Using Science Fiction with School Librarians to Interest and Engage Middle Schoolers in STEM Activities and Topics

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Introduction

Even as curricular content has become increasingly standardized and teachers have decreasing choices about what material they can present, the popularity of science fiction (SF) has returned to the STEM (Science, Technology, Engineering, and Mathematics) classroom. Researchers are exploring this potent resource through the lens of interest development. School librarians, in a welcoming environment for all students, offering project-based curricula driven by guided inquiry and information searching skills, is a potentially effective fulcrum around which STEM subject learning revolves.

STEM education remains one of the hottest topics in educational circles, and countless opinions are being forwarded nationwide about how to best present this material and motivate all students to participate more fully in STEM education and STEM-related activities (Herschbach, 2011). Since the 1950s, educators have touted the use of science fiction (SF) literature both as a motivational teaching tool and as a method to integrate and lessen the anxiety level of some students who fear what they do not yet understand. While some students seem to be predisposed to appreciation of STEM activities and thinking, many students simply do not like and/or are intimidated by STEM subjects and their related concepts. Working with SF does have a generally positive effect on student attitudes toward STEM subjects (De Lepe, et al, 2015) and it shows great promise for STEM interest activation and maintenance.

Why SF?

One of the strong connections between SF, STEM, and career choice is the reality that SF has been dominated through the years as much or more by scientists as by literati. This is one unfortunate but genuine explanation of the gender imbalance in published SF up until this time. An unfortunate misogyny and patriarchy have dominated both authorship and subject matter of SF (Levy, 1999). Generally, gender has the most situational effect on topic interest (Ainley, Hillman, & Hidi, 2002), and situational interest is triggered much more than individual interest. Topic interest also affects persistence, and to a lesser degree, affective response. Girls are more likely than boys to explore lower-interest titles. When topic interest triggering influences affective responses, reading persistence, and ultimately learning. Lower interest materials require more persistence, something girls have more than boys in those situations (Ainley, Hillman, & Hidi, 2002). This reading persistence is something that should be fostered in all students regardless of gender. These levels should be addressed to ensure that STEM career possibilities are available to the greatest number of students.

In *Science Fiction by Scientists* (2017), editor Michael Brotherton professes both his love of science and the clear connection between science and scientists by introducing and compiling stories by active researchers, "working at universities, medical schools, and space agencies . . . [and including] astronomers and physicists . . . neuroscientists, computer scientists, and rocket scientists" (Brotherton, 2017, p. vi). SF is popular with engineers and scientists because it ". . . connects with the human spirit of adventure and imagination" (Shumei Zhang & Callaghan, 2014, p. 353) and empowers designers to innovate. Scientists like SF so much that some of them feel compelled to use their STEM-subject related experience and interest to write SF and disseminate and share their appreciation for the role that SF played and continues to play in their lives and careers. Barry Luokkala (2014) also begins his book *Exploring Science through Science Fiction* by professing his early love of science and SF, but after realizing that SF can be used to teach Science, he begins to incorporate SF film clips and television episode excerpts into his classes to use as a springboard for scientific learning. His seven areas frequently found in SF (Luokkala, 2014) offer a manageable framework to examine student interests and find potential entry points into student contexts, with augmented subject suggestions:

- Nature of space and time (Astronomy, Physics, History of Science, Gravitation)
- Composition of the Universe (Geology, Matter, Light, Energy)
- Machine consciousness (HCI, Artificial Intelligence)
- Aliens (Anatomy, Biology, Zoology)
- The meaning of being human (Scientific method/Taxonomy, Ethics, Values)
- Solving future problems (Hydrology, Meteorology, Technology)
- What does the future hold? (Computer Science, Genetics, Astronautics) (Luokkala, 2014)

The seven SF realms provide a structure with which to examine practically any STEM-related subject. Middle schoolers learning about the elements might deal with the Universe's composition by reading and watching clips of *The Martian* (Scott, et al, 2016) and examining how the protagonist uses his natural environment to survive, while high schoolers might read and watch *The Bicentennial Man* (2008) to prepare for a discussion of ethics and human-computer interaction (HCI). Luokkala (2014) also offers offbeat, STEM-related issues and questions that will appeal to many students, such as the potential effects of launching students into space from a giant gun (Physics, Geometry, Mathematics), possible first contact scenarios between humans and extraterrestrials (Anatomy, Biology, Zoology), and future solutions to feed the hungry (Agriculture, Technology, Genetics).

As a middle school librarian who introduced SF into a semester-length 7th and 8th grade Robotics class, I have witnessed the light in students' eyes when they watch a clip of *Star Trek: The Next Generation*'s Commander Data (Stewart et al., 2013) display his superhuman strength, intellect, and relative immortality, and I have experienced my students' passion for popular books and movies such as *The Hunger Games* (Collins, 2008) and *The Maze Runner* (Dashner, 2014), both of which offer multiple entry points into STEM-related fields. This is a rich area, ripe with possibilities for inspiring the next generation of scientists. Practicing scientists engage in literacy for a range of purposes, such as explaining their findings, conducting research, connecting to the work of others, or sharing ideas with the public. The increasing diversity of available texts and the accumulation of scientific evidence requires a scientifically literate person to be able to critically interpret an author's stance and purpose, distinguish relevant from irrelevant evidence, and use complex information to make decisions (Goss, Min, & Strohl, 2016).

