

Engineering Moment as a Pedagogical Approach: Using Narrative Theory to Promote Student Awareness of their Engineering Identities

Abstract: *This essay approaches narrative theory broadly and explores the structural elements within which individual and collective stories operate. Using Mikhail Bakhtin's concept of the chronotope (an enmeshment of time and space), it examines the implications of contemporary discursive time-space constructions of engineering and engineering education. It proposes a chronotope, Engineering Moment, as a way to denaturalize and engage underlying assumptions about the future of engineering. By positioning the engineering student within this chronotope, it suggests a complementary pedagogical approach. An extra-curricular example demonstrates that engineering students can be empowered to control their perspectives of time, resulting in increased agency and a clearer understanding of their engineering identities.*

Introduction

Stories help us make sense of who we are, individually and collectively [1]. Narrative theory can help us make sense of these stories, and we can examine structures we take for granted, such as time, space, and identity.

Positionality

Various elements of my identity and my professional situatedness influence my approach to this essay and my relationship to my students. I am a straight, white, cis-gendered female in my 50s. I teach an upper-division general education writing course to engineering students at a large west coast research university; I am full-time teaching faculty. The course is grounded in workshop pedagogy, and I have one-on-one conferences with my students throughout the semester. My PhD is in English, and I have an extensive background in narrative theory, identity studies, and rhetoric.

Teaching Observations Prompting this Inquiry

Given my positionality and the nature of my class, some students confide in me when they feel overwhelmed with their school work: beyond the dynamics of “academic momism” [2], the format of my class may provide more personal contact and allow for more flexibility than courses in their major. During Covid, the Pass/No Pass option encouraged students to perform a time-effort calculus when deciding which classes to take for a letter grade and the degree of effort to put into Pass/No Pass classes: students would discuss this with me frankly. Some students began to operate in “triage time” strategically expending less effort for some assignments or a particular class (typically a class taken P/NP and/or a non-major class) so more effort could be applied to other classes. Triage time assumes one is working with limited resources and time and cannot do everything well--while disheartening to me as an educator, engineering students excel in optimization, so I understood their motivation in adopting this essentially limiting mindset. However, I became concerned that a potential by-product of triage time could be the contraction of their perspective of time in the context of their education, the engineering profession, and their identities.

Research Questions and the Value of Narrative Theory

Narrative analysis, as the interpretation of stories, has proven useful in a number of ways for engineering education. For instance, it has been used to address students' positionality and help them imagine other perspectives [3]. Also, in terms of perspective, it can clarify the difference between a student's first-person account and a researcher's analysis [4]. It can help voice and support narrative agency for marginalized students [5], [6], and it can be used to increase student recruitment and retention [7]. From a broader lens, examining the patterns of stories told within engineering education can reveal and potentially change organizational patterns and educational practices [8], [9].

The examples noted above analyze perspective, voice, and action to explore the construction of engineering identity; here, I turn attention to the under-examined role of time perception in engineering education. Bakhtin's concept of the chronotope (an enmeshment of time and space) [10] is used to denaturalize our understanding of time, so we can identify students' mental models of time; then, potentially, we can help students enlarge their relationship to time and empower them with a greater sense of agency and purpose as they form their emerging engineering identities. To this end, this paper seeks to answer the following questions:

Research Question 1: What role does the concept of time have in the institutional representation of engineering as a profession?

Research Question 1A: How does the institutional representation of time in engineering compare to students' experiences of time in engineering?

Research Question 2: Can a minor intervention empower engineering students with a sense of agency in respect to time and their professional identities?

Research Question 1 will be investigated using published texts from the NAE about the future of engineering as a profession and the role engineering education. Research Questions 1A and 2 will be investigated through an IRB-approved study that included a student survey, providing both quantitative and qualitative data.¹

Background

Discourse about engineering and engineering education does not occur in a vacuum. Conceptions of the future of engineering put forth by NAE, for example, are in alignment with a broader consensus about the exponential rate of technological innovation and the generally accelerating rate of change of many aspects of society. The language used by the NAE to describe the future of engineering is no more dramatic than that used by the World Economic Forum to describe the fourth Industrial Revolution: "We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before" [11]. This section will explain the concept of the chronotope; then, it will

¹ I am grateful to the three anonymous reviewers of an earlier version of this paper who suggested I support my theoretical premise with data.

use this concept to explore the NAE's presentation of engineering's future, focusing on the representation of time.

