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Becoming Engineers in the Middle Years: Narrative Writing as Identity Work in an Undergraduate Engineering Science Course*

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In this qualitative research study, we engaged engineering undergraduates enrolled in a 2nd year engineering science course in a narrative reflective writing exercise in order to explore processes of identity recognition and re/construction within the early, technical engineering curriculum. During the final week of the course, ten participants (two female, eight male) generated qualitative data including reflective narrative accounts of their experiences during the semester-long course. After the conclusion of the course, a team of two researchers jointly interpreted the experiential stories in light of participants' course performance records, including homework scores, exam scores, and final grades. The researchers, who were also engineering instructors, collaboratively engaged with their experiences teaching and providing support to students in the course, and with personal reflections on their own undergraduate engineering education, to jointly interpret the data. Student-authored narratives were analyzed in context to identify instances of identity recognition and performance, narrative tensions existing between concurrent roles, and identity re/construction through sense-making. Multiple identity theory and growing bodies of research that link professional role transitions and narrative writing to professional identity development processes were used to scaffold the findings. In this study, we identify and describe multiple instances of personal and professional identity recognition, role-based tensions, and identity re/construction and sense-making within participant narratives. Findings suggest that further exploration of narrative-based reflective writing as a pedagogical tool to support early undergraduate identity development in technical engineering courses is warranted. Findings have implications for the design and instruction of technical courses within engineering, as well as courses within other practitioner-based fields wherein identity development plays a key part in role transition and professional formation.

Keywords: engineering education; identity; middle years; narrative pedagogy; reflection; sense-making

1. Introduction

In the United States, insufficient enrollment, retention, and diversity of engineering undergraduates have led to rising interests in the study of the identity development [1, 2] and professional formation [3] of engineers. Moreover, researchers across many fields, including science and engineering education, have come to regard the construct of identity as critical to understanding students' experiences, outcomes, and development within the context of professional educational systems [e.g., 4–9]. Development of engineering-related identities is considered to play a key role in the professional formation of engineers, which encompasses the "formal and informal processes and value systems by which people become engineers" [3]. Research has shown that undergraduates who fail to come to identify with engineering and/or engineers may leave engineering degree programs to pursue other majors or alternative career paths [10–13]. Thus, deep understandings of the ways in which undergraduates shift and/or negotiate their personal and professional identities, particularly during the "middle years" of engineering education when student attrition peaks and motivation falls [14], are considered essential for informing recruitment and retention efforts, assessment of instructional interventions, and actions taken to increase the diversity of the engineering workforce [1].

Prior work in engineering education reports use of reflection and reflection-based activities [15] to (1) support student learning, in terms of conceptual learning, professional skill development, and/or use of metacognitive learning strategies, within engineering courses [e.g., 16–20], and (2) promote professional skills and identity development through integration of other (i.e., often co-curricular or extracurricular) experiences, such as participation in cross-disciplinary studio-design courses, workshops, internships and co-ops, and work-integrated programs, into their sense of self [4, 21–23]. More limited work, however, has studied the use reflection for the purposes of supporting student identity work as part of the technically-focused areas of the engineering curriculum (i.e., 2nd and 3rd year engineering science courses) [e.g., 24].

This study describes application of a narrative reflective writing exercise, informed by narrative reflective practice [25] and narrative inquiry prac-

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tice [26, 27], within a 2nd year engineering science course. Because prior research reports that quantitative measures of engineering identity constructs, such as engineering identity recognition and performance/competence, fall to their lowest levels among engineering undergraduates in their second year of study [6], this study set out to understand the potential for narrative reflective practice to promote identity work within a required 2nd year engineering science course. Specifically, our goal was to understand whether and how 2nd year undergraduates engaged in personal and professional identity work in writing reflective (i.e., retrospective) stories about their experiences in a technical engineering course. Furthermore, the researchers sought to gain insights as to how to collectively (i.e., at a course level) support personal and professional identity work among undergraduates in the middle years engineering courses through systematic application of a narrative-based reflection.

This paper examines student-authored, written reflective narratives of experiences in a 2nd year engineering thermodynamics course to answer the following research questions:

In the context of the 2nd year engineering course:

1. How do the narratives describe instances of identity recognition by the participants?
2. How do the narratives describe tensions related to competing roles and notions of self that are held by the participants?
3. How do the narratives describe "sense-making," or the negotiation and reconstruction of personal and professional identities, by the participants?

2. Background

In this section a synthesis of the research literature related to reflection, narrative, and identity in professional and/or engineering education is presented.

2.1 Reflection in Engineering Education

Although reflection has not traditionally been considered part of the formal engineering curriculum, application of reflection as a course activity and/or pedagogical strategy is currently on the rise within engineering education [28]. Some researchers attribute increasing use of reflection by engineering instructors to the broader implementation of active learning and student-centered teaching strategies within engineering classrooms [29, 30]. Theoretically, the role of experiential reflection as a necessary process of learning has been suggested by Kolb [31] and Dewey [32]. Schon [33] theorized "reflection-in-action" as an essential thinking practice of working professionals, including engineers, architects, managers, and city planners, who are often presented with complex, ill-defined problems as part of their work roles.

Within the engineering education literature, reflection has been defined as ". . . an intentional and dialectical thinking process where an individual revisits features of an experience . . . and uses one or more lenses in order to assign meaning(s) to the experience that can guide future action and thus future experience" [29, p. 24.776.2]. *Intentionality* suggests that reflection is carried out "actively and knowingly" to create meaning from current experience in order to direct future actions; the *dialectical nature* of reflective thinking implies that reflection is focused on the resolution of opposing tensions within, or competing interpretations of, an experience [29]. The availability and use of *multiple viewpoints*, or "lenses," from which to reflect on an experience demonstrates that singular experiences may be interpreted differently for different purposes (e.g., conceptual learning, professional skills development, identity development) [29].

Researchers from the Consortium to Promote Reflection in Engineering Education (CPREE) have documented five unique purposes for reflection: To help students (1) understand course content and skills, (2) understand their own strengths and weaknesses as learners/students/team members, (3) understand how what they are learning may apply in the real world and in their future careers, (4) explore personal motivation and interests for studying engineering and developing an identity as engineer, and (5) think about issues involving social justice, ethics, or culture [34]. Researchers have also noted that reflection can be a "messy, personal, and complicated" process [30, p.1] and that instructors often face unique challenges when attempting to incorporate reflection-based activities within engineering courses [28, 30]. To assist instructors in overcoming these challenges, Thomas and colleagues [30] documented over 100 reflection-based activities that have been previously implemented and vetted by engineering educators across diverse U.S. institutions, as well as over 300 instructor "tips and tricks" for implementing reflection in engineering classrooms.

2.2 Narrative in Professional Education

In the field of cognitive psychology, Bruner [35] theorized that there are just two modes of human cognition: *paradigmatic understanding* – a type of "logico-scientific" understanding that stems from the application of logic, deductive reasoning, and universal scientific principles – and *narrative understanding* – a type of understanding that comes from

retrospectively joining separate events and actions into "organizational scheme[s] expressed in story form" [36, p. 13]. Narrative, then, may be considered as ". . . a meaning structure that organizes events and human actions into a whole, thereby attributing meaning to individual events and actions according to their effect on the whole[15]" [36, p. 18]. Unlike scientific understanding which requires application of formalized rules and principles to make sense of information, narrative understanding occurs from the reflective examination of individual connections and relationships – between the events and actions occurring within or as a result of *experience* – when presented chronologically, as is done in story-telling and story writing [35, 36]. Here, use of the term "story" is not meant to denote fabrications or misrepresentations [37]. Rather, terms such as "narrative" and "story" are used to describe one's reflective re/organization of elements of experience into a "coherent developmental account" [37, p. 15] that "connects events in a meaningful way for a definite audience" [38, p. xvi].

