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CURR 599: Directed Study Dr. Morgan

Interdisciplinary Collaborations between Science and Literature in Secondary and College Education:

Literature Review

With science fiction and didactic texts leading the cross-curricular collaborations with science, interdisciplinary studies have emerged in secondary and college-level educational settings through chemistry, chemical engineering, physics, genetics, evolutionary studies, biology, and environmental science. Based on that mix, upper-level fusions do not seem overly embedded in the life sciences over the physical sciences, slightly thwarting the concern and prior observation that the physical sciences are “often-neglected” and “underrepresented” in didactic collaborations between science and literature (Plummer & Kuhlman, 2008, p. 98; Sackes, Trundle, & Flevares, 2009, p. 421). Interdisciplinary collaborations at both the secondary and college level have taken more of an integrated approach, fusing the disciplines within one content area classroom (usually science) instead of across. However, there were several exceptions in which English and science teachers came together (Furtan, Kitson, & Andes, 2007; Bull & Dupuis, 2014). To highlight and summarize the past interdisciplinary collaborations in education holistically and in light of theory, each will be discussed based on the extent to which it is a cautionary tale and the extent to which it holds ideas worthy of reproduction.

Regardless of which direction – positive or negative – that their ultimate imbalance leans, all are important in that they provide insight into the nature of upper-level educational collaborations between literature and science, an area less explored than elementary integrations (Fang & Wei, 2010, p. 264). This reality becomes even more regrettable when one factors in how the “best use of the hard sciences….is found in books written for an adult audience” (Estes, 2003, p. 34). In the end, all of the case studies explored strive to reduce secondary teacher skepticism in this unconventional interdisciplinary approach because it is, unfortunately, a skepticism that pushes them to believe literature-oriented science approaches are not as legitimate and, thus, not as successful in teaching science (Fang & Wei, 2010, p. 262, 265).

**Overview of English-Science Collaborations in Educational Settings**

**Secondary Education**

When compared to the college-level interdisciplinary approaches, the secondary collaborations revolve around student-generated texts while the undergraduate classes focus more on literary analysis through science fiction. In other words, secondary cross-curricular activities focus more on the production of material rather than just the analysis of material. While many opt for didactic texts, others rely on nonfiction for the literary component, which are both arguably less authentic approaches. The latter may even strip the literary component of its most valuable, and differentiating, asset to scientific collaborations: the visceral level experience of fiction (Lightman & Goldstein, 2011; Kesler, 2012, p. 349).

Recognizing the overuse of lab reports in the middle school science classroom – an observation supported by Parkinson (2000) who found that 85% of the literacy events that science students participate in are labs (p. 372) – Peterson, Rochwerger, Brigman, & Wood (2006) designed a cross-curricular writing activity during an eighth grade “Mechanical Advantage and Efficiency” unit. Students were required, in the genre of their choice, to write a short story whose plot somehow involved simple machines. Therefore, Peterson et al.’s (2006) interdisciplinary approach supported the belief that narrative can be used to teach the language of science (Morrow, Pressley, Smith & Smith, 1997; Bixler, 2007).

At every stage of the assignment, recognized instructional strategies appeared, indicating high-quality planning and preparation. The four, forty-minute, in-class student writing sessions were extremely well scaffolded. They were preceded by vocabulary preteaching of the relevant science concepts and task-specific modeling of how science can be incorporated into short story form, components that were missing from the college-level interdisciplinary courses by Hamdan, Vengadasamy, Hashim, & Yusof (2011) and Furlan, Kitson, & Andes (2007), respectively (which will be discussed later in more detail). The vocabulary introduction included social collaboration through Think-Pair**-**Shareand hands-on learning with simple machines. Afterwards, Peterson et al. (2006) read aloud Annette Griessman’s 2002 science fiction short story, “Alien Games,” which modeled the use of simple machines in narrative. In the story, the protagonist tries to retrieve a lost ball from a forbidden city through a system of levers and pulleys.

Although Peterson et al. (2006) used a modern work of science fiction for the literary component of her interdisciplinary activity – which was a major absence in the highly classical approaches that the two science fiction-based, college-level interdisciplinary courses took – “Alien Games” is a didactic text, anthologized in Julie E. Czerneda’s “Stardust,” a compilation of science fiction short stories specifically written for use in education to teach science concepts. Didactic texts are widely discouraged in classrooms (Tunnell & Jacobs, 2008a, p. 26; Freeman, Freeman, & Ebe, 2011, p. 234). And integrating an inauthentic literary text as part of the literature component of a science-literature interdisciplinary unit seems like it undermines the discipline.Haviland (2005) actually mentioned the children’s book series, Lemony Snicket’s *The Series of Unfortunate Events,* as a potentialEnglish-science interdisciplinary approach through Violet Baudelaire’s consistent creation of “some sort of simple machine using levers and pulleys and things like that” (p. 14). Therefore, Peterson et. al. (2006) may exemplify how content area teachers often lack knowledge of reading resources to make interdisciplinary integration occur (Plummer & Kuhlman, 2008, p. 100; Fang & Wei, 2010, p. 265; Bull & Dupuis, 2014, p. 76). In that respect, jumping to didactic texts that are easily found with basic research is understandable, but still not permissible.