Chronotopes

The concept of the chronotope ("time-space") was coined by Russian philosopher and literary critic Mikhail Bakhtin in the 1930s [10]. As presented by Bakhtin, the concept of the chronotope refers to the "intrinsic connectedness of temporal and spatial relationships that are artistically expressed in literature....Time, as it were, thickens, takes on flesh, becomes artistically visible; likewise, space becomes charged and responsive to the movements of time, plot and history." [10]. The chronotope, then, is connected to the human and the social, and it positions time not as a universal dimension but as a contextualized element. A simple example of a real world chronotope is a basketball game. During the game, space and time have a special relationship: for instance, referees routinely "stop time" with their calls and only then can coaches and bench players step onto the court with active players; also, when the game clock is ticking the amount of time players can spend in certain parts of the court (such as the key and the backcourt) is limited. A basketball game wouldn't exist without this enmeshment of time and space, so it can be considered a chronotope. The suggestive nature of chronotopes lend them analytical power in many fields. Bakhtin's chronotope of the road, for instance, brings up over 10,000 results of academic work on Google Scholar, ranging from anthropology to zoology. Chronotopes can be used to bring ideological underpinnings to the fore: competing chronotopes can position the same "real world" from conflicting interpretive frameworks, shaping what is considered knowledge and how that knowledge is presented argumentatively [12]. Attentiveness to narrative theory in general and to chronotopes in particular can help denaturalize ideological assumptions by making us aware of alternative perspectives on time and space.

Engineering Moment as Chronotope

As a trope, "engineering moment" combines the concept of a force multiplier ("moment" in the engineering sense of the word) with an awareness of our particular, contextualized point in time ("moment" in the common sense of the word). The concept of Engineering Moment is best understood through a metonymic illustration. Consider a student using a wrench to turn a bolt. In terms of the scientific meaning of "moment" as a force multiplier, the student would be the actor about to apply force to the wrench to turn the bolt, and the wrench would be engineering knowledge. Combining this "moment" with the common meaning of "moment" as a situated point in time, contextual questions arise: Why is the actor turning the bolt? Is the actor tightening or loosening the bolt? What does the bolt represent—a problem, a solution, or more broadly an altered state? And so on. The physicality of this metonymic image is helpful [13], [14], but, of course, the concept of a tool as force-multiplier extends beyond the wrench.

To expand this trope as a chronotope, its time-space enmeshment must to be considered. The Engineering Moment chronotope exists in the time of the anticipated future. Just as Steven A. Goldman contends that "technology is intrinsically action directed" [15], the notion of a lever's moment force has an embedded assumption of someone using the lever to affect a future change. The lever's purpose of existence is potential use, the time of the future. While the chronotopic space of Engineering Moment may be metonymically located in the image of a wrench or a

lever, it is much larger conceptually. The space of the Engineering Moment chronotope is the expansive theoretical space of the most archetypal of all levers, the imaginary Archimedean world-lever: “Give me a lever long enough and a fulcrum on which to place it, and I can move the world.” In short, the Engineering Moment chronotope enmeshes future-looking time and expansive space.

NAE Texts

This section will use the Engineering Moment chronotope to examine the representation of time in two pairs of NAE texts. The texts have different audiences and rhetorical purposes. Using the chronotope, we would expect the texts to place time in the future and to represent space expansively. Indeed, the texts all construct the future of engineering in an expansive space; however, while they all position time in the future, their representations of time vary from aspirational to urgent. Using the chronotope of Engineering Moment, then, foregrounds this slippage of time.