Despite emphasis on scientific, or paradigmatic, understanding within many technical disciplines, Polkinghorne [36] noted that practitioners (e.g., psychologists, teachers, doctors, counselors) work foremost through narrative understanding. As such, narrative is used as an instructional tool within several professional education contexts, including teacher [e.g., 39, 40] and medical education [e.g., 41, 42]. For example, teacher educators created narrative inquiry spaces – spaces set aside to provide a time and place for elementary students to safely share and inquire about personal stories within school classrooms – to enable them to respond to student experiences within in- and out-of classroom spaces [39] and to step away from the classroom "script" and "negotiate a curriculum of diversity" [40, p. 347]. In medical education, student development of a physician's identity is considered to be a critical outcome [43]; medical students need to develop complex professional identities as "technically skilled as well as caring, compassionate and ethical practitioners" [41, p. 765]. Researchers and educators implemented a form of narrative reflective practice consisting of writing, reading aloud, and jointly discussing parallel charts of actual patient cases [41, 42]. Parallel charts served to (1) tell the medical residents' story, including details of relational interaction, personal decision-making, and emotions as they engaged with patients, (2) augment/contrast with the technically-focused, patient medical chart, and (3) connect the human element of medical practice with its requisite technical knowledge and skills. In writing, reading and inquiring into parallel charts, medical students reflected deeply on becoming physicians through their personal encounters with patients, from the experiences of others caring for patients, and from discussions with students and doctors in the parallel chart group.

2.3 Engineering Identity and Professional Formation

Despite identity's key role in the education of professionals and increasing interest in the study of engineering identity and professional formation within engineering education, the current engineering identity literature is described as "narrow," "underdeveloped," and "too disjointed to effectively build on the foundation provided by prior work" [1]. Current engineering identity scholarship reflects a strong focus on academic contexts within engineering, science, and mathematics, as well as racial/ethnic minorities and women. Others in engineering, however, have received less attention; there is no reported research devoted to engineering identity development among majority (i.e., white) students [2] and only a few studies related to engineering identity development among student veterans and service members [e.g., 44, 45]. Engineering identity literature draws on numerous identity frameworks (e.g., Core Identity Theory, Multiple Identity Theory, Sociocultural Theory, etc.) across diverse fields including psychology, sociology, education, cultural studies, anthropology, and social linguistics [1, 2]. While engineering identity scholarship has been praised for its use of interdisciplinary theories, it has been critiqued for its perceived failure to connect between and across potentially overlapping theoretical frameworks [1], and for neglecting to establish its own disciplinary frameworks for identity [2]. Moreover, a lack of intersectional approaches taken to explore the effects of racial, ethnic, gender and other social and cultural identities on engineering identity development is a general critique of the engineering identity literature [1]; scholars emphasize a need to understand how the processes of engineering identity development are "value-laden" and "heavily dependent on the held identities and contexts in which students find themselves" [2, p. 261].

3. Theoretical Frameworks

This study draws from the multiple identity framework of Gee [47] and growing bodies of literature that connect role transitions [48–50] and narrative story telling [51, 52] to processes of professional identity formation.

3.1 Personal Identity

Gee [47, p. 99] defined identity as "being recognized

as a 'certain kind of person'' as one ''acts and interacts in a given context'' [47]. Gee [47, p. 99] emphasized that identities are continually shaped through personal, social, and contextual forces; we are all recognized, at any given time, as ''certain kinds of people'' based on our ''performance in society.'' In this way, identity is developed through self-identification with other individuals and/or groups and '' . . . internalization of roles and reflected appraisals of others'' [8, p. 700].

Gee's multiple identity framework [47] is comprised of four distinct yet overlapping identity dimensions: Nature-identity, Institution-identity, Discourse-identity, and Affinity-identity. According to Gee [47], these four dimensions weave together to form multiple, co-existing identities – that is, who we are in terms of our human 'natures' (Nature-identity), the position(s), title(s), or role(s) we hold within formalized institutions (Institution-identity), our accomplishments as interactionally recognized by others (Discourse-identity), and our experiences within ''affinity groups'' among those who share particular interests (Affinity-identity).

3.2 Professional Identity

Professional identity has been conceptualized as an identity that evolves from ''personal identification with the duties, responsibilities, and knowledge associated with a professional role'' [48]. Novices in most career fields must not only work to adapt their skills and knowledge to meet the demands of new roles and responsibilities, but also adopt and learn to embody new cultural and social norms that prescribe how members act and interact within the field. Because scholars consider identity to influence one's ability to attain ''. . . meaningful connections and pursuits within a larger cultural milieu'' [8, p. 699], career success is often associated with formation of professional identities [53].

According to Ibarra [48, p. 3], professional identities are realized through processes of (1) doing, (2) interacting, and (3) story-telling (i.e., making sense). A comparison with Gee's [47] framework suggests that the professional identity development processes of ''doing'' and ''interacting'' align closely with Affinity-Identities and Discourse-Identities, respectively. Eliot and Turns [4, p. 631] further conceptualized these processes in the context of engineering education as (1) doing: engaging in professional activities (i.e., through project-based learning, laboratories, internships, and co-ops), (2) interacting: building social networks (i.e., through coursework, projects, professional clubs, and internships and that can include peers, faculty, and industry stakeholders), and (3) story-telling: sense-making wherein individuals weigh the demands and affordances of professional roles against personal interests and existing ideas of self. The authors make a subtle distinction between project- or laboratory-based engineering courses and more general engineering ''coursework,'' which seems to suggest that traditional engineering coursework (i.e., coursework that is not guided-inquiry or experiential) does not provide opportunities for ''doing'' engineering (i.e., Affinity-Identity). Eliot and Turns [4] further note that, although a growing number of options enable engineering students to engage in professional activities through doing or interacting (or both), limited opportunities, if any, are made available for undergraduates to engage in processes of sense-making within the formalized engineering curriculum. They suggest that this lack of formalized opportunities for sense-making negatively affects engineering undergraduates' development of professional engineering identities.

3.3 Narrative Identity

Theory also emphasizes strong connections between identity development through sense-making and identity development through narrative (i.e., ''story-telling'') [48]. Weike [50] compared sense-making to moments of reflection, wherein one imposes meaning on situations by framing and reframing events retrospectively to achieve coherence and continuity. These sense-making situations are further likened to ''moments of tension'' in narrative storytelling [52]. Others [51, p. 97] have linked processes of sense-making to ''narrative coherence'' [52, p. 187] – the process of ''telling and retelling, to ourselves and to others, the story about what we are about and what we are (p. 97)'' [52, p. 187]. Bolton [25, p. 205] describes the ease with which we, as humans, use storytelling to make sense of experiences and our place within them:

> ''We are brought up surrounded by stories; they flow through us and ratify us from birth, telling us who we are and where we belong, what is right and what is

Table 1. Four ways to view identity from Gee [47]

Identity dimension	Essence	Process	Power	Source of power
Nature-identity	state	developed from	the forces	of nature
Institution-identity	position	authorized by	authorities	within institutions
Discourse-identity	trait	recognized in	discourse/dialog	of ''rational people''
Affinity-identity	experience	shared in	the practice	of affinity groups

> wrong. . . . We spend our lives storying and re-storying ourselves, and contributing to wider social stories around us: it's as natural to being a person as eating and breathing'' (Charon & Montello, 2002; Doyle & Carter, 2003; Bruner, 2004).

Because sense-making is considered to be a process of self-discovery that leads to acceptance of new interests and abilities in context of existing ideas of who we are and who we are becoming personally and professionally [48], ''. . . some theorists suggest that narratives are identities, that is, people come to know who they are through the stories they tell about specific struggles at specific points in time (Lieblich et al., 1998; McAdams, 1993)'' [53, p. 89]. It is not surprising, then, that narrative approaches are often employed to examine identity and identity formation processes [e.g., 53–57].

4. Study Design

This qualitative inquiry explored processes of identity recognition and re/construction among undergraduates in the context of a 2nd year engineering science course. Qualitative inquiry is an established approach to education research that has been used to study engineering identity [1, 2]. Qualitative inquiry can be recognized by several defining characteristics including situated, naturalistic research settings; use of multiple types and sources of textual and/or image-based data; employment of a complex mix of inductive and deductive reasoning; emergent, evolving research designs; and holistic, reflexive accountings of complex, multi-faceted issues or problems [58–60]. Qualitative inquiry has been called ''open and supple'' based upon its acceptance of varied theoretical perspectives, frameworks, methodologies, and methods [61, p. 25].

