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The role of school librarians in enhancing science learning

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Abstract
School librarians play a pivotal role in facilitating learning of all subjects in primary and secondary schools in the United States, but their potential contributions to science have not been explored. In this paper, we show how school librarian practices can directly enhance aspects of science education by providing concrete examples from a study where we engaged school librarians to co-design and co-implement a science-infused after-school program. We found that librarians are a strong asset in science learning, as they foster youth engagement in authentic inquiry practices and engage young people's everyday life interests in science learning. This study contributes new insight into how librarians can use their expertise to enhance science education efforts in schools.

Keywords
School libraries, science education, science learning, science in everyday life, socio-cultural learning

Introduction

The United States (US) Bureau of Labor defines school librarians as personnel who 'work in elementary, middle, and high school libraries [includes primary and secondary] and teach students how to use library resources. They also help teachers develop lesson plans and find materials for classroom instruction' (Bureau of Labor Statistics, 2012). However, this commonly understood definition of school librarians belies the diverse roles they play in primary and secondary schools in the US which includes kindergarten

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through grade 12 (K–12). The American Association of School Librarians (AASL), which is the official professional association for school librarians in the US, dictates five official roles that school librarians play in schools: information specialist, teacher, instructional partner, program administrator and leader (AASL, 2009a). The information specialist role covers the school librarian's responsibility to 'introduce and model emerging technologies, as well as strategies for finding, assessing, and using information' (AASL, 2009a: 17). This role is carried out through interactions with all members of the school community, from teachers to administrators to students. The school librarian as a teacher 'empowers students to become critical thinkers, enthusiastic readers, skillful researchers, and ethical users of information' (AASL, 2009a: 18). The school librarian offers both guided instruction and facilitated learning – both falling directly into the type of inquiry-based learning suited so well for engaging students in scientific practices. The instructional partner role describes the librarian working 'with members of the school community to develop the policies, practices, and curricula to guide student learning' (AASL, 2009a: 17). School librarians *cooperate* with teachers by providing resources, *coordinate* by using resources to align objectives with other subjects, and *collaborate* by working in conjunction with fellow educators to design and evaluate lessons and plans. The program administrator role guides the school librarian in his or her work as the person in charge of ensuring 'that all members of the learning community have access to resources that meet a variety of needs and interests' (AASL, 2009a: 18). These resources include books, databases, media, and technology in multiple formats. Successfully embracing each of these roles culminates in the school librarian being recognized as a leader in his or her school. As a leader, the school librarian paves the way for the school community to embrace 21st century learning by implementing new innovations and being aware of the quickly changing environment of education.

Historically, the school librarian's contribution to student achievement has always been linked to reading, language arts or social studies. Numerous state-wide studies (Francis and Lance, 2011; Library Research Service, 2011) and district-wide studies (Bailey and Paul, 2012; DiScala and Subramaniam, 2011) have shown that deeper involvement of school librarians in K–12 schools is linked with higher student achievement. A school librarian's success in increasing interest in reading for pleasure or for personal growth among young people has always been connected to traditional literacy development and life-long learning in arts and language (Cart, 2007; Lu and Gordon, 2007).

In this paper, we explore how school librarians' expertise can be leveraged to enhance science learning and science interests among young people. We illuminate how such school personnel are uniquely positioned to enhance science education in particular areas such as facilitating inquiry practices, valuing the diverse experiences students bring to science learning, linking student interests to science, and highlighting the social importance of scientific practices. This study contributes to the need for research on the role of school librarians as partners in science education and sheds light on how science teachers may also leverage school librarians' expertise and skills to enhance their pedagogical practices.

We begin with a literature review on the current roles that school librarians play in science learning. Taking a socio-cultural approach that values the social and cultural experiences that students bring to science learning, we outline how school librarian practices naturally connect to these aspects of science education. Then, we report a qualitative study of the implementation of a science-infused after-school program Sci-Dentity that we co-designed and co-implemented with public middle school (Grade 6 through 8) librarians and pre-service librarians in a large, urban school district in the mid-Atlantic states of the US. In this exploratory study, we highlight how school librarians play a unique part in encouraging student inquiry and the ability for students to link science to their everyday lives. We draw attention to opportunities in science learning where librarians' expertise can encourage young people to incorporate their personal and cultural experiences and identities into their science learning, and facilitate the norms of creating and sharing science knowledge. The study provides new insights into how educators can engage school librarians in the design and implementation of science education programs in schools, include them in the planning of the science curriculum, and use their expertise to facilitate science learning in schools.

Conceptual framework

School librarians' involvement in science learning

The current literature in the area of school library research suggests that the strongest role that school librarians play in science teaching and learning in their schools is as information specialists (Mardis, 2005, 2006; Mardis and Hoffman, 2007). School librarians help science teachers in finding, filtering and imparting science resources and materials that make science learning accessible and available for all students (McIlvain, 2010; Mardis and Howe, 2010; Pandora, 2009; Perrault, 2010; Stroup et al., 2010; Toomey, 2010). For example, science teachers may seek the help of school librarians to find reliable sources of information to supplement students' learning of content in the science classroom (McIlvain, 2010; Mardis and Hoffman, 2007; Pandora, 2009), to acquire science resources that are engaging to students (McLean, 2010; Stewart, 2010; Subramaniam et al., 2012a) or to find resources for special needs students in alternate formats (Perrault, 2010, 2011).

