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Efficacy of Humanities-Driven Science, Technology, Engineering, and Mathematics Curriculum on Integrating Empathy into Technology Design

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There have recently been calls to consider the development of student empathy within engineering coursework. We argue that this goal may be reached by infusing more traditional engineering coursework with humanities. Our Humanities-Driven Science, Technology, Engineering, and Mathematics (HDSTEM) curriculum uses a humanities format as a context to discuss science and engineering advancement. The foundation of an HDSTEM curriculum is that it would reassert the importance of humans and human impact in science and engineering, while recognizing the social, political, and cultural catalysts and outcomes of technological innovation. Therefore, we hypothesize that through an HDSTEM curriculum, students will not only develop technically accurate solutions to problems posed in an engineering curriculum but will also question their ideas' impact on society. For this project, we draw on the case of an HDSTEM course, "World War II and Technology," taught at Texas Tech University (TTU) and Rochester Institute of Technology (RIT). Specifically, we will present the analysis of linking specific problem-solving exercises and assignments that embed empathy with the delivery of the courses following an HDSTEM instruction modality. The problem-solving exercises and assignments incorporate the traditional Six Sigma define, measure, analyze, implement, and control (DMAIC) process. In these assignments, students were asked to reverse engineer technical, scientific, and logistical problems seen during the Second World War. In a more straightforward means to elicit empathy, students were assigned an additional empathize step with the DMAIC (EDMAIC) during two of these assignments. The empathize step was generic, asking students to take the perspective of the creators, users, and others affected by the problem and consider the societal needs and constraints of the time. Students completed four of these assignments (2 DMAICs bookending 2 (EDMAICs) throughout the course. Combining HDSTEM instruction modality and empathy problem-solving assignments, preliminary discourse analysis of assignments, which looks deeply at the language students used to create empathetic dispositions/identities within their work, revealed that students integrated empathy into technology design at various levels at both TTU and RIT. These disposition levels in empathy were observed and subjectively quantified using common rubrics. These outcomes result even from delivery at pre- and post-pandemic timeframes and at two institutions (i.e., the course was offered at TTU in the fall of 2019 and at RIT in the fall of 2022). In this consideration, the HDSTEM curriculum and empathy-embedded assignments have shown a cultivation of empathetic disposition among students. Further, based on these differing implementations, we will also present and comment on the experience of implementing the TTU course treatment at a new institution, RIT, to serve as a protocol in the future. These courses will be offered again in the fall of 2023 to offer a comprehensive comparison between first-time (or one-off) in contrast to a sustained delivery of an HDSTEM curriculum.

Introduction

Historically, disciplinary silos have hindered collaboration and integrated education between engineering and the humanities. More and more efforts in recent years have been made to break down these silos. In doing so, the humanities have been shown to enrich engineering education with further development in creative skills, critical thinking, and communication. These non-

technical skills are key for engineers to learn and are needed for an ever-connected and complex world. One such skill that is wholly needed today is empathy. The ability to try and understand another person or group's feelings and experience is key to being empathetic, and engineers must understand that while they are needed for their technical expertise and competency, how they define and solve problems in the context of others is paramount for bettering the world. Understanding that solutions need to be put in the context of humanity, humanities-driven science, technology, engineering, and mathematics (HDSTEM) curriculum has been created at Texas Tech University (TTU) and Rochester Institute of Technology (RIT) in the form of a "World War II and Technology" course. This course introduces science and engineering problem-solving within a history course. Using six sigma continuous improvement methodology (i.e., define, measure, analyze, implement, control) as a problem-solving methodology, students in this course solve technical problems within a historical context and must consider the people involved. With this added context, discourse analysis of the written problem-solving assignments of students shows growth in empathetic dispositions over a semester. This paper will introduce how discourse analysis has been used in practice to develop perspectives and values of writers and how it has been used in the analysis of written work from this course to cultivate empathetic dispositions in problem-solving.

Background

Theory of Discourse. While our methodological approach is discourse analysis, the idea of "discourse" itself requires some orientation. We are immediately challenged by the fact that there is no one definition of a discourse and, subsequently, no one approach to discourse analysis (e.g., [1-5]. For Foucault [6], arguably one of the first theorists to tackle the notion of discourse, it is composed of "practices that systematically form the objects of which they speak" (p. 49). He argues that discourses are imprecise and historically contingent categories within which exist networked "nodes" (p. 23) that are loosely unified under common ways of speaking and thinking and provides examples of various texts belonging to a different discursive tradition. A mathematics textbook, for instance, speaks about, thinks about, and approaches the world differently than, say, a piece of early 20th-century literature, and we recognize the difference because these carry on specific discursive traditions that have come to be associated with these different genres. Discourses are thus ways to organize and claim knowledge—a piece of information belongs to such a discursive tradition based on ways of speaking about and approaching a subject.