 In terms of the actual writing component of Peterson et al.’s (2006) interdisciplinary assignment, it embraced student choice (they could pick any genre for their original short story), included peer editing activities, and provided students with a self-monitoring writing rubric. The final short stories used humor and images, evidence that the eighth graders wrote with awareness of their peer audience. College undergraduates also injected humor in their original interdisciplinary texts (chemistry-based poetry), which they also wrote partly for a peer audience (Furtan, Kitson, & Andes, 2007, p. 1626). Similar to how one student in that same college-level interdisciplinary course adapted Shakespeare’s *Macbeth* into chemistry poetry (“Chemistry – Macbeth’s Style,” Furlan, et al., 2007, p.1628), one student wrote a parody of Charles Dickens’s *A Christmas Carol* for the physics writing assignment (Peterson, et al., 2006, p. 35). Furthermore, the middle school students independently incorporated literary elements – like foreshadowing and allusion – and characters and plotlines from other stories they had read (Peterson et al., 2006, p. 35). Therefore, theses unprompted student writing approaches actually increased the interdisciplinary nature of the assignment. As a suggestion for future implementations, Peterson et. al. (2006) recommended that the English teacher supplement the science writing through mini-lessons on writing strategies (p. 36).

In the only secondary interdisciplinary approach that involved collaboration between an English and science teacher - instead of the typical integrated approach where a science teacher just brings literature into his/her classroom - Bull & Dupuis (2014) outlined two simultaneous units: nonfiction in English and genetics in science. Also important, it was the only hypothetical, never-implemented approach explored. Believing that students need “ready-made hooks in prior knowledge,” the researchers staggered the onset and conclusion of the units, starting and ending the biology unit a week prior to the English unit (Bull & Dupuis, 2014, p. 75, 77). Fang & Wei (2010) also argued that background knowledge is key for students’ ability to navigate science texts (p. 263). As a result of the scheduling, the interdisciplinary unit spanned over a five-week time period even through each discipline-specific unit lasted four-weeks. This allowed students to build scientific background knowledge – the “hooks in prior knowledge” – during that first week of biology that they could use and activate in the English classroom when reading its nonfiction texts (Bull & Dupuis, 2014, p. 75).

Together, the English and biology unit focused narrowly on a case study about birds to teach students about genetics, natural selection, and adaptation. Such exclusivity not only threatens student engagement, but it threatens the ability of students to generalize those science concepts beyond birds in the future. The units were outlined on a companion website, instead of in the article (<http://interdisciplinaryenglishandscien.weebly.com/>). During the first week of the genetics week, students browsed pictures of birds to hypothesize why they varied in beak and feet shape/size and then learned about natural selection in a hands-on fish tank activity in which food was placed at varying depths for three beak sizes. The second week involved group work through the analysis of four graphic novels on Darwin, evolution, and genetics. Each group reported their observations to the whole class daily. Field trips outside during the third week required students to journal for multiple days about the birds they directly observed (a week for just this seems extensive in a secondary classroom). Concluding the unit, students chose a bird species for a research project.

In the parallel English nonfiction unit, students watched a PBS documentary, *Crash: A Tale of Two Species*, and then paired up to explore a bird-based digital text during the second week. For the third week, students assumed the four traditional literature circle roles and close read a bird-based nonfiction book. The modes of persuasion – logos, ethos, and pathos – were taught in the fourth week, enabling students to wrap up their literature circles with those new concepts to integrate into their literary analyses. As the fifth week’s summative assessment, students used their bird species research from biology and their literary analyses to create a digital video that advocated respect for the environmental issues surrounding the bird species.