4.1 Narrative Approaches to Research

Despite engineering's post/positivist roots, there is growing interest in – and acceptance of – narrative approaches to qualitative research in the field of engineering education [e.g., 62, 63-73]; approaches informed by ''narrative analysis'' [37] have been highlighted as emerging qualitative research methodologies of note [74, 75]. Narrative qualitative inquiry, or simply ''narrative inquiry,'' is described as ''. . . a subset of qualitative research designs in which stories are used to describe human action'' [37, p. 13]. Chase [76, p. 421] explains how ''narrative inquiry is a particular type – a subtype – of qualitative inquiry . . . [that] revolves around an interest in life experiences as narrated by those who live them.'' While all narrative research employs narrative (i.e., storied) data, there are many approaches to narrative research design, data collection, analysis, and presentation located beneath the larger narrative qualitative inquiry umbrella.

4.2 Theoretical Perspective

The researchers adopted a social-constructivist/interpretivist perspective for this work [77–80]. Social constructivism aligns well with the purpose of this study to understand how undergraduates made sense of their lived realities, in terms of recognizing and re/constructing personal and professional identities based upon their experiences in a 2nd year engineering science course. Embracing this perspective, the researchers openly assumed that that ''reality is socially constructed'' [79, p. 9] and that the participants ''. . . experience the world around them in different ways'' [80, p. 152].

5. Methods

5.1 Setting and Participants

During the spring of 2018, the researchers were members of the instructional team for a 2nd year undergraduate engineering thermodynamics course offered at a mid-size, public university in the western United States. While the course is administered by the Mechanical and Aerospace Engineering (MAE) department and required for all undergraduate mechanical engineering majors, students pursuing majors other than mechanical engineering also enroll in the course. Owing to its technically focused content, the course is designed to fulfill two ABET (2016–2017) Criterion 3 Student Outcomes: (a) an ability to apply knowledge of mathematics, science, and engineering and (e) an ability to identify, formulate, and solve engineering problems [81].

The first author, an assistant professor of engineering education and a registered professional mechanical engineer, had been the instructor of record for the course for five semesters prior to the spring 2018 semester. The second author, a 3rd year mechanical engineering undergraduate who had successfully completed the course two semesters prior, was fulfilling the role of a peer-learning assistant for a second consecutive semester. She was responsible for assisting with classroom instruction and providing weekly help sessions for students outside of class. Together, they met weekly during the semester for purposes of curriculum development; they interacted with students, individually and in groups, daily to provide teaching support.

During the course, students were regularly asked to provide written (metacognitive) reflections about their conceptual learning and skill development as part of weekly problem solving assignments. Over time, the researchers became interested in understanding if and how engineering students might also

be re/constructing personal and professional identities as a result of their engagement in the course. Near the end of the spring 2018 semester, the researchers offered students in the course an opportunity to complete an assignment worth two points of extra credit on their final course exam (i.e., worth 0.7% of their course final grade). The optional assignment asked students to "Reflect on your experiences in this course and write a 1–2 page (single spaced) narrative story about learning thermodynamics this semester." No additional guidance, other than the reflective prompt, was provided. The prompt was purposefully stated using the word "learning" to enable students to interpret the prompt in their own way, for example as a more typical prompt to reflect on their processes of learning (i.e., cognition and metacognition) and performance within the course, or as a prompt to reflect on their broader experiences while learning in the technical engineering course.

A total of 55/140 students submitted personal, written narratives to the course learning management system in response to the opportunity and received the extra credit incentive. Following procedures approved by our university's institutional review board (IRB), the researchers emailed students in the course during the summer semester, after final grades were published, to request their participation in the study (i.e., to include the analysis of their personal narratives and course performance records). Data from the ten students (two female and eight male) who responded and provided written informed consent were included in the analysis.

5.2 Data and Data Analysis

Data consisted of the participants' written narratives and a record of their assessment scores received during the course, including homework scores, exam scores, and final grades. Following an approved IRB protocol, researchers linked and de-identified the data prior to analysis. The researchers jointly analyzed the data using the "analysis of narratives" approach described by Polkinghorne [37]. Scholars use this paradigmatic approach to analysis to ". . . locate common themes or conceptual manifestations among the stories collected" [37, p. 13]. To accomplish the analysis, the researchers read the narratives several times individually, searching for instances of identity performance, narrative tension, and sense-making. During multiple individual reading passes, each researcher made memos in the margins of the narratives, a common practice within qualitative thematic analysis [82]. First, Gee's [47] identity matrix (Table 1) was employed as an a priori framework to help identify and categorize instances of identity performance. The researchers then met to discuss and reach shared understandings about inferences made from the narrative texts. Rereading the data together, the researchers discussed situational tensions and instances of sense-making, taking detailed notes as they went. They shared stories of their own experiences working with students in the course to relate to each other's interpretations and the experiences described in the narratives. To further ensure quality in the analytic process, the first author drafted initial findings and the second author read and revised findings. This process continued until both researchers agreed that the research text reflected a joint interpretation of the narratives.

6. Limitations

Because this study took place at a single, predominantly white institution, the institutional context likely affected the experiences, identity performance, and sense-making described by the participants. Thus, care should be taken in directly applying these findings within other institutional contexts. While the timing of the research activity enabled students to reflect on their course experience holistically, it may also have worked to limit the number of study participants, especially the number of lower performing students, in the study. Because participants may have considered that the instructor would read their stories, participants may have written their narratives with the instructor in mind (i.e., to please or gain favor with the instructor). Despite these limitations, the exploratory nature and goals of this study were well aligned with both the institutional and classroom contexts.

7. Findings

Findings from this study are presented in the following order: findings related to (1) participant performance measures in the course, (2) participants' recognition of multiple, simultaneous identities as represented within their narratives (RQ1), (3) tensions or conflicts regarding existing and emerging identities and roles in the participants' narrative (RQ2), and (4) instances of sense-making to narratively reconstruct personal and/or professional identities within the narratives (RQ3).

7.1 Participants

Each participant was an undergraduate enrolled in the college of engineering and pursuing an engineering bachelor's degree; two participants were female and eight were male. Eight participants were pursing Bachelor's degrees in mechanical engineering;

Table 2. Participant performance scores

Homework score (50)	Exam 1 (100)	Exam 2 (100)	Exam 3 (100)	Final exam (100)	Final grade	
					%	Letter
40.9	75.0	74.0	58.5	50.0	74.0	C
49.5	80.0	78.5	69.0	73.5	83.0	B
42.3	91.0	96.5	86.5	84.5	90.5	A–
50.0	78.0	95.0	100.0	89.0	93.8	A
49.4	68.0	56.5	72.5	77.0	79.6	C+
50.0	98.0	92.5	86.5	91.5	94.5	A
49.1	94.0	78.0	102.0	86.5	92.9	A–
47.3	86.0	52.5	82.0	80.0	83.4	B
49.5	86.0	92.5	97.5	89.0	94.0	A
48.2	92.0	76.5	95.5	91.5	92.3	A–
				Average Score	**87.8**	**B+**

one participant was a civil engineering major and one participant was a general engineering major. Performance scores of the ten participants are described in Table 2. We chose not to report participant sex or disciplinary major data linked to performance data (i.e., in Table 2) or narrative data (i.e., via pseudonyms) in order to protect participant confidentiality. For the same reason, the researchers chose to employ gender-neutral pseudonyms and pronouns when quoting from and describing elements of participants' narratives.

The Spring 2018 class – at 140 students – was one of the largest thermodynamics classes the first author had instructed at this institution. The demographics of the ten participants overrepresented women (20% of participants were women) and mechanical engineering majors (80% of participants were mechanical engineering majors) compared to class demographics. Class demographics included 7.8% women, 66.4% mechanical engineering majors, 18.6% civil engineering majors, 10% general engineering majors, 2% computer science majors, and less than one percent each of biological engineering, electrical engineering, public health, and Asian studies majors. Although demographic data related to race and ethnicity were not collected, the demographics of participants generally reflected the overall student body enrolled at the university, a predominantly white institution. The average performance score across the ten participants (i.e., 87.8% or B+) overrepresented the average final score of all students completing the course (i.e., 83.6% or B) by 4.1% or 1/3 of a letter grade.