Foucault [6] elaborates that "each discursive event has three dimensions or facets: it is a spoken or written language *text*, it is an instance *discourse practice* involving the production and interpretation of text, and it is a piece of *social practice*" (p.136, italics in original). Ultimately, discourse for Foucault is outside the control of any individual. While Foucault is interested in how discourse serves a controlling function in the way that different discourses claim knowledge, Fairclough [7] considers how individuals must produce and interpret texts. According to Foucault, discourses have the power to "form the objects of which they speak," [7] but individuals also determine what makes a discourse when we shift to Fairclough's interpretation of discourse. Certainly, existing generic forms of writing (and speaking) exist, and these are relatively stable. However, over time, individuals can shape those genres by adding different perspectives, slowly shifting conventions and considerations over time. Indeed, the topic of this paper is one example; three decades ago, ways of thinking and speaking about engineering education did not include topics like empathy. In the past decade, however, various

thinkers and pedagogues have allowed this to be included in the conversation. These thinkers did not simply ignore all conventions of engineering education literature when writing on this topic; it was, rather, slowly integrated into an existing conversation on social skills, the role of the arts and humanities, etc., within engineering education. While empathy is still perhaps not a "hot topic" in engineering education, its developing prominence in the conversation [8].

We feel the most useful way to think about discourse is through the way Gee [9] describes small-d discourse and big-D Discourse. Small-d discourse is simply the features of a language, including the way it is spoken or written, whereas big-D Discourse is "the ways in which people enact and recognize socially and historically significant identities or 'kinds of people' through well-integrated combinations of language, actions, interactions, objects, tools, technologies, beliefs, and values" (p. 418). By examining how people use language (little discourse), we can determine how they align themselves with different social groups (big Discourse). For Gee, discourse becomes a kind of tool to fashion a social identity. Like Fairclough's account, it is both language used and social practice, but the focus is less on the interplay of discourse and individual on a macro scale and more on individuals themselves. It shifts from a sociological account to a psychological one [10]. Thus, we see resonance with this theoretical understanding of discourse and our methodological approach, wherein we seek to understand how engineering students use text (in the form of EDMAIC assignments) to position themselves as not simply engineers but empathetic individuals as well.

Empathy. Empathy is an important ability and skill, especially with the continued emphasis on human-centered design and social justice. Simply put, empathy is a person's ability to relate to another's feelings, emotions, decisions, and understandings. The adage "put yourself in their shoes" is a familiar concept for empathy [11]. It is one of the very human skills that help us understand each other, and empathy is essential in an ever-growing diverse society. This is particularly true in the STEM fields, where scientific and engineering discoveries help advance humanity. Empathy, however, is a concept that is not readily emphasized in STEM curriculum and is considered an afterthought by may STEM students, whereas scientific and technical skills are at the forefront of learning [12]. Recent work in engineering, STEM pedagogy, and education seeks to change this perception. Hess, et al. [13] discusses pedagogical approaches in design thinking, service-learning, communication, collaboration, and ethics education where engineering educators can introduce and cultivate the concept and skill of empathy. This empathy learning can happen within engineering but can include other disciplines so that engineers can think like or empathize with non-engineers [13]. Jaycox, et al. [14] explicitly discusses the implementation of this pedagogy for empathy integration within courses for ethical reasoning and engineering design. Alsager Alzayed, et al. [15] discusses empathetic creativity and the institution of empathy within design generation. Huerta, et al. [16] discusses a mindfulness training program for first-year engineering students for the development of intrapersonal and interpersonal competencies. Empathy is included within interpersonal competencies and is something that is argued as a teachable/learnable skill. Surveys and interviews of students who took the training program showed improvement in all competencies and in empathy [16].