The current plethora of popular examples of SF with adolescent characters, both young adult (YA) and adult, indicate student interests, and this should be incorporated into STEM-related lessons to enhance interest in the technology those characters use. The choice of a range of speculative fiction (encompassing SF, fantasy and other imaginative ideas) like *Harry Potter* (Rowling, 1998) and *The Hunger Games* (Collins, 2008), or uchronic literature like *The Man in the High Castle* (Dick, 1962), a current Amazon television series, is a logical one for adolescents, considering the connections between SF and the Bildungsroman, or what middle and high school teachers call the "coming-of-age" novel. It is not surprising that many YA series have spawned popular film adaptations. The alienation characters experience in both novels, the way characters feel out of place in their given environments, is a very common theme for adolescents, i.e. Harry is a potential hero at Hogwarts, a fantasy construct, yet he is shunned and misunderstood at home (Rowling, 1998); all of the characters in Dick's novel are existentially in the wrong reality and living a life that never should have existed (Dick, 1962). Buckley (1974) describes the typical Bildungsroman plot as follows: a child gifted in some way is constrained and alienated at home and must leave, and her education in the ways of the world or in the methods of achieving success become equally or more important than school lessons. At the end of the journey, she has been exalted and debased, loved and loathed; she ultimately loses her adolescence and begins her adult journey, sadder and wiser than when she began. That is Harry Potter's journey throughout Rowling's series, and since his story appeals to a wide audience, his use of technology, such as flying during Quiddich, could be a catalyst for a lesson on forces, physics, gravity, mathematics, medicine (if he falls), or any number of STEM subjects. It is also Katniss Everdeen's journey in *The Hunger Games* (2008), a novel that invites lessons on genetics, light, sound, flammable and inflammable materials, weaponry, and an actual example of the media's "fake news" through the representation of the corrupt administration of President Snow (Collins, 2008). The Bildungsroman is the drama of the gifted child (Miller, 1990).

The "bright kid" is one of the most memorable and enduring of the standard characters who comprise a SF story, mainly because many SF fans and authors begin their lives, or see themselves as, those same bright kids, often without the ability to flower and bloom due to societal, familial, cultural, gender-related, or other obstacles, like Harry Potter locked in his closet at home, only able to become his true and fully-actualized self at Hogwarts (Disch, 2005; Rowling, 1998). Those kids often feel out of place and alienated during adolescence, as most people do during rapid industrialization, global wars, deterioration of the cities, and pollution of the environment (Toffler, 1990), all common themes in SF. For example, Asimov's *Foundation* (1951) describes the capital planet of Trantor as so overdeveloped that the only open land on the entire planet is the Emperor's palace grounds; Haldeman's *The*

Forever War (Haldeman, 2009), published at the end of the Vietnam War era, depicts a never-ending war across time; Harrison's *Make Room! Make Room!* (Harrison, 2008), the basis for the popular and still-discussed film *Soylent Green* (Fleischer et al., 1991), is about a world so overpopulated that cities have become slums, drug use is rampant, the environment is a dumping ground, and food is the only important currency that matters to the teeming masses. The "bright kid" is a powerful archetype that should be much more inclusive and appealing; although it is assumed ethically that no one wants to put undue pressure on students, expertise is best developed with a model that feels authentic and a personally-significant reason to strive for it (Goldman, 2001).

In describing the goals of his 2014 work *Exploring Science through Science Fiction*, Barry Luokkala (2014) assumes the connection of SF to science education, promising in the book to use SF as a starting point and anticipatory set for the exploration of popular science topics. Boiero de Angelo, et al (2008) describe the use of SF with English Language Learners (ELL) with enthusiasm, clearly indicating the potential connection to future STEM-related activities and careers by providing access to STEM subjects in a pleasant manner. Though their ELL students expressed surprise at first by the use of SF to teach English, they soon realized the pleasures and benefits: "At the end of the year, however, they felt that reading a story had helped them to access texts other than those specific to their careers, and manifested their interest in reading other stories in English" (Boiero de Angelo, et al, 2008, para. 20). In a similar vein, SF and fantasy (SFF) could assist significantly in the development of science-specific vocabulary, ". . . thereby serving as a bridge from general literacy to scientific literacy" (Rolls & Rodgers, 2017, p. 54). The use of previously-learned biological concepts in the classroom can be the foundation from which students study future directions in SF, offering an ". . . excellent time to develop student awareness of interrelationships among biological concepts" (Marks, 1988, p. 277). Scientific literacy is a key factor in STEM success; scientific literacy demands a new level of critical interpretation of research sources (Goss, Min, & Strohl, 2016). Students often enjoy producing an artifact at the end of a SF-related STEM subject unit, such as an original short story, poem, or film dramatization of a story. The use of technology to learn about technology is both pedagogically sound and important for the development of future productive technology use. The story of Neopets represents an excellent allegory of the power of digital artifact production. Owned by major media corporation Viacom, controllers of children's network Nickelodeon, Robinson & Horst (2010) found Neopets nonetheless to be an engaging gaming site due to its adaptability to individual interests. For example, some participants simply liked the games, while others' interests were drawn to the creative potential of the platform, while still others enjoyed socializing with other Neopets users and sharing their experience in a widening social constructivist environment. This variety offers multiple entry points for diverse audiences.

The Use of SF in the Classroom

SF curricular ideas and pedagogies appear in many forms. Barra (1988) allows students to create stories around chemical equations, formulae, and combinations, hoping to stimulate interest in chemistry specifically and STEM subjects in general. Brake & Thornton (2003) adopt a Dewey-like approach to science education, describing scientific literacy as a right and a requirement for every citizen of a democratic society. They assert that SF is an effective medium through which to examine the relationships between science, technology and society, not only inspiring students to create new ideas and technologies, but to also popularize and disseminate scientific ideas. Czerneda (2006) also notes that SF develops literacies, but she additionally observes that, "We are living in a world that seems science fictional, and SF readers have the advantage of knowing the terrain" (p. 39). With today's rapid technological change and cries of fake news coming from every corner, this may be truer now than ever. Far from just making observations about SF and science, this area features specific curricular suggestions as well.