However, compared to language arts and social sciences related subjects, school librarians still tend to collect and impart less science resources (Barack, 2009). In recent years, there have been suggestions from school library educators and science educators for librarians to play a stronger role in science, primarily as a teacher or an instructional partner in facilitating the inquiry process in science, helping students understand science practices, and collaborating with science teachers to integrate different literacy practices (Fries-Gaither, 2010; Mardis, 2006; Subramaniam et al., 2012a).

Socio-cultural frameworks of K–12 science education

One way to better articulate the potential roles school librarians can play in science education is to situate existing library practices within formal frameworks of science learning. In this study, we take a socio-cultural approach to science learning. A socio-cultural perspective recognizes that science learning involves more than merely understanding facts, but also values learners' personal backgrounds and encourages deeper notions of scientific practice and inquiry. Science learning moves beyond merely applying knowledge to problems. Deep scientific practice also involves skills such as adopting norms of a scientific community and communicating one's ideas in that community (Ford and Forman, 2006). Science practices can be seen as interpersonal interactions including inquiry processes, knowledge sharing, and communication that occur within institutional and cultural boundaries (Lemke, 2001)

Researchers increasingly understand that students' individual backgrounds interact in significant ways with their science learning experiences. For example, a student's prior interests and personal identity (how they view themselves) could conflict or coalesce with the science learning environments they experience (Barton and Tan, 2010; Barton et al., 2008; Polman and Miller, 2010). The linguistic practices of underrepresented, minority youth also play a role in their formal science learning experiences (Brown, 2004). In addition, prior research has illuminated how young females' everyday experiences that introduce science ideas (such as exposure to technology), in addition to role models such as parents and other adults, influence their developing self-concepts and identities as students interested in science (Brickhouse and Potter, 2001). Increasingly, scholars have articulated how social and cultural contexts are influential in how young people take up, adopt, and develop deeper interests in science learning.

Working from this insight, learning scientists are increasingly interested in designing educational environments that (a) encourage students to engage in authentic, social inquiry practices, (b) engage students' everyday life interests, and (c) incorporate their personal experiences and identities into their science learning (Barton and Tan, 2009, 2010; Chinn and Malhotra, 2002; Clegg et al., 2010). For example, Clegg et al. (2010) designed and implemented a learning program that introduces young children to scientific inquiry practices through cooking. The researchers found that this sort of science learning, very different from formal classrooms, encouraged authentic inquiry as children actively worked to figure out their recipes, built from the students' interests in food, and over time influenced the youths' personal identities (e.g. they increasingly saw themselves as cooks and scientists). Barton and Tan (2009) also highlight the importance of building learning experiences around the funds of knowledge young people bring to an educational setting.

Frameworks for science learning also connect to these insights. For example, the National Research Council (2011), a private and influential entity in the US that focuses on improving government decision making and public policy in matters involving science, emphasizes several aspects of science learning that build from a socio-cultural framework. The authors of this report assert the following principles, among many:

1. Children are born investigators – Children and young people learn 'about the world through everyday activities, such as talking with their families, pursuing hobbies, watching television and playing with friends' (National Research Council, 2011: 24). Young people must be encouraged to ask questions, inquire, search for information, build their own ideas of their surroundings (which can include misconceptions), gather evidence and data, and continue refining their prior conceptions.
2. Learning must connect to students' interests and experiences – Personal interest, experience and enthusiasm are critical to young people's learning of science and may also be linked to later educational and career choices.
3. It is vital to embrace diversity as a means to enhance learning science – Students have diverse customs, abilities, and cultural communities that can be leveraged to learn science and build science itself. Identifying such personal connections will illuminate pedagogical means that are best to support young people's science learning.
4. Science learning is a social enterprise – 'Scientific knowledge advances through collaboration and in the context of a social system with well-developed norms' (National Research Council, 2011: 27). Science is as much about social interaction and communication of ideas as it is about understanding facts from textbooks.

When one works from a socio-cultural framework of science learning, ripe opportunities arise for school librarians to play a role in enhancing the learning process. As we

outline in the next section, school librarians are uniquely positioned to help students connect science to their existing interests, engage with diverse media, and understand the social and cultural practices of science disciplines. While we recognize that science teachers play a substantial role in enhancing science learning and science interest among students, school librarians are trained in providing reader advisory (Dresang and Kotrla, 2001; Subramaniam et al., 2012a), facilitating online inquiry and new media literacies in any domain (Thomas et al., 2011) and can tailor such services to the needs and interests of individual students. We consciously made the decision to focus exclusively on the roles that school librarians can play in creating socio-culturally relevant science learning environments to magnify their strengths as discussed in the next section. Such magnification will invoke the attention of the science education community to use these untapped personnel available at their schools.