Both the NAE’s *Grand Challenges for Engineering* [16] and the Grand Challenge Scholars Program [17] are future-looking and expansive, imagining engineering’s future goals and responsibilities in the new century. Indeed, some consider the Grand Challenges too future-looking and expansive, arguing they focus on future technological advancements at the expense of more mundane, current problems [18]. A key audience for the Grand Challenges booklet would be future engineers, with the goal of inspiring them to embrace these ambitious challenges: the future-time has an aspirational charge. A key audience for the Grand Challenge Scholars Program is engineering educators; the future-time of the Program is aspirational, like the Grand Challenges, proposing “a new education model to prepare engineers to be world changers” and its space is expansive, intending to increase program adoption across different global and institutional ecosystems. With the GC published in 2008 and the GCSP in 2009, these companion texts promote an aspirational future within the chronotope of Engineering Moment.

The Grand Challenge endeavor was preceded by another pairing of reports *The Engineer of 2020* (2004) [19] and *Educating the Engineer of 2020* (2005) [20]. Both endeavors operate within the Engineering Moment chronotope of future time and expansive space. However, the future time of the Engineer of 2020 is more immediate than the Grand Challenge future time, rendering it more urgent; the imaginative space remains expansive, but it proliferates potential futures rather than localized potential implementations. The initial report uses scenario planning (notably, a form of narrative theory [21]), which expands the near future by “open[ing] thinking to include multiple possibilities” [19]. The urgency is unmistakable: “But we must ask if it serves the nation well to permit the engineering profession and engineering education to lag technology and society, especially as technological change occurs at a faster and faster pace. Rather, should the engineering profession anticipate needed advances and prepare for a future where it will provide more benefit to human-kind? Likewise, should engineering education evolve to do the same?” [19]. Future time is accelerating in comparison to the aspirational time of the Grand Challenges’ goals for this century; expansive space becomes localized and operationalized in comparison to the expansive and imaginative space of the Grand Challenges.

Together, these pairings show that the intensity and distance of future time can change within the Engineering Moment chronotope. When directed toward future engineers, such as through the Grand Challenge booklet, the chronotope’s future time is aspirational (as it is when strategizing ways to broaden participation in engineering in *Changing the Conversation* [22] and *Messaging for Engineering* [23]); when directed toward engineering educators, the chronotope’s future time is both aspirational and urgent.

Document	Future Time	Expansive Space	Intended Audience	Rhetorical Purpose
GC booklet	Aspirational	Imaginative	Future Engineers	Inspiration
GCSP	Aspirational	Proliferated Locally	Engineering Educators	Implementation/Change
Engineer of 2020	Urgent	Multiplicity of scenario planning	Engineering Educators, Industry	Understand future engineering needs
Educating the Engineer of 2020	Urgent	Systematically embedded in multiple fields	Engineering Educators	Implementation/Change

Table 1. Charting of time-space constructions and rhetorical purposes of the NAE texts

While this chart may be reductive when considering each work independently, examining the chronotope’s fluctuating intensity of future time and its varied permutations of expansive space reveals a structure for understanding implicit values. All documents share a narrative mission of ensuring the continued success and relevancy of the profession through fostering the capabilities of future engineers to meet unknown challenges: the center of the chronotope is the engineering student as future engineer.

Research Question 1: What role does the concept of time have in the representation of engineering as a profession?

In the NAE documents discussed above, engineering is presented as inherently future-focused. However, when time is farther in the future, the tone is aspirational; as time nears, the tone is urgent. For an audience of engineering educators, time is presented as either aspirational or urgent; for an audience of future engineers, time is presented only as aspirational.

Study Method

IRB approval was received for this mixed methods study. Students were offered two opportunities for extra credit: 1) watch a series of videos of recent alumni discussing their career paths and complete an anonymous survey; or 2) watch a documentary and write a brief analysis. The survey was anonymous and administered online; their instructor would not know which

method they used to receive extra credit. The survey included fourteen 5-point Likert scale questions and three open-ended questions. Thirty students completed the survey. Every respondent completed every question.