SF continues to be a catalyst for STEM learning as it struggles to become a more common feature of STEM curricula. Burns (1994) offers the use of Jules Verne's work to teach density and chemical decomposition with the intention of creating an environment in which students can discover the goals and objectives of lessons without having to be told, thereby enabling students to adopt more ownership of and personal attention to activities related to scientific inquiry. Sprague & Cotturone (2003) used *The Science of Star Wars* to teach physics and found their students amazed to discover that they knew more about science than they thought due to SF media exposure, as well as impressed by the actual complexity of concepts like artificial gravity and space travel that are often taken for granted in SF. Freudenrich (2000) asserts that a powerful approach to science teaching is the establishment of a contextual framework for learning, and that SF provides a flexible and accessible introduction to fields such as physics, astronomy, and biology. Freudenrich also argues, like many of the researchers who attempt the integration of SF and STEM, that SF media ". . . readily capture the interest of students, even those who are not SF enthusiasts" (Freudenrich, 2000, p. 45) and that both students and parents enthusiastically embrace this approach. Brake & Thornton (2003) indicate that SF is a cultural phenomenon than encourages scientific creativity and imagination, and it can be used not only to teach specific scientific concepts, but also to analyze ". . . the relationship between

science, technology, and society, both as an inspirational source guiding the direction of scientific development and as a way of popularizing and disseminating scientific ideas" (Brake & Thornton, 2003, p. 32). However, despite the repeated examples of successful implementation of SF into the STEM classroom, the concept never had the opportunity to "go viral" and achieve implementation on a state-wide or national level.

In the last 10 years, the incorporation of SF into the STEM classroom has still remained in the realm of the practitioner, thriving underground but seeing very little of the light of broad implementation due to lack of research support. Studies published since 2010 discuss the use of specific works that have already gained worldwide recognition. Smyth & Waid (2010) present mathematics lessons designed for modern classics *A Wrinkle in Time* (L'Engle, 2007) and *Harry Potter and the Sorceror's Stone* (Rowling, 1998). However, these ideas have largely thrived in limited environments.

Though name recognition of series such as *Harry Potter* (Rowling, 1998)*, The Hunger Games* (Collins, 2008)*,* and *The Maze Runner* (Dashner, 2014) can motivate student interest, not all SF encounters in STEM-related classes must be linked to specific works. Engel & Schmidt (2004) describe a creative and dynamic solution to integrate into mathematics lessons: The Galactic Spaceship Tour Challenge. Students are broken into groups and given a scenario in which they are the owners of a spaceship travel company and must calculate the miles, fuel costs, and other expenses involved in transportation to different star systems in order to charge fair but profitable prices and maintain their business. Engel & Schmidt (2004) maintain that solving individual problems may reinforce basic mathematical skills, but true development and advancement requires larger, more encompassing projects that actively engage students and involve them in social problem solving as well as calculation. Kay & Golden (1991) use a similar method, asking her students to imagine they are on an alien world and describe things like pets, jobs foods, etc. on the new world. Freudenrich (2000) establishes context with a SF film, then addresses scientific forces like gravity and acceleration shown in the film, while Dubeck, et al (1993) makes science relevant by examining concepts in SF films and discussing their potential for actually occurring, leading to discussions on scientific concepts employed in the examples. One particularly compelling idea is to use *Star Wars* radio serials to enhance literacy education (Davis, 2016).

Some researchers have been more ambitious than simply suggesting one unit of study, using literature across the curriculum to promote the power of SF narratives to teach and encourage students to develop research, creativity, critical thinking, debating, and decision-making skills. Goldbort (1991) uses Mary Shelley's *Frankenstein* and other literary works with similar themes, to explore some ethical and scientific considerations of such ideas as cloning, life-prolongation, and genetic engineering, while Burns (1994) suggests Jules Verne's work for brainstorming on how to deconstruct scientific processes. Boblick (1991) digs up old movie serials from the 1940s and 1950s to discuss issues of propulsion, force, and gravity, whereas Smyth & Waid (2010) present ideas for use with many middle school-level SF books like *Flatland* and *Harry Potter and the Sorceror's Stone*.

Perhaps the most compelling idea for an SF literature project uses Susan Collins' *The Hunger Games* trilogy, the most popular SF series of this generation; by 2012 over 50 million copies of the 3 books had been sold (Scholastic, 2012). Cook, Keller, & Myers (2014) offer a unit on genetic engineering featuring *The Hunger Games* (Collins, 2008), complete with tie-ins to national standards and lessons on both scientific literacy and ethical sensibility. Citing Next Generation and Common Core Science Standards, Cook, Keller & Myers (2014) raise real-world ethical and moral questions as they explore the science of genetic engineering, a practice that has existed for many years, in contrast to its use in *The Hunger Games*. Burton, Goldsmith, & Mattei (2018) may as well be describing middle schoolers when they assert that ". . . any field that involves practice requires not only technical proficiency of its practitioners but also ethical proficiency, as manifest not only in a command of the relevant knowledge but also the inclination and ability to let that knowledge take precedence over laziness or self-interest" (p. 58). The idea of ethics education as an element of media education and use is a potent and cogent one. Fiction mirrors life and can therefore represent a form of verisimilitude to which students can relate: "Fiction allows educators to reframe recognizable human situations and problems in terms of unfamiliar settings and technology" (Burton, Goldsmith, & Mattei, 2018, p. 60). The use of SF over other genres is supported: "Science fiction thus permits a curricular design that hews more closely to the concerns and quandaries of computer-related fields of study and work" (p. 59), hence to media studies and education. SF has real-world interest and excitement built in; it is ripe for use to engage and excite students about STEM subjects. By relating science to reality and using highly popular literature to introduce it, educators strive to make STEM material more relevant and more accessible for all. Despite socioeconomic, educational, gender, and racial factors as contributors to the general decline of STEM interest and the exclusivity of STEM clubs and organizations, working with SF does have a positive effect on student attitudes toward STEM subjects (De Lepe, et al, 2015).