Linking a socio-cultural framework to school librarian expertise and skills

The core goals of school librarians are to promote reading as a foundational skill for learning, and to teach inquiry and information skills to help students to thrive in complex learning environments. Librarians also strive to teach skills such as: technology and information literacy, ethical decision making, and critical thinking. These skills are essential in the selection, use, creation, and evaluation of information and can also be significant barriers to science learning when students have not had opportunities to develop them. Researchers have found that information skills such as online inquiry and search literacies play an important role in science learning, and are quite difficult for novice learners (Quintana et al., 2005). In addition, young people must also have equitable access to resources and opportunities to learn. Sharing and learning from others is vital in the current information environment, which dictates that learning is enhanced by having a social context. Socio-cultural learning principles of inquiry, equity, social context, and making connections to young people's interests and experiences are also evident in the core standards of school librarian practices (AASL, 2009b). In the following discussion, we outline several ways in which school librarian practices align with aspects of science learning.

Promoting young people's natural instincts to investigate and inquire through search skills. To engage young people in continuous inquiry and investigation, school librarians are trained to facilitate an inquiry-based process that makes connection to the real world and allows the development and refinement of a range of questions to frame the search for information. They can assist young people with the techniques to develop higher order questions that can instill critical thinking skills. Librarians introduce information search process models and information literacy skills to young people to guide their search process (Eisenberg, 2008; Kuhlthau et al., 2008). Information search process frameworks such as Kuhlthau's Information Search Process Model characterize the stages of information search – task initiation, topic selection, topic exploration, focus formation, resource collection, and presentation. Such frameworks allow young people to be conscious of the stages of information search, their feelings during the search and cognitive activities (Kuhlthau, 2004; Kuhlthau et al., 2008). More simplified models for K–12 such as Big6, REACTs, Pathway to Knowledge, FLIP IT, and I-Search are abundantly used by school librarians to support the information search process among young people (Eisenberg, 2008; Thomas et al., 2011). Librarians develop charting tools such as graphic organizers that can provide young people with a mental 'picture' of the entire information search process by assisting them to categorize ideas, understand relationships among aspects of topics and conceptualize the thinking process (Thomas et al., 2011). Apart from teaching and facilitating the information search process, librarians also encourage young people to consider resources in a variety of formats and genres beyond the resources provided in the school (Project Tomorrow, 2010). A rigorous information search process helps motivate the students to construct new understandings of science phenomenon and be knowledge creators (AASL, 2009b; Quintana et al., 2005).

Connecting learning to students' interests and experiences. A primary role of school librarians is to develop and maintain resources (books, media, and technology) that can relate to the school's curriculum and student interests (Subramaniam et al., 2012a, 2012b). School librarians often make purchasing decisions of resources by keeping abreast with newly released books and media for the age groups in their schools (e.g. elementary or secondary), research on new media and technology use among young adults and the curriculum needs at each school. These job responsibilities uniquely position school librarians as personnel that can reach all students in a school. School librarians often follow young people's interests in animals, computers, science fiction, natural phenomenon, cultural institutions, or community issues more closely than other staff in the school. Inherently, young people are fascinated with many science phenomena without realizing the science in these events or objects. As Roche (2010: 143) observes of young people: 'Without cognition of the discipline [science], they [actually] surround themselves with science'. School librarians are positioned to direct young people with interests in science to materials and experiences that may spur their engagement (Subramaniam et al., 2012a). Most importantly, school librarians are already trained to provide a reader advisory service to young people, where they recommend appropriate materials based on the reading level,

literacy, special needs and interests of these young people (Subramaniam et al., 2012a).

Embracing diversity as a means to enhance learning science. Librarians teach young people to solicit diverse opinions and sources in information search and knowledge creation by providing prompts and scenarios that relate to their cultural and personal lives. Services for young people that take into consideration their diverse backgrounds have a long established history in librarianship. Librarians are knowledgeable in the resources and media that connect with young people across their race, ethnicity, gender, physical and learning disabilities, sexual orientation, socio-economic statuses and nationality (Hughes-Hassell and Cox, 2010; Jaeger et al., 2011; Mestre, 2010). Librarians can identify media that features diverse protagonists, different family structures (such as single parent or no guardian households), and portrayal of non-traditional gender roles. It is a common trope of children's and young adult literature that parents are absent, but the protagonist rises above. In popular books such as Kenneth Oppel's *Airborn* (2005), female characters defy historic convention to engage in scientific research. Ethnic and racial diversity can often be found in science fiction and in books representing the future. For example, Paolo Bacigalupi's critically acclaimed *Shipbreaker* (2010) and its companion novel *The Drowned Cities* (2012) depict characters of a wide variety of races in a thoughtful way as they answer the challenges of a flooded world. Such strong messages encourage young people to see their own selves reflected in these resources. Librarians are trained in various pedagogical strategies and programming that can stimulate young people to have a healthy discourse on their diverse backgrounds and opinions.

Promoting science learning as a social enterprise. A socio-cultural framework to science learning acknowledges that scientific advancement is achieved through collaboration, communication between scientists, and norms of the discipline. School librarians' unique expertise in technology and media (Everhart, 2007) can be leveraged to build and sustain science learning environments that are collaborative, allowing the sharing of ideas and solutions and engage in social learning opportunities. One of the core areas of knowledge that librarians possess is their ability to articulate the ethical use and sharing of information and technology – which includes plagiarism, fair use, copyright, and citation styles (AASL, 2009b). Librarians can incorporate this knowledge into science learning, and are often tasked to train young people to be cognizant of ethical use of information and technology. These issues of information, technology, ethics, and community are key aspects of science practice.

