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Debra T. Bourdeau
Embry-Riddle Aeronautical University, taylo13f@erau.edu

Beverly L. Wood
Embry-Riddle Aeronautical University, woodb14@erau.edu

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Debra T. Bourdeau

WW/English and Humanities, Embry-Riddle Aeronautical University, USA
taylo13f@erau.edu

Beverly L. Wood

Mathematics, Embry-Riddle Aeronautical University, USA
woodb14@erau.edu

Synopsis

Getting students who are planning on technical careers to value their general education courses, particularly in the humanities, is not an easy task. The experiences of two professors from disciplines that cross the so-called divide between STEM and Humanities motivate not only a series of courses blending the two to the advantage of their own students but also a virtual pedagogical community to support efforts taking place elsewhere.

Keywords: *STEM, humanities, cross-disciplinary.*

Introduction

This article explores our quest to discover the best solution for countering the hostility of our STEM-focused students to general education courses. Students often question the need for these classes, particularly their humanities requirements, and are not easily persuaded that the competencies addressed by the courses are transferrable, or otherwise valuable, beyond providing one more step toward their degree. After reading a number of pieces published by industry leaders and scholars alike, it became clear that employers see value in the critical thinking and communication skills provided in the humanities.

Further, they long for graduates who think creatively and empathetically, who express comfort with complexity, and who are not overly indoctrinated into any specific disciplinary-focused mindset.

Ultimately, we developed an idea for a set of courses that would combine the STEM topics that our students have embraced with the humanities subjects that they dread. We termed this course series "Humanistic STEM" and defined it as a path blending the study of science, technology, engineering, and mathematics with interest in, and concern for, human affairs, welfare, values, or culture. Goals for students would include an understanding of the humanities through the lens of the STEM disciplines that would not exist without the human focus on the progress of society in the areas of rhetoric, literature, history, philosophy, art, religion, and ethics.

We are currently developing the initial Humanistic STEM class — an upper-level course called *How Fiction, Film and Popular Culture Represent Science and Mathematics*. We have also received support from our administration in the College of Arts and Sciences for both the creation of an H-STEM minor and the establishment of a Humanistic STEM Center to assemble and house materials for those who are considering a similar approach. This article, then, will discuss how the Humanistic STEM concept was determined to be the most promising solution for bringing prominence to the humanities at our STEM-focused university.

Arguing for a Need for the Humanities

Industry leaders are, with increasing frequency, articulating clear preferences for graduates who have competencies typically found in humanities courses, including strong writing skills, the ability to collaborate, information literacy aptitude that allows students to discern a quality source from "fake news", and the oft-lauded, but rarely-defined, ability to think critically. A spate of recent articles defending the existence of the liberal arts in the academy have countered the influx of pieces that claim to identify the most "useless" or "worthless" majors — stereotypically featuring mainly humanities disciplines such as English, history, and philosophy — guided by metrics such as average salaries of graduates and myopically identified (and ridiculously worded) "related occupations". Industry leaders' voices add gravitas to the debate about the value of the humanities, offering a unique defense of the marketability

of skills that are not overtly technical in nature. In fact, articles justifying the humanities often express concern that students who do not take these courses will lack curiosity and creativity. Additionally, future leaders may not have the ethics background to make moral, empathetic choices.

LinkedIn, the career-focused social media site, published "Why Liberal Arts and the Humanities are as Important as Engineering" [6], penned by Harvard's Vivek Whadhwa who confessed, "Earlier in my academic career, I used to advise students to focus on science and engineering, believing that they were a prerequisite for success in business". He finally realized that these fields were insufficient to encourage the creativity needed for successful entrepreneurs, to develop the empathy needed to provide solutions to social problems and to think critically to solve the unique challenges posed by our increasingly technology dominated world.

Whadhwa [6] cites Steve Jobs's defense of humanities in the 2011 iPad2 unveiling. Jobs notably and eloquently provided a counter to rival Bill Gates's argument that American education should focus primarily on STEM to ready students for a job market focused increasingly on these skills. Jobs passionately stated that it was not technology alone that created the innovative iPad:

> It's in Apple's DNA that technology alone is not enough — it's technology married with liberal arts, married with the humanities, that yields us the result that makes our heart sing and nowhere is that more true than in these post-PC devices. (as cited in [2])

Jobs was able to demonstrate a tangible example of how a blend of humanities and STEM could result in something very real and financially successful.