These are all compelling lessons and ideas using SF from practitioners and academics working with practitioners, but there is much less evidence that middle schoolers would benefit in the same ways due to their lack

of context of some issues or situations that more mature students may be able to more easily grasp. People are motivated to pursue and engage in certain activities based on two primary factors: desire for accuracy and desire for a particular conclusion (Kunda, 1990). Middle schoolers will develop interest in reading SF and in STEM activities because they think it is the right thing to do and/or because it is the desirable thing to do; the latter is more likely to lead to prolonged interest (Renninger & Hidi, 2016). Prolonged interest needs access to feed it, especially among underrepresented populations. "A vital question to answer is how to engage underrepresented young people in STEM and help them persist in these fields as they progress through their education and professional trajectories" (Subramaniam, et al, 2012, p. 162).

Scientists and science teachers generally like and appreciate SF because it delves into worlds they enjoy thinking about and suggests the possible futures and consequences of their actions (Luokkala, 2014; Freedman & Little, 1980; Marks, 1978). However, there is a disconnect between scientists and science teachers and home life; many underrepresented youth do not have STEM role models at home. Without role models in STEM fields to guide them, many middle schoolers have little opportunity to develop the scientific literacy needed to succeed in increasingly-difficult classes (Ahn, et al, 2014). The concept that SF can help to demystify science for students is almost certainly one of the reasons fans enjoy it so much (Brake & Thornton, 2003). More attention should be paid to students before eighth grade because those years may be more formative to their development of scientific literacy (Tai, et al, 2006). School librarians can fill that role.

Role of the School Librarian in STEM Education

The school librarian should be the captain of the research team, the conduit through which the direction of projects flow. Subramaniam, et al (2015) present a case for ". . . the unique contributions that [librarians] can make to young people's learning of science" (p. 3) and other STEM fields. This is the link to librarianship that drives this study. Most students can Google an answer, but concerns arise about unprepared STEM researchers in a Project-Based Learning (PBL) environment that stresses the use of technology, sourcing, and collaboration among class members and potentially others: Who is teaching them to self-reflect, and what is the value of reflection? Who is teaching resource and content vetting? (Harada, Kirio & Yamamoto, 2008). Specifically addressing middle-level students (ages 8-12), Subramaniam, et al (2015, "Simple") argue for new digital literacy programs in an environment more conducive to ". . . building on tweens' existing heuristics and thereby resulting in strategies that are simultaneously compatible with their natural inclinations within the online environment and likely to consistently lead them to accurate credibility-related judgments" (p. 550). Subramaniam, et al's (2015, "Simple") study illustrates the digital divide, perpetuated by socioeconomic factors, that still exists. Such gaps as the lack of on-grade literacy and reading skills, effective methods to assess online credibility, and lack of interest in accuracy in favor of search result matching key phrases stultify the effectiveness of research and learning. This is a time when school librarians are needed more than ever to teach and promote digital literacy as effective teachers (Mardis, Kimmel & Pasquini, 2018). The problem with school librarians as school leaders and teachers is that few administrators understand and appreciate what school librarians can do and what they are capable of bringing to schools (Mahoney & Khwaja, 2016), so it is unlikely that they will be assigned leadership roles unless they advocate so much that they are unable to perform their daily duties. Although school and district leaders may value media literacy, concerns about lack of funding, teacher training, and an uneven spread of technology across the district are still major factors in decision making (Mahoney & Khwaja, 2016). Time constraints on teachers and school librarians hinder collaboration (Rawson, Anderson, & Hughes-Hassell, 2015). Also, school librarians are not always encouraged to teach due to multiple building responsibilities (Zmuda & Harada, 2008).

The style of connected learning that Subramaniam (2016) describes is ideal for engaging students in STEM subjects and related interests, since many of the activities associated with STEM engagement occur outside of the classroom in informal environments such as social media platforms, clubs, and museums. It follows the Future of Library Services for and with Teens report that advocates for libraries to promote ". . . the three spheres of learning (interest-driven, peer-supported, and academically-oriented) among non-dominant teens" (Subramaniam, 2016, p. 2). Subramaniam suggests using Radical Change theory, a blend of the digital concepts of interactivity, connectivity, and access to promote growth and improved response to teens by librarians. By examining changes in librarians' interactions with teens, a new and more responsive method of engagement can be developed. Her method features the analysis of 23 cooperative learning projects resulting in three themes, all working with children aged 5 to 17: ". . . the foundation for the cooperative inquiry method, a selected cooperative inquiry technique or techniques involving children/teens in the design of technology or learning programs, and an extended explanation of the choice of cooperative inquiry technique in the design of specific technologies and learning programs (beyond simply saying that they used a selected technique)" (Subramaniam, 2016, p. 7). To achieve success, not only do students have to adapt to changes in information content needed in their cognitive toolbox, but also to changes in learning styles and

formats, depending upon societal forces such as technology advancement, sociocultural shifts, and educational trends such as statewide testing. This is a socially constructivist view of learning incorporating a Vygotskian, contextual Zone of Proximal Development (the area between what a person believes she knows about a subject and what she actually knows, and the space in which mentorship is enabled) that aligns with current theories on the ways in which students construct information and seek assistance from mentors and peers. Since students are growing up in a networked world, a networked learning philosophy seems logical and cogent.