7.2 RQ1: How do Participant Narratives Describe Personal and Professional Identity Recognition?

In response to the first research question, the identities that the participants described within the context of their narrative were classified as personal or professional. Identities that did not reflect a current or potential future career path were coded as personal identities, while those that did describe a current or future career were coded as professional identities. For example, a general identity as a student was coded as a personal identity, while an identity of an engineering student was coded as a professional identity.

As depicted in Fig. 1, participants recognized personal identities such as being a spouse, parent, and student. Parent identities included working parent and being a future parent. Personal student identities included struggling (i.e., under-performing) student and balanced student. Participants recognized professional identities including engineering student, engineer, professor, and non-engineer. Professional engineering student identities

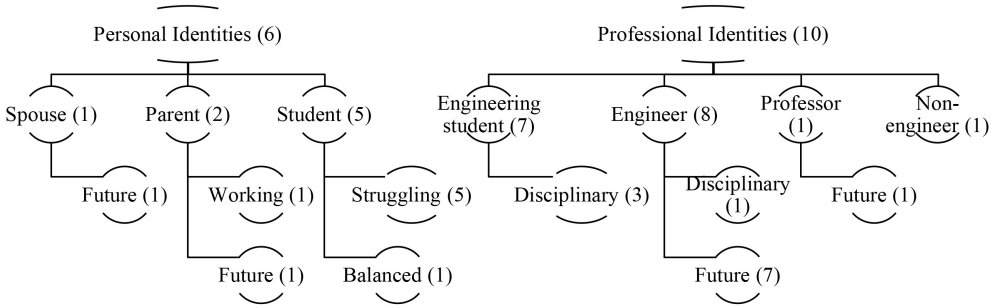

Fig. 1. Personal and professional identities described by participants within their narratives of experience in the thermodynamics course. Parentheses indicate the number of unique participants who recognized a given identity.

included disciplinary engineering student (i.e., mechanical, civil, etc.). Engineer identities included disciplinary engineer (i.e., mechanical, civil) and a future engineer. The professor identity was recognized as being a future professor.

Each instance of a personal and professional identity in the narratives was categorized as one (or more) of the four dimensions of identity (i.e., Nature, Institutional, Discourse, and Affinity) as theorized by Gee [47]. In keeping with Eliot and Turns [4], participant identities related specifically to the thermodynamics course, which was taught using a traditional problem-solving pedagogy, or other courses in the formal engineering curriculum were classified as Institutional-Identities (i.e., constructed by being in an engineering course, major, or college as sanctioned by a university) and not Affinity-Identities (i.e., constructed doing or practicing engineering). Identities related to interactions with and/or the perceptions of others, whether interactions occurred in or out of class, were classified as Discourse-Identities (i.e., constructed through dialog with and among others). Identities related to participants' perceptions of doing/not doing authentic engineering work were classified as Affinity-Identities (i.e., constructed by doing or practicing engineering). Identities related to participants' innate characteristics, tendencies, or interests were classified as Nature-Identities.

Next, each identity dimension was coded with a valence (i.e., "+" or "–") to denote whether that instance seemed to support the participant in becoming an engineer (+) or, instead, seemed to be in conflict with the participant becoming an engineer (–). When it was not clear if an instance supported or conflicted with the participant becoming an engineer, the researchers marked that instance with a (+/–). Frequency counts of each dimension of identity found within the participant narratives are provided in Table 3.

As shown in Table 3, nearly half of all identities recognized by participants were categorized as Institutional identities (44.0%), which suggests that much of the "authorization" [47] participants used to construct (or deconstruct) their engineering-related identities came from the university institution itself. Institutional authorization often came in the form of the types of courses participants were taking as well as their records of performance in those courses. Institutional dimensions of identities appeared to both support and conflict with the participant becoming an engineer equally. Nature (26.0%) and Affinity (24%) identities together, accounted, for another 50% of recognized identities. While Nature identities, such as being a parent, being good at math and science, and not being interested in engineering, appeared as immutable characteristics of the participants themselves, Affinity identities were mostly developed from classroom experiences that were perceived/not perceived to authentically replicate engineering practice. Similar to Institutional identities, Nature and Affinity identities appeared to support or conflict with the participant becoming an engineer equally. Only 6.0% of all recognized identities were categorized as Discourse identities; it is noted that all Discourse identities appeared to be in conflict with the participant becoming an engineer.

Table 3. Identity dimension frequency counts

Identity dimension	# Times appearing in narratives	Dimension count total (%)
Nature (+)	5	13 (26.0%)
Nature (–)	8	
Institutional (+)	13	22 (44.0%)
Institutional (+/–)	1	
Institutional (–)	8	
Discourse (–)	3	3 (6.0%)
Affinity (+)	7	12 (24.0%)
Affinity (–)	5	
	Total: 50	

In the following sections, the recognized identities of three participants, Brighton, Finley, and Indy, are described.

Brighton

Each participant's narrative was analyzed to identify instances of identity recognition. Brighton, for example, described recognition of two personal and two professional identities: struggling student (personal), working parent (personal), engineering student (professional), and future engineer (professional). Brighton wrote:

> "The last topic I wanted to touch on is the increase in my confidence that I can become an engineer. The idea that I can get through a rigorous field of study and graduate as an engineer has often intimidated me and still does a little, but as I am entering the professional-level classes I'm starting to see that I really am doing this. Trying to get through school while having to work and raise a one-year-old used to have me doubting myself at times, but deep down I know that I want this so bad, no matter how hard it gets and how hard I have to work for it. I am learning to keep pushing out the excuses and the people who don't agree with the idea of me being a student right now. With the increase in my confidence that I can have a career in engineering one day, I am also feeling a greater need to understand what I am learning in my classes rather than only trying to get a certain grade because I want to be a great engineer who is good at their job."

In analyzing Brighton's narrative, the researchers noted six narrative representations of identity recognition (Table 4).

Table 4. Brighton's identities

Identity	Narrative Representation	Dimension
Personal: parent		
Working parent	"Trying to get through school while having to work and raise a one-year-old used to have me doubting myself at times. . ."	Nature (–)
Personal: student		
Struggling student	"The idea that I can get through a rigorous field of study and graduate as an engineer has often intimidated me and still does a little. . ."	Nature (–)
	"I am learning to keep pushing out the excuses and the people who don't agree with the idea of me being a student right now."	Discourse (–)
Professional: student		
Engineering student	". . . as I am entering the professional-level [engineering] classes I'm starting to see that I really am doing this."	Institutional (+)
Professional: engineer		
Future engineer	". . . the increase in my confidence that I can become an engineer."; " With the increase in my confidence that I can have a career in engineering one day. . ."	Institutional[1] (+)
	"I want to be a great engineer who is good at their job."	Affinity (+)

[1] Here, Brighton describes their increase in confidence about having a career in engineering based on their progress through the formalized engineering curriculum.

For Brighton, persistent Nature and Discourse identities brought doubt about having adequate abilities, and an appropriate choice of timing, to pursue an engineering degree. Growing Institutional identities of being an engineering student ("I am really doing this") and becoming an engineer ("I can become an engineer") helped Brighton persist and to start to imagine a future self that is a "great engineer" who is "good at their job" (a emerging Affinity identity).

Finley

Finley, like Brighton, recognized a mix of both personal and professional identities in relation to the course. Finley wrote:

> "Ever since I was young I nearly broke everything I touched in order to understand how they worked. I like to justify that trail of dismantled belongings with the notion that each one lead me closer to an interest in engineering – it's important to stay positive. It's just as important to learn from mistakes, that is to say, I find it important to learn from things that don't come easily. Thermodynamics has been one of the subjects which doesn't come as easily to me, but I recognize its significance in keeping me from perpetuating my youthful destructive habits."
>
> "Looking back, I think my roadblocks with Thermodynamics come from my view of it being messy, though I'm not entirely sure why I see it that way. Perhaps it's the fact that energy can cross boundaries meaning boundaries aren't as 'solid' as they appear. Maybe it's due to the principle of increasing Entropy where a seemingly 'still' system is continually shifting towards less 'stillness'. Whatever the reason, it doesn't click right away with me, but I value the way it has forced me to learn view things differently than how I prefer. . . . Thermodynamics is simply a different angle of what I've been learning in other classes, like the thermo-expansion of a beam in Mechanics of Materials. While the math presents itself in different ways I can look at it and say, 'Hey! Increasing specific volume, that's a thing!' Even so, while I haven't mastered the principles of Thermodynamics, I have been able to get a different picture of what my experience in the world of engineering has to offer."