In *The Chronicle of Higher Education*, Beckie Supiano [5] examined an AAC&U survey of employers who lamented that graduates lack "transferrable skills" such as writing and public speaking. Furthermore, while graduates seem prepared for entry-level positions, they are overly focused on majors that they perceive as marketable. Colleges have responded by placing emphasis on these degrees and the success rates of graduates in these specific fields. Similarly, Northeastern University's Benjamin Schmidt [4] argued that students are "wrong" for turning to fields specifically because they may lead to greater chances for higher incomes. In addition to creating a precipitous

drop in humanities majors, students are being made to feel as they should major in disciplines that provide a greater "return on investment". Not only is the perception that humanities majors earn significantly less based on questionable data, the exclusive focus on STEM fields (and other perceived money makers) has shifted students' understanding of the purpose of higher education.

Clearly, the defense of the humanities goes beyond how graduates can transfer skills into the workplace. In a *Washington Post* piece called "Why We Still Need to Study Humanities in a STEM World" [3], Gerald Greenberg notes that an attack on the humanities is an assault on the meaning and value of a college education itself. The liberal arts, argues Greenburg, offers something completely vital to the very concept of the educated mind: "Only through engaging in the thinking processes practiced in these areas that one can be exposed to various ways of thinking, analyzing, and questioning". Greenburg states that it can be difficult to identify the specific fields encompassed by the humanities. Unlike the sciences, where disciplines are easily classified, the humanities elude specific definition. In spite (or perhaps because) of their elusive nature, wading into the humanities provides students with the ability to deal with complex, ever-shifting and murky issues.

It is through both these practical and philosophical defenses of the need for STEM students to embrace the humanities that we came to understand a need to create an option for our own students to show how seemingly disparate disciplines actually inform, complement, and even rely upon each other. After all, it is impossible to truly understand any public scientific debate without realizing how it is discussed in multiple realms — how it finds its way into the discourse of philosophers, novelists, journalists, as well as practitioners.

Our Students & Ourselves

The aviation and aeronautics students at Embry-Riddle Aeronautical University want black/white answers to direct questions rather than the open-ended responses prevalent in their literature or ethics courses. They rarely even see the value in communicating their mathematical or statistical reasoning as long as their answers are correct. The Worldwide Campus students we see are particularly vocal about their lack of perceived value for the general

education courses that support their degree programs. These students are overwhelmingly older (83% over age 25, mean age of 32), already-employed students seeking a degree to further their existing career or to facilitate a career change. Nearly 60% of our students are US military members (active or separated), and only 11% are female.

More than half of student enrollments are in the College of Arts and Sciences, primarily engaged in the General Education Program. The College of Business and the College of Aeronautics (home to all of our STEM degrees) each have roughly a quarter of enrollments. Looking by declared majors, however, Aeronautics accounts for fully two-thirds of active students and Business nearly 30%, leaving a mere three percent in Arts & Sciences (Communication, Emergency Services and Interdisciplinary Studies degrees). Finding a way to engage that two-thirds of majors, or 60% career-focused military students, in the humanities is what we have set out to do!

A key reason for our interest in this integration of humanities and STEM emerged from casual, personal conversations about film and literature, specifically around the stereotyping of mathematicians and scientists. Dr. Bourdeau is the Department Chair for English, Humanities, and Communication with interests in drama and philosophy. Dr. Wood is Discipline Chair for Mathematics in the Department of Mathematics, Physical & Life Sciences with interests in the history of mathematics and mathematics education. A request for reviewers of a set of plays on historical mathematics came to Dr. Wood through the Mathematical Association of America (MAA) community discussions in the summer of 2017. We agreed to do a partial review collaboratively, feeling as if we both had valuable perspectives to offer.

The First scene of Act 1 is dialogue between Gottfried Leibniz and Christian Huygens dramatizing the real life relationship that taught Leibniz the mathematics necessary for the "invention" of differential calculus (independent from Newton). Dr. Bourdeau was astounded that the object of ridicule in Voltaire's satirical masterpiece Candide was not only a philosopher but also a mathematician; she'd had no idea of Leibniz's other reputation. Dr. Wood was equally astounded to learn about the philosophical disagreement that put Leibniz in the unfavorable opinion of Voltaire; she'd had no idea, either. That experience inspired us to seek ways to give Embry-Riddle students the opportunity to see more than one perspective to get a broader, more complete picture of the STEM subjects they are motivated to study.

As a result, we determined to create a course that would allow us to combine our perspectives and allow students to see how the worlds of the humanities and mathematics inform each other in fiction and film. An important first step was to determine if similar courses existed, specifically classes that could be team-taught and delivered in an asynchronous format.

What (and Where) is Higher Education Doing to Meet the Need?

A known starting point was the Humanistic Mathematics community that makes regular contributions to the History of Mathematics Special Interest Group of MAA (HOM-SIGMAA) and publishes an online, peer-reviewed journal. We made the case to our dean that we both needed to attend the Joint Mathematics Meetings 2018 (JMM) to make in-person connections to educators who may be working toward the sort of integration we envisioned as a response to the concern expressed in the public media and the needs of students like ours. The JMM program offered two sessions sponsored by the Journal of Humanistic Mathematics and four sponsored by the Mathematics and the Arts SIGMAA — we attended nearly every one of the presentations actively looking for like-minded educators.

