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Brave New Worlds: Transcending the Humanities/STEM Divide through Creative Writing

Adam Watkins

Zahra Tehrani

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Adam Watkins and Zahra Tehrani

Purdue University

Abstract: Creative writing offers a critical and innovative form of inquiry promoting integrative learning that transcends disciplinary barriers. Authors first provide an overview of the scholarship on creative writing pedagogy, its unique capacity to engage a range of knowledge domains, and its significance for honors education. They then offer primary examples of incorporating creative writing projects into two honors classes that bridge STEM fields and the humanities. Analyses of student reflections ($n = 35$) in relation to learning outcomes strongly suggest that creative writing helps students explore course concepts through several ways of knowing—critical, situational, and affective—while fostering new perspectives on these concepts, their interconnections, and their implications. The value of creative writing as a platform for self-directed and interdisciplinary learning within the transdisciplinary context of honors is discussed.

Keywords: interdisciplinary education; Science, Technology & Society (educational movement); inquiry-based learning; integrative learning; Purdue University Honors College

INTRODUCTION

In "Honors Education: Innovation or Conservation," Scott Carnicom makes the compelling argument that much of what is innovative about honors education is, in fact, based in traditional models (50). In his view, the reason to value honors "is that it fosters the best educational practices of our culture's history, maintains a tradition of critical inquiry that transcends disciplinary

boundaries, promotes creativity, and prepares students to become learn-ers, thinkers, innovators, and leaders for the rest of their lives" (53). To be sure, honors education is rooted in the liberal arts tradition and aligns with Renaissance perspectives that shunned "specialist thinking" as an "excluding position from which to develop human understanding" (Morley 155–56). The paragon of this Renaissance perspective, Leonardo da Vinci, argued that the ideal was to develop a complete mind, which required one to "[s]tudy the science of art. Study the art of science. Develop your senses—especially learn how to see. Realize that everything connects to everything else" (qtd. in Morley 166).

The need to bridge humanities and STEM learning in order to promote interdisciplinary inquiry and cultivate complete minds has become an impor-tant talking point in honors education as well as a core goal at the Purdue University Honors College. Such a goal is necessary if we wish to free stu-dents from the silos of higher education that train them to "think in terms of rather narrow, often extremely narrow, research interests" (Werth 37). In true Renaissance spirit, Andrew Martino suggests that "honors can be a cel-ebration of the imagination and of what it means to be human," which can be achieved "in collaboration with other STEM-based disciplines" by cultivating an appetite for inquiry and intellectual exploration that spans a truly "interdis-ciplinary milieu" (29). Such an approach would be an important step toward fulfilling Da Vinci's edict to study the science of art and the art of science, and to look deeply into complex interconnections of the world around us.

The question remains, however, how best to fulfill Da Vinci's edict. With Carnicom's insight in mind, we might look for innovation in tradition. We might also acknowledge that the division of the arts and sciences was not always the way of the Western world. As Laura Otis outlines wonderfully in her anthology *Literature and Science in the Nineteenth Century* (2002), the per-ceived split between the two cultures of literature and science "was never a nineteenth-century phenomenon"; instead, "[s]cientists quoted well-known poets both in their textbooks and in their articles for lay readers, and writers we now identify as primarily 'creative' explored the implications of scientific theories" (xvii; see also Morley 155–59). As Otis highlights, both scientists and literary authors engaged in creative works to explore the social, personal, political, and philosophical implications of scientific discoveries. Mary Shel-ley's *Frankenstein* (1818) and H. G. Wells's *The Time Machine* (1895) are popular examples from either end of the century, but between them one finds physicians like Oliver Wendell Holmes and S. Weir Mitchell turning to

fiction as an alternate mode of inquiry. This imaginative rather than empirical approach allowed them to explore scientific concepts and theories from new perspectives and encouraged them to speculate about complex relationships between mind, body, society, and environment. The dynamic relationship between creative writing and sciences did not stop at the end of the nineteenth century, of course, and continues today in science fiction and a variety of other genres. In other words, creative writing has long been recognized as a dynamic platform for self-directed inquiry, one that allows authors to embed scientific concepts in the situated realities of their characters or speakers, i.e., the physical, social, and technological contexts of their lived experience. In this way, authors have explored the implications of these scientific concepts and their interconnections with other ways of knowing.

We believe, in concert with Amaris Ketcham, that creative writing could be an "interdisciplinary tool" of significant value to honors students. In the right contexts, creative writing and other arts act as dynamic arenas for interdisciplinary thinking in which "[t]he humanities can easily combine with other disciplines through applied speculation," leading to complex and rich learning moments where "art, literature, history, and philosophy can inform and enlighten STEM studies" (32). We also believe, though, that STEM concepts can in turn enlighten humanistic inquiry and its driving questions. Scientific and technological concepts have the potential to revolutionize the ways students understand themselves and their world, though this kind of transformative and integrative learning is rarely promoted in discipline-specific STEM courses. Conversely, creative writing courses rarely encourage students to explore concepts from other disciplinary fields, focusing instead on the craft elements of literary genres. Honors education—given its commitment to interdisciplinarity and self-directed inquiry—provides an ideal context for leveraging creative writing as a platform for transformational learning that reunites the arts and sciences.