Video Series

The goal of this extra-curricular project is to help students imagine their future selves by presenting curated thematic video clips of alumni discussing their professional journeys [24]. The videos clips are two to five minutes each, and they are organized into four categories: 1) You're graduating! Now what?: Leaving the educational nest; 2) Welcome to the working world—and adulthood; 3) Working beyond the cubicle: There is more to work than just tasks and deadlines; and 4) The bigger picture: remembering that you have a life outside of work. The three alumni in the videos graduated four and five years ago, helping students more easily make the connection to imagining their own short-term future selves; it has been shown that the closer the time frame to an imagined future self, the stronger the connection [25], [26]. Research shows that being able to envision a vivid, positive future self can foster a long-term mindset, even at the expense of short-term sacrifices [25]. Potentially, by more effectively imagining their potential professional futures, students can begin to shift their perspective of time.

Participants

The participants were all students in Advanced Communication for Engineering at the University of Southern California in the Spring of 2022. All students identified as engineering majors in the survey. The total pool of invited students included 3 sophomores, 14 juniors, and 23 seniors. The survey was anonymous, so it is unknown which students participated and no demographic information is available.

Results

The results presented below are both quantitative and qualitative.

Students' Experience of Time

Students were asked questions about short-term and long-term thinking.

Q11 - During the semester, I tend to think short-term about my future and focus on my classes and assignments over my professional future.

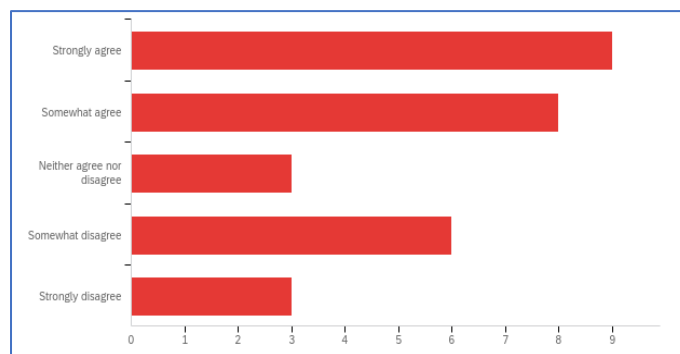


Figure 1. Bar graph visualization of responses to Question 11

The inverse of this question provided general confirmation of the sentiments.

Q12 - During the semester, I tend to think long-term and focus on my professional future over my classes and short-term assignments.

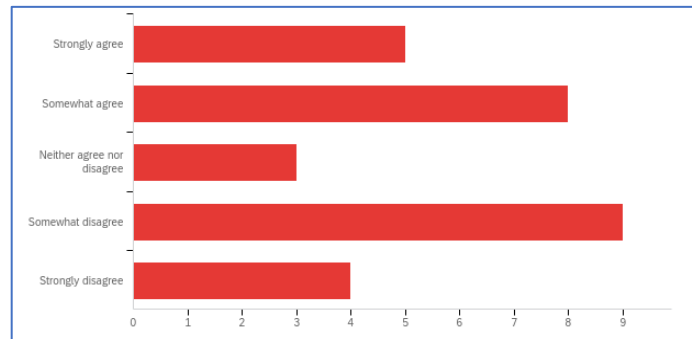


Figure 2. Bar graph visualization of responses to Question 12

The question was rephrased to focus on students' current experience of time, rather than a short- or long-term perspective.

Q13 – With the requirements of school, I typically don't have the time or energy to think about my professional future in a specific way.

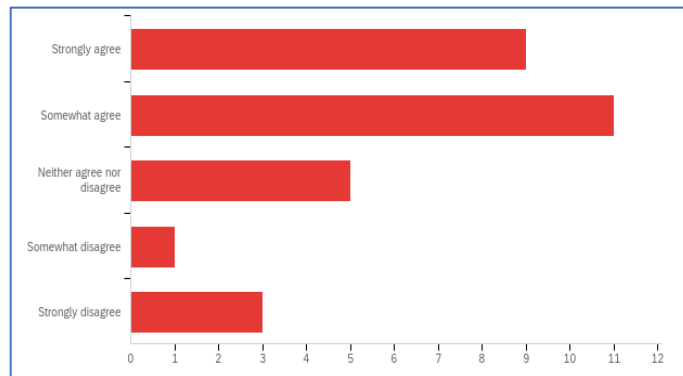


Figure 3. Bar graph visualization of responses to Question 13

General Attitudinal Effects

Students indicated a general awareness of their future selves before watching the videos. In response to the question “During the course of my school work, I think about my future self often,” no student disagreed: 18 strongly agreed, 8 somewhat agreed, 1 neither agreed nor disagreed, and 1 somewhat agreed. However, another question showed a split in the vividness of the students' vision of their future selves, with the mean falling nearest to “neither agree nor disagree” in response to “During the course of my school work, I maintain a clear sense of my future self.”