As the personnel responsible for teaching many of the vital skills in science learning as discussed above, school librarians can contribute to the creation and implementation of socio-culturally relevant and intriguing environments that may encourage science learning. Viewed through a socio-cultural lens, there are many opportunities and areas where library practices align well with science education, and may enhance the science learning process for students. We transformed the above conceptual frameworks into practice by designing and creating an after-school, science-infused program Sci-Dentity implemented in public school libraries. In this program, we collaborated with librarians to build socio-culturally relevant learning environments with the goal to encourage science interest and science learning among underrepresented middle school students. This setting serves as the context for the study.

Context

Sci-Dentity is a weekly after-school program co-designed and co-implemented with librarians in four middle school libraries in a large urban city in the US. The program is designed to encourage middle school students to read science fiction, popular science, and graphic novels, watch sci-fi movies, and play science-infused games during these after-school sessions. The short-term goal of the curriculum is to encourage students to imagine the underlying science that inspires these popular forms of media and to cultivate science practices and literacies that are essential for the development of science interest. The long-term goal of the research is to understand how to utilize popular media and storytelling to help underrepresented youths identify more deeply with science ideas. In addition to the four librarians who implemented this program, we were also assisted by ten pre-service school librarians who facilitated and acted as observers in these after-school sessions.

During a typical session, students are exposed to science-infused media focused on a variety of high interest topics among these students. These topics were usually identified in collaboration with the librarians. For example, we ran one session that focused on the idea of utopias and dystopias to coincide with the release of *The Hunger Games*, a popular young adult fiction series. Through group discussion and activities, we guided the students to imagine how new technologies might interact with society to create either utopian or dystopian visions of the future. In another session, students watched a storm chaser short movie, discussed the reasons why storm chasers are involved in such endeavors, and identified the technologies used in this activity. Students then were prompted to write stories of themselves as storm chasers and explain the activities and technologies that they would perform and use in this role. In this session, students engaged in various scientific explorations, which included searching for information about various types of storms, the strength and intensity of storms, technology used to measure the intensity of storms, etc. Similarly, in each session, students create stories using their

newly discovered science information in a fictional or factual context and share their stories on an online community created for this project (http://scidentity.org). The site is designed as a social media platform, allowing students to comment productively on other's stories and to use the online community outside of the program sessions. The site was designed in collaboration with the participating librarians and is iteratively redesigned based on the input from the librarians and the students in the program.

Approximately 57 sixth graders (11 to 12 years old) participated in the after-school program in the first semester that ran from February 2012 to May 2012. We obtained demographic information on 39 of these students who completed surveys given by the researchers in the first implementation of the project. In this sample of students, 17 (43.6%) are male and 22 (56.4%) are female. In terms of ethnicity, 22 (56.4%) self-identify as African American, 3 (7.6%) as Latino/Hispanic, 4 (10.2%) as White, 4 (10.2%) as Multiracial, 5 (12.8%) as 'Other', and 1 (2.6%) did not respond. Three of the four schools were restructuring due to missing targets for Annual Yearly Progress (AYP) in student achievement, suggesting low academic achievement in these schools. The students that participate in this after-school program were generally underrepresented in science, technology, engineering, and mathematics (STEM) and are in high needs schools.

Activities with the school librarians

The middle school librarians (including their district Manager for Library Media Services) participated in two formal co-design sessions with the researchers, one prior to the start of after-school sessions and one after the end of the sessions. This co-design method, also known as cooperative inquiry (Druin, 1999, 2005; Guha et al., 2005) is heavily grounded in human computer interaction research and theories of participatory design, contextual inquiry, cooperative design, and activity theory (Druin, 2010). The cooperative inquiry method emphasizes three principles throughout the design of a technology or a program: (1) multidisciplinary partnership with users; (2) field-based research; and (3) iterative 'low-tech' and 'high-tech' prototyping (Druin, 1999). Multidisciplinary partnership 'capture[s] the complexity and somewhat "messy" real-life world …' (Druin, 1999: 593) by partnering with users to encapsulate all tasks that are completed collaboratively and the needs of all users that will be utilizing the program or technology. Grounding the design of the technology or program in the field or the context that users are parts of illuminates the needs of the users within that context. Such grounding can happen by observing and analyzing patterns of interaction and communication (Guha et al., 2005). The third principle of cooperative inquiry calls for the use of 'low-tech' and 'high-tech' prototypes for design teams to visualize their ideas about the program or technology. Typically a member of the research team along with co-designers, such as school librarians, conducts sessions to create prototypes and sketches of new programs and technologies (Druin, 1999, 2010).

We had our first co-design session in January 2012 whereby librarians and researchers collaborated to develop session topics for each after-school session that were timed to the science curriculum for sixth grade, provided maximum appeal to the students, and created opportunities for writing and incorporation of storytelling media (comics, digital picture books, etc.). We also worked together to develop a social media site for students to write and share their stories (http://scidentity.org). In our second co-design session, in May 2012, we similarly engaged the librarians to brainstorm the session topics and media that will be used for the next school year sessions. In this session, we also revisited the past semester, and brainstormed how we can further strengthen the program activities to ensure that we are meeting the goals of the program.