By the end of the week, we had come to the conclusion that a large number of mathematics courses use art to encourage arts/humanities students to appreciate mathematics but we want to use STEM to encourage STEM students to appreciate the arts and humanities. We were also exposed to uses of history to deepen the understanding of mathematics majors and a variety of special topics courses (often offered as freshman seminars or as short courses in winter or summer) that attempted to provide a dual-discipline course.

Prior to our JMM experience, we made an effort to locate any courses or programs at institutions in the area around the San Diego Convention Center in hopes of finding non-mathematicians to visit and discuss the cross-disciplinary aspect of our idea. This turned out to be a cumbersome task with few results on institutional websites and very time-consuming effort to search course catalogs. We were unsuccessful in meeting the cognitive scientists, media technologists, or history of science professors we did uncover, but it did give us hope that we were not entirely alone in our thinking.

Expanding our quest across the entire nation was a formidable task. Our dean once again provided some funding to hire a graduate student to comb

through websites and catalogs on our behalf. It took some time to hone in on keywords for searching and collect a purposeful sample of institutions for our research assistant to investigate. Two types of institutions were of interest: technical universities (e.g., MIT or Virginia Tech) or those located within driving distance from Daytona Beach, Florida, where we would both be for May graduation ceremonies after meetings at the Embry-Riddle Worldwide headquarters. We were slightly more successful at making some in-person contact at Florida institutions in May, though it was through personal contacts rather than cold calls from our web search results.

Our post-graduation road trip also included a couple of museums with current or recent exhibits that appeared to be crossing the STEM/Humanities divide. The Dalí Museum in St. Petersburg has hosted *Dalí and DaVinci* as well as *Dalí and Disney* in recent years, exhibits that delved into how technology, science and mathematics influenced Dalí's work. Their education director was not in town during our visit but is willing to continue the email conversation started in May. The Museum of Science and Industry in Tampa has a continually updated exhibit *Connectus*, which is advertised as a way to "get hands-on with tomorrow and discover how innovators put STEAM skills to use in real life". We visited both of these places, sparking more discussions on the various sides of Salvadore Dalí and his mathematical/technological art plus the science and technology in society evident through innovation.

After a year of living with our idea, investigating its place in the wider world of academia, and continuing public media attention, we are convinced that a blending of humanities (and, eventually, art) with STEM subjects that matter to our aviation and aerospace students will produce graduates ready for workplaces that value both technical skill and human creativity.[1]

Bringing Humanistic STEM into the Curriculum: HUMN 333

Embry-Riddle's initial Humanistic STEM offering will be an upper-level Humanities course which will allow students to fulfill an important general education requirement in a unique way. HUMN 333: *How Fiction, Film and*

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[1] The STEAM movement, of course, brings together STEM with the arts. Our goal was to introduce a new dimension to the picture that involved not only finding places where the arts fit into STEM curriculum but also compelling students to adopt multiple disciplinary perspectives, to see problems as both mathematicians/scientists and as humanists.

Popular Culture Represent Science and Mathematics is, as its course description states, a class where "Students will explore representations of mathematics and science in literature, film and popular culture. Traditional media (books, drama, film, and television) as well as web-based media (webcomics, YouTube series, and podcasts) will be the venues in which students discuss the portrayal of the lives of scientists and mathematicians as well as scientific theories and mathematics concepts." The course goals indicate that

> This interdisciplinary experience will allow students to integrate ideas and issues from diverse academic disciplines in order to expand their capacity for analysis and critical thinking. They will learn the language and methodologies commonly associated with various disciplines, both to understand their commonalities and also to appreciate their differences. They will learn how one discipline (humanities) perceives, interprets and discusses another (science and mathematics).

The student learning outcomes (SLOs) are as follows:

- Evaluate and write about the accuracy of the scientific/mathematical concepts depicted in works of fiction in various media.
- Engage in integrative learning by making connections across disciplines.
- Demonstrate critical thinking skills in discussions of literary elements.
- Recognize and discuss how science/mathematics and the humanities influence each other in the intellectual environment of their time.
- Demonstrate in writing an understanding of the portrayal of professional ethics in works that represent science and mathematics.

The course will be team developed and team taught, offering students the rare opportunity to be exposed to multiple disciplinary perspectives in the classroom. Additionally, the course will be developed for online delivery, a modality where team teaching is rare.

