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Abstract

Upward Bound Math and Science, a federally funded initiative, aims to persuade U.S. high schoolers to become college STEM (science, technology, engineering, mathematics) majors. The program attempts this persuasion by developing students' content and procedural knowledge so that students may succeed in high school and college STEM courses. Primary focus on knowledge acquisition, however, may cause missed opportunities to engage the imaginative dimensions of students' science identities and students' senses of wonder for science. In this reflective essay, I describe a *science fiction prototyping* assignment that meets the knowledge-based objectives of the Writing Skills course in a five-week Upward Bound summer program at one Eastern U.S. public university and, at the same time, prompts students to perform science identities by writing narrative genres that echo students' *wonder-at* attitudes toward science. This assignment is informed by science educator and theorist Yannis Hadzigeorgiou's argument that imagination should be at the center of science education, as well as by Etienne Wenger's communities-of-practice framework that describes imagination as one key way of forging belonging in society. By thinking about how future innovations may impact future families through the activity of composing a narrative and an informative genre, students communicate understanding and wonder for science to disciplinary and general audiences, with benefits for their attitudes toward and identities related to science.

Author/Artist Bio

Justin Nicholes' research explores the role writing plays in constructing disciplinary identities, enhancing disciplinary learning, and supporting retention efforts.

Keywords

UBMS, Science Fiction Prototyping, STEAM, Writing Skills

Developing STEM Interest and Genre Knowledge Through Science Fiction Prototyping

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Introduction

Assignment Context

Upward Bound Math and Science, a federally funded initiative in the United States, recruits high schoolers into year-round programs in hopes of enticing them to become college STEM majors ("Programs: Upward Bound Math-Science," 2017). For years, recruiting and retaining STEM majors has challenged U.S. higher education, in part because economic projections have estimated a need for "approximately 1 million more STEM professionals than the U.S. will produce at the current rate over the next decade" to remain competitive in the world (President's Council of Advisors on Science and Technology [PCAST], 2012, p. i). Research into STEM-student retention offers justification for programs such as Upward Bound as remedies for addressing the STEM-student shortage. After all, high schoolers' exposure to STEM-field courses has been associated with students choosing STEM-field majors in college (Wang, 2013), and, in addition to overall high school GPA (Wao et al., 2015), grades specifically in high school math have been associated with students becoming college STEM students (Wang, 2013). In addition to grades, having friends in a common STEM major helps students persist in college STEM programs (Ost, 2010). As a year-round program with a summer-experience immersion module, then, Upward Bound represents a response to a U.S. economic and higher-education need by aiming to help students develop skills to succeed in high school and future college STEM coursework and to become socialized into college and STEM disciplinary communities.

Additionally, Upward Bound exclusively recruits potential first-generation college students and/or students from low-income households. In this way, Upward Bound seeks to prepare students at higher risk of dropping out of college in general (Martin Lohfink & Paulsen, 2005; Padgett, Johnson, & Pascarella, 2012; Soria & Stebleton, 2012) and of dropping out of STEM majors in particular (Mamiseishvili & Deggs, 2013). Upward Bound, then, represents an initiative that seeks to establish greater equity in the U.S. regarding who becomes a scientist and who directs scientific inquiry. A diverse population of scientists that more closely reflects the diverse population of the U.S. ought to assist in scientific inquiry and localized initiatives responsive to diverse needs.

Imagination, STEAM, and Science Fiction Prototyping in Science Education

Yet while Upward Bound is an evidence-based response to the importance of community building and knowledge acquisition to recruit and retain college STEM majors, I argue this focus on learning risks missing chances to engage the imaginative dimensions of students' science identities and students' senses of wonder for science.

As a teacher of Writing Skills in the Upward Bound program at an Eastern U.S. public university, I have attempted to draw on the work of Hadzigeorgiou (2016), who has emphasized the importance of imagination in STEM education and, in particular, the way narrative writing and thinking promote students' senses of wonder toward science (Hadzigeorgiou & Fotinos, 2007). I have attempted to operationalize the importance of imagination encouraged through narrative genre composition through a science fiction prototyping assignment, which I have designed both to meet the knowledge-based objectives of the Writing Skills course in the five-week Upward Bound summer program and, at the same time, to prompt students to perform science identities by writing narrative genres that reflect students' *wonder-at* attitudes toward science.