In Finley's narrative, the researchers noted five narrative representations of both personal and professional identities (Table 5).

Finley recognized being naturally inclined toward and having an interest in engineering from early on. Finley's Institutional identity as an engineering student is recognized in the description of participating in engineering subjects and courses, like Thermodynamic and Mechanics of Materials. While Finley's experiences in the thermodynamics course promoted the development an Institutional identity as a struggling student, Finley was also able to appreciate these experiences for broadening the view of their future career field.

Indy

In contrast, Indy's narrative recognized only professional identities (i.e., no personal identities): engineering student, disciplinary (i.e., mechanical) engineering student, and future engineer. Indy wrote:

> "I originally wanted to study Mechanical Engineering because throughout my life math and physics had always come really easy for me. I was also confident that I would enjoy engineering classes much more than English and history classes. While it is still true that I would much rather take an engineering course compared to most other classes on campus, I now have a much different perspective of engineering courses as well as the knowledge and skills which are required for professionals who work in related fields. As an engineering student, I started with math and science classes. I enjoyed these classes but still didn't understand what a class in engineering is like. . . . Thermo-

Table 5. Finley's identities

Identity	Narrative Representation	Dimension
Personal: student		
Struggling student	"Looking back, I think my roadblocks with Thermodynamics come from my view of it being messy, though I'm not entirely sure why I see it that way."	Institutional (–)
	"Thermodynamics has been one of the subjects which doesn't come as easily to me, but I recognize its significance in keeping me from perpetuating my youthful destructive habits."	Nature (–) Institutional (+)
Professional: student		
Engineering student	"Thermodynamics is simply a different angle of what I've been learning in other classes, like the thermo-expansion of a beam in Mechanics of Materials."	Institutional (+)
Professional: engineer		
Future engineer	"Ever since I was young I nearly broke everything I touched in order to understand how they worked. I like to justify that trail of dismantled belongings with the notion that each one lead me closer to an interest in engineering – it's important to stay positive."	Nature (+)
	"Even so, while I haven't mastered the principles of Thermodynamics, I have been able to get a different picture of what my experience in the world of engineering has to offer."	Institutional (+) Affinity (+)

> dynamics in particular has played a significant role in what I feel is developing additional problem-solving skills, which are used by actual engineering professionals. In thermodynamics we often examine real life situations and examples. . . While engineering courses are extremely challenging, I am still just as confident that I want to continue this educational journey in becoming an engineer. I feel that I am beginning to develop the thinking and problem-solving methods necessary to work as a professional in engineering disciplines. I do find it intimidating to think that I am half way through my experience as an undergraduate in engineering, yet only have the surface level understanding of what I feel I would need as a professional."

In Indy's narrative, the researchers noted six narrative representations of professional identity recognition (Table 6).

Indy held strong Nature identities related to being a mechanical engineering student that resulted from early interest and demonstrated abilities in math and physics. Indy's Institutional identity as an engineering student grew stronger from enjoyment of early college math and science courses, and then solidified as they began taking engineering courses. Indy also developed an Affinity identity as a future engineer by considering how they have already implemented problem-solving skills akin to those used by "actual engineering professionals." Indy's Affinity identity, however, was not fully formed; Indy questioned whether college (the Institution) would provide adequate opportunities to share in the practice of engineering in order to ensure adequate levels professionalism in the field.

A summary of the narrative representations of all ten participants' recognized personal and professional identities is provided in Appendix A.

Table 6. Indy's identities

Identity	Narrative Representation	Dimension
Professional: student		
Engineering student	"I was also confident that I would enjoy engineering classes much more than English and history classes"	Nature (+)
	"As an engineering student, I started with math and science classes. I enjoyed these classes but still didn't understand what a class in engineering is like. . . .."	Institutional (+/–)
Disciplinary engineering student	"I originally wanted to study Mechanical Engineering because throughout my life math and physics had always come really easy for me."	Nature (+)
Professional: engineer		
Future engineer	"Thermodynamics in particular has played a significant role in what I feel is developing additional problem-solving skills which are used by actual engineering professionals."; "While engineering courses are extremely challenging, I am still just as confident that I want to continue this educational journey in becoming an engineer. I feel that I am beginning to develop the thinking and problem-solving methods necessary to work as a professional in engineering disciplines."	Institutional (+) Affinity (+)
	"I do find it intimidating to think that I am half way through my experience as an undergraduate in engineering, yet only have the surface level understanding of what I feel I would need as a professional."	Institutional (–) Affinity (–)

7.3 RQ 2: How do Participant Narratives describe Tensions between Co-Existing and Emerging Identities or Roles?

In response to the second research question, the researchers identified conflicts, or narrative tensions, experienced by the participants and related to their existing and/or emerging engineering identities and roles. Tensions described within each narrative are provided on Table 7.

Varied tensions among the participants revealed how each was situated within individual processes of professional identity development.

Addison

Addison, for example experienced personal conflict between his budding professional identity as an engineering student, his personal desire for work balance and socializing, and the practical ramifications of having been identified by the engineering college and university as an underperforming student. Addison wrote:

> "Reflecting . . . is made more profound as I recollect that it very nearly didn't happen. Mere days before I was supposed to report for classes I was informed that my scholarship, which I was entirely dependent on as an out-of-state student, had been cancelled. My GPA for the previous semester . . . had fallen 0.08 points below the required mark. Upon an appeal my scholarship was reinstated, but I was placed on academic probation. . . . I have never been one who could devote myself solely to academics, so finding balance was an experiment in and of itself. Through trial and error I discovered that a level of sociability and activity outside of my schoolwork allowed me to maintain greater positivity and to study with purpose. The boundaries of my life had begun to expand on multiple fronts. Efficiency in my day-to-day life could no longer be an afterthought. In the end, all of these aspects of my struggle have contributed to a level of fulfillment and accomplishment that I can take pride in. Even now I still stand in jeopardy of losing my scholarship for the coming semesters, but I no longer am gripped by the fear of this possibility. The increased study and its resulting confidence brought me to apply for my internship. I am eager to test the knowledge and skill that I have cultivated in Thermodynamics as it will prove most valuable to me in my soon to begin internship that will have me working with the cycles and devices that I have been studying all semester. The future is yet uncertain, but this semester has served to prepare me in ways that I never would have anticipated."

Addison describes a struggle to find and maintain an appropriate balance of work and social interaction in order to protect his health and well-being while performing well enough to keep his much needed scholarship.

Morgan and Nevada

Morgan and Nevada experienced very different tensions than Addison did. Their tensions centered on perceptions that the thermodynamics course was not supporting their interests and emerging identities as practicing engineers. Morgan, for example, noted that there were no internship opportunities that required thermodynamics coursework. Morgan understood that to mean that the study of thermodynamics is not useful for practicing engineers. Morgan wrote:

> "As a student looking for an internship this Summer I've noticed something strange. Most of the positions are looking for someone who knows a 3D CAD program and FEA. Only one of my engineering courses has helped me learn these skills: MAE 1200. I've been starting to wonder how much each individual class helps me prepare to be a real-world engineer. For example, in this class we learned how to analyze devices

Table 7. Narrative tensions related to conflict among existing and/or emerging identities and roles

Pseudonym	Narrative Tensions	Identity Dimensions
Addison	Personal identities as struggling and balanced student Vs. requirements of being an engineering student	Institutional, Nature Vs. Institutional
Brighton	Personal identities as struggling student and parent Vs. requirements of being an engineering student	Nature, Discourse Vs. Institutional
Emerson	None described	–
Finley	Interest and positive practical experience in other engineering courses vs. performance in the thermodynamics course	Nature, Institutional Vs. Institutional
Indy	Requirements of engineering education Vs. emerging identity as future engineer	Institutional Vs. Affinity
Jordan	Personal identities as non-engineer, future spouse, and future parent and interests Vs. requirements/stereotypes of engineering careers	Nature Vs. Discourse
Kassidy	Personal identities as struggling student Vs. requirements of being an engineering student	Nature Vs. Institutional
Landry	None described	–
Morgan	Focus of the thermodynamics course Vs. emerging identity as future practicing engineer	Institutional Vs. Affinity
Nevada	Requirements/focus of the thermodynamics course Vs. identity as a civil engineering student/ future civil engineer	Institutional Vs. Affinity

> and cycles. I haven't seen a single intern position that asks for this skill. I'm having a hard time seeing how my current classes apply to a future job. I like learning and understanding things but I wish I saw more problems that more closely correlates with what I would do after college. These things being considered I think this class has helped me learn new things and understand some things better but because I am having a hard time seeing how it will help directly in a future job it hasn't helped me as much as it could have.''