In what follows, we will provide an initial discussion that further explores creative writing's value and potential as an interdisciplinary pedagogy. We are particularly interested in highlighting the unique mode of inquiry creative writing affords, how it lends itself to interdisciplinary thinking and the adoption of new perspectives, and how it thus works to address the learning needs of honors students. In the second section, we will offer our respective experiences with incorporating creative writing into honors courses that engage important intersections of the humanities and sciences.

CREATIVE WRITING:
AN INQUIRY-BASED AND INTERDISCIPLINARY
MODE OF LEARNING

The issue of specialization in higher education and the subsequent need to promote interdisciplinary thinking in honors education is already clear, although this issue is connected to several others. As Kate Wintrol and Maria Jerinic suggest, the current academic culture is one that relies heavily on testing and rote learning, a culture in which honors students have excelled (47; see also Badenhousen 28). As Sara L. Sanders and Janet S. Files suggest, honors students are "masters at traditional ways of learning and at verbal and analytic intelligence" (57). To their credit, honors students tend to be adept critical thinkers in spite of an academic culture that is over-reliant on memorization and testing, so honors education rightly places an emphasis on the cultivation of critical thinking skills. As Leslie Donovan observes, however, "the investment in the critical capabilities of [honors] students" has been unfortunately coupled with the neglect of creative thinking skills and creative modes of inquiry, such that "the educational advantages of artistic creation are frequently ignored or even lost" (96, 98; see also Woodard 39). This neglect is unfortunate as it sacrifices the benefits that Sanders and Files observe when creative writing is employed in honors education: a "joyful exuberance for learning" that results in "enhanced forms of thinking and representing" and gives students "another perspective on the material, another way to *see* it, to care about it, and to *know* it" (57). Jennie Woodard also affirms that creative writing lends itself to "creative problem solving" in the context of an interdisciplinary course on social justice (40).

A review of recent scholarship on creative writing as a mode of inquiry and learning tool offers further clarity on its educational advantages. In his chapter for *The Psychology of Creative Writing* (2009), Mark A. Runco makes explicit a key misconception about creative writing: while too often thought of as a product, creative writing "is best described as a process" that involves "not just a recording of ideas" but rather "a way of interacting with ideas" (184, 188). For Cathy Day, creative writing in educational settings allows for "a thinking process involving student-centered questioning and inquiry," where ideas from research and students' own lived experience of the world can inform one another (166). In this way, creative writing is not altogether different from more academic forms of composition, Day suggests, but creative writing affords a less restricted mode of exploration (173). Meryl Pugh

reinforces this point when she argues that, in contrast to traditional academic writing, creative writing offers "radically different ways of asking and saying and knowing" that are equally essential to higher education (44).

A key part of this radical difference is the highly integrative quality of creative writing. While academic papers often work toward conclusions within a particular field of study, creative writing offers an inclusive and synthesizing intellectual arena, one that not only involves "many different aspects of human creative practice and human critical understanding" but also "a range of knowledge types" (Harper 106). This range of knowledge types incorporates the different disciplinary domains of the academy but also other knowledge types such as experiential knowledge, embodied knowledge, and affective knowledge. Such a mode of inquiry embraces different perspectives and challenges its practitioners to explore the interconnections between the world of ideas and the world of our lived experience; it privileges complexity, ambiguity, and the ongoing development of new questions.

Because of the intellectual flexibility it affords and its capacity to engage such a wide variety of concepts, creative writing has become increasingly popular as a mode of learning in disciplines across the university. Alexandria Peary has been the foremost scholar on this development, which she has dubbed Creative Writing across the Curriculum, or CWAC. According to Peary, narrative construction in particular is useful for activating course concepts and allowing students to see them through the lens of their characters' experiences (358–59). Another facet of narrative, highlighted by Trent Hergenrader, is the act of world building, or creating the contextual or situated realities of characters, which requires students "to work out in detail how different aspects of the world operate and interrelate, including governance, economics, social relations, and cultural values" (136).