Science fiction prototyping (SFP) had been defined as "a learning activity where fact and imagination are coupled to create a story of how an innovation put to use in a future setting would affect the people of that time socially and economically" (De Lepe, Olmstead, Russell, Cazarez, & Austin, 2015, p. 190). A type of forecasting, SFP results in the making of *fictive scripts* (Garraway, 2016) that prompt students to learn about an innovation as they construct plausible yet imaginary scenarios. Used in industry and higher education to communicate and develop ideas (Atherton, 2016; Draudt et al., 2015; Kymalainen et al., 2015), SFP was something I attempted to leverage to spark students' imaginations about science and to provide opportunities for students to discover how science writing can involve both informative/persuasive genres, such as posters and lab reports, as well as narrative genres, such as short stories, comic-book stories, and photo essays.

As I have tried to employ it, SFP operationalizes the STEAM movement in science education, defined by Yakman (2012) as "Science and Technology, interpreted through Engineering and the Arts, all based in Mathematical elements" (p. 15). According to Wynn and Harris (2013), "STEAM is an opportunity for teachers to partner, learn, and teach about the many areas where art and STEM intersect" (p. 53). How best to implement STEAM has been debated, with Clapp and Jimenez (2016) describing "STEM-with-stickers" approaches, where art is included incidentally and peripherally to meaning making and communicating of science. In developing my SFP assignment, I attempted to use narrative writing of imagined futures as a central imaginative activity, in that way skirting a superficial application of art.

Successful Outcomes and Limitations of the SFP Assignment

The SFP assignment promises excitement in the classroom. At the start of the assignment, students are asked to read the *SmartThings Future Living Report* (Aderin-Pocock, Mamou-Mani, Burgess, Aitken, & Leclercq, 2016) to choose a future innovation, such as aquatic homes, integrated artificial intelligence, homes equipped with medical screening technology, or other predicted innovations. Because futurists have predicted these innovations could plausibly become reality, this assignment qualifies as science/speculative fiction rather than fantasy fiction, making it an easier sell to science students who may perceive science writing as excluding imaginative or creative writing (Nicholes, 2018). Seated in a computer lab classroom, students have enthusiastically blurted names and descriptions of predicted innovations that surprised them, with other students going online to read more about encountered innovations and examples of other plausible, life-changing innovations. One positive outcome expected from this assignment, then, is a level of wonder and excitement for scientific and technological innovations to come.

Yet another positive outcome concerns the involved thought that goes into constructing a fictive script about a family interacting with an innovation. After students choose an innovation to write about, they are then asked to select a narrative genre to convey a fictive script. They may choose to compose a comic-book story, a photo story, or a short story. Whatever genre they choose, students must explicate that genre’s signature rhetorical situations. That is, students have to describe the usual audience, purpose, rhetorical appeals, and stylistic and formal conventions that characterize that genre. Students also must purposefully use modes of fictive characterization, such as description, action, thought, exposition, and dialog. After narrative writing, students compose informative genres as if the innovation existed today. This genre, such as an encyclopedia entry or news report, again requires rhetorical analysis of model genres and composition in response to characteristic genre conventions. Since students' ability to be explicit about their writing choices in specific communities has been associated with writing-skill and writing-knowledge transfer (Adler-Kassner, Clark, Robertson, Taczak, & Yancey, 2016; Driscoll & Wells, 2012), another positive outcome of this assignment is that students demonstrate rhetorical knowledge concerning target genres and systems of human interaction where those genres work. The aim is that this assignment supports the summer class's goal of fostering transfer of knowledge to later writing situations across disciplines.

The SFP assignment, however, has its limitations. Without careful scaffolding toward the composition of a narrative genre, students may begin composing drafts that inform about an innovation rather than tell a story about a family. That is, genre analysis to understand how narratives engage readers needs to happen at various points during the composition of narratives. This should be done to help students avoid reporting about the details of an innovation while neglecting to develop characters and conflicts that they imagine could arise as people interact with future innovations. Another challenge related to this assignment concerns what young potential STEM majors may believe counts as STEM writing. My research into undergraduate chemistry majors' feelings toward disciplinary writing experiences, including the composing of research posters and lab reports, has indicated that science majors may prize past creative writing experiences but nevertheless understand STEM writing as distinct from "real" or "creative" writing happening in English classes (Nicholes, 2018). Indeed, that scientists have varying understandings of what science writing entails is corroborated by the research of Emerson (2016), who conducted 106 semi-structured narrative interviews over five years with scientists in North America, the United Kingdom, and Australia from 17 total universities, concluding that scientists with greater confidence and a broader understanding of science writing as comprising multiple genres were most likely to write for disciplinary *and* public/layperson audiences.