Nevada experienced conflict between the requirements and focus of the thermodynamics course and deeply held professional identities as a civil-structural engineering student and future civil engineer. Nevada felt that the concepts and skill learned in thermodynamics were irrelevant to their chosen career path and did not support their goals for the future. Nevada wrote:

> ''I entered thermodynamics with a positive attitude, and a willingness to try new things. I did not know what I was getting myself into. As I sat in class and we went over what the class would cover, I realized that very little of the information discussed would pertain to my chosen field as a civil engineer with an emphasis in structural design. The majority of the material in thermodynamics felt very theoretical and conceptual. My brain works better with physical phenomena and observable evidence. In this class I gained a better understanding of the physical world that is not so easily observed. Thermodynamics course work involved critical thinking and problem solving, but I don't believe that I was any better at problem solving when the class ended. I did the homework, and took the tests, but I can't say that I understand these concepts much better than I did before.''
>
> ''I think that I mostly struggled with these concepts because I didn't have much desire, or need, to really understand them. As a civil engineer, I don't think I will spend much time calculating changes in enthalpy or the work produced by a simple system. I question the motives in requiring thermodynamics or electrical engineering for civil engineering students. I understand that people, specifically professionals, should be well-rounded. However, engineering in any specialty requires far more work and schooling than many fields of study for a bachelor's degree. I don't feel that I grew very much while taking thermodynamics. The course seemed repetitive, and did not seem relevant to my chosen career. If it is important to my career, it was never explained to me how I would potentially use it. . . . I found no personal connection or interest in the topics covered over the course of the semester, making it harder for me to succeed.''

In ways similar to Morgan, Nevada took a direct and immediate view (i.e., ''I don't think I will spend much time calculating changes in enthalpy or the work produced by a simple system'') of what the knowledge and skills learned within thermodynamics (or electrical engineering) might have to offer engineers working outside these fields. Nevada critiqued the engineering curriculum not only for requiring students to takes courses outside their chosen discipline (i.e., civil engineering), but also for requiring ''far more work and study'' than other undergraduate majors.

Emersen and Landry

As counterpoints to the eight narratives that described tensions between existing and emerging identities and roles (Table 6), the narratives of Emersen and Landry did not describe any specific conflicts. For Emersen, taking the thermodynamics course seems to have been a positive and, perhaps, eye-opening experience. Emersen wrote:

> ''I once had a teacher draw a small circle and explain that this circle is like the people that think they know everything, while in reality, their knowledge is small, like the area of the circle. He then drew four or five question marks around the circle and said they think they know everything because they have very few questions. He proceeded to draw a significantly bigger circle and related it to the people that are constantly learning and striving to know more. The number of question marks he could fit around this circle was significantly more than were drawn on the previous circle. If there ever was a single class that I felt exemplified this story; it was thermodynamics. I have learned so much but also the question that I had during the class led me to learn more that I had ever planned.''

Similarly, Landry described a positive and nearly conflict-free experience in thermodynamics. Landry noted how the ''things I have learned in Thermodynamics have been, honestly, very interesting'' and, although thermodynamics was their ''hardest class'' during that semester, it had also been their ''favorite because it challenged'' them ''to learn more than . . . in the other classes.''

Last, it is noted that the participants' course performance scores (Table 1) did not appear to correlate to tensions/lack of tensions as revealed within the narratives. In other words, there was no discernible pattern between participants' narrative plotlines and performance scores. For example, in some cases, participants who experienced substantial tensions achieved very high performance scores. In other cases, the reverse was true. Therefore, one cannot directly infer participant performance (Table 1) based on tensions revealed in their narratives (Table 6).

7.4 RQ: 3 How do participant narratives describe sense-making and re/construction of professional identities?

In response to the third research question, the researchers identified several examples of participants engaging in a process of sense-making between emerging professional identities from their existing ideas of self based upon their experiences in the course.

Kassidy

While Kassidy recognized a professional identity of being a mechanical engineering student as soon as college, began, Kassidy later acknowledged they lacked understanding of what that meant and soon began to doubt whether it had been a good choice. Kassidy's narrative depicts a back and forth process of wrestling with doubt and emerging interest to develop a professional engineering identity. Kassidy wrote:

> "Two academic years ago as a freshman I don't think I fully understood what I was getting myself into by setting my major in Mechanical Engineering. That misunderstanding was both good and bad – good because I don't know if I would have had the courage to do it if I had know how hard it would be – and bad because I had no idea how much I was going to enjoy the field. The past few years, and this semester specifically have had a huge influence on my growth both professionally, and in my work ethic and personal development. I feel like this semester has given me experiences on both ends of the spectrum in terms of intense emotions. I've had days this semester where it got tense enough that I seriously considered dropping out of engineering altogether. I've also had days this semester where I've felt really good about being an engineer. Especially in the thermodynamics class, it's been really satisfying to finish a homework assignment, lecture, or exam and realize 'I'm actually going to use that someday!' . . . We learned about specific devices and then used what we learned in problems throughout the rest of the class. I left each class feeling like a 'real engineer.' . . . Overall, I feel like my level of enjoyment has risen quite a bit over the past semester. At the beginning, I was pretty stressed about what everyone told me about how hard it would be and how they barely made it through the class. That concerned my quite a bit. As I mentioned before, I was pretty close to switching out of engineering but I decided to stick with it for another semester and see how bad it really was. After this semester, I've realized just how much I enjoy solving a problem correctly and finding ways to make things run more efficiently. In the end, because of how rigorous the coursework is, being an engineering student (and a professional engineer in the future) is one of the most rewarding things I've experienced in my life."

Kassidy soon developed a personal identity as a struggling student due to the pervading student Discourse about the thermodynamics course. Kassidy contemplated dropping out, then finally decided to take a chance and "stick with it for another semester." Experience in thermodynamics supported increasing personal interest and satisfaction in completing course assignments, as well as a budding Affinity identity as a "real engineer" based upon engagement in problem solving about real mechanical devices in the course.

Jordan

Jordan's narrative describes a process of professional identity sense-making as they weighed long and closely held personal identities, emerging interests, and an expanding vision of professional career opportunities against one another. Jordan wrote:

> "I always thought I would be the type of person that knew exactly what [they] wanted to be when [they] graduated high school. I was going to graduate college in four years . . . and start a family. . . . I entered college not really knowing what I wanted to do. I had loved my sports medicine class I took in high school, but my mom pushed me towards math, and I mean really pushed! My first math class on campus was calculus II. After that semester I never wanted to do math again. So I didn't take a math class the next semester . . . [and] took anatomy classes . . . . I decided . . . I was going to be an athletic trainer and looked into transferring . . . ."
>
> "After shadowing our head AT . . . , I decided I didn't like the atmosphere. Fall semester came and went with more anatomy classes, and I realized that I missed math. My counselor . . . pointed me in the direction of biomechanics, which mixes math and anatomy. It was intriguing. After emailing back and forth with a biomechanic professor, he said there were two routes I could take: mechanics or biology. Then graduate school would mesh them together. Truthfully, I chose mechanical engineering because I had more credits completed on the ME plan than I did on the biology plan."
>
> "I never wanted to be an engineer. Never. I had met some engineers and they were cool people, but I wasn't interested in robotics or airplanes or buildings or bridges . . . but I decided I was going to go for it. I was going to complete arguably the hardest major on campus, and finish my exercise science degree at the same time. . . . I started research with a professor and two Ph.D. students fall of 2017. I wanted to do something that would allow me to integrate the two majors, really apply the material I had been learning. Again, never had I ever considered a career in research. I was still planning on . . . not really using my degrees . . . ever. . . ."
>
> "Skipping ahead, I was beginning to love engineering. The robotics and the math were much more interesting and enjoyable than I had previously thought. Classes were hard, homework was hard and time consuming, but boy, did it feel good when you completed a semester. This semester I really put thought into what I wanted to do with my life. . . . Watching [the thermodynamics instructor] teach has been so cool. [An] . . . engineer who loves what [they do] and has a family! I have realized there is so much more I can do with my life. . . . My education and the research I am doing have become my passions. This is something I want to do for the rest of my life! . . .When I finally become a professor I want to pattern my class off of [this] thermodynamics class. . ."