Every middle schooler is entitled to the tools she needs to succeed in an uncertain future. School librarians need to be a part of that future. They do not merely create an environment in which higher standardized test scores become more likely (Lance & Hofschire, 2012). The school librarian is the only individual in the building ". . . tasked with building and maintaining a collection of diverse, high quality, current resources that support curriculum, complement adopted texts, enable professional learning, and pique student interest" (Mardis, 2014, p. 250). AASL defines the five primary roles of school librarians: information specialist, instructional partner, teacher, program administrator, and leader (American Association of School Librarians, 2014). No one else in the building is capable of this range of capabilities. Additionally, and probably in response to a growing movement, they describe librarians' possibilities of creating semi-formal learning environments in school libraries, excellent choices for librarian collaboration since they can offer more media, more guidance, and more interest-driven topics and themes.

Collaboration is crucial to building success; no educator should be an island (Meyer, 2017). Teachers and school librarians, when working on professional or curricular development, characterize the relationship as a partnership of equals, with teachers providing subject expertise and intimate knowledge of their students and librarians providing information literacy expertise, knowledge of resources, technology expertise, and guidance to students through the conceptual and emotional challenges of the research process (Yukawa & Harada, 2009). There may also be an overly high degree of confidence that simply connecting to learner interests or creating and participating in an active culture of science enhances science learning and connections to STEM fields (Yip, et al, 2014). The school librarian is the link the binds all elements of the school together, and she has no claims to information ownership. Above all of her functions, the school librarian is most importantly the only person in the building certified and trained to understand and teach information search processes and practices. Not only do school librarians increase reading scores, their absence nullifies that effect in a major Colorado-based study (Lance & Hofschire, 2012). This is crucial, since a lack of information search, assessment, and organization can profoundly affect adolescents' self-efficacy and potential for a long and successful life, exemplifying the need for librarians to teach those skills (Subramaniam, et al, 2015, "Bit").

Defining the role of school librarians in enhancing science learning, Subramaniam, et al (2015, "Role") conclude that school librarians should be playing a greater role in science learning because they can:
1. encourage young people to engage in authentic inquiry practices by teaching them about information search models and strategies;
2. engage young people's everyday life interests by linking science learning to media and technology that appeals to them or they 'see themselves' in; and
3. promote the norms of ethical and social interaction in sharing science knowledge. (p. 10)

Guided Inquiry

An important companion to the explosion of technology access on school campuses at all levels is guided inquiry design. Kuhlthau, Maniotes, and Caspari (2012) describe guided inquiry as both grounded in best practice and research and crucial for successful living and transition to the workplace. Guided inquiry is authentic to students because they work with peers and with chosen, not assigned, subjects, or at least chosen sub-topics within a curricular theme. Technology's ability to enable users to simultaneously create and share, plays an important role in successful critical skill building in students, the ultimate goal of guided inquiry design. Without guidance, students often approach the process as a simple collecting and presenting assignment that leads to copying and pasting with little real learning. With guidance, students are able to concentrate on constructing new knowledge in the stages of the inquiry process to gain personal understanding and transferable skills. Students' feelings play an important part in the constructive process of inquiry that indicates a zone of intervention for teachers and librarians. For example, students get frustrated in the exploration stage of inquiry and need encouragement to take time to read and reflect and guidance in making sense of information that does not fit together smoothly. Guided Inquiry, based upon Kuhlthau's (1991) information search process (see Figure 1), is intended to be collaborative, engaging, reflective, and iterative, as students explore new ways to solve problems, answer questions, and create artifacts. Motivation, interest, relevance, and affect are primary factors in engaging in guided inquiry learning.

Model of the Information Search Process

	Initiation	Selection	Exploration	Formulation	Collection	Presentation	Assessment
Feelings (Affective)	Uncertainty	Optimism	Confusion Frustration Doubt	Clarity	Sense of direction / Confidence	Satisfaction or Disappointment	Sense of accomplish-ment
Thoughts (Cognitive)	vague ⟶			focused ⟶ increased		interest	Increased self-awareness
Actions (Physical)	seeking	relevant Exploring	information ⟶	seeking Documenting	pertinent	information	

Figure 1. Kuhlthau's (1991) 6-stage, 3-domain ISP Model

Guided Inquiry prioritizes and defines that space for students and staff alike by providing opportunities for engagement and reflection (Kuhlthau, Caspari, & Maniotes, 2015), especially since students often mis-assess their searching skill and then wrestle with the cognitive, affective, and behavioral ups and downs predicted by Kuhlthau (St. Jean, et al, 2015). Self-reflection helps students and teachers during this time, and both benefit from activities like log-keeping (Harada, 2016).

In order to map out the information search process using guided design theory, Kuhlthau, Maniotes, and Caspari (2012) designed a new 8-step ISP model to augment the previous 6-step ISP cited above. The newer model includes opportunities for students to practice the guided inquiry behaviors of analysis and sharing.
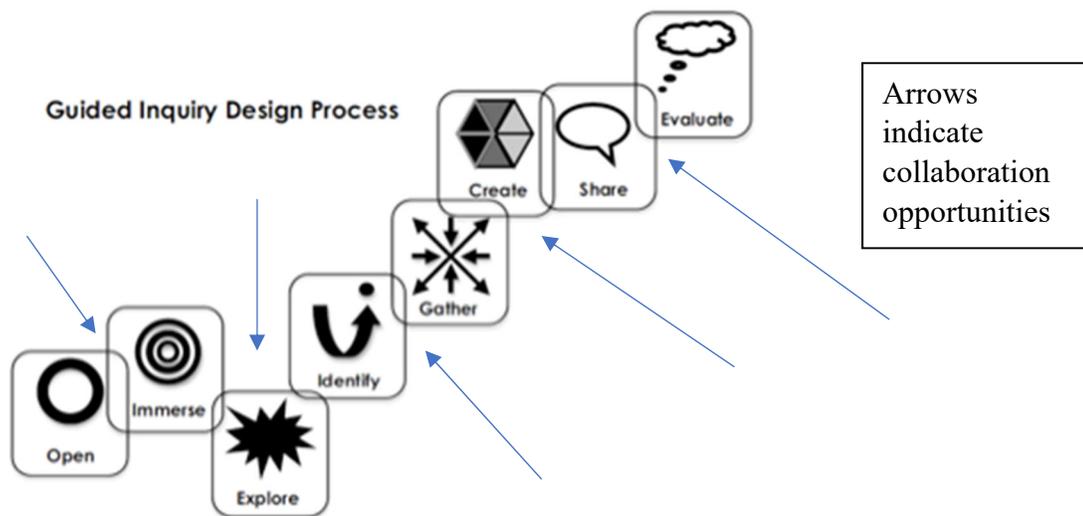
Guided Inquiry Design Process

