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Using Humanities as Context for STEM Empathy Development: A Discourse

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Abstract

The need to provide science, technology, engineering, and mathematics (STEM) learners, particularly engineers, with an understanding of humanities is becoming increasingly apparent. Continued globalization through technologies means that what engineers create has an impact on how we communicate within/across societies. Humanities and STEM education are currently siloed, limiting the connection between topics and fields. However, links between the humanities and STEM can deepen students' educational experiences. Exploring the links between STEM and humanities, the Texas Tech University Honors College has developed an interdisciplinary curriculum incorporating the arts and humanities and STEM. Unlike other iterations of this technique, namely STEAM, where arts are included to help promote more creative, innovative problem-solving, this approach uses the humanities as the foundation for STEM learning. We coin this approach Humanities-Driven STEM (HDSTEM). HDSTEM education goes beyond creative thinking and problem-solving, providing soft skills through application of the humanities. Our paper focuses on the development of empathy, one soft skill. Specifically, discourse analysis was used to examine course assignments that ask students to reverse engineer technical dilemmas from World War II. In some instances, students were asked simply to reverse engineer; in others, they were asked to consider broader, contextual, humanitarian concerns during WWII. Results show development in empathetic language, such as emotionally evocative terms, attention to societal aspirations, and human-centric focus over more abstract problem-solution oriented thinking. We believe this illustrates a definite link between empathy development and technical problem-solving.

Introduction

Traditionally, the humanities have played a limited role in STEM education1; yet, there are natural connections between the humanities and STEM, which may be used to deepen students' educational experiences[2, 3]. In the exploration of these links and modes of learning, the Texas Tech University (TTU) Honors College has developed an interdisciplinary curriculum that incorporates both the arts and the humanities and STEM. Unlike other iterations of this technique, namely STEAM, where arts are included to help promote more creative problem-solving and innovative thinking, this approach uses the arts and humanities as the foundation and impetus for STEM learning. This approach has been coined Humanities-Driven STEM (HDSTEM). HDSTEM provides students benefits that go beyond creative thinking and problem-solving and provide additional soft skills through application of the arts and humanities. These soft skills are key in the workplace[4] as they go beyond technical knowledge and application and cover communication, relationship development, and empathy.

Background

Empathy may be one of the most important soft-skills, especially with the continued emphasis on human-centered design and social justice. Empathy has also been considered an afterthought by many engineering students[5]. 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. Surprisingly, one's ability to empathize and think critically are closely linked. Critical thinking, broadly defined, is "the ability to engage in purposeful, self-regulatory judgement"[6]. It has also been conceived as the ways that an individual applies existing knowledge to solve novel problems or reach decisions about certain topics. The nature of STEM requires that students develop strong critical thinking skills [7]. How empathy and emotional intelligence play a role in the development of critical thinking skills has not been well studied [6, 8]. This is especially concerning given that studies suggest strong links between rational judgement and critical thinking [9, 10]. In fact, Paul and Elder [11]suggest that "to reason justifiably through an issue, you [sic] must identify points of view relevant to the issue and enter them empathically" (p. 28). The argument is that with the development of what Paul and Elder [11] call "intellectual empathy," students can move beyond the narrow scope of their own thinking and weigh more possibilities as they consider others' dispositions and beliefs when solving a problem. Lloyd and Busby [12] offer a similar sentiment, suggesting that students often consider problems as having a finite number of solutions. The number of possibilities is expanded, they argue, when students are taught to empathize, asking, "what if?" Empathy is related to critical thinking because it allows students to consider a greater number of approaches to solve a problem.

The humanities have previously been used to aid STEM students as they develop creativity, innovative thinking, and communication skills [13, 14]. Typically, humanities modules are embedded into STEM coursework [15]. Singer et al. [16] examined engineering students and found that interdisciplinary courses resulted in students developing a better understanding of engineering and its social impact than traditional courses [16]. Other examples include that of Stengel [17] and Mikic and Grasso [18]. They examined first-year engineering students at an all-female college. As part of the curriculum, these women designed toys to teach students about technology. Students reported that their understanding of the design process and the relationship between engineers and society were increased as a result of project participation. Many more examples exist that illustrate how humanities may be used with STEM to support students as they explore engineering and scientific principles [19-22].

In summary, empathy and ethical reasoning are often an afterthought for STEM students [5]. Team teaching among humanities and STEM instructors can encourage the development of empathy and soft skills [23] through instructional modeling with team-teaching. The HDSTEM course titled "War, Machine, Culture, and Society: History and Engineering in the Second World War" is co-taught by humanities and STEM faculty, offering students different perspectives throughout the learning process. WWII pushed humans to their extremes, from their most courageous and hopeful to their most destructive and hateful. This backdrop provides an ideal framework in which to examine students as they develop engineering identities and empathy. "War, Machine, Culture, and Society: History and Engineering in the Second World War" provides a specific context for engineering and scientific discovery, which directly links STEM to the humanities. This link is an initial starting point for the development of empathy. Work in development of problem-solving assignments and the explicit requests to empathize with this context can further the development of empathy.