During each design session, the researchers engaged the librarians in a variety of brainstorming activities to develop ideas for lessons, topics, and the design of the social media site. Some examples include: creating mind maps as a group to choose lesson topics; using sticky notes to provide anonymous feedback on site design (Druin, 2010); role playing as young people in the program and engaging in open dialog about the experience. Each design session was either audio or video-recorded and all 'low-tech' artifacts (such as the mind maps and sticky-notes) were photographed and retained. Each researcher reflected on the design sessions in internal memos that were shared with the team.

The four librarians led their school sessions in the after-school program with assistance from a team of pre-service librarians and the researchers. Following each after-school session, the school librarians, the pre-service librarians, and researchers debriefed to reflect on the session and consider revisions for future lessons. The pre-service librarians also met with the researchers bi-weekly to debrief and reflect on past sessions in each school. At the end of the first semester, librarians from the four schools were interviewed to probe their experiences more deeply.

Purpose and research questions

The overarching goal of this study is to explore how school librarians work as active contributors in advancing science learning among young people through the various skills and expertise that they possess. Using Sci-Dentity as a context, we examine the following exploratory question: How did these school librarians facilitate socio-cultural aspects of learning science such as encouraging the inquiry process, connecting to young people's everyday interests, incorporating young people's diverse experiences into science, and enhancing the social interaction in science learning?

Methodology

We use an approach known as design-based research (DBR), which is commonly used in the learning sciences (Collins et al., 2004). In DBR, the researchers co-design learning programs, technologies, and environments with educators (as described earlier). During phases of implementation, data is collected in depth and on an ongoing basis and is continually reviewed and incorporated into the iterative design of the program. We chose this method for several reasons. First, we are interested in engaging the school librarians as co-designers of Sci-Dentity and a DBR approach allows us to continuously seek input from them to revise the after-school sessions and the technologies we develop as part of this project. DBR allows the school librarians to see immediate changes to the programs based on their suggested revisions and be motivated to continuously contribute to the iterations of the program. Second, the adoption of DBR in such studies benefits the students participating in this program as changes to the programs are not delayed and students will be motivated to continue to participate in a program that continues to improve. For example, as we capitalized on the librarians' knowledge of their students' interests, we were able to create a session on dystopia as a result of the librarians informing us about the popular buzz about the recently released (at the time) *The Hunger Games* movie. Third, DBR allows articulation of ties between learning theory and practice, and between researchers and practitioners, which is absolutely vital to our commitment to better understand the relationship between school librarianship and science teaching and learning. In this way, the researchers can explore the learning processes at work more deeply and continually refine the use of curriculum and technologies to capitalize on successes and minimize ineffective strategies.

Data collection

We employed ethnographic methodologies for data collection for this study. As mentioned above in the *Context* section, we conducted many activities with the middle school librarians and the pre-service librarians. To answer the research questions for this study, we used the following data:

1. the transcription of the two co-design sessions;
2. the artifacts produced in the co-design sessions;
3. the internal memos that were kept by the research team members to document changes made to the after-school sessions and the site;
4. the observation notes taken by the pre-service librarians and the researchers during the weekly implementation of the learning program; and
5. the transcription of the individual interviews with the four librarians conducted at the end of the semester.

In the findings below, we refer to the librarians and the Manager of Library Media Services (who participated in the co-design sessions) using pseudonyms – Polly, Grant, Amy, Leslie, and Nancy. We do not identify the pre-service librarians by names, but reference their observation notes through affiliation with the librarian that they were observing.

Data analysis

Using the principles of open coding, the research team began the coding process by individually coding the transcript of one librarian interview. Each researcher created an initial codebook that would later be compared with the other three researchers working on the analysis. Codes were developed with the research questions in mind. As researchers discussed each code, the dominant themes of the analysis became apparent and a master codebook emerged. While the original set of codes used in the comparison contained only parent codes, sub-codes were added during collaborative meetings among the research team, incorporating the other team members' codes. The researchers were able to come to an agreement on coding the data. After the codebook was finalized, the researchers coded all data sources in Dedoose, an online qualitative data analysis software (www.dedoose.com), using the master codebook. In the event that additional themes/codes emerged, the researchers discussed as a team where in the codebook the new code should be placed. Memos were kept of coding decisions to establish an audit trail. The emergent themes were combined in queries to identify specific passages in the data for analysis and findings described in detail below.

Findings and discussions

In the *Conceptual Framework* section above, we elaborated on how school librarians' expertise and practices aligned with socio-cultural aspects of learning science. Through implementation of Sci-Dentity in its first semester, we provide concrete examples on how the librarians' expertise and practices encouraged young people to engage in authentic inquiry practice, connected these young people to their everyday life interests, encouraged the incorporation of young people's own personal and diverse experiences into science learning and facilitated the social interaction in science.