The world-building aspect of fiction affords numerous opportunities for exploring the implications of a course concept, which can be embedded in a physical and social reality and explored from the numerous perspectives within that context. Hergenrader has noted that his colleagues in various fields have come to recognize the "interplay between characters and setting" as a particularly valuable tool for learning, one that has provided "a useful handle for their students to better understand their own disciplines" (144). He continues by suggesting how writing stories about different scenarios and through the unique perspective of multiple characters might "shed new light on other areas of humanistic inquiry," including "political science, public policy, criminal justice, philosophy, psychology, and even the natural sciences"

(144). Peary's work affirms that the educational benefits of creative writing are increasingly of interest to faculty from a wide variety of disciplines, including those in the physical and human sciences. Instructors in other disciplines who have adopted creative writing in their courses "repeatedly point to its ability to strengthen students' personal understanding of course material as well as to draw students' attention to larger social forces and issues and the perspectives of others" (Peary 352).

We concur with Peary's sense that creative writing has an "enormous potential as an interdisciplinary pedagogy" (341) in that creative writing's flexibility as a learning tool makes it adaptable to a variety of disciplines. We also believe that creative writing can be an effective learning tool in courses that are already deeply interdisciplinary because it allows students to bring various disciplinary concepts into play within the situated realities of their narratives. As honors educators in a STEM-oriented university, we have both sought to create classes that bridge STEM and humanities, and we have successfully employed creative writing as a keystone in that bridge. Each of us has a unique perspective to offer, not only because of the differences in our courses and the creative writing projects we employ in them but also because we hail from opposite poles of the humanities/STEM spectrum. Adam Watkins earned an MFA in poetry before going on to do a PhD in literary studies, with an interdisciplinary focus on nineteenth-century British literature, the history of human sciences, and environmental studies. Zahra Tehrani earned her PhD in molecular, cell, and developmental biology, with her current work focusing on public perceptions of scientific advancements, particularly stem cell treatment. Given our disparate backgrounds, we have approached the bridge between humanities and STEM learning from opposite ends and have encountered unique challenges in crossing it.

Despite these differences, we share an overarching pedagogical approach in both our classes, which aligns closely with Science, Technology, and Society pedagogy, or STS. The STS approach emerged within science education in the late 1980s and has been gaining traction in higher education ever since. According to David D. Kramer and Daryl E. Chubin, STS offers "a window for looking at the social and natural world differently. Its intellectual value stems from its breadth and its attentiveness to context and stakeholders in the outcomes of issues, controversies, and disputes that contain a science or technology component" (2). In a 2010 article, Erminia Pedretti and Joanne Nazir suggest that STSE (many have now added "Environment" to the initial triad) involves six major currents, with four being relevant to our own courses. The

first is the historical current, which "focuses on extending students' understanding of the historical and sociocultural embeddedness of scientific ideas and scientists' work" (610). The sociocultural current is closely related in that it recognizes science and technology as "not self-contained activities but embroiled in politics, economics, and culture" (615). A key point of emphasis in this current is that science is "only one way of knowing," and approaches to this current often bring multiple knowledge systems to bear on a single topic. The two other currents are the logical reasoning approach and the value-centered approach, both of which promote student understanding, analysis, and problem solving regarding socioscientific issues: the former privileges a scientific approach to such issues and the latter an ethical and moral reasoning approach (612–14). According to Pedretti and Nazir, the historical, sociocultural, and value-centered approaches are particularly effective at promoting an affectively rich, multi-perspectival, and deeply contextualized understanding of the interconnections between science, technology, and society. Thus, they align strongly with the educational affordances of creative writing, which can similarly engage multiple ways of knowing and explore the interconnections of diverse ideas within situated realities. The merger of these two interdisciplinary pedagogies is well suited to honors education and its efforts to promote, in the words of Andrew Werth, "a truly holistic, systemic, integrative worldview uncluttered by familiar limits and barriers" (36).

ADAM WATKINS:
LITERATURE AND SCIENCE IN HUMAN REDESIGN

Following the history of an idea model, I developed HONR 399: Human Redesign with a focus on the evolving conceptions of the human subject across the nineteenth century. Based on my interdisciplinary research on this era, I had grown to appreciate how radically the concept of the human had evolved and how integral both science and literature were to this evolution, so I felt it would make an ideal subject for an interdisciplinary course that coupled STEM and humanities learning. Following the theoretical work of Thomas Kuhn and Michel Foucault, the course was organized around chronological paradigms, with key shifts occurring at the end of the eighteenth century, in the middle of the nineteenth century, and at the end of the nineteenth century. The goal, then, was to provide a learning context in which students could begin to identify overarching patterns of shared meaning across different knowledge bases, to recognize the unique modes of inquiry that different

disciplines brought to a single topic, and to investigate how these modes of inquiry were operating within a larger sociocultural environment with competing views and values.