Open — Immerse — Explore — Identify — Gather — Create — Share — Evaluate

Arrows indicate collaboration opportunities

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Fig. 2. 8-step Guided Inquiry Design Process (from Kuhlthau, Maniotes, and Caspari, 2012, p. 2)

The Exploration stage, here called Explore, is basically the same as it was in the original model. Students are encouraged to browse and scan many sources and consider themes and ideas rather than simply gathering facts and figures. It is possible that Google Answer Boxes are serving to affect this phase of the guided learning process insofar as students may not be experiencing the confusion and oversaturation of information indicated by Kuhlthau, Maniotes, and Caspari (2012) because their trust of the Answer Box supercedes their tendency to overwhelm themselves with too much information from too many sources (Miklosik & Dano, 2016).

Collaborating with a Science teacher for a semester in a middle school Robotics class has demonstrated to me that researching with students in a STEM environment is an ideal location to explore these questions. SF film and television clips, as well as short stories, poems, and potentially novels (if time allows) and fan fiction (age-

appropriate) related to one or more of Luokkala's seven foci (2014) are ideally suited to motivate students to become more engaged with STEM-relate activities and interests, and curricula featuring SF as an entry point into STEM interest and blending discussion, artifact creation, reflection, and familiar contexts should be considered and implemented to maximize students' STEM potential. Interventions should be developed by practitioners until there are enough SF-based curricula available to all students.

Conclusion

Collaborating with a Science teacher for a semester in a middle school Robotics class has demonstrated that the power and influence of SF research with students in a STEM environment would be an ideal location to explore these questions, and such research should be conducted with interviews, surveys before and after the experience, language arts interventions, and creation of artifacts related to the material. SF film and television clips, as well as short stories, poems, and potentially novels (if time allows) related to one or more of Luokkala's seven foci (2014) are ideally suited to motivate students to become more engaged with STEM-relate activities and interests, and curricula featuring SF as an entry point into STEM interest and blending discussion, artifact creation, reflection, and familiar contexts should be considered and implemented to maximize students' STEM potential. Interventions should be developed as the project progresses. Special attention will be given to collecting pre-and post-intervention data to demonstrate the potential effectiveness of the use of SF in a STEM environment.

Two areas that have been touched upon in this study should be investigated and considered further. Use of Guided Inquiry during STEM and SF work is one area that deserves greater scrutiny, as several researchers cite the social constructivism and intergeneralizability involved with researching and creating around specific topics or in specific communities. Also, access limitations to STEM-related activities and fields due to culture, race, gender, and ability level need to be addressed to ensure equal and accessible education for all students, and equal access to potential future success and the maximization of the natural abilities and talents that all students inherently possess.

References

Ahn, J., Subramaniam, M., Bonsignore, E., Pellicone, A., Waugh, A., & Yip, J. (2014). "I want to be a game designer or scientist:" Connected learning and developing identities with urban, African-American youth. Presented at International Society of the Learning Sciences Conference, Boulder, CO. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/ download? doi=10.1.1.696.1012&rep=rep1&type=pdf

Ainley, M., Hillman, K., & Hidi, S. E. (2002). Gender and interest processes in response to literary texts: Situational and individual interest. *Learning and Instruction*, *12*, 411–428.

American Association of School Librarians (2014, December). *Causality: School libraries and student success (CLASS)*. Retrieved from https://files.eric.ed.gov/fulltext/ED561868.pdf.

Asimov, I., Asimov, I., & BBC Radio. (2010). *The Foundation trilogy*. New York: BN Publishing.

Barra, P. A. (1988, October). It was a dark and stormy chemistry class: How one teacher's class turned fact into fiction. *The Science Teacher*, 33-35.

Boblick, J. M. (1991). Science fiction in the science classroom. *The Science Teacher*, *58*(3), 48–49.

Boiero de Angelo, M. C., Jure, G., Fernandez, L., & Remondino, L. (2008). Creating spaces for improving reading competence: Science-fiction in ESP courses. *Researching and Teaching Languages for Specific Purposes, Cahiers de l'Apliut, 27*(3), 33–47.

Brake, M., & Thornton, R. (2003). Science fiction in the classroom. *Physics Education*, *38*(1), 31–34.

Brotherton, M. (2016). *Science fiction by scientists: An anthology of short stories*. New York, NY: Springer Berlin Heidelberg.

Buckley, J. H. (1974). Season of youth: The Bildungsroman from Dickens to Golding. Cambridge, Mass.: Harvard University Press.

Burns, J. (1994). One for the Books: Using literature-based science lessons. *The Science Teacher*, *61*(7), 38–41.

Burton, E., Goldsmith, J., & Mattei, N. (2018). How to teach computer ethics through science fiction. *Communications of the ACM, 61*(8), 54–64. https://doi.org/10.1145/3154485.

