Supporting STEM Education: Needs Assessment of Southeastern Rural Teacher Librarians

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A current focus in schools in the United States is STEM education, which prepares students for successful employment and post-secondary studies that require unique and more-technically advanced skills through teaching and learning in the areas of science, technology, engineering, and mathematics (STEM). This approach is grounded in problem solving, discovery, and exploratory learning, which requires students to actively engage in a situation in order to find its solution. Students engage in STEM learning in many different ways, with technology and digital resources playing an important role. The prominence of technology in STEM education provides leadership opportunities for teacher librarians. Yet, teacher librarians must be prepared to lead in the integration of technology to support STEM education. This report presents identified needs of teacher librarians in regards to supporting STEM education and discusses implications for better preparing pre-service teacher librarians to lead in order to address the needs of a new generation of learners.

Introduction and Research Purpose

STEM education prepares students for successful employment and post-secondary studies that require unique and more-technically advanced skills through teaching and learning in the areas of science, technology, engineering, and mathematics (STEM). STEM education has been defined as an "interdisciplinary approach to learning where academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy" (Tsupros, Kohler, & Hallinen, 2009, p. 6). Educating students in the STEM areas not only prepares them for successful employment and post-secondary studies, but also for life, by teaching how to think critically and solve problems through a collaborative, hands-on, problem-solving, and project-based approach to education.

Despite the national initiatives focusing on STEM, students continue to rank lower in science, in general, and literacy in both math and science compared to their counterparts in other countries. American students rank 17th out of 33 in science literacy and 25th in math literacy among students in developed countries according to the most recent Programme for International Student Assessment (PISA) report, leading to continued concerns that U.S. schools are not preparing students to enter STEM fields (e.g., Desilver, 2017; Heim, 2016; National Academy of Engineering & National Research Council, 2014; National Science Foundation 2015; Randazzo, 2017).

STEM education is grounded in problem solving, discovery, and exploratory learning, which requires students to actively engage in a situation in order to find its solution (Young 2013). Students

engage in STEM learning in many different ways, with technology and media playing an important role (e.g., Mardis & Payo, 2010; Subramaniam, Ahn, Fleischmann, & Druin, 2012; Subramaniam & Edwards, 2014; Subramaniam et al., 2013; Young, 2013). In 2016, the International Society for Technology (ISTE) in Education renewed their *National Educational Technology Standards for Students* and added "computational thinker" to their list of seven major areas of focus in terms of K-12 students' knowledge, skills, and abilities in the K-12 context and beyond. Students need exposure to current and emerging technologies appropriate for STEM learning, but also instruction on how to interact with and utilize digital tools for communicating, participating, organizing information, problem solving, and generating new knowledge to improve learning in all subject areas and to acquire lifelong knowledge and skills (AASL, 2018).

Teacher librarians with advanced digital information abilities, along with expertise in inquiry learning can engage students and support teachers by providing access to digital resources, encouraging students in authentic inquiry practices, and providing real-world collaborative learning opportunities to promote STEM learning. Therefore, the purpose of this research is to explore and document the needs of teacher librarians in regards to supporting STEM education efforts in their schools, specifically through the utilization and integration of digital tools and resources, to address the research question:

> What are the knowledge, skills, and abilities needed by teacher librarians in order to support STEM learning?

This investigation specifically seeks to identify the current knowledge and abilities of teacher librarians in regards to supporting science, technology, engineering, and mathematics content areas and the gaps in knowledge and skills in order to serve as the basis for curriculum development for teacher librarians preparation programs, as well as creating professional development/continuing education opportunities for practicing teacher librarians.

Review of the Literature

The studies to date that have examined the relationships between teacher librarians and the needs and priorities for STEM education find that teacher librarians can play an important role in supporting students and teachers (e.g., Hoffman & Mardis, 2008; Mardis, 2014; Rawson, Anderson, & Hughes-Hassel, 2014; Subramaniam et al., 2013; Subramaniam et al., 2012; Subramaniam & Edwards, 2014). The role of information specialist has been found to demonstrate the most potential for supporting STEM education efforts (Mardis, 2007; Mardis & Hoffman, 2007; Subramaniam et al., 2012; Subramaniam et al., 2013). In the 2018 AASL *National School Library Standards*, the responsibilities of the role of the information specialist are embedded throughout the Domains of "Think, Create, Share, Grow." Yet teacher librarians are still directed to introduce students to emerging technologies and teach them how to find, assess, and utilize information for learning (AASL, 2018).