For Jordan, engineering education became an answer to the question of merging interests in human anatomy and mathematical problem solving into a career without a stereotypical engineering flavor (i.e., ". . . robotics or airplanes or buildings or bridges"). By double majoring (i.e., in mechanical engineering and exercise science) and pursuing experiences as an undergraduate research,

Jordan constructed an emerging professional identity as an aspiring biomechanics professor – a career in which Jordan envisioned not only synthesizing these professional interests, but also remaining true to long-held personal identities. For Jordan, experiences in the thermodynamics course appeared less important for building professional competencies in solving problems like engineers do, and more important for providing insights into a career path that allowed space for Jordan's personal identities and professional interests to co-exist and mutually thrive.

8. Discussion

This study set out to explore if and how undergraduates engaged in identity work as they authored reflective narratives of their experiences in a technical, 2nd year engineering science course. Our findings revealed that all ten participants recognized multiple co-existing and emerging personal and/or professional identities (Tables 4–6; Appendix A) and eight described tensions between these existing and emerging roles (Table 7) in the context of the course. While five participants (e.g., Addison, Brighton, Indy, Jordan, and Kassidy) described personal processes of sense-making between emerging engineering-related roles and identities within their narratives, others did not – in some cases only scratching the surface of the potential tensions and sense-making processes occurring underneath. As Bolton [25, p. 208] reminds us, "In life 'we always begin in the middle' (Lyotard, 1992, p. 116), and 'we are always in the middle' (Chuang Tsu, 1974, p. 136)," we understand that as we write personal stories about discrete events or experiences, we begin with a self-story already in progress. Often, therefore, it can be difficult to clearly discern and delineate complete narrative elements, such as character, plot, and denouement, within a single personal story. It is when these single stories find their place within our larger, "endless" self-story that narrative coherence and sense-making become visible:

> "Life-as-lived lacks the comforting fictive form recognized from infancy, with a beginning, middle and end, clearly defined characters and sense of place. The function of the endless stories we tell and write is to give life a spurious, satisfying, recountable and memorable sense of shape." [25, p. 207]

Given the ample evidence of identity work revealed in our data despite the one-time nature of the narrative writing exercise explored, the results indicate that narrative reflective practice is a promising approach for promoting personal and professional identity sense-making among engineering students in middle years curriculum.

Our findings also point to narrative's ease of implementation within the 2nd year instructional setting, even among engineering students enrolled in and accustomed to the problem solving based assignments of a technically-focused engineering science course. For the most part, the malleability of the participants' emerging professional identities within their narratives was seen. The researchers noticed how the engineering students in the course were generally open to engaging in personal narrative writing, even when provided minimal guidance from the instructor. This result points back to the natural propensity for humans to engage in narrative-style reflection through storied experiences [25]. In fact, our results suggest that sense-making through narrative reflection may be easily accepted, if not welcomed, by engineering undergraduates who are consistently obligated to complete assignments steeped in logical reasoning and scientific understanding.

Our findings further showed that all ten participants recognized multiple co-existing personal and/or professional identities within their narratives (Tables 4–6; Appendix A). The role-based tensions and sense-making that arose within the interplay of personal and professional identities, in the context of a technical engineering course, suggests that even instructors of technical courses influence students developing engineering identities. That approximately one-half (44%) of the instances of identity recognition described in the data were categorized as Institutional Identities points to the substantial effect that institutionally controlled factors (i.e., curriculum, assessment, academic policies that provide access to engineering career paths) may have on students' abilities to see themselves becoming engineers. Therefore, it is considered that institutional factors may be especially influential during the early years of engineering education when other dimensions of identity (i.e., Affinity and Discourse) may not yet be salient for many engineering students. The fact that the Institutional Identities that were recognized in this study seemed to support more than hinder construction of engineering-related identities suggests that Institutional influences on engineering identity development are not inherently or necessarily negative. Our data show that a problem-solving curricula and assessments – especially those that explicitly connect academic tasks and assessment to engineering practice and thus help reinforce engineering Affinity-related identities – can support students' development of engineering identities.

Finally, our data provide interesting insights into the potential effects of disciplinary engineering (i.e., civil engineering, structural engineering) identities on students' perceptions of their academic experi-

ences in engineering programs. On the one hand, our data revealed that having a strong disciplinary engineering identity (i.e., Nevada's identity as a civil-structural engineering student and future civil engineer) appeared to provide students with resilience to withstand experiences (i.e., poor course performance) that might otherwise detract from their sense of becoming engineers. In this way, the existence (i.e., Nature Identity) and/or development (via Institutional, Affinity, Discourse Identities) of a strong disciplinary identity may positively affect engineering student intent to persist. On the other hand, a deep sense of disciplinary identity, especially when coupled with a lack of curiosity or interest in the interrelationships between a preferred discipline and the larger engineering landscape, may work against educator's efforts and industry needs to develop interdisciplinary problem solvers and systems thinkers for the 21st century engineering workforce.

9. Implications

The implication of this work for engineering education is that narrative reflective practice may provide a simple yet effective approach for engaging engineering undergraduates in personal and professional identity sense-making directly within the middle years (i.e., technical) curriculum. While it is commonly held that students develop engineering professional identities through participation in professionally related activities (i.e., projects, laboratories, internships, co-ops, professional clubs, etc.), results from this study indicate that a portion of undergraduates can be engaged in professional identity work, in the context of an early engineering science course, in response to a simple, narrative prompt. More research is needed to understand how to systematically implement narrative reflective practice within the larger undergraduate engineering curriculum (i.e., which courses, how many courses, which years of study, etc.) and to study its effects both longitudinally and among diverse (e.g., racially, ethnically, socio-economically, gender, higher and lower performing, etc.) students.

While more research is needed, this study provides insights related to how narrative reflective practice might be implemented in technical engineering courses. As is done with content based reflections, instructors could ask students to reflect weekly, providing prompts that ask students to consider how the specific engineering science topics (e.g., energy transformation, process efficiency, energy balances, entropy generation) or problem solving practices (e.g., applying units systems, making assumptions, defining systems, solving equations using variables, etc.) they are learning intersect with or support/hinder their professional career interests and goals. It could be a powerful experience, then, to ask students to identify the big ideas in their reflections at the end of the course. Alternatively, instructors of requisite courses could, as a group, ask students to periodically reflect on their coursework experiences (e.g., at the beginning and end of each course), and then ask students reflect on their entire journey thus far at the start of each semester. This approach, which would require collaboration across courses and instructors within a program, would enable students to see their growth as an engineer longitudinally and more holistically. Along with providing opportunities for sense-making, use of narrative reflective practice might also provide important insights for the instructors themselves. For example, as was seen in this study, student reflections may uncover the impact of strong disciplinary (i.e., biological, civil, mechanical, etc.) engineering identities on motivation to learning in a large, required engineering science courses. Student reflections might suggest to the instructor the need to promote interdisciplinary thinking and system expertise among students with varied disciplinary majors and interests.

10. Conclusion

This exploratory, qualitative research study adds to the literature on engineering student identity development and professional formation. Specifically, this research highlights how majority (i.e., white), 2nd year undergraduates perceived and wrestled with existing personal and emerging engineering professional identities in the context of a 2nd year course in thermodynamics. Uncovered using a simple reflective narrative writing prompt, the identity work reported in this study indicates that undergraduates can and often do begin to negotiate their emerging professional identities as early as the 2nd year and within technical course contexts. Therefore, these results suggest that engineering instructors can impact the professional formation of their undergraduate students within the context of the middle years engineering science curriculum.