HUMN 333 students are required to have prerequisites of an English composition course (ENGL 123) and at least three hours of a mathematics (MATH) course. We strongly believe that having this basic knowledge will provide students with the disciplinary "language" that they will need to understand the course material and effectively contribute to classroom discussions.

This course will also strongly support several of our university's seven general education competencies. Following the standards advocated by national education associations such as the Association of American Colleges and Universities as well as the advice of its own Industry Advisory Board, Embry-Riddle has adopted seven general education competencies: collaboration, communication, critical thinking, cultural literacy, information literacy, quantitative reasoning, and scientific literacy. HUMN 333 specifically maps to critical thinking, communication, cultural literacy, and scientific literacy. It is rare to have one course that is so clearly mapped to so many competencies and even more unusual to see this specific array of competencies addressed by a course.

HUMN 333 will be developed for a March 2019 offering in a process where a course designer from the university's Instructional Design and Development (IDD) department works closely with a subject-matter expert from the discipline (in our case, two subject-matter experts — one humanities specialist and a mathematician). Because Embry-Riddle uses templated courses, the importance of strong course development and design principles cannot be overstated. Every future online offering of the class will use the exact same readings, assessments, and rubrics established during this process. The IDD uses a backward design process to ensure that all assignments align with stated module outcomes, that all module outcomes align with course SLOs, and that all SLOs fit within the general education program outcomes and competencies.

The course will compel students to examine how science and mathematics are represented in film. Examples will include clips from *Hidden Figures*, *The Man Who Knew Infinity*, *The Martian*, *Interstellar*, *Gattaca*, and even *Jurassic Park*. Students will also explore such representations in works of fiction including *Frankenstein* as well as texts by Ray Bradbury, Ursula Le Guin, and others. Going beyond these more typical genres, students will discover relevant blogs, such as Dan Koboldt's "Science in Sci-Fi, Fact in Fantasy" series (http://dankoboldt.com/science-in-scifi/, last accessed on January 28, 2019) or Alex Kasman's "Mathematical Fiction" database (http://kasmana.people.cofc.edu/MATHFICT/browse.php, last accessed on January 28, 2019). They will explore YouTube videos and webcomics that provide an insight into mathematics and science through the lens of the humanities.

The Future of Humanistic STEM

The HUMN 333 class will serve as an introduction to the concept of Humanistic STEM, but we are envisioning several more courses in order to create a 15-hour minor. The minor will be touted as a way for students to show employers that they can think beyond the silo of their discipline and that they have engaged in opportunities to practice advanced thinking and writing skills. Currently planned are courses in data visualization, humanities computing, and mathematics in the visual arts. Existing courses in the history of aviation and science/technology in society will round out the offerings.

In addition to course offerings, Embry-Riddle Aeronautical University Worldwide's College of Arts and Sciences supports the creation of a Humanistic STEM Center, a virtual pedagogical community and storehouse of curricular materials for others seeking information and guidance in the creation of similar courses and programs. Though we enjoy considerable support for this idea from college administration, we are also seeking additional external funding to support the initiation of this center. Serving as hub for the collection of syllabi and other course materials as well as a forum for identifying and promoting opportunities for collaboration in the H-STEM realm, the existence will help to eliminate many of the issues we experienced attempting to search out examples and potential collaborators

A recent article in *AAC&U News* [1] demonstrates that the "integration of STEM and the liberal arts" is an idea that is gaining popularity as a way to educate "students who are going to end up in STEM programs by getting them to think about how the liberal arts inform their interests, but also for liberal arts majors … so they understand the importance of STEM and the technological parameters of their interests". The article discusses Olin College's Grand Challenges Program. Despite the reality that its 400 students are all engineering majors, the college remains committed to ensuring it is "delivering students the kind of well-rounded, multidisciplinary education often found at liberal arts institutions". One of Olin's partner institutions, Lawrence Tech, requires humanities seminars that look closely at existing STEM research projects, including an example where "the biomedical engineering and philosophy departments morphed a generic ethics class into a course on live human experimentation". Clearly, these universities see the value of Humanistic STEM as a way to

deepen the perspectives of their students, countering the higher education-as-training mentality that often threatens the very existence of the liberal arts. A Humanistic STEM Center would provide a home to share ideas, experiences, and successes for those who wish to attempt similar initiatives.

Conclusion

The establishment of Humanistic STEM is a way to offer multidisciplinary perspectives that seem to fit the sensibilities of our students. As we offer our first course designed specifically with the H-STEM perspective, we will be able to define our future direction more sharply. A Humanistic STEM center will allow us to consolidate information about the innovative ways that other universities are addressing these concerns. We are at the beginning of our journey with H-STEM, but we are armed with evidence that clearly shows that the world needs STEM graduates who are also creative and empathetic critical thinkers.

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