Bull & Dupuis (2014) justified its nonfiction English unit through the Common Core State Standards (CCSS) and its push for more nonfiction texts in all disciplines (p. 76). However, based on how a survey completed by middle school students indicated that students identify nonfiction as the most obvious literary connection to the sciences (Howes, Hamilton, & Zaskoda, 2003, p. 500), a nonfiction English unit does little to expand student thoughts about the potential for a literature and science collaboration. Bull & Dupuis (2014) inadvertently tapped into how nonfiction may be cop-out by mentioning the ease at which it slides into other disciplines: “A nonfiction unit in English class offers tremendous possibility for cross-curricular collaborations with multiple subject-area teachers” (p. 78). A nonfiction English tie-in is arguably straightforward and obvious, and interdisciplinary collaborations should be thoughtful bridges that expose unanticipated parallels. Furthermore, by its exclusive embrace of nonfiction, Bull & Dupuis’s (2014) English unit chose the only literary genre that fails to possess the main benefit that literature brings to science: fiction’s ability to emotionally affect its readers (Lightman & Goldstein, 2011; Kesler, 2012, p. 349). Related to this idea, the emotional enjoyment of the arts is what prompts us to engage and causes us to become interested in a non-artistic topic (Furlan et al., 2007, p. 1625). According to Lightman & Goldstein (2011), “if you want a person to really care about something…you have to hit him in the amygdala,” which they assert is where fiction makes its largest impression on us. Therefore, after more than a month of learning about birds with no fiction text in sight, it is questionable how realistic is it to believe that students will still be motivated to learn about birds. The choice of nonfiction drains the visceral learning potential from the literature potion of the interdisciplinary unit so that nonfiction’s inclusion is barely representative of the ELA discipline.

When literature is paired with studies in environmental science, the approach seems to produce more hands-on learning opportunities for English instruction, so the interdisciplinary collaborations prove that a common reason for science teachers’ integration hesitancy – literacy approaches conflict with their commitment to hands-on teaching (Plummer & Kuhlman, 2008, p. 95; Fang & Wei, 2010, p. 265) – operates around the illusion that both disciplines don’t hold potential for interactive learning. Ronau & Karp (2001) conducted a middle school interdisciplinary unit with sixth graders around the topic of environmental pollution. Through a read-aloud, the teachers introduced students to environmental pollution with Don Madden’s 1993 picture book, *The Wartville Wizard.* The book chronicles an older man’s mission to curb littering through magical powers that enable him to fasten the trash directly onto their litterbugs for shame-induced accountability. Armed with recording sheets, garbage bags, and plastic gloves, the students then explored the school grounds to tally the types of litter on campus. Since only this real-world environmental data and a small concluding online research activity for environmental clean-up organizations composed the science portion of the interdisciplinary study, students continued the unit by working with mathematics – graphs, fractions, and percentages – to organize the science data (Ronau & Karp, 2001). However, with the literature component isolated at the beginning of the unit and not maintained throughout, the interdisciplinary collaboration between mathematics and science overshadowed the sequential one between literature and science.

 In another middle school interdisciplinary collaboration involving environmental science, Howes, Hamilton, & Zaskoda (2003) ran an experimental, mutli-grade level (5-8) minicourse, “Linking Science and Literature through Technology.” For the project, students drew aerial-view maps of their neighborhood, scanned and uploaded them to a shared website, and linked landmarks to specific content-related webpages (i.e. a tree illustration linked to a website about that specific tree species). Similar to the way in which roles are assigned in literature circle activities, groups were then organized to restrict students’ further work with the website. There were four work groups: a layout team, internet researchers/ writers, technical engineers, and field researchers/writers.

 Although the researchers claimed that project used “computer technology to enrich students’ connections to their local environment” (Howes et al., 2003, p. 504), the work groups split up the interdisciplinary project into smaller assignments of varying interdisciplinary responsibility. Howes et al. (2003) even admitted that the “field researchers and writers were the most interesting group for [them] to study in terms of problematizing and working through interdisciplinary possibilities of science and literature” (p. 501). With writer’s notebooks and digital cameras, that group of four students took weekly walks from the school to the Hudson River pier, observing the subtle (i.e. how weather affected distal vision) and obvious (i.e. concrete apartments to a nature-filled park) environmental changes. The walk led students to write questions that could be addressed “scientifically,” such as “Why do flowers bloom?” and “How deep is the river at this point?” (Howes et al., 2003, p. 502). The internet and field researcher/writer groups engaged in interdisciplinary activities in their roles (but in drastically different (and thus virtually incomparable) ways), and the layout coordinators and the engineer positions lacked clear access to interdisciplinary learning. So, in general, the project seems poorly defined as a literature-science interdisciplinary collaboration, especially based on the researchers’ introductory purpose-setting: “We introduced students to *our* website. Using a computer protector, we toured the site on a large screen to generate enthusiasm and provide a context for the assignment” (Howes et al, 2003, p. 501; italics not in original). Arguably, the researchers used the course as more of a way to gain help building their website than to offer clear and equal interdisciplinary instruction or experience.