The Role of the Teacher Librarian Supporting STEM

Education research illustrates that utilizing technology effectively in the classroom can improve students' critical thinking skills, improve standardized test scores, provide numerous innovative educational opportunities, increase student motivation, and enhance the overall learning experience for students (e.g., Delgado, Wardlow, McKnight, & O'Malley, 2015; Donovan, Green, & Hartley, 2010; Fu, 2013; Johnson, Adams, Becker, Estrada, & Freeman, 2015; Levin & Schrum, 2013). Yet, research finds that teachers continue to have difficulty locating appropriate digital content and

are uncomfortable using digital content (Project Tomorrow, 2015; U.S. Department of Education, 2017).

Teacher librarians, as information specialists, can find resources to support STEM content areas for teachers to utilize in their instruction (Hoffman & Mardis, 2008; McIlvain, 2010; Mardis, 2014; Perrault, 2007; Rawson, 2014; Subramaniam, 2015; Subramaniam, et al. 2013). Digital resources and tools enrich student learning by enabling them to comprehend, visualize, and explain difficult concepts, which are otherwise difficult to portray inside the classroom, and by providing authentic learning and analytical experiences, such as demonstrations, simulations, experiments and observations of real world events, which were once limited to scientists (Guzey & Roehrig, 2009; Subramaniam et al., 2012). The increased sense of urgency around how to effectively use digital tools and content to impact student learning, paired with teacher's continued struggles and discomfort with using digital content, positions teacher librarians to train teachers and model for teachers how to effectively use technology and media for STEM learning (Albertson & Johnston, 2016; Johnston, 2012; Pandora, 2009; Mardis, 2014; Subramaniam et al., 2013; Wolf, Jones, & Gilbert, 2014).

Teacher librarians can also interact with and engage all students in effectively utilizing digital resources, such as digital videos, simulations, and online gaming, that will develop scientific problem solving thinking (Mardis & Hoffman, 2007; McIIvain, 2010; Perrault, 2010; Project Tomorrow, 2015; Subramaniam et al., 2012; Subramaniam et al., 2013). The top subject areas in which video is utilized to support learning are science and math (Henriques, 2016; Johnson et al., 2015) and it is commonly the teacher librarian who recommends videos to teachers (Albertson & Johnston, 2016; Mardis, 2007, 2014; McIIvain, 2010; Wolf, Jones, & Gilbert, 2014). Teacher librarians can build a rich multimedia collection and teach students about utilizing a variety of digital tools, such as databases, online digital libraries, and apps, to locate information and to organize their findings through curriculum and interest based projects (Mardis, 2014; Mardis, 2015; Mardis & Payo, 2007; Subramaniam et al., 2013; Young, 2013). Additionally, teacher librarians can help teachers and students locate data from online databases to answer questions, collect evidence to support arguments, and develop data literacy practices especially related to science and engineering (Fontichiaro, 2016; Henriques, 2016;).

Digital resources and media have opened up a participatory world where students can connect to a global world of information and learn; it is teacher librarians that can teach students ethical and responsible behaviors to become global literate citizens (Subramaniam, et al., 2012). As Subramaniam et al. (2012) found, "school library program is the ideal place to connect young people, media, and technology to engage students in STEM" and by leveraging expertise in integrating, utilizing, and managing digital information, teacher librarians can engage students in K-12 libraries to facilitate inquiry and digital literacies in STEM areas (p. 163). "School libraries emerge as an ideal hybrid space to bridge the formal classroom with the broader world" by making connections between the digital resources and concepts and their application to the world outside of the classroom or library (Subramaniam et al., 2012, p. 163).

Teacher librarians can also provide a learning environment that promotes inquiry, collaboration, and exploration (Schultz-Jones, 2010; Schultz-Jones & Ledbetter, 2009, 2010; Subramaniam et al., 2012, Young, 2013). Library spaces can be utilized to facilitate curiosity and inquiry to create innovative learning opportunities and these "experiences can influence STEM-related learning and career goals" (Small, 2014, p. 17). Providing an authentic 21st century learning environment in the school library in which technologies are integrated in more effective ways helps to achieve the fluent use of technology and information in various forms (Sharkey & O'Connor, 2013).

