2018.
17. J. v. Butler, Inequality and Relative Ability Beliefs, *The Economic Journal*, **126**(593), pp. 907–948, 2016.
18. K. Coffman, M. Collis and L. Kulkarni, ''Stereotypes and Belief Updating,'' 19–068, 2021.

19. R. E. Wood, A. J. Mento and E. A. Locke, Task Complexity as a Moderator of Goal Effects: A Meta-Analysis, *Journal of Applied Psychology*, **72**(3), pp. 416–425, 1987.
20. M. Alias and N. A. H. M. Hafir, The relationship between academic self-confidence and cognitive performance among engineering students, in *2009 Research in Engineering Education Symposium, REES 2009*, 2009.
21. B. Doosje, N. Ellemers and R. Spears, Perceived intragroup variability as a function of group status and identification, *J. Exp. Soc. Psychol.*, **31**(5), pp. 410–436, 1995.
22. D. Verdín, A. Godwin, A. Kirn, L. Benson and G. Potvin, Understanding how engineering identity and belongingness predict grit for first-generation college students, in *CoNECD 2018 – Collaborative Network for Engineering and Computing Diversity Conference*, 4, 2018. [Online].
23. H. Matusovich, R. A. Streveler and R. L. Miller, Why do students choose engineering? A qualitative, longitudinal investigation of students' motivational values, *Journal of Engineering Education*, **99**(4), pp. 289–303, 2010.
24. A. Wigfield and J. Eccles, The development of achievement task values: A theoretical analysis, *Developmental Review*, **12**(3), pp. 265–310, Sep. 1992.
25. G. Potvin and Z. Hazari, The Development and Measurement of Identity across the Physical Sciences, in *2013 PERC Proceedings*, Jul. 2014, no. May, pp. 281–284.
26. J. Eccles, Understanding Women's Educations and Occupational Choices, *Psychol. Women Q.*, **18**, pp. 585–609, 1994.
27. P. Molina-Gaudo, S. Baldassarri, M. Villarroya-Gaudo and E. Cerezo, Perception and intention in relation to engineering: A gendered study based on a one-day outreach activity, *IEEE Transactions on Education*, **53**(1), pp. 61–70, 2010.
28. D. Verdín, A. Godwin, A. Kirn, L. Benson and G. Potvin, Engineering women's attitudes and goals in choosing disciplines with above and below average female representation, *Soc. Sci.*, **7**(44), pp. 1–25, 2018.
29. G. Potvin et al., Disciplinary differences in engineering students' aspirations and self-perceptions, *ASEE Annual Conference & Exposition*, no. #7350, 2013.
30. V. A. Shivy and T. N. Sullivan, Engineering students' perceptions of engineering specialties, *J. Vocat. Behav.*, **67**(1) SPEC. ISS., pp. 87–101, 2005.
31. D. A. Trytten, S. E. Walden and T. R. Rhoads, Industrial engineering student perceptions of computer science, computer engineering, and electrical engineering, in *Proceedings – Frontiers in Education Conference, FIE*, vol. S1H, pp. 1–6, 2005
32. J. Eccles, Who am I and what am I going to do with my life? Personal and collective identities as motivators of action, *Educ. Psychol.*, **44**(2), pp. 78–89, 2009.
33. C. Carrico, H. Matusovich and M. C. Paretti, A Qualitative Analysis of Career Choice Pathways of College-Oriented Rural Central Appalachian High School Students, *J. Career Dev.*, **46**(2), pp. 94–111, 2019.
34. A. Abbey, C. Dunkel-Schetter and P. Brickman, Handling the Stress of Looking for a Job in Law School: The Relationship between Intrinsic Motivation, Internal Attributions, Relations with Others, and Happiness, *Basic Appl. Soc. Psych.*, **4**(3), pp. 263–278, 1983.
35. M. Pinnell, R. Blust, J. Brahler and M. Stevens, Can service-learning in K-12 math and science classes affect a student's perception of engineering and their career interests, in *Proceedings – Frontiers in Education Conference, FIE*, no. T3D, pp. 13–16, 2008.
36. V. Y. Rito, J. L. Aschenbrenner and J. L. Heier Stamm, Toward broadening participation: Understanding students' perceptions of industrial engineering, in *ASEE Annual Conference & Exposition*, no. #10084, 2014.