 With Ronau & Karp’s (2001) sequential collaboration and Howes et al.’s (2003) spotty and disjointed collaboration tarnishing the cross-curricular potential in hands-on environmental science studies, Cooper (2011) brought the premise to the college-level in a substantially more effective interdisciplinary course. The following summary and analysis is based on personal experiences in the Fall 2011 English elective, “Literature and the Environment,” at SUNY Geneseo. To explore the “convoluted interface” between human culture and the environment, Cooper (2011) designed varied assignments that actually parallel the ones in the aforementioned two middle school approaches, showing how an alternative approach – and a clearer long-term vision – can make a stark difference in the quality of an interdisciplinary collaboration.

Similar to how Howes et al.’s (2003) field researchers/writers kept “writer’s notebooks” to observe their weekly Hudson river walks (p. 502), “Literature and the Environment” required a weekly, ungraded entry in a “writing journal” that urged students’ introspective reflections on their personal interactions with their physical environment instead of reader-response entries based around the course texts. Cooper (2011) scaffolded students to the informal writing assignment through Henry David Thoreau’s essay, “On Keeping a Journal.” While the two course papers were research-based, the nature of the research differed in the same way it did between Howes et al.’s (2003) field and internet researcher/writer groups. The first essay required hands-on, student-driven research via field work and a personal interview with a self-selected local Genesee Valley food or farming establishment. Similar to the course’s writing journal, the essay was informally scaffolded through the class reading of Michael Pollan’s *The Omnivores Dilemma: A Natural History of Four Meals*. Therefore, unlike Ronau & Karp’s (2001) frontloaded literature approach, Cooper’s (2011) literature infusion was not only dispersed, but purposefully so in alignment with their relevance to the course assignments. The course’s dense, seven-book required reading list juxtaposed contemporary and classical texts to survey literary depictions of the American environment (i.e. Sarah Orrne Jewett’s 1896 short story, “The Country of Pointed Firs,” and Leslie Marmon Silko’s 1999 *Gardens in the Dunes*), and the course kept the literature relevant until the end with a comprehensive final essay exam that required students to integrate the course texts with the environmental themes discussed in class.

Furthering the authenticity and meaningfulness of the first essay task, students uploaded the paper, upon completion, to the Geneseo Food Project (<http://www.geneseo.edu/food_project/agri-culture>), a website moderated by Cooper (2011). Therefore, unlike Howes et al. (2003), who segregated online work and field work into two groups, “Literature and the Environment” created a direct link between students’ technology use and field work. However, due to a lack of professor follow-through on the online essay submission, many students never uploaded, so this interdisciplinary component was never fully actualized during the Fall 2011 semester (although, based on the website content, the digital link was achieved in a 2008 run of the elective). As a side note, Cooper (2011) encouraged original photograph accompaniments to the first essay assignment, embracing the perception that visuals enhance cross-curricular communication (Howes et al., 2003, p. 499; Peterson et al., 2006, p. 36; Furlan et al, 2007, p. 1626).

With the first essay paralleling the task of Howes et al.’s (2003) field researcher/writer group, the second paper embodied the premise of Howes et al.’s (2003) internet researcher/writer group. The longer second essay was a basic, online-sourced research paper about a particular environmental discourse. Lastly, “Literature and the Environment” attracted a heterogeneous student body of biology and English undergraduate majors, which bolstered the interdisciplinary potential of in-class discussions about the course texts (i.e. the English professor often picked on the biology majors during class to elicit a science perspective on the reading). Therefore, due to a technology component directly relevant to students’ field work, a literature-infused curriculum, and introspective writing as well as research writing from both hands-on and online environmental research, Cooper (20011) designed an elective course that overlapped the disciplines of literature and science in a variety of meaningful ways that collectively redeem the interdisciplinary potential of English with environmental science after Ronau & Karp (2003) and Howes et al.’s (2001) inferior efforts.

 Returning to the secondary level but staying with the idea of hands-on learning in interdisciplinary collaborations, Haviland (2005) experienced success with an eighth grade middle school lesson involving a hands-on science extension activities inspired by a picture book. First, the teacher read-aloud of Dr. Suess’s *Bartholomew and the Oobleck*. Despite its elementary association, the tale of how a king’s desire for an alternative to rainfall brings a sticky – problematic – substance, called “oobleck,” from the skies in the Kingdom of Didd engaged all students (Haviland, 2005, p. 14). Bringing the text to life, students then made “oobleck” (cornstarch and water) and “gack” (glue, water, and borax solution). By comparing and contrasting “gack” and “oobleck” through observation and chemical reaction tests (Haviland, 2005, p. 14), students were led into an effective, literature-based, and hands-on chemistry lesson, despite teacher beliefs that such triangulation is impossible (Plummer & Kuhlman, 2008, p. 95; Fang & Wei, 2010, p. 265).