The primary textbook was Otis's *Literature and Science in the Nineteenth Century*. Beyond an excellent selection of texts, Otis offers insightful accounts of the complex relationships between literature and science in her introductions to different topic areas, including Sciences of the Body, Evolution, Sciences of the Mind, and Social Sciences. In reading works from this anthology along with a few other selected texts, students saw that questions about the human were addressed from a variety of perspectives: what does it mean to be a human being? what is the proper way to study the human? are all people equally human? what differentiates a good versus a bad human? Students also witnessed how these questions spurred the emergence of several major disciplines and theories, including sociology, psychology, neurology, educational theory, and evolutionary biology. To further affirm the role played by literary authors in this discourse, students read three significant literary works that engaged with contemporaneous sciences and evolving conceptions of the human: Mary Shelley's *Frankenstein* (1818), George Eliot's *The Lifted Veil* (1859), and Robert Louis Stevenson's *The Strange Case of Dr. Jekyll and Mr. Hyde* (1886). During the weeks we covered these texts, we took time to summarize and synthesize the new ideas about the human that had been explored up until that point in the unit, most of which were integrated to some extent within the literary works. Students were able to see, then, how Shelley, Eliot, and Stevenson were not simply engaging new concepts about the human but were also defining those concepts further, exploring new implications, and shaping the paradigms of their day.

For the second iteration of the course, I included two creative writing assignments. Most of the students were STEM majors, and I wanted them to experience firsthand how writing a story can allow meaningful engagement with a socio-scientific discourse. The project also provided students a creative interface—an intellectual sandbox—where they could integrate scientific, philosophical, and cultural concepts from course readings. The first project was a 1,500-word scary story along with a 300-word critical reflection. In the reflection, students identified the course concepts they engaged, how they used the format of a scary story to put these concepts in play within the situated realities of their characters, and what they consequently learned about the concepts and their implications. To prepare students for this project, our discussions of Shelley's *Frankenstein* as well as Edgar Allan Poe's "The

Tell-Tale Heart" and "The Masque of the Red Death" addressed the cultural attitudes and anxieties these texts reflected. Even more crucial to the project, I led discussions on how these authors used narrative frameworks, character development, physical and social settings, and dramatic events to explore a particular idea, question, or issue that was central to the contemporaneous discourse on the human. The discussions on Shelley and Poe were followed by more explicit conversations about the respective perspectives, ideals, affordances, and shortcomings at stake in literary and scientific modes of inquiry, and thus their respective capacities for exploring questions about the human subject. In this way, I not only prepared students to write stories that embedded course concepts and explore their implications through situational thinking, but I also set them up to think critically about their creative process as a form of thought experiment.

The other piece of creative writing was to create a quack theory that was rooted to some degree in a scientific concept that had been offered in the nineteenth century. For models, we explored phrenology, which was based on early science of the mind, and mesmerism, which was inspired in part by Galvani's theory of animal electricity and Faraday's work on magnetic force. After reading several quack theories from this period, we discussed the forms and strategies that authors used to establish the credibility of their ideas. We also examined how these theories reinforced cultural values, undermined certain core beliefs, and/or agitated new fears about the human subject. As with the scary story, students included a critical reflection that outlined the course concepts they engaged, the creative choices they made, and what they learned in the process.

Based on my analysis of submitted projects from my fall 2018 course, students were successful at achieving the core learning outcomes of these assignments. For the scary story assignment, every student developed a compelling narrative that explored interconnections between course concepts as well as the personal or social implications of these concepts. One student, inspired by the work of James Cowles Prichard, portrayed a character's biologically determined descent into madness and criminality in order to interrogate issues of free will, personhood, and ethics. Another student depicted a traumatic family event in order to explore the influence of trauma on sanity and personal identity as understood in this period. Most of the other students took their lead from early neurological theories, focusing on the implications of a physiological mind that could be influenced or even controlled by environmental factors, whether by mind-controlling tonics, mob

mentality, extreme forms of education, parasitic organisms, or electric shock treatments. In each case, students showed strong engagement with an issue that was central to the early nineteenth-century reimagining of the human as well as cultural anxieties about the overreach of science, the power of institutional discipline, and the place of women and lower classes in society.

In the critical reflections for the scary story project, several key themes emerged. The first is that students gained a clearer and more integrated understanding of course concepts. Several students noted in their reflections that the scary story format allowed them "to pull ideas from multiple texts we have discussed in class" (Karl), and all seventeen students described integrating course concepts from at least two texts that would now fall under different disciplines. As Hannah wrote, "All these ideas were floating around my head, but I could not get a clear grasp on them," but once she began to "mix everything together into this story," many of the ideas become clearer:

> Portraying these fears through a complex narrative made the mixture of ideas very clearly meld into one, and that clear message is much easier digested than by a simple explanation in a 1200-word essay. For that reason, I highly enjoyed the experience of writing this.