In future usage of SFP, I will attempt to capitalize on the positive outcomes of the assignment while addressing its potential limitations. For instance, after students have explored and expressed wonder for possible future innovations and worlds, students should then go through activities that prompt greater reflection and application. One way of fostering structured reflection and application is through Johnson's (2011) proposed SFP sequence, which includes steps of,

1. *Picking an aspect of science/building a world*, in which authors select an innovation and build a setting where that innovation exists.
2. *Scientific inflecting point*, in which authors explore and describe a challenge or failure of that innovation.
3. *Ramifications of science on people*, in which authors explore how that challenge or failure would affect people.
4. *Human inflection point*, in which authors explore how people would respond or react upon the challenge or failure.
5. *Reflection on lessons learned*, in which authors explicate a lesson or moral.

Johnson's process can be used in future SFP assignments to facilitate post-draft reflection and revision. Additionally, this sequence allows for analysis of how other authors used Johnson's sequence themselves, as illustrated, for instance, in Burnam-Fink (2015), who described SFP products resulting from a SFP event among artists and scientists hosted at a Western U.S. university. Students could benefit from having models to follow and build upon at various points in the composition experience.

Imagination's Role in Science Identity Construction

Sparking students' imaginations so that they feel wonder toward science has been described as a prerequisite for maximally efficient learning of science content (Hadzigeorgiou, 2016; Hadzigeorgiou & Fotinos, 2007). Yet, in addition to nurturing excitement for and learning of content and procedural knowledge, imagination also represents a powerful way that people develop ways of belonging in communities (Wenger, 1998). In Wenger's (1998) communities-of-practice theory, identity forms *in context* and signals belonging, and this belonging can be achieved in three main ways:

1. *Engagement*, meaning active involvement in mutual processes of negotiation of meaning [related to how practice relates to reifications].
2. *Imagination*, creating images of the world and seeing connections through time and space by extrapolating from our own experience.
3. *Alignment*, coordinating our energy and activities in order to fit within broader structures and contribute to broader enterprises. (pp. 173-174)

Ultimately, identity construction is mediated through Wenger's modes of belonging, including more immediate engagement with and more remote imagination about communities.

Looked at through a communities-of-practice framework (Wenger, 1998), Upward Bound Math and Science attempts to leverage mainly *engagement* as a mode of belonging in college STEM communities. This can be seen in the program's mission of providing students with exposure to math and science classes as well as with STEM educators and classmates ("Programs: Upward Bound Math-Science," 2017).

Imagination as a mode of belonging, however, can be purposefully leveraged as well. Through the science fiction prototyping assignment described in this reflective essay, I have suggested one way of doing so. The assignment asks students to investigate future innovations that are plausible, to imagine how people will interact with that innovation, and to conclude what final lessons or ethical considerations arise from this interaction. At the same time, students conduct rhetorical analyses meant to sharpen their collection of vocabulary and terms useful for understanding genres meant to inform, such as research posters and lab reports, and genres meant to tell stories, such as short stories, comic-book stories, or photo essays. This explicit discussion of how other genres work promises transfer of writing knowledge to other writing situations and communities, in that way meeting knowledge-based objectives of the Writing Skills course. The final outcome of science fiction prototyping may be a chance to expand how young, future scientists understand what counts as science writing while, at the same time, helping students realize and convey wonder toward science and their belonging in STEM disciplines.

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Appendix A

Science Fiction Prototyping Assignment

Science fiction prototyping (SFP) is "a learning activity where fact and imagination are coupled to create a story of how an innovation put to use in a future setting would affect the people of that time socially and economically" (De Lepe et al., 2015, p. 190). This assignment has two parts: a narrative component and an informative component. In part 1, think of some possible (not purely fantastic or impossible) future innovation in science, technology, engineering, or math. Write a story about how that future innovation would impact an imagined future family. This future innovation should be designed with the hope of improving people's lives (which excludes weaponry or other tools for hurting people) even though it may have unintended negative consequences. **Possible narrative genres you may choose:** a comic-book story, a photo story, or a short story. In part 2, imagine that this new innovation already exists. Now, give information about this new future innovation using an informative genre. APA formatting will be needed for any in-text citations and end-of-text references. **Informative genres you may choose:** encyclopedia entry, charts/infographics, a news article, a documentary film, or a business memo.

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