The makerspace movement in school libraries is one such example of creating spaces and projects encourages students to move from being users and consumers to being creators and

innovators (Kurti, Kurti, & Fleming, 2014). Based on constructivism, makerspaces provide an inquiry-based approach to the development of knowledge and thinking processes promotes a richer engagement and curiosity within the STEM disciplines and encourage students to think creatively, collaborate and problem solve (Dougherty, 2013; Kurti, Kurti, & Fleming, 2014). Makerspaces invite learners to engage in the innovative uses of technology and target a "unique package of complementary 21st century skills and aptitudes such as creativity, innovation, transmedia navigation, visual literacy" (Bowler, 2014, p. 59). Teacher libraries can provide a resource rich flexible environment for discovery and exploration, which is an important part of STEM education. Additionally, these spaces can be extended past just the physical space to include hybrid learning spaces, virtual worlds, and online learning communities (Schultz-Jones, 2010; Subramaniam, et al., 2012). While research on makerspaces is growing, the research looking at preparing future educators to implement makerspaces for educational purposes is limited (Bowler, 2014; Moorefield-Lang, 2015).

Challenges in Supporting STEM

Yet, despite these opportunities for teacher librarians to become actively involved in STEM education, research suggests that teacher librarians are not embracing them (Montiel-Overall & Grimes, 2013; Rawson, 2014; Subramaniam et al., 2012; Subramaniam et al., 2013). Shultz-Jones and Ledbetter (2009) find that even though information literacy and science literacy goals correspond, collaboration does not often take place, attributing this to science and math teachers' concerns regarding the teacher librarian's credibility and a lack of awareness of how the teacher librarians can positively affect student achievement. The same holds true for math teachers, who discount the teacher librarians and the needed expertise in mathematics to serve as an instructional partner (Subramaniam & Edwards, 2014).

Another barrier reported is the teacher librarians themselves. Previous research finds that teacher librarians do not feel confident in their content knowledge of STEM areas (Mardis, 2007; Perrault, 2007; Rawson, 2014; Rawson, Anderson, & Hughes-Hassell, 2015; Subramaniam & Edwards, 2014; Subramaniam et al., 2012; Subramaniam et al., 2013). Some attribute this to the fact that many teacher librarians come from a humanities background and lack the content knowledge in the STEM areas and are therefore hesitant to collaborate with teachers in these areas (Mardis, 2007; Perrault, 2007; Schultz-Jones, 2010; Schultz-Jones & Ledbetter, 2009, 2010; Young, 2013). This lack of familiarity with the STEM areas and content standards can also lead to an inadequate collection of resources – both print and nonprint to support STEM education (Hoffman & Mardis, 2008; Mardis, 2014; Mardis, 2015; Schultz-Jones, 2010; Shultz-Jones & Ledbetter, 2009; Young, 2013).

There is a natural connection between information literacy and the STEM areas, especially math and science, in that they are both based on inquiry learning and teach the research process along with critical thinking (e.g., Mardis, 2006; Schultz-Jones, 2010; Schultz-Jones & Ledbetter, 2009; Rawson, 2014; Rawson et al., 2015; Subramaniam & Edwards, 2014; Subramaniam et al., 2012: Young, 2013). This provides the opportunities for teacher librarians to partner with STEM area teachers to in facilitate the inquiry process, develop technology fluency, and integrate different literacy practices (Mardis, 2007; Subramaniam & Edwards, 2014; Subramaniam et al., 2012; Subramaniam et al., 2013). Yet, this deficit in the knowledge, skills, and abilities that teacher librarians need to support STEM has led to feelings of inadequacy with STEM content areas and digital tools, resulting in hesitation to work with students and teachers in these areas and therefore leading to leading to inadequate services for the STEM needs of students and teachers.

Research Design

Needs assessment research is a "systematic approach to studying the state of knowledge, ability, interest, or attitude of a defined audience or group involving a particular subject" (McCawley, 2009, p. 3). In this research, the defined group is teacher librarians in rural areas of the southeastern United States and the topic is the state of their knowledge, ability, interest, or attitude in supporting STEM learning in their school library programs. This type of assessment is conducted in order to allow the target audience to verify its own level of knowledge and skill, as well as its perceptions on the gaps and possible solutions (McCawley, 2009). This research followed the needs assessment process as defined by McCawley (2009): determine objectives, define the target audience, and collect the data. The methods of key informant interview and observation were utilized for data collection.