37. J. Eccles and A. Wigfield, In the Mind of the Actor: The Structure of Adolescents' Achievement Task Values and Expectancy-Related Beliefs, *Pers. Soc. Psychol. Bull.*, **21**(3), pp. 215–225, 1995.
38. A. M. Lucietto, S. Tan, L. A. Russell and M. E. Johnson, Public perception of engineering technology: A literature review, *School of Engineering Education Faculty Publications*, no. Paper 61, p. #29770, Jun. 2020.
39. H. Marshall, L. McClymont and L. Joyce, ''Public Attitudes to and Perceptions of Engineering and Engineers 2007,'' 2007.
40. E. Specking, B. W. Henderson and B. Hill, Perception: Industrial Engineering Jobs, in *ASEE Annual Conference & Exposition*, p. #14640, 2016.
41. S. E. French, C. R. Bego, J. L. Hieb and P. A. Ralston, Gender, psychological cost, and retention among engineering students, in *ASEE Annual Conference & Exposition*, 2021.
42. SRI International, ''Promoting grit, tenacity and perseverance: Critical factors for success in the 21st century,'' Menlo Park, CA, 2018. [Online].
43. N. Ye, T. Y. Fok, J. Collofello and T. Coronella, Common and Uncommon Characteristics of Engineering Student Retention After the First Year in University #33120, in *ASEE Annual Conference & Exposition*, pp. 1–15, Aug. 2021.
44. R. Su and J. Rounds, All STEM fields are not created equal: People and things interests explain gender disparities across STEM fields, *Front. Psychol.*, **6**(189), pp. 44–63, 2015.
45. R. L. Shehab, T. R. Rhoads and T. J. Murphy, Industrial engineering: Why students come and what makes them stay?, in *ASEE Annual Conference & Exposition*, pp. 7971–7980, 2005.
46. C. E. Foor and S. E. Walden, 'Imaginary engineering' or 're-imagined engineering': Negotiating gendered identities in the borderland of a college of engineering, *NWSA Journal*, **21**(2), pp. 41–64, 2009.
47. M. Allen, ''Ethnography,'' *The SAGE Encyclopedia of Communication Research Methods*. SAGE Publications, Inc, Jul. 20, 2017.
48. [W. Shumar, Making Strangers at Home: Anthropologists Studying Higher Education,' *J. Higher Educ.*, **75**(1), pp. 23–41, 2004.
49. G. B. Black, S. van Os, S. Machen and N. J. Fulop, Ethnographic research as an evolving method for supporting healthcare improvement skills: a scoping review, *BMC Med. Res. Methodol.*, **21**(1), p. 274, Dec. 2021.
50. G. S. Ryan, An introduction to the origins, history and principles of ethnography, *Nurse Res.*, **24**(4), pp. 15–21, 2017.
51. D. C. Berliner and W. J. Tikunoff, The California Beginning Teacher Evaluation Study: Overview of the Ethnographic Study, *J. Teach. Educ.*, **27**(1), pp. 24–30, 1976.
52. D. Holland and M. Eisenhart, *Educated in Romance: Women, Achievement, and College Culture*, University of Chicago Press, 1990. Accessed: May 31, 2022. [Online].
53. B. M. Olds, B. M. Moskal and R. L. Miller, Assessment in Engineering Education: Evolution, Approaches and Future Collaborations, *Journal of Engineering Education*, **94**(1), pp. 13–25, 2005.
54. S. M. Lancaster, S. E. Walden, D. A. Trytten and T. J. Murphy, The contribution of office-hours-type interactions to female student satisfaction with the educational experience in engineering, in *ASEE Annual Conference & Exposition*, pp. 2279–2289, 2005.

55. G. Morales-Román, Retrato narrativo de las experiencias, retos y motivaciones de la mujer adulta: estudiante del Programa Doctoral en Educación [Narrative portrait of experiences, challenges, and motivations of adult women: student in the PhD in Education Program], *Revista Iberoamericana de Educación Superior (RIES)*, vol. VI, no. 16, pp. 143–163, 2015.
56. L. McClure, T. Combrink, C. E. Foor, S. E. Walden and D. A. Trytten, I wish someone would've told me: Undergraduate engineering students offer advice to incoming students, in *ASEE Annual Conference & Exposition*, 2006, no. June 2006.