Seeing that empathy is both cognitive, relating to gathering and understanding knowledge as it relates to others, and affective, relating to emotional understanding, the concept of empathy as an educational tool or developable skill takes an interdisciplinary approach. For example, Walther, et al. [17] discusses the development of course modules created in collaboration between

engineering and social work that institute empathy as a communication component. Their model of empathy is based on intuitive, emotional understanding and cognitive recognition through "perspective taking," providing engineering students with multiple aspects to analyze contemporary engineering problems. Walther, et al. [18] furthers the link and transdisciplinary work needed between engineering education and social work regarding this model of empathy. The modules have been implemented in Walther, et al. [19] and Walther, et al. [8]. Walther, et al. [19] discusses student responses to the modules and provide further pedagogical suggestions for teaching empathy. Further analysis of student empathy is discussed in Walther, et al. [8]. Student reflections were analyzed using a social phenomenology framework focusing on the intentional acts in how students understand empathy and the "meaning context" for which the relationship between students and their subjects are made. The interdisciplinary or even transdisciplinary approach for developing and analyzing empathy embedded in engineering education provides a link to expand into other analysis techniques, such as discourse analysis.

Others have certainly seen the benefits of discourse to think through empathy in education. Warren [20], for instance, reflects on the ways that adopting different, critical classroom discourses is important for creating and expressing a culturally sensitive and empathetic disposition. Nolan [21] understands teacher discourses and dispositions as almost synonymous, explaining that teachers' dispositions are mediated through the various spaces or "fields" they occupy in their lives, especially related to mathematics education and teacher education broadly. In another study, Frank and Rice [22] explored the ways that examining discourses (e.g., messages) on poverty in the United States allowed students to develop a greater sense of empathy toward those in lower socio-economic groups. A small but consistent pool of literature ties empathy, dispositions and attitudes, and discourse and language together. Further, it is clear from this literature that classroom discourse affects students' and teachers' behaviors and attitudes. Overall, the ability to understand and emotionally feel another's situation can lead to more thoughtful consideration and understanding for solving problems, decision-making, and design. In turn, these abilities to act ethically, think critically, and empathize are essential skills for success in the workplace [23].

Courses and Assignments

Courses. Two courses were carried out where problem-solving assignments were analyzed. These HDSTEM courses were team-taught, pairing an engineering instructor with a history instructor: "HONS 1301: War, Machine, Culture, and Society: History and Engineering in the Second World War" at TTU in the fall of 2019 and "HIST 255: History of World War II" at RIT in the fall of 2022. Both engineering instructors were industrial engineers covering the STEM content. Historians were a specialist in European and Italian history for TTU and a specialist in East Asia history for RIT. Based on these specialties, each course covered the timeframe from the Great War (WWI) to the end of the Second World War (WWII) with differing focuses (i.e., Euro-centric versus East Asia-centric). Within the context of the history of WWII, engineering and scientific principles were discussed and used in problem-solving assignments. These courses were open to all majors and had enrollment of 18 students (5 engineering) for TTU and 27 students (3 engineering) for RIT. Demographically, the 5 engineering students from TTU included 4 males and 1 female, and the 3 engineering students from RIT were all male. All participants would be categorized as Caucasian except for one Hispanic student.

Problem-solving assignments. In total, four problem-solving assignments in both the HDSTEM courses were analyzed. The problem-solving assignments were based on Six Sigma's Define, Measure, Analyze, Implement, and Control (DMAIC) model, with some assignments altered with an additional, Empathize step (i.e., EDMAIC). The DMAIC model is introduced at the start of the semester, and the first problem-solving assignment was to follow the DMAIC model. Following the first assignment, an empathize step asked the students to consider the society, culture, and people involved in their problem before solving with DMAIC. The second and third assignments followed this EDMAIC format. The fourth assignment allowed the students to do either DMAIC or EDMAIC. For TTU, the first assignment covered problems and issues from WWI, and the last assignment covered the end of WWII. For RIT, the first assignment and last assignments were open to any problem from before, during, and after WWII.

War and Empathy. These HDSTEM courses and their assignments introduce the concept of empathy within the context of war. On the surface, this pairing seems paradoxical, but the dichotomy of WWII provides such extremes that empathizing and understanding human behavior and emotion can be done in this context. The very best of what humanity has to offer with advances in life-saving and -improving technologies along with bravery and courage can be seen in this time period. The very worst can also be seen with hate and genocide. In both cases, it is important to understand why events occurred to provide a way to promote the beneficial outputs and find ways to avoid the negative ones. Working within this context provides a means to empathize to help in this understanding. On a grander scale, these HDSTEM courses challenge students to gain this understanding on a conceptual level, and the DMAIC and EDMAIC assignments provide a practical application and analysis with this understanding.