Promoting young people's natural instincts to investigate and inquire through search skills

The librarians had tremendous ability to facilitate an inquiry-based process that made a connection to the real world and allowed the development and refinement of a range of

questions to frame the search for relevant information. The librarians assisted the research team to design sessions that will delve deeper into the inquiry of science by introducing information search process models and information literacy skills to students to guide their search process. For example, as mentioned previously, one session was dedicated to the concept of utopia and dystopia. Students were asked to consider different conceptions of the future based on the optimism of the 1950s and the dystopian lens popular in young adult fiction today. Students were then asked to write a story that encapsulated their view on utopia or dystopia. The pre-service librarians facilitated science information search in small groups or one-to-one sessions with students during this session (and typically in all sessions), and walked through stages of the information search process models with students. Here is a field note from a pre-service librarian (working with Grant) who facilitated a student's learning of search skills – to frame her Google search to find how long it will take to travel from the planet Mars to Earth for her story writing:

> I [the librarian] reminded her that the scientific fact that we had discussed during the last session was how long it would take her Martian character to travel from Mars to Earth. I told her that we would assume that it would take a Martian the same amount of time it would take a human to travel to Mars, and suggested she use her iPad to find out how long that would take. Victoria guessed 200 days, and since I had researched this fact myself prior to the session, I told her she was very, very close (the actual number was 214) and helped her form a search in Google. She was having trouble coming up with the wording in order to search her fact. She tried writing 'how long does it take,' but was not sure where to go from there. I helped her along by providing her with different ways she could phrase her question. She took one of my suggestions then, and clicked the first link in her search results. The answer was on the first line of the article she opened …

Frequently, framing the search phrase seems to be the most difficult and frustrating process for students, as mentioned here by the pre-service librarian, who worked with Grant:

> I also overheard Kyrah speaking to [Grant] about the ability to move objects with your mind, and that neither of them could think of the word for it. I suggested telekinesis and searched it on my phone to make sure that was the right word. Kyrah was very pleased to add this vocabulary word to her story.

A field note from another pre-service librarian (working with Nancy) highlighted how she facilitated the science information search for a student by asking the appropriate questions and eased the process of topic exploration and focus formation in his information search process:

> Carlos' science fact had to do with a Nike shoe that was made from a new kind of fabric that made the wearer feel like they were wearing socks. He wasn't sure how to work that into a story, so I helped him develop a story by asking him questions about how such a shoe could make a difference and what problems could be solved by the scientist who invented this shoe.

In the examples above, librarians assisted the students in developing their search skills and their higher order critical-thinking skills to construct new knowledge and understandings based on the science fact that these students were interested in. Based on suggestions and input from the librarians and the pre-service librarians, we used graphic organizers in two sessions in the semester to structure the information search and story-writing processes. Graphic organizers are a form of advance organizers (Ausubel, 1978) – a tool typically used by librarians that includes prompts to define topics and characters, sequence ideas, find related information, and understand relationships between various sources of information (Small et al., 2012). See Appendix A for an example of a graphic organizer that was used in the program.

Connecting learning to students' interests and experiences. It is important that learning be connected to students' experiences. The librarians participating in Sci-Dentity provided ways for students to make that connection to their 'real life'. For example, during the utopia/dystopia session, a pre-service librarian who worked with Amy observed that discussion about technology advances seem to spark interest to innovate and invent gadgets and devices that personally appealed to the students:

> The examples of tech advances since 2000, such as the electric car, iPod, and the artificial heart, combined with our explanation/examples of utopia and dystopia, seemed to really spark their interest in inventing their own cool piece of technology for their stories. In my small group, Stephen invented an 'i-helmet' that would speed up learning in the future, and Aaron thought that all of the buildings could be touch-controlled. The girls thought in terms of special clothing and mode of travel, but as we talked definitely started to think more about the technology and the problem we would solve in our story.

In the same session at another school, a pre-service librarian who worked with Grant reflected on how she encouraged her students to connect their interest to science:

> Takia said she wanted her story to be based on an anime show she likes about a demon butler and his living boy master. She told me about the plot of the show but said she would like her story to be less dark. I asked her some questions about the characters and the storyline she wanted to develop to help her get started. Victoria asked me to write down her ideas, so I took her binder in hand and jotted them all down. Her ideas were derived from the Nickelodeon show [Fairly] Odd Parents. She said she wanted to write about a boy named Big Boy from

> Mars who could shape-shift into anything by turning a knob on the belt he wore. She said he traveled to earth, shape-shifted into a human, and started following around a boy on earth named Little T, who was an undercover ninja. She said at first the ninja boy wanted to fight the Martian boy, but then he realized the Martian just wanted to be friends. In order to get her started in thinking about science facts, I asked her how long it took Big Boy to travel from Mars to Earth …

In both design sessions, the librarians talked about students' interest in superheroes. During the topic-mapping exercise in the first design session, librarians conveyed that superheroes and related special abilities were very intriguing to students. Although we did not include sessions on superheroes during the first semester of the program, many students' stories reflect characters with advanced abilities or are based around the mythos of a superhero universe. As this theme keeps returning, and is rife with possibilities for scientific exploration, superheroes will form the arc for the coming year's sessions. Possible topics as identified in the final design session include: the science behind superheroes such as what is and is not possible; real life superheroes, such as rescue personnel and athletes; the science that supports their undertakings; and biomedical engineering and bionic limbs. Working with the librarians in SciDentity, we were able to venture into topics that align with the personal interests of these students and bridge to their out-of-school current interests in technology and media. The *Speak Up 2009* (an initiative of Project Tomorrow, a non-profit organization in the US dedicated to empowerment of student voices in education) data confirms that school librarians are more likely than teachers to communicate and collaborate via digital media tools (Project Tomorrow, 2010), further reinforcing that librarians are engaged in the media and technology that young people are immersed in, and are viewed as media mavens.