**Post-Secondary Education**

Of the four interdisciplinary college courses highlighted – “Science as Narrative,” “Depictions of the Theory of Evolution in Science Fiction,” “Chemical Engineering and Science Fiction,” and a first-year general chemistry course – only one was a course in the English major track and only one chose poetry over science fiction as its literary component. They were evenly split in subject matter between the physical sciences and the life sciences, and they were also evenly divided between required courses and optional electives. Therefore, although a small sampling, the breakdown indicates a potential lack of science-literature interdisciplinary opportunities for college English majors and professors’ possible higher confidence level with science fiction-based science instruction over poetry-based science instruction. The courses also draw heavily from classical science fiction, neglecting contemporary works in the genre. Overall, unfortunately, many exhibited design and implementation flaws that prevented them from being authentic and mutualistic interdisciplinary collaborations between English and science.

Due to the unsatisfactory initial implementation of their compulsory sophomore English course, “Science as Narrative,” Hamdan, Vengadasamy, Hashim, & Yusof (2011) explored its design flaws by surveying past and incoming students to gauge the former’s perceptions of the course and the latter’s expectations for the class. Offered at Universiti Kebangsaan Malaysia, “Science as Narrative” is an international example of a college-level science-literature collaboration. Embracing one of James Gunn’s three approaches to teaching the genre of science fiction – “the ideas in Science Fiction” (historical and “great books” are the other two) – the course sought, as its main objective, to help students relate science fiction themes to contemporary contexts (Hamadan et al., 2011, p. 416). However, due to a lack of familiarity with the science fiction genre, the students were unable to achieve what Fountas & Pinnell (2006) would call “within,” or literal, text comprehension of the works, rendering them incapable of participating in the desired text-to-world discussions. Consequently, the course dissolved into one-sided lectures that merely informed students of the texts’ literal meaning, like plot and conflict (Hamadan et al., 2011, p. 416).

According to the questionnaire results, both the incoming and prior students believed that they needed knowledge of science to study the science fiction in the course successfully. The prior students claimed that they had expected to be “exposed to terms related to the genre as well as science to overcome their unfamiliarity with the genre” (Hamdan et al., 2011, p. 417-418). After reading the course description, the incoming students believed that they would be “learn[ing] about scientific concepts and theories” (Hamdan et al., 2011, p. 417). By classifying this as a “misconception” about the course, Hamadan et al. (2011) revealed that their course, in its original design and intention, did not see the need to acknowledge science’s role in the stories to scaffold the students’ relation of the science fiction to real-world issues (p. 417). Therefore, “Science as Narrative” was not actually offered or designed as a science-and-literature interdisciplinary course. And due to the first trial run’s failures, that decision proved detrimental. The prior students cited three primary reasons why they struggled in the class: fantastical terms and concepts imagined by the author; hard-to-visualize settings; and unknown, but plot-advancing (so important), science concepts (Hamadan et al., 2011, p. 418). The last directly stems from the absence of science instruction in the literary course. If implemented, all of the proposed revisions for the course would reconstruct it as a more genuine science-and-literature collaboration.

Based on the questionnaire data, Hamadan et al. (2011) arrived at four primary course revisions: film study supplements to the readings, topic-based discussions instead of only theme-based discussions, nonfiction science and technology paired texts, and the preteaching of pertinent science concepts (p. 418). Not only do the revisions account for the students’ perceptions of their needs, but they also align with the educational theories on how best to scaffold students’ to scientific literacy through a science-English interdisciplinary approach. Especially since Fang & Wei (2010) stressed that a way to “improve students’ science reading is to build their background knowledge about science” (p. 263) and Bull & Dupius (2014) agreed, the last three modifications would be a thorough approach toward explicitly teaching the science topics and concepts in the short stories to aid reading comprehension. However, just as Sackes, Trundle, Flevares (2009) found that many science-based picture books held a combination of fantasy and science ideas, the prior students claimed imaginary settings and imaginary concepts in the science fiction hindered their comprehension. And those two sources of confusion are applicable to the genre as a whole, since “science fiction….digs into scientific concepts with imagination, creativity” (Czerneda, 2006, p. 39), so the mix is commonly employed. Therefore, although the content of the proposed topic-based discussions was unspecified, they should differentiate the fantasy and science topics in the stories, an important clarification for students that can be achieved through simple discussion according to Sackes et al. (2009).