Collins, S. (2008). *The Hunger Games* (1st ed). New York: Scholastic Press.

Columbus, C. (1999). *The Bicentennial Man*. Burbank, CA: Buena Vista Pictures.

Cook, K., Keller, D., & Myers, A. (2014). Bioethics in The Hunger Games: Evaluating the effects of genetic engineering through popular fiction. *The Science Teacher, 81*(1), 31-37.

Czerneda, J. E. (2006). Science fiction & scientific literacy: Incorporating science fiction in the classroom. *The Science Teacher, 73*(2), 38-42.

Dashner, J. (2014). *The maze runner*. New York: Delacorte Press.

Davis, M. J. (2016). Padawan's journey: Remixing *Star Wars* radio for adolescent literacy education. *Journal of Media Literacy Education, 8*(1), 93–100.

De Lepe, M, William, O., Connor, R., Lizbeth, C., & Lloyd, A. (2015). Using science fiction prototyping to decrease the decline of interest in STEM topics at the high school level. *Ambient Intelligence and Smart Environments*, 189–196. https://doi.org/10.3233/978-1-61499-530-2-189

Dick, P. K. (1992). *The man in the high castle* (1st Vintage Books ed). New York: Vintage Books.

Disch, T. M. (2005). *On SF*. Ann Arbor: University of Michigan Press.

Dubeck, L. W., Suzanne E. M., Matthew H. B., & Judith E., B. (1993). Finding the facts in science fiction films: Two thumbs up for this activity. *The Science Teacher*, *60*(4), 46–48.

Engel, B., & Schmidt, D. (2004). The galactic spaceship tour challenge. *The Mathematics Teacher*, *97*(5), 314–319.

Fleischer, R., Greenberg, S. R., Seltzer, W., Thacher, R., Heston, C., Taylor-Young, L., … MGM/UA Home Video (Firm). (1991). *Soylent green*. Culver City, CA: MGM/UA Home Video.

Freedman, R. A., & Little, W. A. (1980). Physics 13: Teaching modern Physics through science fiction. *American Journal of Physics*, *48*(7), 548–551.

Freudenrich, C. C. (2000). Sci-fi Science: Using science fiction to set context for learning science. *The Science Teacher*, *67*(8), 42–45.

Goldbort, R. C. (1991). Science in literature: Materials for a thematic teaching approach. *The English Journal, 80*(3), 69-73.

Goldman, A. I. (2001). Experts: Which ones should you trust? *Philosophy and Phenomenological Research, 63*(1), 85-110.

Goss, M. M., Min, H., & Strohl, C. (2016). Designing standards-driven curriculum to support: Access to science for all students. In Zehlia Babaci-Wilhite (Ed.), *Human Rights in Language and STEM Education Science, Technology, Engineering and Mathematics.* (pp. 35–54). Rotterdam: SensePublishers.

Haldeman, J. W. (2009). *The forever war* (1st St. Martin's Griffin ed). New York: Thomas Dunne Books.

Harada, V. (2016). A practice-centered approach to professional development: Teacher-Librarian collaboration in capstone projects. *School Library Research, 19*. 1-47.

Harada, V., Kirio, C., & Yamamoto, S. (2008). Project-Based Learning: Rigor and relevance in high schools. *Library Media Connection, 26*(6), 14–16.

Harrison, H. (2008). *Make room! Make room!* (1st Orb ed). New York: Orb.

Herschbach, D. R. (2011). The STEM initiative: Constraints and challenges. *Journal of STEM Teacher Education*, *48*(1). https://doi.org/10.30707/JSTE48.1Herschbach

Kay, A. L., & Golden, M. (1991). Science fiction across the curriculum. *Learning, 20*(4), 40-43.

Kuhlthau, C. C. (1991). Inside the search process: Information seeking from the user's perspective. *Journal of the American Society for Information Science*, *42*(5), 361–371. https://doi.org/10.1002/(SICI)1097-4571(199106)42:5<361::AID-ASI6>3.0.CO;2-#

Kuhlthau, C., Maniotes, L., & Caspari, A. (2012). *Guided inquiry design: A framework for inquiry in your school* . Santa Barbara, CA: Libraries Unlimited.

Kuhlthau, C., Caspari, A., & Maniotes, L. (2015). *Guided inquiry: Learning in the 21st century*. (2nd ed.). Santa Barbara, CA: Libraries Unlimited.

Kunda, Z. (1990). The case for motivated reasoning. *Psychological Bulletin, 108*(3), 480-498.

Lance, K., & Hofschire, L. (2012). School librarian staffing linked with gains in student achievement, 2005 to 2011. *Teacher Librarian, 40*(1), 15–19. Retrieved from http://search.proquest.com/docview/1115041880/

L'Engle, M. (2007). *A wrinkle in time* (1st Square Fish ed). New York: Square Fish.

Levy, M. M. (1999). The young adult science fiction novel as Bildungsroman. In Levy, M. M., & Sullivan III, C. W. (Eds.). *Young Adult Science Fiction.* Westport, CT: Greenwood Press. pp. 99–118.

Luokkala, B. B. (2014). *Exploring science through science fiction*. New York: Springer.

Mahoney, K., & Khwaja, T. (2016). Living and leading in a digital age: A narrative study of the attitudes and perceptions of school leaders about media literacy. *Journal of Media Literacy Education, 8*(2), 77–98.

Mardis, M. (2014). Ready for STEM? A leading commercial multimedia database as a source for meia-rich science, technology, engineering, and mathematics assets for K-12 library collections. *Library Resources & Technical Services, 58*(4), 250–264. Retrieved from http://search.proquest.com/docview/1667947147/

Mardis, M., Kimmel, S., & Pasquini, L. (2018). Building of causality: A future for school librarianship research and practice. *Knowledge Quest, 46*(4), 20–27.