Determining Objectives

The first step in conducting a needs assessment it to determine the objectives of the study. The objectives of this study were taken from the overarching research question: 1) determine the knowledge, skills, and abilities that teacher librarians working in STEM schools felt were needed in order to support STEM education efforts; and 2) learn if the teacher librarians perceived if they had been adequately prepared for this role; and if not, where do they perceive the gaps. It is important in a needs assessment to not limit information gathered to just existing knowledge or skills, but to investigate what the audience already knows or believes about the topic, what other efforts they may have taken to address deficiencies, and the audience's opinions and perceived solutions (McCawley, 2009).

Defining the Target Audience

Needs assessments document the current situation for a target audience, therefore the second step in conducting a needs assessment is to thoroughly define the target audience, or those who will provide the data (McCrawley, 2009). The target audience for this study was teacher librarians working in schools that are designated as a "STEM school." For the purposes of this research a STEM school is one that has been certified by their state department of education or local area ruling school body as a STEM school, or has some type of "official" designation as a STEM school, academy, or magnet school.

To further define the target audience, a geographical criterion was imposed, as the rural southeastern United States. Rural school districts face formidable challenges, particularly when compared to urban/suburban schools in the advancement of STEM education. These challenges include tight budgets, inflexible curricula, lack of technology, struggles with recruiting and retaining great teachers in shortage areas like STEM, and a lack of professional development opportunities for teachers (Johnson, Mitchel, & Rotherman, 2014; Randazzo, 2017; Smith, 2015). The report *Why Rural Matters* finds that "over 9.7 million students are enrolled in rural school districts, more than 20 percent of all public school students in the United States" (Johnson, Showalter, Klein, & Lester, 2014, p. 27). This report analyzes the contexts and conditions of rural education in each of the 50 states and finds that the southeastern states of Alabama, Georgia, and Louisiana all rank in the top 12 in states in leading the way in critical importance with high rates of rural students and districts considered rural, high socioeconomic challenges, and ranking near the bottom nationally on National Assessment of Educational Progress (NAEP) science and math scores. Therefore, teacher librarians working in rural areas from the states of Alabama, Georgia, and Louisiana were selected as the target audience. The rural and culturally diverse populations found in these areas comprise

some of the lowest socioeconomic indices in the country, so there is a critical need for support in STEM education that a teacher librarian can provide.

Collecting the Data

The next step in the needs assessment process is to gather appropriate and sufficient data that provides concrete evidence that can be used to determine which of the possible means-to-the-ends are most effective and efficient for achieving the desired results (Gilchrist & Williams, 1999). It was determined that the most appropriate methods to employ for this research were key informant interviews and observation. The needs assessment process is not a linear one, it is iterative with loops, with what you learn from your observations may inform what you ask in the interview, and what you learn in the interview may lead you to see things differently in your observations (McCawley, 2009).

Key informant interview method. Key informant interview is a qualitative research method in which the researcher conducts in-depth interviews with a select group of individuals who are likely to provide needed information, ideas, and insights on the particular subject of study (Gilchrist & Williams, 1999; Kaplan, 2013; Tremblay, 2003). In-depth interviews are conducted with a small number of key informants, usually 15-35, and focus on a topic that the interviewees have first-hand knowledge. The interview is usually conducted using an interview guide that list topics, issues, or general questions to be covered during the interview. The interviewer frames the actual questions during the course of the interview. This semi-structured interview with a key informant should have an informal tone, like a conversation. The interviewer probes to elicit more information from the informant throughout the interview. The primary goal is to obtain qualitative description of perceptions or experiences, rather than measuring aspects of the experience (Gilchrist & Wlliams, 1999; Kumar, 1989; Tremblay, 2003).

Selecting the key informants. Key informants are individuals who meet specific selection of criteria based on their personal experiences and knowledge, in the case of this research the key informants were defined in the targeted group, as those teacher librarians currently working in schools designated as STEM schools in the rural southeastern U.S. Key informants are purposively selected because they are knowledgeable and/or have experience with the topic under study, in this case the knowledge, skills, and abilities needed to support STEM learning, and can provide significant contributions to the inquiry (Kaplan, 2013; Kumar, 1989; Tremblay, 2003).