DMAIC and Discourse Analysis

Discourse analysis was used on variations of a problem-solving assignment known as Define, Measure, Analyze, Improve, and Control (DMAIC) assignment in an implemented HDSTEM course titled "War, Machine, Culture, and Society: History and Engineering in the Second World War." The DMAIC assignment has students consider the historical, social, and cultural constraints to reverse engineer technology and systems from WWII. Providing the historical context spurs further thought in the student's problem solving that makes them consider beyond the technical details of discovery and innovation. A modified E-DMAIC assignment, where students are asked first to empathize, furthers this connection. With the empathize step, students must take the perspective of the creators, users, and others affected by the problem they are solving. With this step, they need to determine the societal need, societal constraints/freedoms, and the average life of the people involved.

These DMAIC assignments were analyzed using content analysis, as described by Stemler[24], and discourse analysis, as described by Gee [25]. Content analysis is a method to systematically compress large quantities of material, such as a series of text-based assignments for ease of analysis [24]. Using content analysis, researchers look for key words or phrases within a piece of text and attempt to make various assertions based on the kinds of words (content) that they find. While content analysis involves identifying recurring words within texts, Stemler suggests using what he terms "frequency counts" of concepts that appear across texts rather than word counts: the difference, he states, is that frequency counts allow for the examination of the contexts within which those concepts are expressed. Contet analysis was useful in helping us determine what areas of the assignments we should begin analyzing through discourse analysis. Discourse analysis examines language beyond the level of the sentence [26] to determine attitudes, affects, and identities performed by those who use the language. To begin this content and discourse analysis, we read through each student's DMAIC and E-DMAIC assignments to orient ourselves to the material, making memos specifically when we noticed language or rhetorical moves that seemed to differ between the two. As a group, we reached a consensus on several factors to begin exploring: use of human-centered subjects vs. non-human subjects, use of affective language, the scope of the problem being discussed, what entity the problem affected, and word counts. We argue that each of these categories (except for word counts) helps us to understand how students adopt a humanistic understanding of the problem under consideration. That is, changes in these categories across DMAIC and E-DMAIC assignments become a proxy for changes in attitude and values as they relate to humanity and empathy, reflected in their language use.

From the content analysis, we identified and tracked six concepts: the presence of human subjects within sentences; personal references such as "I think/feel;" reference to affective states (e.g., happy, sad, horror, despair); descriptions of quality of life; who the student's technical problem-solving analysis impacted (ranging from an individual person to all people in the world); references to human desires; and overall word counts. We saw an increase in each of the six concepts from the DMAIC to the E-DMAIC. The E-DMAIC added an extra step to the DMAIC assignment, and thus we would expect word count to increase. However, it increased beyond expectation within the E-DMAIC, and students generally wrote more for each individual step in the E-DMAIC over the DMAIC, suggesting that they have more to say when asked to empathize while problem-solving.

From the Discourse Analysis, empathetic language was seen in all assignments; however, empathetic language was more prevalent in E-DMAIC assignments. We saw students referring to the people involved in the problems they solved with greater frequency in the E-DMAIC, especially when placing people, groups, and societies as the subject of sentences. On a related note, the scope of problems tended to expand in the E-DMAIC. For instance, while the topicsopics within DMAIC assignments tended to be those faced by soldiers (how to cross no man's land; how to shoot more bullets more frequently), problems addressed in the E-DMAIC tended to focus on quality of life (how not only to transport troops by air, but to make commercial air travel a reality; how to allow for greater and more enjoyable leisure time). It is important here to note that students had free choice to select any technical "problem." For instance, they may have addressed the development of movies/film within their DMAIC assignments and machine guns in their E-DMAIC, but this was not the case. This suggests to us that when students are asked explicitly to consider empathizing, they shift their thinking to more global concerns. Another finding was that while emotionally charged language was not common in either assignment, it tended to appear more in the E-DMAIC. References to fear, hatred, happiness, and sadness appear across several students' E-DMAIC assignments, whereas such references are virtually non-existent in the DMAIC.

Summary and Conclusions

The social and technical challenges that confront STEM professionals require them to empathize with numerous stakeholders. Yet, STEM curriculum often fails to teach this important concept [27-29]. Prior research indicates that interdisciplinary and holistic approaches may be more effective than traditional programs in developing empathy [23, 30, 31]. HDSTEM courses provide unique opportunities to link the humanities with STEM disciplines. Formally, "War, Machine, Culture, and Society: History and Engineering in the Second World War" provides a context where scientific and engineering discovery can be discussed in historical and technical details. Within this context, problem-solving methods, like DMAIC, can be used to go beyond technical formulations. HDSTEM alone can lead to more empathetic dispositions. Further, modification with explicit requests to empathize can exacerbate this effect.

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