After recognizing student’s negative perceptions of introductory chemistry courses at the University of Pittsburgh at Titusville, Furlan, Kitson, & Andes (2007) revamped the standardized, “stressful and demanding” instructional procedures (i.e. weekly quizzes, class note-taking, homework, etc) with an annual poetry poster project. The university professors described their experiences after eight years of success with the interdisciplinary assignment. Since the project is founded on the idea that “beauty, elegance, and emotional enjoyment are often the sources that inspire and enthuse us to engage, learn overcome, and discover” (Furlan et al., 2007, p. 1625), the rationale aligns with how Lightman & Goldstein (2011) described what English can offer science in the broad terms of what fiction brings to nonfiction topics: fiction has an “emotional impression on us, and that impression is very deep.” The professors believed the way in which the project would emotionally engage students would lead not only to a more varied curriculum, but to students’ increased understanding of, and interest in, chemistry.

To launch the project, a professor from the Humanities department would visit the chemistry lecture and spend twenty-five minutes highlighting the ideal visual and textual components of research posters through examples from past semesters. A professor from the English department was also invited for the same length of time and overviewed the essential elements of good poetry. However, the English professor organized his mini-lesson generally, describing six basic guidelines about form and literary elements with model poetry not necessarily embracing a chemistry subject. Therefore, he was missing the task-specific relevance in his modeling that the poster presentation possessed through use of past course posters. Not only are task-specific examples normally important to students (Gore, 2010, p. 80-81), but both Sundaralingam (2011b) and Snow (1959) identified specific flaws that emerge from science-poetry collaborations. That indicates that a general introduction to the qualities of well-written poetry may not provide students with the specific preparation needed to best execute their task. For example, the English professor advised that students avoid cliché expressions and “humdrum platitudes” are a common problem of scientific poetry because they often fail to “reenvision scientific data with fresh metaphors” (Sundaralingam, 2011b). However, the English professor only provided examples like “happy as a clam” and “clever as a fox” (Furlan et al., 2007, p. 1626), rather than examples of trite scientific metaphors which would probably be more difficult for students to think of their own, and thus more beneficial for the professor to model.

The two month-long project accumulated to 3% of students’ course grades – the equivalent of two lab reports – and ended with a round table (not whole-class) poster presentation, award competition, and hallway poster display (Furlan et al., 2007, p. 1626-1627). Generating only four negative comments out of forty students, the project made chemistry enjoyable, provided chemistry review, and motivated outside research on chemistry topics, according to student reflections. Through Furtan et. al’s (2007) inclusion of original poetry in this interdisciplinary approach, the project adheres to many educational theories that suggest the development of scientific literacy in science-English cross-curricular approaches with student-generated texts (Howes, Hamilton, & Zaskoda, 2003; Peterson, Rochwerger, Brigman, & Wood, 2006; Fang & Wei, 2010). Peterson et al., (2006) stressed the importance of expanding students’ science writing beyond lab reports, offering fictional narrative as an ideal alternative (p. 32). Fang & Wei (2010) urged that school science curriculums incorporate student-generated texts into their goals: the curriculum should foster “students’ ability to access, comprehend, and produce science texts” (p. 262). Through a middle school student survey, Howes et al. (2003) found that students only correlated note-taking and rewriting texts with ways to write in response to science reading (p. 500-501). As part of their opening rationale for their poetry-creation approach to chemistry, Furtan et al. (2007) acknowledged the dominance of in-class notetaking (p. 1625), suggesting that the interdisciplinary approach sough to expand students’ beliefs about the possible types of science writing.

Interestingly, the poetry project’s effect on lower-ability level students is comparable to the effect of Miller’s (2008) infusion of digital-video technology into an eleventh-grade English classroom. Furlan et al. (2007) noted that the best poetry posters were often created by the “B-” and “C-” students, not the course’s “A” students (p. 1629 - although maybe the top students were the only ones who were smart enough to realize a project worth 3% of their course grade did not warrant a strong work ethic, haha). Similarly, a Digital-Video project prompted an “impressive change” in Darrius – a notoriously “nonresponsive” English student and a “troublemaker” – who sacrificed lunch periods and stayed after-school to work on his book-based movie (Miller, 2008, p. 447).

Both studies offer an insight, which is transferrable to the other, of why it was successful in that specific way. Miller’s (2008) reflection on how “the arts encircle learning with meaning and thereby make comprehension and engagement fundamental for participation” (p. 447) is relevant to the interdisciplinary poetry poster because it promoted students to express chemistry “aesthetically” (Furtan, Kitson, & Andes, 2007, p. 1625). Furtan et al. (2007) mentioned that its poetry poster was an unconventional assessment measure and that many of the students who excelled on the posters received poor test scores (p. 1629). The combination of those two points – which are also applicable to Miller’s (2008) iMovie through Darrius – suggests the importance of allowing students to demonstrate their knowledge in a variety of formats to combat the fallibility of traditional assessment measures, like tests or essays. The fact that this analog interdisciplinary approach had similar positive effects as a digital media project seems notable in this digital age where students are all digital natives.