Positionality Statements

John Carrell: I am an early middle age white male from the United States. I hold my degrees and training in manufacturing and industrial engineering. I am a faculty member in the TTU Honors College. The Honors College is an undergraduate serving, small liberal arts style college within a R1 Research University. As an engineer, I value the liberal arts and the humanities. I believe the can provide us with life skills and understanding that can enrich the specific technical skills and competencies of engineering education. I teach the TTU's version of the WWII and Engineering course. I enjoy the blending of the learning process in history and how it can relate to the learning process of engineering. Seeing things from different perspectives in this regard is important to me and is something I convey to the students.

Joshua Cruz: I am an assistant professor at Texas Tech University and the lead methodologist on this project. I have always had a fascination with language, and in addition to education, I carry a graduate degree in English. When posed with the question about how to measure empathy in this project, discourse analysis seemed the best suited approach, as the ways that people express themselves can operate as an inroad into their thinking. I am a bleeding heart and apologist for the arts and humanities, and I would say I have a vested interest in this project, despite coming to it late in its inception. As such, I am first taking special care to consider where empathy *is not* happening in student assignments as I analyze. Second, I have recruited a team of graduate researchers to talk over interpretations with as a means of increasing reliability and keeping my own biases and interests in c heck.

Erika Nuñez: Because discourse analysis is rooted in social and cultural perspective, it was important for me to consider what dispositions I brought to this research as both a graduate

student and an instructor. My experience as a graduate student increased my ability to notice when language was affected by the desire to express competence and reflect a certain identity, two important elements in our study of empathetic disposition. Through my teacher lens, I was able to discern shifts in speech that indicated a change of attitude or perspective at both historical and personal levels. As someone who values human-centered research and empathetic pedagogy, I worked to maintain impartiality in my analysis through reflexivity and collaboration with the other analysts on our team to help ensure my interpretations of the data remained close to the students' intent. I remain excited and hopeful about the future of research at the intersection of engineering and empathetic problem-solving.

Rebekah Fan: As an international doctoral student with an Asian background and a master's degree in applied linguistics, I bring a unique perspective to this research project. I recognize the importance of cultural and linguistic diversity in this study, and I am committed to exploring the ways in which language is used to convey identity, intention, empathy, and understanding. In conducting this research using the discourse analysis method, I strive to stand in the shoes of learners in order to understand their perspectives better and to gain insights into their empathy progress. As a researcher, I am committed to maintaining an open and reflective stance, and to working with colleagues to ensure that multiple perspectives inform my interpretations and analyses. I believe that research in empathy has the power to shape and improve the way we teach and learn, and I am excited about the potential impact of this study.

Nafisha Tabassum: My cultural background as a graduate student in counseling education includes being a South Asian Muslim female, coming from a working-class family, and growing up in a rural area. These experiences and identities impact my research viewpoint and methodology, particularly my focus in relationships between technicality and empathy viewpoints in my field and beyond.

As a student in this profession, I've been taught the value of reflexivity, and I'm devoted to recognizing and correcting my own biases throughout the study process. In conducting a discourse analysis of counseling education literature, I aim to explore the ways in which language constructs and reinforces empathy within STEM based students.My positionality as a counselor education student may influence how I interpret and evaluate the data, and I intend to engage in continuing reflexivity to recognize and correct any potential biases that may occur. I hope to generate a more nuanced and insightful analysis of the discourse in my work moving forward.

Andrew Herbert: I am a late middle-aged white male non-native to the U.S. I have been trained in the scientific method (Biology) with a background in quantitative work (Psychology). I have limited experience with qualitative research, and kept this in mind while interperting the results of our study. I tend not to think about how my identity is affecting my interpretation of data without prompting. As a non-engineer, educator, and social scientist, my biases are that empathy and critical thinking are integral to the development of deep-thinking. Career-focused beginning students are unlikely to take a critical look at the field of they have just entered, and need to see examples of this. I attempted to assist with data analysis and interpretation as the project has been implemented.

Michael Laver: I am a forty-nine year old white, cis-gender male from Indiana, currently living in Rochester, New York. I received my bachelor's degree from Purdue University, West Lafayette in 1996 in both history and psychology, and my Masters and PhD in East Asian

Languages and Civilization from the University of Pennsylvania in 2006. I am currently a professor in the Department of History at the Rochester Institute of Technology and have taught at RIT for 15 years. I value team teaching courses, especially when the two instructors bring vastly different backgrounds and expertise to the course. In this particular project, I am the lead instructor for the College of Liberal Arts, teaching alongside an instructor with an engineering background. My responsibility is to deliver the historical content, lead discussions around the historical content, and grade the research project in the course. I also participate in the engineering content portion of the course, including the DMAIC and EDMAIC methodology used in the course.