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Appendix A: Participant personal and professional identities as recognized in the narratives

Identity	Pseudonym	Narrative Representation	Dimension
Personal: parent			
Working parent	Brighton	"Trying to get through school while having to work and raise a one-year-old used to have me doubting myself at times. . ."	Nature (–)
Future parent	Jordan	"I always thought I would be the type of person that knew exactly what she wanted to be when she graduated high school. I was going to graduate college in four years . . . and start a family."	Nature (–)
Personal: student			
Struggling	Addison	"I was placed on academic probation. . ."	Institutional (–)
	Brighton	"The idea that I can get through a rigorous field of study and graduate as an engineer has often intimidated me and still does a little. . ."	Nature (–)
		"I am learning to keep pushing out the excuses and the people who don't agree with the idea of me being a student right now."	Discourse (–)
	Ethan	"At the start of the semester learning about closed systems I felt like I was goanna [sic] be lost the entire time. . ."	Nature (–) Institutional (–)
	Finley	"Looking back, I think my roadblocks with Thermodynamics come from my view of it being messy, though I'm not entirely sure why I see it that way"	Institutional (–)
	Finley	"Thermodynamics has been one of the subjects which doesn't come as easily to me, but I recognize its significance in keeping me from perpetuating my youthful destructive habits."	Nature (–) Institutional (+)
	Karl	"At the beginning, I was pretty stressed about what everyone told me about how hard it would be and how they barely made it through the class. That concerned my quite a bit. . . . I was pretty close to switching out of engineering but I decided to stick with it for another semester and see how bad it really was."	Discourse (–)
Balanced	Addison	"I have never been one who could devote myself solely to academics"; ". . . finding balance was an experiment in and of itself. Through trial and error I discovered that a level of sociability and activity outside of my schoolwork allowed me to maintain greater positivity and to study with purpose."	Nature (–)
Professional: engineering student			
	Addison	"The increased study and its resulting confidence brought me to apply for my [engineering] internship. I am eager to test the knowledge and skill that I have cultivated in Thermodynamics as it will prove most valuable to me in my soon to begin internship that will have me working with the cycles and devices that I have been studying all semester."	Institutional (+)
	Brighton	". . .as I am entering the professional-level [engineering] classes I'm starting to see that I really am doing this."	Institutional (+)
	Ethan	"After I got a grasp of the tables in the book and knew which laws and properties to apply when and where I felt a lot more confident in doing the homework, following along in class, and taking tests. I started to look at different things in life as a thermodynamic system and just think of how the things I have learned in class apply to almost everything that happens in life."	Institutional (+)
	Finley	"Thermodynamics is simply a different angle of what I've been learning in other classes, like the thermo-expansion of a beam in Mechanics of Materials."	Institutional (+)

	Karl	"In the end, because of how rigorous the coursework is, being an engineering student (and a professional engineer in the future) is one of the most rewarding things I've experienced in my life."	Institutional (+)
	Ike	"I was also confident that I would enjoy engineering classes much more than English and history classes"	Nature (+)
	Ike	"As an engineering student, I started with math and science classes. I enjoyed these classes but still didn't understand what a class in engineering is like. . . ."	Institutional (+/–)
	Lance	"I feel like the things I have learned in Thermodynamics have been, honestly, very interesting. It has probably been my hardest class this semester, but also probably my favorite since it has challenged me and helped me to learn more than I have in the other classes."	Nature (+)
Disciplinary engineering student	Ike	"I originally wanted to study Mechanical Engineering because throughout my life math and physics had always come really easy for me."	Nature (+)
	Karl	". . . as a freshman I don't think I fully understood what I was getting myself into by setting my major in Mechanical Engineering."	Institutional (–)
	Nate	"I realized that very little of the information discussed would pertain to my chosen field as a civil engineer with an emphasis in structural design."	Institutional (–)
Professional: non-engineer			
	Jordan	"I never wanted to be an engineer. Never. I had met some engineers and they were cool people, but I wasn't interested in robotics or airplanes or buildings or bridges. . . ."	Nature (–) Discourse (–)
Professional: engineer			
Future engineer	Brighton	". . . the increase in my confidence that I can become an engineer."; "With the increase in my confidence that I can have a career in engineering one day . . ."	Institutional (+)
	Brighton	"I want to be a great engineer who is good at their job."	Affinity (+)
	Finley	"Ever since I was young I nearly broke everything I touched in order to understand how they worked. I like to justify that trail of dismantled belongings with the notion that each one lead me closer to an interest in engineering – it's important to stay positive."	Nature (+)
	Finley	"Even so, while I haven't mastered the principles of Thermodynamics, I have been able to get a different picture of what my experience in the world of engineering has to offer."	Institutional (+) Affinity (+)
	Ike	"Thermodynamics in particular has played a significant role in what I feel is developing additional problem-solving skills which are used by actual engineering professionals."; "While engineering courses are extremely challenging, I am still just as confident that I want to continue this educational journey in becoming an engineer. I feel that I am beginning to develop the thinking and problem-solving methods necessary to work as a professional in engineering disciplines."	Institutional (+) Affinity (+)
	Ike	"I do find it intimidating to think that I am half way through my experience as an undergraduate in engineering, yet only have the surface level understanding of what I feel I would need as a professional."	Institutional (–) Affinity (–)
	Kassidy	" After this semester, I've realized just how much I enjoy solving a problem correctly and finding ways to make things run more efficiently."	Nature (+)
	Karl	"Especially in the thermodynamics class, it's been really satisfying to finish a homework assignment, lecture, or exam and realize "I'm actually going to use that someday!" This has actually been my favorite MAE class that I've taken . . .because of how we learned about specific devices and then used what we learned in problems throughout the rest of the class. I left each class feeling like a 'real engineer'."	Institutional (+) Affinity (+)
	Lance	"I feel like I have learned a lot about being an engineer over the course of this past semester. I have been taking quite a few heavier engineering classes and they have helped me to learn more about what I might be doing as an engineer in the future, and quite a bit about various processes and things going on in the world around me that I have never thought about before."	Institutional (+) Affinity (+)
	Lance	"I feel that this class is very good for developing skills we will use as engineers, even if some of us won't ever use thermodynamics very much in our future jobs."	Institutional (+) Affinity (–)
	Max	"After taking this class I feel like I've learned things that will help me in the future as an engineer. One of the things that I felt helped me is learning how to use tables. I've had previous classes where the professor had said something like, "This is given but in the real world you just look this up." The tables themselves I think are intuitive but learning interpolation, how to find the correct value for your specific conditions, I think will help me in the future. . . . Also, from this class, I learned about common devices and cycles. These show up often in the real world and having a knowledge of them can only help."	Institutional (+) Affinity (+)

Disciplinary engineer	Max	"As a student looking for an internship this Summer I've noticed something strange. Most of the positions are looking for someone who knows a 3D CAD program and FEA. Only one of my engineering courses has helped me learn these skills: MAE 1200. I've been starting to wonder how much each individual class helps me prepare to be a real-world engineer. For example, in this class we learned how to analyze devices and cycles. I haven't seen a single intern position that asks for this skill. I'm having a hard time seeing how my current classes apply to a future job. I like learning and understanding things but I wish I saw more problems that more closely correlates with what I would do after college."	Affinity (–)
	Nate	"I think that I mostly struggled with these concepts because I didn't have much desire, or need, to really understand them. As a civil engineer, I don't think I will spend much time calculating changes in enthalpy or the work produced by a simple systems."	Nature (–) Affinity (–)
	Nate	"I question the motives in requiring thermodynamics or electrical engineering for civil engineering students. I understand that people, specifically professionals, should be well rounded. However, engineering in any specialty requires far more work and schooling than many fields of study for a bachelor's degree."	Institutional (–)
	Nate	"The course seemed repetitive, and did not seem relevant to my chosen career. If it is important to my career, it was never explained to me how I would potentially use it"	Institutional (–) Affinity (–)
Professional: professor			
	Jordan	"My education and the research I am doing have become my passions. This is something I want to do for the rest of my life! When I finally become a professor. . ."	Affinity (+)

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