Embracing diversity as a means to enhance learning science. The entire premise of this work and the collaborative approach between researchers and librarians and between the students themselves are built upon the idea that learning is predicated on an open and respectful exchange of information and ideas across cultures and customs. While this thread ran through the entire program, some lessons elicited more discussion about diverse experiences and points of view. In the utopia/dystopia session, we began the session by asking students to contrast the video clips of the *Jetsons* and the *Hunger Games* movie trailer. The students responded well to our prompts and discussions, but as the discussion evolved, we realized that some of these students did not 'see themselves' in the media shown. As observed by a pre-service librarian who works with Amy:

> My final thought for this week has to do with diversity. We showed two videos – *Jetsons* and *Hunger Games* [to differentiate utopia and dystopia] – and I think it's noteworthy that the students who had not heard of or seen those videos before were mainly African-American. One of the students brought up the movie *The Book of Eli*, which is a recent film starring Denzel Washington. I think we need to be a bit more considerate when we choose media and try to be a bit more diverse in our selection.

Almost all the librarians and pre-service librarians made similar observations in their field notes and debriefing after this session. They all pointed out the need to bring media starters that connect with the diversity of students in these schools.

Another pre-service librarian who works with Leslie, made an observation about Jackie, a student who was attempting to make relationships between her science fact to the world that she is familiar with. This pre-service librarian felt that the librarians must think about various ways to make such connections to the diverse individuals participating in this program, in her reflection:

> What if the science fact does not relate to anything in her life? How does she go about making it relevant? How can we help her? How can she create a story from an internal well of information and experience if the well is dry? Maybe that is one of the reasons why some of the students have a hard time relating a science fact and writing a story about it. The application of a science fact does not relate to anything they know as familiar in their life. How does this fact relate to anything they have experienced? How can they write about something that is so foreign to them? As 6th graders, their world is hopefully about family, school and friends. They may have a limited vision of the world as a whole.

These are all articulations on how diversity of students can be incorporated into science learning. We did not initially focus on the librarians' role incorporating elements of diversity into the after-school sessions, yet the need to focus on this approach found its way into the sessions. We believe librarians' knowledge about young adult literature and media offers great potential to embrace the diversity that students bring to these sessions (cultural, family and/or gender preferences) by connecting them to media that they are accustomed with (American Library Association, 2010; Hughes-Hassell and Cox, 2010), leveraging their own experiences and make substantial connections to science learning.

Promoting science learning as a social enterprise. In SciDentity, students conclude their inquiry-based research process by sharing their stories on our social media site. The librarians and researchers worked to encourage students to respect the copyright of image creators, to cite their source, and to understand the ethics of using and sharing information. As a result, the librarians together with the researchers embedded information within the sessions about noting the source of images and suggesting use of Creative Commons.

Using information and technology ethically and responsibly is the pillar of any information instruction. We found much evidence in our analysis of the librarian facilitating the process of understanding plagiarism, fair use, copyright, and citation styles. In one instance, the structure of the Sci-Dentity site allowed students to 'clone' another person's story for remixing and receiving full credit in the form of points attached to their online profile (each activity in the site allows for the accumulation of points as an incentive for participation), without technically requiring changes. Some students in one school discovered this feature and began to clone the work of students from other schools, vastly increasing their points and their school's points. A librarian alerted us about the abuse of the 'cloning' feature. With the help of the librarians, we then implemented a session on copying, plagiarism, remix, and attribution (Ahn et al., 2012).

Throughout the program, the librarians assisted students in keeping track of the sources of information, providing citation assistance, and worked with the students in addressing technical glitches that complicated the process of keeping track of citations. A pre-service librarian working with Amy provides this example that augments the role of the librarian in facilitating the use of information and technology responsibly:

> it's not easy to cite photos found on the iPad for use in ComicLife – the way that Flickr works, it doesn't give the full citations via the iPad, so that is an issue. Also, Aaron [a student in the program] was making electronic notes for himself, and there's not an easy way for him to retrieve those notes, as the iPads aren't currently set up for email …. To resolve the photo and file issues, [Amy] suggested that the students copy the urls where they find photos (in lieu of finding the copyright information) and store them, and any other files, either via a Google account or a drop-box account.