Iris Rivero: I am a professor of materials and manufacturing processes with academic training and degrees earned in the U.S. in industrial and manufacturing engineering. My cultural background exposed me, at an early age, to manufacturing since while growing up in Puerto Rico its ecomomy depended heavily on U.S. manufacturing companies that established company branches in the island. Therefore, my academic career emphasizing manufacturing is deeply rooted on my background. In that view, my teaching and research emphasizing manufacturing has always intertwined understanding technology design decisions and the impact of the technology to stakeholders. In this project, I partipate co-teaching a university level first year course in World War II and Technology. In that course I introduce materials of engineering design and facilitiate discussion along with a history professor in the course. Besides introduction to design principles, my role is to incentivize discussion for students to critically think about the decision process they follow to arrive to a final technology design. I am interested in learning from this project *who/what* do the students identify as stakeholders of the technology being proposed and how that affects their decision process.

Methods

Discourse Analysis. For TTU, five students' first and last DMAIC assignments were analyzed with discourse analysis. Similarly, the assignments of three RIT students were analyzed. We largely used Gee [24] discourse analysis toolkit as a way to begin our analysis. If discourse is a tool that individuals can use to fashion and communicate an identity to others, then delving deeply into students' writing can tell us about the empathetic attitudes that they develop—or at least perform—for classroom assignments. Before beginning the analysis proper, Gee suggests breaking data into lines and stanzas resembling poetry. This is not an exact science, but each line should have its own justifiable "micro-topic" and each stanza should have its own general topic. This helps to organize the information and forces researchers to consider the ways that the words in the sentences relate to one another. Though each of the analysts had different arrangements of stanzas and lines, we generally agreed upon the topics of each.

Below, we include a table, description, and examples of the different components of language that we examined within student assignments. Those that end with "tool" are taken from Gee's toolkit, and others we found to be helpful for our specific research questions around empathy:

Tool	Description	Example
Why this way and not that way? tool	Examining why students made specific word choices	A student refers to German submarines as a "pack" that is "hunting" U.S. cargo ships

	within their texts as opposed to other word choices	(described as “prey) is an intentional use of language to make Germans more animalistic.
Deixis tool	Looking for words that change meaning depending on their context	A student states “we needed a way to protect our troops.” Both “we” and “our” are deictic words that bear better understanding of who exactly these words refer to, especially as the student is aligning themselves with a certain faction.
Building significance tool	Examining how language is used to diminish or make certain ideas more important	A student states “while many resources became scarce during the war, rubber was possibly the most difficult to obtain.” In this case, the student foregrounds rubber scarcity by juxtaposing it to other scarce resources
Human centered language	Sentences are written with human subjects vs. non-human subjects	“There needed to be a way to trace bullets” is a way to downplay the human activity associated with shooting and create a sort of objectivity around the topic. Compare to “soldiers needed a way to trace their bullets”
Use of coordinating conjunctions	Looking at the ways and, but, or are present in student writing	These words show where ideas are parallel (and), juxtaposed or negating (but), or exclusive (or). A student suggests: “dropping the atomic bomb won the war, but it was a costly and wager.” The word “but” negates the importance of winning the war of brings into focus the cost of such an action.
Identities building tool	Looking at what the language used might communicate about the student and the way the student identifies	A student, writing about landing planes, uses specific language (e.g. pitch or yaw) to suggest that they might

		understand piloting as a way to build credibility
Specific naming	The student names individuals, groups, or countries	Students might refer generically to "all nations" as experiencing a similar issue during the war, or they might refer to the needs of more specific groups.

As we explored students' written discourse through various tools, we were continuously cognizant of how student language might be used to create empathetic ties to their readers or to the groups they were writing about. We regularly stopped during analysis to further ask "how does this speak to their ability to relate to others emotionally?" In an effort to maintain credibility of our interpretations, two interpreters were assigned, and each met to discuss their interpretations of each students' assignments. Typically, there were no disagreements during these meetings, but individual raters sometimes pointed out relevant interpretations of the data that their partners had missed.

As an additional measure of interrater reliability, interpreters further provided a 1-4 empathy rating based on the AACU Intercultural Knowledge and Competence Value Rubric. We used Pearson's correlations to determine 1) if scores were similar and 2) if empathy ratings differed consistently between reviewers when judging students' first and final assignments. Through discourse analysis, we saw a number of empathetic rhetorical moves in later student assignments that were not present in their initial assignments. We speak in greater depth about these in a forthcoming paper, but we provide some examples here.