The Georgia Department of Education has a program in place where PK-12 schools can apply to be a certified STEM school (Georgia Department of Education, 2016). This list of STEM certified schools was utilized to locate STEM schools in Georgia. The researcher then conducted internet searches to find the websites of each school to determine location, then locate the school library page to first see if they had a teacher librarian (all did not), and to look at the programming going on in the library. In staying with the suggest size of 15-35 informants, the researcher selected 13 teacher librarians in Georgia to email to see if they would be willing to be interviewed about their efforts to support STEM learning in their schools. Twelve teacher librarians responded positively and agreed to be interviewed.

In the states of Alabama and Louisiana there is no state STEM certification program so internet searches were performed to locate schools that are designated at a STEM school, academy, or magnet. A list of 15 STEM schools in Alabama and 15 in Louisiana was compiled. Each school's website was examined following the same procedure as in Georgia. Another strategy in selecting key informants is consult with relevant experts who should be able to recommend the optimal key informant candidates (Kaplan, 2013). Therefore, the researcher also consulted with teacher library

professional contacts in each state that were able to recommend school librarians at STEM schools. Twelve teacher librarians in Alabama and 12 in Louisiana were emailed to see if they would be willing to be interviewed about their efforts to support STEM learning in their schools. Eight school librarians from Alabama and six from Louisiana responded positively and agreed to be interviewed bringing the total number of interviews to 26.

Key informant interviews. It is important to establish a rapport with the key informants in order to obtain in-depth information about practices and perceptions (Kaplan, 2013; Kumar, 1989; Tremblay, 2003). The researcher began this rapport with email communication with an informal tone and explaining the project. The researcher traveled to each school to conduct interviews over a three-month time period.

An interview guide was utilized with interview topics/questions to be covered during the interview (Appendix A), the researcher asked questions according to the situation to "seek insights, ask follow-up questions, explore different points made during the course of conversation and identify distinctions in perspectives" (Kaplan, 2013, p. 1). All questions were asked informally in a conversational tone, usually while walking around the school library rather than formally at a table. More issues or topics were covered during the interview than identified in the interview guide, because as the key informants talked about their experiences or giving views and recommendations and the researcher asked more probing questions to seek more details and clarification. This type of interview provides flexibility to explore new ideas and issues that are relevant to the study's purpose (Kaplan, 2013; Kumar, 1989; Tremblay, 2003). After obtaining permission, all interviews were recorded with a digital audio recorder and the researcher also took extensive notes throughout the interview. It is recommended that key informant interviews are all recorded and supplemented with research notes to ensure the collection of accurate and comprehensive responses (Gilchrist & Williams, 1996; Kaplan, 2013; Kumar, 1989; Tremblay, 2003).

Observation method. Observation was chosen as complimentary to the interviews with the key informant teacher librarians due to the important part that the environment and use of space in the school library plays in supporting STEM learning (Schultz-Jones, 2010; Schultz-Jones & Ledbetter, 2009, 2010; Subramaniam et al., 2012, Young, 2013). The needs assessment process is iterative and informal direct observations led to more questions for the informants during the interview. Observation allowed for notes of how space was being used, the activities going on in the school library, the collection, and of special programming to support STEM. The researcher made detailed notes of the setting and activities taking place in the library and most informants gave detailed tours and descriptions of how their spaces were being used and special programming going on such as STEM centers, makerspaces, robotics tables, and Lego walls; all these descriptions were recorded. Photos were also taken of each school library to document ways that STEM learning was supported. Observation is also used as a way to increase the validity of the study, as observations may help the researcher have a better understanding of the context and phenomenon under study (Kawulich, 2005). The audio interviews were transcribed each night after the researcher conducted the interview. A file was created for each interview that included the audio recording, transcripts of the recording, observation notes, and photographs taken.

Data Analysis

A total of 26 key informant interviews were conducted with teacher librarians in STEM schools in the states of Georgia, Alabama, and Louisiana, therefore staying within the ideal size of 15-35 key informants. Analysis in needs assessment research is about looking for trends and patterns (McCawley, 2009). Thematic analysis is a method for identifying, analyzing, and reporting patterns (themes) within data. Themes that emerge "capture something important about the data in relation

to the research questions" and are important to the description of the phenomenon under study (Fereday & Muir-Cochrane, 2006; Kaplan, 2013; Vaughn & Clark, 2006). Therefore, thematic analysis of the interview transcripts, direct observation notes, and photographs was conducted. Since this is exploratory research, an inductive approach was taken in that the themes emerge from the frequent, dominant, or significant themes inherent in the data (Vaughn & Clarke 2006).