Although it was not an initial goal of the project, the consequences of Furlan et al.’s (2007) poster hallway exhibit feeds directly into Snow’s (1959) call for more communication between scientific and the non-scientific minds (p. 2-3). One student reflected, “It was cool trying to help ‘outsiders’ understand a little more about chemistry” (Furtan et al., 2007, p. 1627). Further substantiating that the poetry posters were “an aesthetic presentation of materials that engaged the general viewer,” a non-chemistry faculty member praised the project for allowing him to encounter aspects of chemistry he would not have come across otherwise, and another took home several posters to hang in her elementary son’s bedroom with the intention of sparking his interest in the sciences (Furtan et al., 2007, p. 1629). Therefore, not only did this interdisciplinary project enhance the comprehensibility of a chemistry curriculum for chemistry students, it enhanced a public audience’s understanding of chemistry.

As the former professor of an honors biology course, “Depictions of the Theory of Evolution in Science Fiction,” Bixler (2007) highlighted one of her two-day lecture lessons to exemplify the potential to integrate science fiction and evolutionary science for educational purposes. However, the described approach falls short in several ways. After taking the first day to teach speciation, Bixler (2007) reinforced the evolutionary topic during the next lecture session through H. G. Wells’ 1895 science fiction novella, *The Time Machine.* Interestingly, this approach differs from Haviland (2005) and Ronau & Karp’s (2001) approach; they introduced the science concepts through the literature first (Dr. Seuss and *The Wartville Wizard*, respectively). However, like Bixler (2007), Peterson et al. (2006) embraced literary reinforcement in her simple machines lesson, and that ordering corresponds with the idea of building background knowledge to navigate science texts (Fang & Wei, 2010, p. 263; Bull & Dupuis, 2014, p. 75)*.* Studying which order is more effective would be interesting.

Bixler (2007) admitted rarely requiring students to read the novella to reinforce the science on the second day (p. 338). When discussing the use of literature to supplement science concepts, Haviland (2005) acknowledged the superfluity of “overwhelm[ing] [students] with the whole book” (p. 15). However, Bixler (2007) detrimentally surpasses the alternative posed by Haviland (2005): reading just a section of it in class (p. 15). An excerpt saves time and decreases the cognitive burden of the integration while still providing students with an authentic text experience. In contrast, on the second day, Bixler (2007) exposed her students to the story only through an oral recap or a summary handout (p. 338), even though authentic text exposure was feasible and necessary. Not only is the original novella less than 100 pages, *Graphic Classics* offers a 40-page graphic novel version (Capututo & Frail, 2005, p. 97-137). After being introduced to the story, students formed groups to discuss questions that prompted them to relate the story to speciation. It is severely questionable how insightful such discussions would be if students only had a summary-level knowledge of the story’s plot to draw from. Depriving students of the real text limits both the quantity of interdisciplinary connections they can make and their ability to see how the science actually operates within the literature. Using an oral or written summary as the literature component of an interdisciplinary collaboration with science is overly superficial and thus barely didactic.

Bixler (2007) also taught her course through the lens that “science fiction frequently contains errors” (p. 337), outlining her use of *Spider Man* or *The Incredible Hulk* to show students their inaccurate portrayal of mutational changes in an entire organism (p. 339). While Czerneda (2006) acknowledged that this is one of the most common classroom uses of science fiction, she discouraged the approach because it results in “students who come to distrust anything that sounds like science” in literature and because “science fiction has so much more to offer in terms of good science and how science works” (p. 39). By constantly and exclusively having students pick out the flaws in science fiction, they are taught that literature corrupts, not enhances, science. So the gap between English and science continues.

Despite these prominent design flaws, Bixler (2007) offers a valuable comparison that illuminates why fiction is an ideal instructional supplement to science. Even though real case studies of science concepts are abundant, they often include difficult secondary concepts and their associated jargon. Therefore, since “fictitious examples provide entraining and easy-to-understand scenarios, but ones into which students may delve deeply and thus discover much” (Bixler, 2007, p. 337), fiction is a more engaging and understandable medium that doesn’t sacrifice science content depth to be so. Bixler’s (2007) perspective contradicts the concern that “hybrid books that present the scientific concepts in a narrative format might not accomplish the task of teaching the language of science to children” (Sackes, Trundle, & Flevares, 2009, p. 416). However, she joins others who have voiced similar counterarguments in defense of fiction in science instruction. Since people think in terms of narrative structures (Tunnell & Jacobs, 2008b, p. 142; Kazerneck, Louisell, & Wellike, 2004), Morrow, Pressley, Smith, & Smith (1997) also assert that introducing scientific concepts in a familiar language would be inevitably beneficial for children (p. 58). Even though how Bixler (2007) approaches interdisciplinary collaborations between English and science is imperfect, at least the reason why she tries to collaborate is on target.