Results

TTU Discourse. This group was composed of five students: Paul, Stuart, Kyrie, Chandler, and Gustav. Based on numeric ratings on the empathy rubric and Pearson's correlations, reviewers saw an average of 1 point of empathetic growth for each student on a 4-point scale when comparing their first and last DMAIC.

First, we see the focus shift from strictly technical problems of the war to what we are calling "quality of life" concerns. For instance, both of Paul's "define" entries describe reducing the number of casualties during the war. Whereas his first entry is focused on more efficient gas masks as a way to keep soldiers in the field, his final entry, the atomic bomb, focuses on ending the war to "bring home millions of soldiers" to preserve their lives. Whereas the concern is simply having more soldiers fighting in his initial entry, his final entry is concerned with life for life's sake. Similarly, Chandler writes about trench warfare in his first define entry and plane manufacturing in the final entry. The problem with trench warfare, he states, is that it was impossible for either side to gain an advantage, and it was difficult to "efficiently dispose of advancing troops." There is a kind of coldness to this language, referring to human lives as disposable; in comparison, Chandler considers the reasons for having a strong air force in his final entry as "the increased safety of local populations… as well as millions of others… at the homestead." Both Chandler and Paul refer to "millions" of lives, which is admittedly a quantifying of lives (and thus objectifying), but they apply what might be considered a utilitarian logic to their final entries that is not present in their first. It is also clear that the scope of their

final entries comprises more than simply soldiers' lives and ability to perform effectively, and now focuses on a more general well-being for a population.

Another point that we found was that students were much more likely to position themselves around a certain faction in their final assignments than attempting to remain neutral in their initial assignments. On the AAC&U Value rubric, one of the primary indicators of empathy is perspective taking. Generally, the more perspectives a student is able to juggle and accept as justified, the more empathetic the student is. We see this kind of perspective taking when we compare Stuart's first define entry to his final define entry. In the first entry, which was only 21 words long, he explains how "both sides were facing a lack of information." It should be noted here that he does not specifically name sides, although we might infer that it refers to Axis and Allied powers. In his final define entry, however, he explores the reasons for the deeper motivations of American and Japanese naval units in the Pacific theater, considering the no-surrender culture of the Japanese and the ultimate decision to use the atomic bomb against the Japanese. By indicating no specific perspective in the first assignment, it seems that Stuart is attempting to remain objective. He is not particularly interested in the stories, lives, or motivations behind the topic. In short, there is very little perspective taking. Alternatively, we see Stuart considering various perspectives in the final assignment. Kyrie's define entries are similar, and while her first entry looks at the reasons for the invention of the Maxim machine gun ("[enabling] Europeans to cut each other's throats with greater facticity"), she also considers the culture of the Japanese in her final entry, noting that "they refused to surrender." She also uses the word "we" in her final assignment, aligning herself with U.S. forces. Using a first-person collective pronoun removes the objectivity that nearly every student strove for in their first entry and brings them into the conversation as well. We believe this usage of the first person shows that students are more aware of what would have been at-stake for various companies during WWII, and they are able to better identify with a side. "We" in Kyrie's writing suggests not a singular viewpoint, but a collective worldview. Comparing Gustav's first define to his last define entry, we see a similar concern for various factions' motivations appearing in the latter that did not appear in the former. Gustav's first entry was concerned with tracer bullets. He does consider the soldiers' difficulty fighting day and night, but he does not name any particular side in this entry. Comparatively, in his final entry, he considers why other nations might fear Germany and why Roosevelt would ultimately approve of the Manhattan Project, knowing the potential implications of the approval. In both cases, students put themselves in others' shoes in their final entry whereas they did not in the first.

Even when students at TTU were no longer asked to empathize in their assignments, we see them performing various moves that indicate empathy. In short, over the duration of the course, their coursework began to show them thinking about how different technologies might impact the quality of life, and they began to think more deeply about how, when, and why it might be appropriate to use different technology, especially considering various cultural norms and motivations during the war.

RIT Discourse. This group was composed of three students: Dustin, Dillon, and Dilbert. Based on numeric ratings on the empathy rubric and Pearson's correlations, reviewers saw an average of over 1 point of empathetic growth for each student on a 4-point scale when comparing their first and last DMAIC. While we have a small population to draw from, this shows promise that in both locations, we saw students grow empathetically over the duration of the course. Further,

our discourse analysis provides examples of how precisely students displayed empathy in their coursework.