This exploratory research followed the step-by-step method for thematic analysis defined by Vaughn and Clark (2006). The data collected from the interviews and notes was transcribed by the researcher, during this process the initial thoughts and ideas were noted down as this is considered an essential stage in analysis. The transcribed data was then read and re-read several times and, in addition, the recordings were listened to several times to ensure the accuracy of the transcription. This process of "repeated reading" and the use of the recordings to listen to the data, results in data immersion and refers to the researcher's closeness with the data (Vaughn & Clark 2006). The interview transcripts, direct observation notes, and photographs were uploaded into NVivo and sorted into folders based on the site where they were gathered. Word frequency queries were run an all data sources and all data were coded by word. The researcher conducted analysis to identify and synthesize recurring themes emerging from the data based on prevalence, which was counted in terms of the number of occurrences across all of the data sources collected from all the sites and the core meanings evident in the data that were relevant to the research objectives. The visual representation features in NVivo were utilized to sort the coded data in to overarching themes and then each piece of coded data was examined to ensure that the theme captured the meaning and aspects of the coded data. Sub-nodes were made according to these themes to capture additional data specific to these themes as well.

Limitations of this study include that it was conducted with a very specific population and that results are non-generalizable. Yet the purpose of this research is exploratory, as an initial investigation into the specific knowledge, skills, and abilities needed by teacher librarians in order to support STEM learning. This exploration can inform future research, including investigations into the needs identified by these participants to determine if they hold true for other populations and in other settings.

Findings and Discussion

The thematic analysis process that was applied to the transcripts elicited patterns or themes that were evident in the data. These themes are viewed as essential in determining the needs of all the participants. The major overarching themes emerged as: STEM Content Knowledge, Technology, Resources, and Environment.

STEM Content Knowledge

One of the overarching themes that emerged was knowledge of STEM areas content. Teacher librarian participants frequently spoke of the need to know and understand the content areas of science, math, engineering, and technology and the curricular standards that guided each area. Their comments frequently included statements about "making connections" across the disciplines and that research skills could be integrated in all areas. Inquiry based learning was mentioned by a majority of participants in the context of a way that they could support these learning in the STEM areas, which are based on this type of framework. Several participants spoke about knowledge of the standards that guided these areas, specifically mentioning *The Next-Generation Science Standards*, the *NETS for Students* and the *Common Core State Standards,* specifically the *Common Core State Standards for Mathematics*. One participant expressed "in my preparation program we mainly

focused on collaborating and co-teaching with Language Arts teachers and learning how to support literacy standards and reading comprehension." Another expressed these same sentiments, "I really feel like I had to educate myself on the curricula of the STEM areas and how I as a school librarian could support and work with these teachers."

One area of STEM that was frequently mentioned was the importance of teaching students a process of thinking; engineering design process, inquiry based learning, and computational thinking were all mentioned by participants as ways to teach problem solving and critical thinking. Participants spoke of a lack of knowledge from their preparation programs in this area and how they had taken it upon themselves to learn various instructional methods to promote the collaborative problem solving aspect that is an important element of STEM education. Participants expressed their efforts to teach students through partnering with teachers. "I work with teachers whenever possible to develop inquiry based lessons that we can connect to science." Inquiry based learning was mentioned frequently by participants, which was expected since the *AASL Standards for the 21st Century Learner* were based on inquiry learning (AASL, 2009). It should be noted that this research was conducted before the new *AASL National School Library Standards* were released in late 2017. Participants also spoke of emphasizing problem-solving and critical thinking in their instruction and three participants mentioned utilizing the "Engineering Design Process– Ask, Imagine, Plan & Design, Create, Test, Improve."

Nearly all participants mentioned teaching coding in some way or form to students in their schools, ranging from incorporating within their instruction, setting up coding centers in their libraries, organizing programming such as Hour of Code, and developing coding clubs. Knowing how to code requires computational thinking skills and an understanding of how to troubleshoot, problem solve, and think critically; when a young person learns to code, they gain STEM skills (Braun & Visser, 2017). One participant expressed "I had no idea what computational thinking was, much less how to teach it." Participants described ways they had tried to implement coding as a way to support STEM "I decided to begin a coding club for students during lunchtime as a way I could support the STEM goals of my school. It wasn't easy because I first had to teach myself, but there are a ton of great resources out there." But, there was an overall sense that there was a lack of connection between coding and computational thinking. Many participants spoke of coding as a way to "teach STEM," indicating a lack of STEM content area knowledge.