The following pairs of questions asked students to evaluate any change in their perspective on their future selves after watching the videos. The questions approach the topic from positive and negative perspectives.

Q7 – Before watching the videos, thinking about my future self made me feel confident.

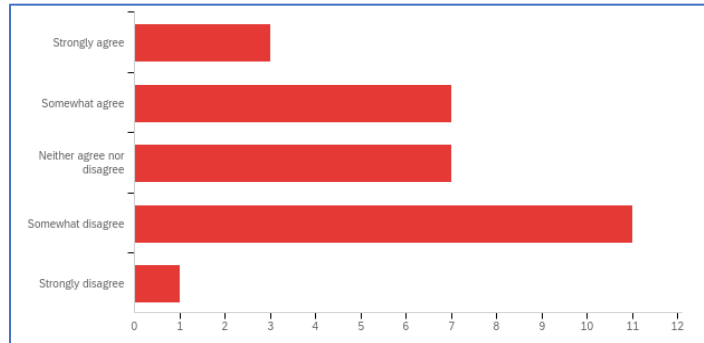


Figure 4. Bar graph visualization of responses to Question 7

Q8 – After watching the videos, thinking about my future self made me feel confident.

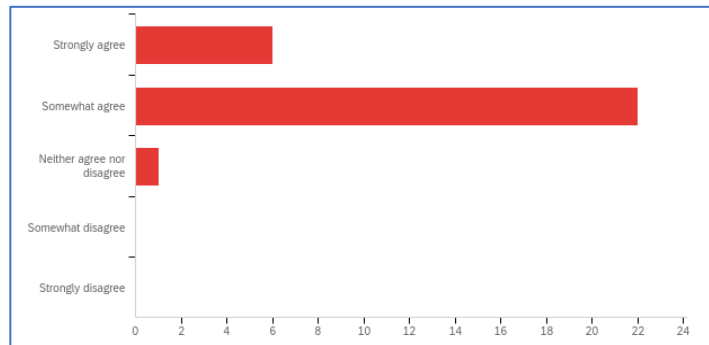


Figure 5. Bar graph visualization of responses to Question 8

Q9 – Before watching the videos, thinking about my future self made me feel stressed.

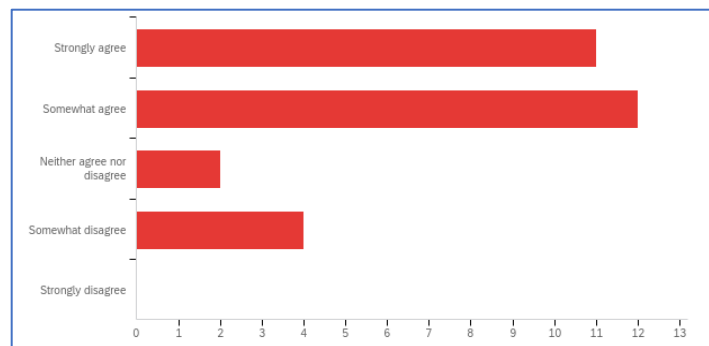


Figure 6. Bar graph visualization of responses to Question 9.

Q10 – After watching the videos, thinking about my future self made me feel stressed.