For instance, Dustin showed many empathetic moves in his final define entry that did not appear in his initial. His first entry focused on the development of aircraft carriers, and the last focused on Axis energy weapons production. Like the define entries from TTU, Dustin at RIT considers the motivations of individuals and the nation more directly in his final entry than in the first. In his first entry, Dustin is concerned with the technical aspects of flying a plane and the length a runway needs to be for landing; on the other hand, Dustin considers reasons the Germans may have been desperate to develop new and terrifying weapons beyond simply winning the war. He considers, for instance, their defeat at Barbarossa and uses the term "allied naval superiority" showing why the Germans may have felt inferior. He also recognizes the Germans fighting a "battle of attrition," and he describes both the manpower and supplies that would have made such a battle. Whereas his first entry primarily focuses on the need of planes, the second focuses more heavily on the needs of a wounded nation and helps paint a picture of a struggling army. Additionally, Dustin seems to consider his audience more carefully. In his initial entry, Dustin occasionally uses technical language to align himself with an engineering and piloting discourse (e.g., "stall speed"), but we see a lack of this kind of technical language in his later entry, making it more accessible to a wider audience.

Dillon wrote about the advent of freeze-drying and allied landing at Normandy for his first and last entries, respectively. Like Dustin, Dillon does not seem to align with any particular side for his first define, using words such as "recipient" when describing the soldiers or emphasizing the "massive advantage" freeze-drying provided to demonstrate that innovators have overcome the difficulties of war, but it is unclear in his first assignment who precisely benefited from these innovations or who gained an advantage. This neutrality distances himself from taking on or exploring different perspectives. This contrasts with his final assignment when he discusses the cruciality of Allied success. Here, Daniel recognizes the perspective of the Allied soldiers and considers the motivational and emotional elements at play during the Normandy invasion, especially with the phrases "given the risk" and "would prove costly to Allies," creating a kind of cost/benefit metaphor for allied soldiers. This language shows the careful consideration one side of the war would have to give to certain options in order to win, whereas he does not provide us with this type of insight in the initial assignment.

Dilbert's first assignment considers night fighting during the war, and his final assignment examines submarines. In the first entry, Dilbert frames the issue of low visibility combat as a deficit of resources and centralizes not having enough light as the problem. As with the other two, there was no focus on any particular side of the war. It is worth acknowledging, however, that in this assignment, Dilbert does consider the fact that Germans discovered the photocell, which later developed night vision technology. In contrast, in his last assignment, he considers the difficulties that Germans faced when submerged as well as the difficulties Allies faced when having to deal with German submaries. Dilbert's ability to look at problems from multiple perspectives in this assignment gives his writing more dimension and an empathetic outlook. In the first entry, Dilbert wrote about the many sides of low visibility combat: the difficulty of fighting in the dark, the possible use of lights, and the eventual development of night vision. In the last entry, Dilbert wrote about the advantages of submarine possession and detailed the countermeasures needed to defend against these weapons. In the first assignment, Dilbert sticks to distant language like "the enemy" or "a nation," but in the final assignment, we see him

explicitly name “German crews” and “the allies” as he explores their perspective. This direct mention of the people operating the technology goes one step beyond “the Germans” he references in his first define assignment (who he references for contextual information only--they discovered photocell long before the events of his assignment). Outside of simply naming them, in the final entry, Dilbert taps into the German crew’s vulnerabilities to Allied forces and the limitations that the submarines placed upon them, such as slow battery power and diesel fuel that required resurfacing for oxygen. This empathetic portrayal positioned the German crew as the “mouse” in “the cat and mouse game” Dilbert references. Phrases like “forced back under [water]” and “forced to remain submerged for longer” in the final entry suggest the lack of control German crews may have felt (as they were forced) and it alludes to a specific and frightening kind of death: drowning. This human need to breathe, along with the element of time and exposure to Allied forces, ultimately creates a much more emotional take on combat than Dilbert’s writing about night vision technology.

Discussion

It is worth noting there were not many differences between the two different contexts (pre-pandemic TTU students in an honors context and post-pandemic RIT students outside the honors context). Further, differences in course focus (e.g., European-centric and East Asia-centric) have not correlated to major changes in discourse. Any differences in discourse may be attributable to the limited number of cases analyzed. Currently, we have not analyzed enough assignments from RIT to determine a statistically significant interrater reliability, but on average, raters agreed that there was a jump of approximately one point based on the empathy rubric in both contexts. We found that in both contexts, students engaged in some similar discursive/rhetorical moves in their final “define” assignments, especially related to considering the deeper motivations of individuals and nations within wartime, siding with certain players in the war, and using more human-centered language. While we recognize that it is still early to make this claim (and we are still in the process of data collection and analysis), the fact that similar moves happened across relatively different contexts and with different instructors suggests that there may be strategies to show empathy that are not contextually bound but are, instead, common across students when they are placed in a situation that calls for empathetic positioning.