In comparison to the traditional academic essay, Hannah found this narrative approach to inquiry a better learning tool for the integration of diverse concepts. As another student noted, part of the value of the project was that it allowed students to render difficult or abstract ideas more tangible by embedding them into the narrative:

> As the story develops though, I feel like we're able to incorporate other more abstract fears one might have during this century. . . . So overall the story is able to touch on a number of different ideas and tie them altogether. Which I find really interesting how everything is able to be related to each other, it's really led me to see everything as an abstract organism [in] some sense. (Kip)

Through such embedding, students not only gained a better handle on abstract ideas, they also found that they can connect ideas in new ways. The result, as Kip suggested, was that the once disparate array of course concepts became a larger, nuanced, organic understanding of the concepts and their integrated meaning.

Evident in both Hannah's and Kip's statements is a sense of creative writing as process-oriented, in which the act of developing the narrative catalyzes new questions and ways of thinking. Four other students specifically

referenced this aspect of their creative inquiry process, with the following two statements being exemplary:

> The story brought questions to my mind. How far would people go in this generation when listening to authority? Does a person's self-worth impact their likelihood to be peer pressured? (May)

> The goal of this piece was to raise a lot of questions about what it means to be human and the problems associated with being human— essentially questions we have been attempting to answer in this class. Does the narrator have control over himself? . . . What effect did the narrator's obsession with crime as a child have on his sorry state as an adult? After exploring all of these questions, I realized that I myself don't have a firm answer for all of them. This assignment has encouraged me to think critically about what I believe insanity is, how strong a force determinism is, the effect of loneliness, etc. (Sam)

As these statements show, students came to new questions through the development of their stories, questions that opened up new possibilities for critical thinking about specific course concepts as well as the larger themes arising from shifting notions about what it means to be human.

For thirteen of the seventeen students who completed the project, the exploratory nature of creative writing led to changes in how they understood the concepts they were exploring or to deeper thinking about major course themes. For Rhonda, the project helped her see some of the "darker" implications of discipline in child development: "My thinking about discipline evolved throughout this process into something far more disturbing than before and made me understand that the theory of discipline really stems from a fear of not being able to maintain control over others." Kim's story led her to a new recognition of a key problem at the heart of the nineteenth-century conception of the human as she realized that "to be human is to be able to make choices but those choices you get to make will always be determined from something beyond your own control." For a handful of students, the key learning outcome pertained to the complex relationship between science and literature. Kim acknowledged that the literary readings from class and his own work on the scary story revealed the greater capacity of literature to explore the cultural implications of scientific progress: "While science is good at everlasting inquiry into the natural elements, I think literature might be doing a better job inquiring about the inquiries, regarding their ethics, uses, and implications." Jack, on the other hand, gained a new perspective on

the epistemic challenges of early science, when existent knowledge was insufficient for vetting new theories; in such a situation, "it is almost impossible to differentiate what is just some quack theory with what could be groundbreaking science." Jack continued, "This is something I hadn't considered until I got to watch Dr. Hoskins"—the tragic protagonist of his story—"do it in front of me."

As suggested by these comments, the creative thinking at stake in this project led to significant critical thinking about course topics and themes, yet I also want to highlight one other way of knowing that this project facilitated: perspective-taking and empathy. By writing these stories and thus exploring the perspectives of characters they developed, students were able to suspend their twenty-first century perspective in order to better understand the viewpoints and anxieties of nineteenth-century subjects. Six of the seventeen students stated in their reflections that the project facilitated perspective-taking and subsequent learning. One student noted that she previously found the nineteenth-century discourse about disease to be overdramatic; however, she chose to imagine herself as the protagonist of her story and found that by "putting myself in that situation" she better understood the nineteenth-century anxieties that resulted from a lack of knowledge about disease and contagion (Elen). Jack similarly acknowledged that he was at first "hesitant to accept that I could fall victim to the same anxieties" that resulted from Hartley's theory of nervous vibrations and its implications for mental determinism, yet writing the story "helped me empathize with what they must have felt reading [Hartley and others] for the first time, which in turn helped me understand the anxieties themselves better." Many of the reflections affirmed that creative writing proved a synthesizing activity, not just between abstract ideas but also between different modes of knowing, such that logical analysis, situated problem-solving, and affective thinking were simultaneously employed in the effort to engage course concepts through narrative. This approach clearly resonated with students; as John notes, "It was interesting to explore these ideas via a horror story, because it allowed for more chilling ideas to creep in, in comparison to just a straight analysis."

The emphasis on creating a story that deals with cultural attitudes and anxieties further enhanced the affective learning component but also resulted in an intellectual exploration that felt different from the usual academic papers with which students are more familiar. Tinesha described this project as an opportunity to "play around" with ideas that had real meaning for her. Sam, who stressed the myriad questions her story raised, affirmed that

the exploratory nature of the project allowed her to encounter intellectual ambiguity in a way that was at once beneficial to her learning and pleasurable: "[A]lthough I cannot say with confidence that I now magically have definite answers to those questions, I can say that I have explored these topics deeper and have thoroughly enjoyed doing so." Jack acknowledged, for instance, that "this story resonated with me," and this kind of personal relevance deepens the learning outcomes associated with the project. Overall, twelve of the seventeen students indicated in their reflections that the scary story project facilitated not only a unique way to engage critically with course concepts but also a more enjoyable one.