As professors of the “Chemical Engineering and Science Fiction” undergraduate elective at Simon Bolivar University, Derjani-Bayeh & Oliversa-Fuentes (2011) used an English-science interdisciplinary approach to teach chemical engineering through the deconstruction of science fiction’s unrealistic portrayal of outer space-based science concepts, similar to Bixler (2007) and as frowned upon by Czerneda (2006). In one part of the course, students read Ben Bova’s 1999 science fiction novel, *Return to Mars*. Since the slipperiness of dry ice sheets is a recurring danger throughout the story as astronauts attempt to climb a mountain on Mars, students were tasked with researching the atmospheric conditions of the planet and constructing its pressure-temperature phase diagrams to determine whether the dry ice conditions described in the story were valid (Derjani-Bayeh & Oliversa-Fuentes, 2011, p. e104-e106). As another course assignment, students read Poul Anderson’s 1954 science fiction short story, “The Big Rain,” and Frederik Pohl and Cyril M. Korthbluth’s 1952 science fiction novel, *The Space Merchants.* Revolving around the human colonization of Venus, both texts propose the use of “Hilsch tubes” to harness Venus winds into a cold stream (to refrigerate settlers’ shelters) and a hot stream (for power generation). Students researched thermodynamics and the atmospheric conditions of the planet to determine whether such would be possible (Derjani-Bayeh & Oliversa-Fuentes, 2011, p. e106-e109).

Both of the designed student explorations led them to discredit the science fiction: the perpetual instability of carbon dioxide on Mars does not allow high enough pressure for slippery dry ice; and the performance of Hilsch tubes on Mars would be tremendously less efficient than presented (Derjani-Bayeh & Oliversa-Fuentes, 2011, p. e106, e110). Therefore, even though the professors recognized that books can “create an interest, where, unhappily, science alone might fail” and used the literature as vehicles for very student-centered, sophisticated assignments (p. e103), they still ultimately cast literature’s relationship with science in a negative light. Through their assignments, Derjani-Bayeh & Oliversa-Fuentes (2011) presented literature as untrustworthy sources of science content even though science fiction often does accurately portray science concepts because their authors ensure they are well-informed and well-researched (Czerneda, 2006, p. 39; Stewart, 2000, p. 17). Their one-sided spotlight on science fiction perpetuates the illusion of literature’s inability to house science without misconstruing it. Reading science fiction merely to debunk its science also perpetuates another popular belief that polarizes literature and science: fiction is read for pleasure and only nonfiction is read for knowledge and information (Lightman & Goldstein, 2011; Kesler, 2012, p. 341).

**Conclusion**

The overabundance of didactic texts and classical science fiction accentuates the glaring absence of poetry in current English-science interdisciplinary approaches. It is understandable based on how the proverbial “poetry phobia” affects students and teachers alike, but unfortunate based on the timelessness and seriousness of the integration – it dates back to 1755 with a poem line engraved on the base of a Newton statue (Fara & Money, 2004) and was officially recognized by scientific journals in 1984 with the publication of a astrophysics paper as a 38-stanza poem (Popova, 2013) – and how almost every theory advocating the relationship between literature and science specifically cites the benefits of poetry and doesn’t cower under the umbrella term of “fiction.”

There were many areas that appeared in the educational and general theories behind science-English interdisciplinary collaborations, but were not well-represented in practice. Most integrations came together to address concrete topics – like bird adaptations, solvable outer-space atmospheric conditions, and litter – not mysteries (Sundaralingam, 2011a; Lightman & Goldstein, 2011). And explicit reading strategy instruction to aid the navigation of science texts only appeared loosely in two approaches, despite the research (Grant, 2004, p. 35; Fang & Wei, 2010, p. 263). However, the collaborations did offer some helpful insights into effective approaches. They also raised awareness about potential problems, so they can be anticipated, prepared for, and avoided in the future. For example, the idea of staggering the end points of simultaneous units shined as a big takeaway. And students’ difficulty navigating science fiction’s imaginary concepts illuminated the need for visualization activities and explicit differentiation between fantasy and science elements in literature. We may still have a lot to learn in terms of secondary English and science interdisciplinary instruction, but we also have a lot to listen to.

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