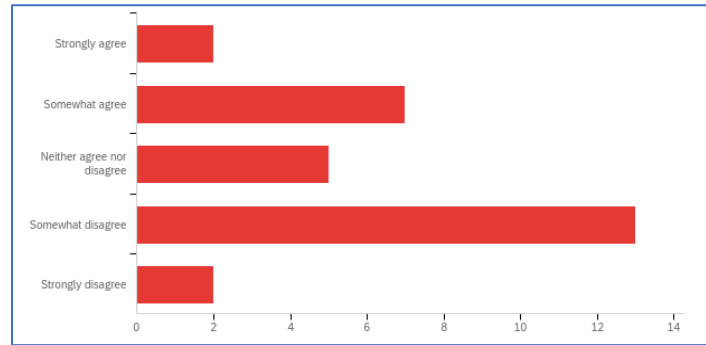


Figure 7. Bar graph visualization of responses to Question 10

Student Comments on the Videos

The survey included an open-ended question about the value of watching the videos: “What did you find most valuable about watching the videos?” Twenty-nine out of thirty responses considered watching the videos a valuable experience, with feedback ranging from appreciative to effusive. (The one outlier noted, “I learned a lot of this by discussing this with my mentors that I found over the years.”) The sentiment most often expressed, noted in 18 of the 29 positive responses, was a sense of “reassurance,” “comfort,” or “relief.” These words do not appear elsewhere on the survey, so students thought of these descriptions without suggestion. The second most common sentiment expressed was a pervasive state of “stress” (a word which appeared twice in the survey, in Questions 9 and 10 discussed above), “pressure,” or “anxiety.” In all cases, this negative sentiment was contextualizing as have been improved through the experience of watching the videos. The remaining responses were more general (such as “they share valuable information” and “they were helpful and offered a relatable perspective”).

Table 2 below presents representative responses of reassurance according to their time perspective. As noted, the majority of students expressed feeling reassured after watching the videos: while reassurance implicitly engages the future (“things will be okay”) this response is positioned as a present state of mind. Some students explicitly imagined their future, in effect taking active agency to shift their perspective of time. The majority of students who considered the future also expressed reassurance.

	Present positioned	Present positioned leading to explicit future focus	Implicit future focus
Reassurance	“The comfort in them. It is really isolating and lonely to feel like you don’t know what you’ll do in the future, like you’re ill	“It gave me security in not knowing what the future holds. There are so many possibilities for me in the future and I sometimes get caught	“It was motivating and validating of the hard work I am putting into my classes right now.”

	equipped to go out into the world despite attending a good university, or like you're working your hardest every day but your future is still intangible. Watching the videos helped remove some of those concerns and made those feelings seem less lonely.”	up in trying to find something, but these videos assured me that I will find a path.”	
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Table 2. Mapping of reassurance to placement in time

The videos helped some students imagine multiple visions of their future, accessing the expansive space connected with the future time of the Engineering Moment chronotope. Representative responses are:

- “Everybody’s path was so different, and there isn’t one correct way to ‘be an engineer.’ ...As an engineer, we aren’t locked into any specific company or industry or lifestyle. It’s comforting to hear that, as someone who has thought about changing my major to a different discipline of engineering more than once.”
- “It helped me realize that the first job out of college isn’t a permanent position and there will be many opportunities that will fit my desired lifestyle and passions for working....It made the field seem more obtainable to me.”
- “I like how it gave a broader view of engineering. As classes get really technical, it can be easy to get stuck in a one-track minded approach to my future, but these videos show you can pivot.”

Discussion

This section will respond to Research Questions 1A and 2 based on the Results section data. Additionally, it will suggest broader implications of the study, and it will consider the Engineering Moment chronotope as a pedagogical approach.

Research Question 1A: How does the institutional representation of engineering time compare to students’ experiences of engineering time?

Institutional representations of time in engineering range from the urgent to the aspirational; students’ self-reported experiences of time are intensified and have a shorter-term focus. 57% of students report they focus on short-term school tasks over their professional future. 87% of students were positive or neutral that they don’t have the time or energy to think about their professional future because of the requirements of school. Students’ repeated comments about feeling reassured after watching the videos of alumni describing their career paths suggests the

stress-based intensity of triage time. When students are first encouraged to pursue engineering as a profession and future identity, the field is presented as expansive and aspirational. Not only do students experience a stressful and limited perspective of time as they shift into triage time, their experience represents a contraction of their perspective and a shrinking of their expectations.