The quack theory project led to many of the same learning outcomes as the scary story. Nearly all students acknowledged engaging and connecting diverse concepts from different course texts. Six of the seventeen students stressed in their reflections that the assignment promoted perspective-taking and thus a new lens for understanding course concepts. For instance, Kim wrote, "After writing my quack theory I am now at a better understanding of why the ideas about hysteria were accepted during the time and how women felt about the disease and the potential of having it." Helen affirmed: "In my experience, the empathy and perspective I gained was the most valuable takeaway from the assignment. I can now say that, at least much more than prior to this assignment, I have a genuine understanding for the people and culture of the nineteenth century." Also akin to the scary story project, students stressed how much they enjoyed approaching difficult course concepts through the quack theory project, with six students emphasizing that they felt free to explore topics that interested them and "have fun with this assignment" (Margaret). Mike described the assignment as "a fun way to explore concepts we could otherwise explore in significantly less fun ways." Elen wrote, "I really enjoyed this assignment!"

One notable difference I saw in the quack theory project was the way students' critical and creative thinking were engaged. Instead of integrating course concepts through narrative contexts and characters, students took a course concept and developed from it a theory that was equal parts rational and absurd. The effort to develop a coherent if misguided theory helped many students see course topics and themes from new perspectives. Helen's reflection epitomizes this well:

> When I began to write this, I thought the idea of a fully connected mind and body was ridiculous. As the assignment title suggests, it was a quack theory to me. But, throughout the writing process

something changed. I had to come up with rationalizations for the characters and I had to make the theory connect, and through that I understood the theory as meaningful and understandable.

In total, ten out of seventeen students identified ways their understanding of course concepts or key themes were altered or transformed through the project. Some, like Helen, developed a new perspective on a course concept with which they were already familiar. Others, like Sam, got a new perspective on overarching concepts: "Although my [quack theory] is founded on the timeless good vs. evil topic, writing this piece made me think deeper on this topic than I have before." Other students gained a new perspective on the precariousness of scientific knowledge in this era, with most realizing how easily a scientific truth could be distorted in order to cater to the values, hopes, and fears of a society as they had seen done in several course texts.

The students' scary stories and quack theories were a pleasure to read and showed a strong effort to engage, interrogate, and connect course concepts. At the same time, I found that in a few cases students struggled to articulate in their reflections the critical and creative thinking that I could see at work in their scary stories. My impression was that many students were more enthused by the creative writing than the critical reflection and chose to focus most of their time on the former. I also gathered that some students had a hard time with the metacognitive work that goes into analyzing one's own thought processes and learning. For that reason, I gave students the opportunity to revise their reflection for the scary story if they wished. All but one student had earned a solid B or higher, so I was surprised when eight of the seventeen students took this opportunity, even two who had received low A's. Most of the revisions were light yet demonstrated a continued effort to think critically about narrative choices and how the creative process led to new or more complex perspectives on course concepts. The same opportunity was not provided for the quack theory. Those reflections were more consistently successful, suggesting that the students had a better understanding of my expectations and/or had improved in their ability to think critically about their creative process.

ZAHRA TEHRANI: IMMORTALITY

The recent movement in higher education to integrate the humanities and sciences presents many opportunities for innovation in the classroom. Many integrative approaches are used in higher education curricula with

varied learning goals of integration (National Academies of Sciences, Engineering, and Medicine). One integrative model is to apply content and/or pedagogies from the humanities and social sciences to the natural sciences and engineering to foster student understanding of the societal, economic, and political impact of scientific discoveries and technological developments (Akcay and Akcay; Han and Jeong). In one integrative assignment, I used creative writing as a platform to explore the scientific concepts (i.e., digital uploading of one's consciousness) and the social, legal, and ethical implications of mind uploading technology.

Like many honors programs, the Purdue Honors College encourages faculty to experiment with interdisciplinary approaches in the classroom. To this end, I developed an honors seminar titled "Immortality," which looked at what it would mean to be immortal and why we are drawn to the idea. The course first examined biological immortality by introducing students to biological theories of aging and biomedical technologies that could potentially lead to extreme, if not indefinite, life extension, thus laying the foundation to investigate issues of population, resources, family dynamics, and the value of mortal limits. The question of biological immortality prompted consideration of other possible forms of immortality, such as digital immortality via mind uploading. Mind uploading is the process of constructing a one-to-one model of every neural connection in the entire brain on software such that it behaves essentially the same way as the original brain (Sandberg). Mind uploading has been the muse of science fiction writers and transhumanist philosophers for many years. However, these futuristic visions were not grounded in science. To provide real scientific insights into the feasibility of mind uploading, a series of content-based lectures on the neuroscience of brain emulation encouraged students to think critically about complex issues. Through a series of scientific and philosophical discussions based on primary literature, we examined the nature of the uploads (e.g., Are digital copies conscious? Do they retain the identity of the original person?) and the biological mechanism of mind uploading (e.g., Does the person's body physically die during the transfer process? What features of the brain give rise to consciousness, and can those features be digitally extracted?) (Chalmers; Pigliucci). Furthermore, students considered what impact uploading would likely have on society by watching films that feature a future in which mind uploading is prevalent ("White Christmas" and "USS Callister" from the Netflix series *Black Mirror*), and they identified social, legal, and/or ethical questions raised in the films: e.g., Who will have access to the technology? Who will have