Marks, G. H. (1978). Teaching biology with science fiction. *The American Biology Teacher*, *40*(5), 275–279.

Meyer, L. (2017). Higher STEM: dynamic programs designed by universities and engineers for K-12 students. *School Library Journal, 63*(4), 38-40.

Miklosik, A., & Dano, F. (2016). Search engine optimization and Google answer box. *Communication Today*, *7*(1), 82–91.

Miller, A. (1990). *The drama of the gifted child*. New York: BasicBooks.

Rawson, C. H., Anderson, J., & Hughes-Hassell, S. (2015). Preparing pre-service school librarians for science-focused collaboration with pre-service elementary teachers: The design and impact of a cross-class assignment. *School Library Research, 18*. American Association of School Librarians. http://www.ala.org/aasl/slr/volume18/rawson-anderson-hughes-hassell.

Renninger, K. A., & Hidi, S. (2016). *The power of interest for motivation and engagement*. New York, NY: Routledge.

Robinson & Horst. (2010). *Hanging out, messing around, and geeking out: Kids living and learning with new media* (M. Itō, S. Baumer, M. Bittanti, & J. Antin, Eds.). Cambridge, Mass.: MIT Press.

Rolls, H., & Rodgers, M. P. H. (2017). Science-specific technical vocabulary in science fiction-fantasy texts: A case for 'language through literature.' *English for Specific Purposes*, *48*, 44–56. https://doi.org/10.1016/j.esp.2017.07.002

Scholastic, Inc. (2012, July 19). Scholastic announces updated U.S. figures for Suzanne Collins's bestselling *The Hunger* Games trilogy: More than 50 million books in print and digital in the U.S. [Electronic press release]. Retrieved from http://mediaroom.scholastic.com/press-release/scholastic-announces-updated-us-figures-suzanne-collinss-bestselling-hunger-games-tril

Scott, R., Goddard, D., Kinberg, S., Schaefer, M., Sood, A., Huffam, M., & Weir, A. (2016). *The Martian*. Los Angeles, California: Twentieth Century Fox Home Entertainment.

Shumei Zhang, & Victor Callaghan. (2014). *Using science-fiction prototyping as a means to motivate learning of STEM topics and foreign languages.* 353–356. DOI: https://doi.org/10.1109/IE.2014.76

Smyth, T., & Waid, B. (2010). Smyth, T., & Waid, B. (2010). Integrating Literature: A Novel Idea! The Mathematics Teacher, 104(2), 113–119. *The Mathematics Teacher*, *104*(2), 113–119.

Sprague, M. M., & Cotturone, J. (2003). Motivating students to read physics content. *The Science Teacher*, *70*(3), 24–29.

Stewart, P., Frakes, J., Spiner, B., McFadden, G., Dorn, M., Burton, L., … Paramount Pictures Corporation. (2013). *Star trek, the next generation*. [Television series].

St. Jean, B., Subramaniam, M., Taylor, N. G., Follman, R., Kodama, C., & Casciotti, D. (2015). The influence of positive hypothesis testing on youths' online health-related information seeking. *New Library World, 116*(3/4), 136-154.

Subramaniam, M., Ahn, J., Fleischmann, K., & Druin, A. (2012). Reimagining the role of school libraries in STEM education: Creating hybrid spaces for exploration. *Library Quarterly, 82*(2), 161–182. https://doi.org/10.1086/664578

Subramaniam, M., St Jean, B., Taylor, N., Kodama, C., Follman, R., & Casciotti, D. (2015). Bit by bit: using design-based research to improve the health literacy of adolescents. *JMIR Research Protocols, 4*(2), e62–e62. https://doi.org/10.2196/resprot.4058

Subramaniam, M., Ahn, J., Waugh, A., Taylor, N., Druin, A., Fleischmann, K., & Walsh, G. (2015). The role of school librarians in enhancing science learning. *Journal of Librarianship and Information Science, 47*(1), 3–16.

Subramaniam, M., Taylor, N., St. Jean, B., Follman, R., Kodama, C., & Casciotti, D. (2015). As simple as that?: Tween credibility assessment in a complex online world. *Journal of Documentation, 71*(3), 550–571. https://doi.org/10.1108/JD-03-2014-0049

Subramaniam, M. (2016). Designing the library of the future for and with teens: Librarians as the "Connector" in Connected Learning. *The Journal of Research on Libraries and Young Adults*, *7*(2). 1-18.

Tai, R., Liu, C., Maltese, A., & Fan, X. (2006). Planning early for careers in science: young adolescents who expected to have a career in science were more likely to graduate from college with a science degree, emphasizing the importance of early encouragement. *Science, 312*(5777), 1143-1144. https://doi.org/10.1126/science.312.5777.1137b.

Toffler, A. (1990). *Future shock*. New York: Bantam Books.

Yip, J., Clegg, T., Ahn, J., Uchidiuno, J., Bonsignore, E., Beck, A., … Mills, K. (2016). The Evolution of Engagements and Social Bonds During Child-Parent Co-design. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, 3607–3619. https://doi.org/10.1145/2858036.2858380Yukawa, J.,&

Yukawa, J., & Harada, V. H. (2009). Librarian-Teacher partnerships for inquiry learning: Measures of effectiveness for a practice-based model of professional development. *Evidence Based Library and Information Practice, 4*(2), 97–119. https://doi.org/10.18438/B8GG7K

Zmuda, A., & Harada, V. (2008). Librarians as learning specialists: moving from the margins to the mainstream of school leadership. *Teacher Librarian, 36*(1), 15–20.