Research Question 2: Can a minor intervention empower engineering students with a sense of agency in respect to time and their professional identities?

Watching the videos took approximately one hour, so it could be considered a minor intervention. The survey data show students reported feeling significantly more confident and less stressed after watching the videos (see Figure 8).

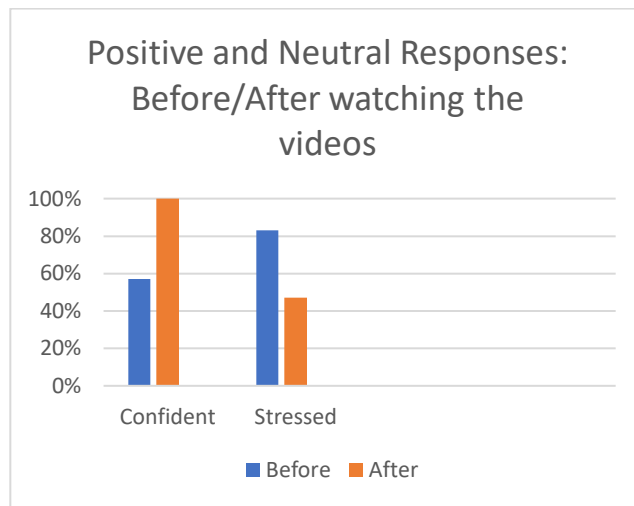


Figure 8. Student reported feelings

It should be noted that even though 100% of the students reported positive or neutral feelings of confidence about their future selves after watching the videos, 47% of them still felt stressed. This suggests they maintained their sense of triage time, but they were able to expand it to also include an aspirational version of future time.

Collectively, the open-ended responses overwhelmingly expressed a feeling of reassurance. In many cases, this sentiment functioned as a cognitive bridge to the future. Additionally, some students expressed being able to envision multiple paths for their future. These two themes—bridging from current stress to future possibility and envisioning multiple future paths—represent an expansion of time perception beyond triage time. Triage time is narrow thinking, a process of ranking and prioritizing; however, it does not need to be an exclusive mental model for time—as observed above with some students simultaneously feeling confident and stressed after watching the videos, students can reconcile a functioning triage time with a motivating aspirational time.

The study's data indicate the minor intervention of watching alumni videos for an hour can empower students with a sense of agency in respect to time and their professional identities, helping them extend their perception of time beyond triage time.

Engineering Moment Chronotope as Pedagogical Approach

At its core, narrative theory considers three elements: time, space, and identity. These same elements are fundamental to engineering education. While Engineering Moment as chronotope demystifies conceptions of time and space within the discursive structure, Engineering Moment as a pedagogical approach focuses on the third element of narrative theory, identity. As Michael Holquist explains: “Quite simply, chronotopes provide the clock and the map we employ to orient our identity in the flux of existence” [27]. As a pedagogical approach, Engineering Moment aims to teach students how to locate their professional identity within the chronotope of future time and expansive space: it fosters an empowered time-space perspective within which students can expand their identity awareness to include both their current student-selves and their future-selves as engineers. As engineering educators, we are charged with preparing students for a future dramatically different from today: we must “predict the roles engineers will play in the future, and to position engineering education in the United States for what lies ahead, rather than waiting for time to pass and then trying to respond” [20]. Certainly, this includes innovative curriculum, but it also includes nurturing students’ ability to access different versions of future time, enlarging their capacity to imagine and prepare for the indeterminate future of the profession. The engineering student as future engineer contains both the present and future.