Frequently the librarians engaged in conversations with students about norms of online social interaction, in response to any unacceptable behaviors that they observed in the site. For example, a pre-service librarian who works with Leslie shares an observation in her field notes:

> We also went over a few housekeeping issues, asking the students to let us know after the session about any concerns they had with posting to the site and reminding students of what good online behavior means. Regarding the appropriate behavior, the kids offered up 'no being mean;' 'no posting awkward stuff;' 'don't talk about people in Sci-Dentity.' The librarian also emphasized that the site is not for status updates, and that … students are not to heckle to students at the other schools. The student who made that post – Aaron – definitely looked chagrined. She told the students to make their posts 'substantive,' and explained what it means to be substantive…

Librarians used their unique knowledge of their students to draw out participation in discussions and on the site while emphasizing the ethics and responsibility that come with social interaction and the use of information. Numerous roles as information literacy experts are at play in these above examples of our librarians' work in the program, and each of these roles enhances the learning process for students.

Table 1 shows a summary of how school librarians involved in Sci-Dentity facilitated socio-cultural aspects of learning science such as encouraging the inquiry process, connecting to young people's everyday interests, incorporating young people's diverse experiences into science, and enhancing the social interaction in science learning.

Conclusion and further research

Research documents librarians' influence on boosting achievement in reading and writing among young people (Francis and Lance, 2011; Lance and Russell, 2004; Library Research Service, 2011). In this study, we discovered that librarians' knowledge and expertise can be leveraged to assist in science learning. Through the co-design activities and co-implementation of the after-school sessions, we found that school librarians function as an asset to assist the creation of socio-cultural learning environments that are conducive to science learning. Our analysis suggests that librarians' most valuable contributions to creating a socio-cultural environment for science learning are to:

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.

We observed clear linkages between roles, expertise, and activities embarked on by the librarians to the principles of building and sustaining socio-cultural science learning environments. We will continue to encourage the librarians to strengthen these contributions, and continue to leverage their expertise in building a fertile science learning environment surrounding the Sci-Dentity program.

Our analysis revealed that the contributions of librarians were less strong in the aspect of embracing the diversity of students as a means to learning science. A sensitivity about and appreciation for using diverse sources with the students were identified, but in this first implementation of the program, were not enacted yet. The potential to embrace diversity in a program that is led by librarians is rich. As reflected in the thoughts of the pre-service librarians and students numerous opportunities manifested themselves during the program. We use this analysis as a reflective moment to continue to brainstorm with the

Table 1. Summary of findings.

Socio-cultural aspects of learning science	Examples of librarians' contributions
Promoting young people's natural instincts to investigate and inquire through search skills	Librarians helped students engage in the scientific information search process by: • teaching research question development skills; • helping students frame search phrases; and • implementing lessons using research tools such as graphic organizers.
Connecting learning to students' interests and experiences	Librarians connected science to students' real lives by: • engaging the students in discussion of their favorite entertainment and connecting themes to science topics; • identifying technology and other issues that interest the students; and • helping researchers design sessions around themes to which the students could relate.
Embracing diversity as a means to enhance learning science	Librarians capitalized on the diversity of their students by: • using the cultural context of their students (media influences, priorities, etc.) to create more relevant lessons; and • identifying the different backgrounds of the students and relating these to the students' interactions with storytelling and science information.
Promoting science learning as a social enterprise	Librarians encouraged the ethical use of information by: • demonstrating the importance of giving credit for work by pointing out improper citation of students' own work by other participants; • teaching students proper citation skills, even when the source is not standard (i.e. Flickr pictures found on the iPad); • showing students sites that provide open source data, such as Creative Commons; and • engaging the students in conversations about proper online behavior.

librarians on how we can leverage librarians' knowledge about students, their culture, families, and community, use this knowledge to entice students into learning science, and to continue to magnify librarians' roles in the next iterations of Sci-Dentity. This will be the focus of the sessions in the next year of the program.

This paper focuses on ethnographic data collection methods that provide insights on how librarians can facilitate the development of science interest and learning. In further establishing the critical role that school librarians can play in science learning, we intend to gather data on changes in science interest (if any) from participating students. At the beginning of Sci-Dentity, we conducted a baseline science interest survey (adapted from Fraser, 1981) that captured participating students' initial science interest. We will continue administering this survey annually to observe changes in science interest as a result of participation in Sci-Dentity. In addition, annual interviews with participating students will also be conducted to further obtain data from the students' perspectives.

As Sci-Dentity is a less structured program implemented outside the formal curriculum in schools, we hope to further this exploration by making deeper connections between the school curriculum and students' lives, and extending this conceptual framework for stronger involvement of school library programs in formal science learning. Involvement in formal science learning poses further challenges such as resource allocations, institutional structures, scheduling, time investment, division of labor, and many more aspects of the school systems that will need to be explored and studied in the future. School librarians also differ in their background, graduate training, certification requirements, and interest; that may also have an impact in their abilities to function in creating and sustaining socio-cultural science learning environments in their schools. With the focus on science learning shifting from the memorization of facts to learning by capitalizing on socio-cultural aspects surrounding the young people's interests and environments in the US and internationally (UNESCO, 2010), we believe that librarians have exciting opportunities to deepen science learning and that young people will benefit tremendously from the contributions of school library programs.

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Appendix A

Sci-Dentity Session 3 Science Fact! Science Fiction!

Your main character is a _____ scientist whose name is _____. They live in _____ and are _____years old. Name one character trait they have (see box above for some ideas) _____.

What is your science fact?

Where is it from?

Where does the story take place?

What is the problem?

How does your character help solve the problem?

What is different now at the end of the story?