ownership of digital uploads? Should digital copies have rights protected by law? What should those rights be, and where should those rights stand in relation to the real person?

To deepen their understanding of these complex issues, students wrote a thought experiment in the format of a 1000-word short story in which they explored one idea from class about digital immortality along with a 500-word critical reflection. A thought experiment is "the act of considering an untested, observable system designed to help evaluate a scientific concept, model, or theory—and attempting to predict aspects of its behavior" (Stephens and Clement 3). Thought experiments are a powerful tool for learning because they enable students to draw on experiential knowledge along with logical inference and conceptual knowledge in generating new knowledge (Reiner). Thought experiments are also an effective learning tool in science education (Roth).

Creative writing can be a useful vehicle for thought experiments. Students were excited by the opportunity to engage in creative writing and found it a refreshing change from philosophical and scientific discussions; however, most of them were from STEM majors and did not have any prior training in the craft; neither did the instructor. To overcome this difficulty, we needed a model to demonstrate how a thought experiment can be conveyed as a creative piece of fiction. To this end, we did a close reading of Alan Lightman's *Einstein's Dreams*, a collection of short stories about the nature of time told from the imagination of Albert Einstein in 1905 as he worked on his theory of relativity. One of the stories features a world in which people live forever, and students could see Lightman's reflections on how people's behaviors and social dynamics might change depending on their relationship to time. Using his framework and style as inspiration, they drew from the knowledge they had gained from the readings, films, and class discussions to tell their own stories about a future world in which mind uploading is possible and about its potential ramifications.

Rather than assessing students' creative work, I assessed their critical reflections on the writing process. Their reflections were required to address the following questions:

1. What specific idea about mind uploading did you choose to explore in your story?

2. Pointing to creative details in your story, how did you explore the idea? (e.g., Was it looked at from different perspectives? Did you analyze specific aspects or contexts of the idea?)

3. How did the writing process change your thinking about this topic, and how did it affect your understanding of digital immortality and/or its implications?

Students who successfully achieved the learning outcomes of the assignment (67%; 12/18) were those who strongly engaged ideas from the course content by, for instance, referencing a specific text and/or film and who developed new insights or a more complete understanding about digital immortality and its implications. Some students engaged the course content vaguely or struggled with metacognitive awareness by reiterating discussion points from class with no new insights (33%; n = 6/18).

One intriguing outcome was how drastically student perceptions of the technology changed after writing their stories. During initial class discussions, many students were optimistic about the benefits of uploading: it would solve all of society's problems—homelessness, overpopulation, food scarcity, or climate change—and would provide an appealing escape from death as well as opportunity to expand the range of human experiences.

However, in their critical reflections, most indicated that they felt conflicted and even hesitant about uploading, as reflected in three notable examples.

(1) In the "The Choice," the student explored the theme of reduced human suffering in the digital world, which he saw as the primary driver for people to leave their families and friends in the physical world and join the digital, but the student also explored how a perfect world would redefine happiness and ultimately lead to a less meaningful life:

> It's easy to think of the simulated world as a utopia with infinite possibilities. However, as I explored in the story, happiness might be much more difficult to come by than one would expect. First, if the simulation removed suffering and hardship, people would have no basis for what happiness is; indeed, much of happiness comes from overcoming hardship and reaching a point of satisfaction. It would be like a drug high—perhaps it is happiness by some definition, but it's not fulfilling. How can you take an adventure if you've experienced everything already? Why fall in love if you can live a whole life with someone and still move on to the next person? While some people may be able to live successfully in the simulation, it is fair to predict that many people would struggle. Writing the creative piece made me think much more about what life in the simulated world would be like. On a surface level, the idea of a simulated world is exciting to me.

We all have some fear of death, and a simulation would be an escape. After digging deeper, however, I don't know if it's possible to create a simulation that eliminates the problems of the real world while still allowing its inhabitants to live meaningful lives.