As shown in Figure 10, aspirational time can contain urgent time and triage time, but triage time cannot accommodate aspirational and urgent times. Just as the NAE texts demonstrated that engineering educators must access both urgent time and aspirational time (and arguably triage time as well), students need to be able to hold multiple versions of time simultaneously and to toggle between them with intentionality and agency. Repeated and consistent exposure to time

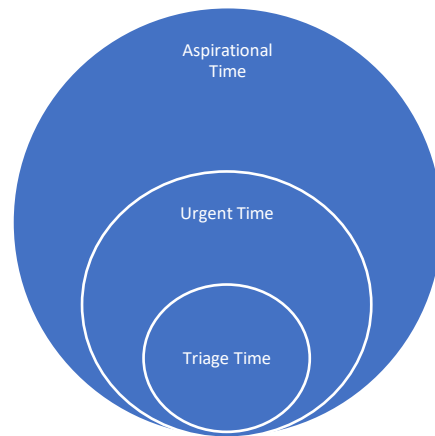


Figure 9. Visual representation of different time perspectives

beyond triage time can foster this ability in students. As educators we can train students to experience urgent time through longer-term experiences, such as capstone projects and internships. In this way, urgent time can serve as a bridge to aspirational time, helping students remember “the why” that led them to engineering in the first place. Additionally, self-reflective programs like the Grand Challenge Scholars Program can help students access the expansive

space and aspirational time of the Engineering Moment chronotope by framing their concrete educational experiences in broader terms. Even minor interventions, such as the one in this study, can have some impact; this study could be adapted, for instance, by having students attend alumni talks or networking events. Because Engineering Moment is an institutionally perpetuated chronotope, engineering educators have the responsibility to help students develop a meta-critical perception of the chronotope's future-time, so they can move beyond the contracted experience of triage time and re-engage with the aspirational time and expansive space that drew them to engineering in the first place.

Implications

Although triage time is a stressful mindset and a narrowed experience of time, it can be a functional and at times necessary strategy. Very likely, students who can't successfully triage their assignments and classes grow overwhelmed with the demands of being an engineering major; however, retention is a topic beyond the scope of this paper. Similarly, the ability to vividly imagine one's future self as an engineer likely connects to retention, which could disproportionately affect underrepresented minorities who don't readily see role models in the field. This, too, is beyond the scope of this paper, but the two examples point to the intertwined nature of time, space, and identity and highlight our duty as educators to empower students with agency and purpose.

In contrast to retention problems of students leaving engineering, Erin Cech contends that many who stay become "disengaged" [28]. Cech analyzed the level of public welfare engagement of engineering majors at four well-regarded but very different institutions, MIT, Smith, Olin, and UMass, and she found that the students' level of public welfare engagement decreased during the time of matriculation at all four schools. Cech suggests, "The uniformity across diverse school contexts in public welfare beliefs suggests that a culture of disengagement may be a profession-wide phenomenon in the broader culture of engineering, rather than being the product of individual organizational climates" [28]. Cech's study demonstrates the difference between place and space: while the schools are distinct places, they all comprise the space of engineering education. As explored in this paper, the Engineering Moment chronotope would suggest that the students' mental time model was one of triage: perhaps the reported disengagement from public welfare was a symptom of the students' time contraction from aspirational to triage.

CONCLUSION

A limitation of this study was its small sample size. Additionally, the video series is a work in progress and it needs more diverse alumni voices. Future work includes increasing diversity of the alumni in the videos and increasing the number of students who take the survey. The survey will continue to be refined.

Bakhtin notes, "Chronotopes are mutually inclusive, they co-exist, they may be interwoven with, replace or oppose one another, contradict one another or find themselves in ever more complex interrelationships" [9]. Examining the chronotopic structures of other representations of engineering and engineering education could complement, contradict, or broaden the chronotope of Engineering Moment: of course, all formulations of engineering are not future-looking and

expansive. For instance, the strategy of using narrative analysis to help students enlarge their identities by adopting other perspectives mentioned in the introduction [1] could be considered a Dialogical Self chronotope: this chronotope constructs and intertwines the space of the triad (I, me, and “thirdness”) [29] with the time of exchange: it has its own underlying assumptions, for instance about spatial interiority, external knowability, and the power dynamics of exchange. Other engineering education pedagogies, such as culturally sustaining pedagogies (CSP) demonstrate the value of reaching across to other cultures instead of forward through time [30]: their space is expansive while their time is simultaneous and potentially nostalgic.

The chronotope’s value is in exposing naturalized structures of a worldview. Just as Archimedes couldn’t physically find a place from which to stand with his imaginary lever, as engineering educators we cannot locate ourselves outside the chronotopes we naturalize.

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