More broadly, perhaps the largest takeaway is that engineering students are highly capable of perspective-taking. The difference between the first and final define entries in nearly every case is the fact that they begin to align themselves with different factions in the war, considering the successes, failures, and motivations of these factions. This perspective-taking is nearly absent from the first Define entries.

We recognize that such perspective-taking was required for the EDMAIC assignments; however, the first and final assignments did not require the “E” aspect. It is worth noting that one of the RIT students completed an EDMAIC rather than a DMAIC for the final assignment, explicitly indicating a section where he considered an empathetic approach; however, each student provided some indication of each step they were taking in the assignment, and apart from that one case, none of them explicitly indicated that they were attempting to empathize in the final assignment. Still, we saw empathetic positioning occurring, even when they were asked only to define. We might attribute this to the theory of discourse we used to situate our method. As mentioned earlier, the discourses used in the classroom establish norms for teachers and students: norms for behavior, language, and thinking (we might even call these latter norms

epistemologies). From the perspective of discourse, if students are not discussing issues of empathy or thinking empathetically [25-27], it is because the communities of which they are a part do not normalize this way of speaking or thinking. Quite simply, within the HDSTEM class, this way of thinking *was* normalized, and students responded by adopting the expected discourse.

However, if discourse entails beliefs and values [6, 9], then it is not always conscious. This would explain why students, once a discourse of empathy has been normalized in their coursework, would choose to develop more empathetic leanings or dispositions even in the assignments that do not ask explicitly for empathy; they absorb the idea that that empathy is a value within the HDSTEM course based on the discussions and assignments therein, and their language reflects this fact. On the surface, this simply means that if students are asked to empathize, they will. On a deeper level, if discourse theory holds any weight, HDSTEM effectively developed a more empathetic student. One concern, however, is duration. While they could adopt and perform an empathetic disposition for this course, if they enter into other discourse communities that no longer consider empathy a value, they may re-conform to those discourses, and the empathetic outlook supported in the HDSTEM course will mean little. As such, if we are trying to develop engineers with empathetic dispositions and habits, it is incumbent upon other engineering courses to communicate to students that empathy is valued.

Conclusion and Future Work

While still at a preliminary level of analysis with a limited number of participants, interdisciplinary courses, such as HDSTEM, provide a unique opportunity to analyze engineering learning that extends beyond the specific technical aspects of the profession. In particular, empathy can be analyzed with the added context provided by the humanities in problem-solving. From the initial analysis, these engineering students empathize and take a perspective with the added context of history. And this cannot be attributed to being in a select group (Honors) given the similarity of developmental arcs for the RIT and TTU students. Further, engineering students can empathize when asked to in their problem-solving assignments. Through the course of a semester with the detailed HDSTEM courses and with empathy assignments, students' empathetic dispositions changed and were enriched.

From these basic conclusions, more work is needed in expansion of the analysis and in consideration of HDSTEM treatments. Work is currently underway expanding the discourse analysis to regular engineering courses where similar DMAIC and EDMAIC assignments were instituted. This will provide a key comparison point to the overall effectiveness of the HDSTEM treatment and the added "Empathize" step. Further, the WWII courses at RIT and TTU will be run again to add more participants for analysis. To go along with the detailed discourse analysis here, other means of analysis are being made with surveys and interviews.

While the initial analysis has been established with the HDSTEM WWII courses presented here, expansion into other historical eras or humanities fields can be made. It could be argued that in the study and teaching of history, students are not only introduced to historiography and the way history is written and framed, but they also develop empathy for the people they are studying, as well as the historical circumstances in which they lived. This would provide endless opportunities for HDSTEM courses based on different historical periods and developments. Further, other HDSTEM courses outside of history at TTU do exist and could be analyzed with similar problem-solving assignments. One such course, Science and Science Fiction, concerns the relationship between scientific and engineering discovery with popular culture. This course

provides a context for scientific and engineering problems very similar to the WWII courses. The flexibility of the DMAIC and EDMAIC assignments could be used in the Science and Science Fiction course along with other HDSTEM courses.

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