(2) "Second Form Citizen" examines the influence that uploading service companies would have over the lives of digital minds. In the story, uploaded minds have become fully integrated with the internet and the sole purpose of people in the physical world is to maintain the perfection of the digital world. The student connected uploading to the contemporary debate about internet privacy and protection to gain new insights about the relationship between physical and digital entities:

In the imperfect world we live in, I could see a company manipulating the constructs of digital entities in order to control them or limit their reach. . . . An uploaded mind with endless time and knowledge through the power of the internet would be a dream come true for many people, yet it would have the potential to be extremely destructive. Would limiting the power and scope of digital entities be justifiable? . . . My story reflects this [dilemma] through a work orientation for human technicians who "fix", or censor, the experience of digital entities. The physical existence is completely focused on managing the digital existence, which promises perfection. In reality, the digital experience has been manipulated and has been removed of autonomy. Thus the promise of a second life would only trap humanity in a cycle of anticipation and disappointment enforced by the structures and organizational capacity of an industry.

(3) The story "Deletion Day" confronts the reality that computers, though powerful in many ways, have finite storage space. As a result, those who have chosen to upload their minds have to periodically undergo memory deletion to make room for infinite new memories. This student's critical thinking about a technical issue led her to raise a novel question that had not been considered before in the class: What are the social and psychological consequences of memory deletion?:

Being acutely aware of the long-term negative consequences of immortality (meaninglessness of life, loss of motivation, etc.), I had always viewed immortality as detrimental to humanity from a purely philosophical standpoint. However, this project pushed me to explore more practical aspects of immortality such as the different

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forms of uploading and storage methods along with their complications, all of which I had never considered before. For example, with memory deletion mandated in the story, which memories do you choose to delete? What if you deleted a memory that was important to a loved one? What happens if someone irresponsibly commits crimes knowing he could erase those memories later? . . . There are many nuances to consider with the idea of immortality, digital or biological, and the complications discussed in lectures and assigned readings demonstrate that the utopia immortality seemingly offers ironically becomes a dystopia.

As these examples illustrate, creative writing can be transformative as a pedagogical tool by affording writers an opportunity "to examine issues from multiple viewpoints and explore their own thoughts on the problem in front of them" (Woodard 1). Many students recognized through their stories that technology could lead to unintended consequences and change what it means to be human.

THE CHALLENGES

As a molecular biologist by training, I was unfamiliar with creative writing, and assigning a project without having the skillset made me apprehensive at first. Realizing that my discomfort stemmed from a lack of familiarity with humanistic methodologies, I visited the classroom of my colleague Adam Watkins, whose background is in creative writing and literary studies. I observed how one might lead students through a close reading of a fictional text paragraph by paragraph, first observing the facts and details and then interpreting the observations to draw a conclusion, e.g., what this phrase or paragraph accomplishes or what point the author is making. I used this experience as a guide to conduct a close reading of *Einstein's Dreams* in my Immortality class. The experience also forced me to reevaluate some of the fundamental assumptions and genuine misunderstandings I had about humanistic practices, mainly that the interpretation of literature is purely subjective, when in actuality each interpretation is validated by referencing specifics from the text and the text as a whole.

Teaching outside of one's area of expertise can be daunting. It gave me confidence, as well as put my students at ease, when I acknowledged that I did not have any training in fictional writing, nor was I trying to make advanced writers out of them. I made it explicit that the goal of the assignment was

simply to expose them to creative practices and humanistic inquiry as analytical tools that can be used to examine science and technology in a critical way.

Bridging the sciences and humanities required me to step outside of my comfort zone and invest extra time to learn the tools of another discipline, but even a single assignment can offer an easy way to experiment with integrative pedagogy. Ultimately, it was a productive and fun learning experience for me and the students, and more importantly it strengthened students' understanding of the course material and enabled them to build cross-disciplinary respect.

CONCLUSION

In both our classes, creative writing proved an effective pedagogical tool for promoting transformational learning within an interdisciplinary curriculum, allowing students to gain a deeper and more nuanced understanding of course concepts and themes. Students began to see scientific concepts from humanistic perspectives while at the same time seeing humanistic forms of inquiry as a vital means of knowledge production that merges creative and critical thinking. Through the coupling of creative writing and STS pedagogies, students could fulfill Da Vinci's edict to see the art in science and the science in art, all in an effort to examine the world and the complex interconnection of things within it. That said, what proved most essential to the success of these creative projects was the self-guided, exploratory, and affectively rich forms of inquiry they afforded our students. While we primed our students in class with our own questions, the creative projects gave them a dynamic arena in which to create their own thought experiments and explore the questions that mattered most to them. Our students were not the passive recipients of these outcomes but were instead the authors of their own transformational learning. We hope that, given their new understanding of creative writing as a tool for analysis and inquiry, students will continue to employ creative forms in a lifelong effort to see their world from new perspectives and to make sense of their place in it.

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The authors may be contacted at

aewatkin@purdue.edu.