57. T. J. Murphy, R. L. Shehab, T. R. Rhoads and D. A. Trytten, A multi-institutional study of student perceptions of industrial engineering, in *Proceedings – Frontiers in Education Conference, FIE*, no. S1G, pp. 3–8, 2006.
58. M. Crescimbene, F. la Longa, R. Camassi and N. A. Pino, The Seismic Risk Perception Questionnaire, *Geological Society, London, Special Publications*, **419**(1), pp. 69–77, 2015, [Online].
59. M. DeJonckheere and L. M. Vaughn, Semistructured interviewing in primary care research: a balance of relationship and rigour, *Fam. Med. Community Health*, **7**(2), p. 57, Mar. 2019.
60. P. Sedgwick, Questionnaire surveys: sources of bias, *BMJ*, **347**(7923), 2013.
61. J. G. Nicholls, B. G. Licht and R. A. Pearl, Some dangers of using personality questionnaires to study personality, *Psychol. Bull.*, **92**(3), pp. 572–580, Nov. 1982.
62. M. Crang and I. Cook, *Doing Ethnographies*, SAGE Publications Ltd, 2007.
63. R. A. Krueger, Using Stories in Evaluation, in *Handbook of Practical Program Evaluation*, 4th ed., K. E. Newcomer, H. P. Hatry and J. S. Wholey, Eds. Jossey-Bass, pp. 404–423, 2015.
64. G. E. Molnar and R. J. Delauretis, Predicting The Curriculum Mobility Of Engineering Students: A Comparison Of Discriminant Procedures, *J. Couns. Psychol.*, **20**(1), pp. 50–59, 1973.
65. J. B. Main, K. J. Mumford and M. W. Ohland, Examining the influence of engineering students' course grades on major choice and major switching behavior, *International Journal of Engineering Education*, **31**(6), pp. 1468–1475, 2015.
66. C. E. Brawner, M. M. Camacho, S. M. Lord, R. A. Long and M. W. Ohland, Women in industrial engineering: Stereotypes, persistence, and perspectives, *Journal of Engineering Education*, **101**(2), pp. 288–318, 2012.
67. R. M. Felder, Meet Your Students. 1. Stan and Nathan, *Chem. Eng. Educ.*, **23**(2), pp. 68–69, 1989.
68. W. C. Adams, Conducting Semi-Structured Interviews, in *Handbook of Practical Program Evaluation*, 4th ed., no. August 2015, K. E. Newcomer, H. P. Hatry, and J. S. Wholey, Eds. Jossey-Bass, pp. 492–505, 2015.
69. R. J. Chenail, Interviewing the investigator: Strategies for addressing instrumentation and researcher bias concerns in qualitative research, *Qualitative Report*, **16**(1), pp. 255–262, 2011.
70. J. S. Wholey, H. P. Hatry and K. E. Newcomer, Eds., *Handbook of Practical Program Evaluation*, 3rd ed. Jossey-Bass, 2010.
71. S. Rädiker and U. Kuckartz, *Focused Analysis of Qualitative Interviews With MAXQDA: Step by Step*. 2020.
72. A. J. Onwuegbuzie, W. B. Dickinson, N. L. Leech, and A. G. Zoran, A Qualitative Framework for Collecting and Analyzing Data in Focus Group Research, *Int. J. Qual. Methods*, **8**(3), pp. 1–21, 2009.
73. D. A. Trytten, R. L. Shehab, T. R. Rhoads, M. J. Fleener, B. J. Harris, A. Reynolds, S. E. Walden, S. K. Moore-Furneaux, E. Kvach, K. R. Warram and T. J. Murphy, 'Inviteful' Engineering: Student Perceptions of Industrial Engineering in *ASEE Annual Conference & Exposition*, pp. 3557–3568, 2004.
74. J. Cruz and N. Kellam, Beginning an Engineer's Journey: A Narrative Examination of How, When, and Why Students Choose the Engineering Major, *Journal of Engineering Education*, pp. 556–582, 2018.
75. M. Hammersley, What is ethnography? Can it survive? Should it? *Ethnography and Education*, **13**(1), pp. 1–17, 2018.

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