Teachers librarians need background knowledge of the STEM content areas, including the foundational principles and the curricular standards that guide each area. This lack of STEM content area knowledge influences the collection and resources provided, the programs offered, the ability to effectively integrate technology for teaching and learning, and collaborative efforts with teachers in these areas; all leading to inadequate services for the STEM needs of students and teachers.

Technology

Technology was the most frequently mentioned topic by participants when discussing how they support STEM education in their schools. Concepts that emerged as sub-themes as needs were determined as: the knowledge of how to effectively integrate technology to support STEM; the skills to teach students how to access and utilize digital information; and the ability to stay up-to-date on emerging technologies.

Effectively integrating technology for teaching in the STEM areas. While an important aspect of teacher librarians supporting STEM areas is the purchasing of a variety of technology and digital resources, participants spoke more about how to integrate the resources into the teaching and learning process. Participants expressed that sometimes they felt they did not have enough knowledge on how to integrate the resources effectively in the STEM areas. This overlaps with the

content area knowledge theme. "There is so much technology that can be utilized for supporting the STEM nowadays ranging from digital microscopes to virtual reality simulations, but you need a sound understanding of how to best use these resources for learning. I think this is an area I could have learned more about in library school." Other participants expressed this deficit in their preparation programs as well, stating "I feel like there was a lot of look at all these great resources you can find online, but not enough learning the principles of integrating them to support learning." Again, indicating that teacher librarians need some background knowledge of the STEM content areas and what STEM education in general entails in order to effectively integrate technology to support teaching and learning in these areas.

Participants also frequently spoke about the expectation that they train teachers on technology. One teacher librarian expressed that "my district continually purchases equipment and other resources, like iPads for each school. But they never provide any training." The role of professional developer is one that the teacher librarian can enact and therefore support teachers. All but two participants mentioned the importance of providing training for teachers on technology for use to support STEM. Many STEM concepts can be hard for students to grasp just by reading about them, but the effective integration of digital resources can bring concepts alive (Mardis & Payo, 2007; Mardis, 2014; Subramaniam et al. 2012; Subramaniam et al. 2013; Subramaniam & Edwards, 2014; Young 2013). Yet teachers still struggle with integrating technology effectively for instruction. Participants expressed that there was the expectation from their administrators that they assist with this. "My principal sees that I should be more than just a provider of these great resources for teacher – that I should be able to train the teachers on how to use them too." Teacher librarians must be able to make the connection for teachers to appropriate technologies for STEM education and how to integrate them for teaching and learning.

Teaching students how to access and utilize digital information. Technology has become a crucial element of teaching and learning, especially when it comes to preparing students that are equipped with the skills and knowledge they need to succeed in the technological society of the 21st century and beyond. Participants expressed their efforts to teach students through partnering with teachers. "I try to work with teachers to come up with lessons for researching topics in the science and math areas" and "I promote lessons to teach students about how they can find up to date information online." In modeling and partnering with teachers, teacher librarians can guide instructional design and offer expertise on the integration of emergent technologies to create engaging and relevant learning experiences for students (AASL, 2018; Johnston, 2012). Sadly, several participants expressed the lack of collaboration with teachers in the science and mathematics areas. "Supporting teachers in the STEM areas should be just like supporting reading and social studies, but those teachers don't seem to want to work with me." Others expressed that it was about "putting more effort into reaching out to those teachers" and being "proactive to design lessons that show teachers that I do have something to offer their students." It is about "marketing yourself and your program."

There was a strong focus on teaching students how to locate and use information they find online, through databases and other online resources. "I have increased my subscriptions to online databases, especially those with a science focus, and I have expanded my teaching about the databases through all grade levels – even down to First Grade." In describing how they teach these skills, participants mentioned that they "try to incorporate teaching databases into authentic research lessons and projects with each grade level." The states of Georgia and Alabama both have state supported database services, GALILEO and Alabama Virtual Library, which participants mentioned utilizing for instruction. The importance teaching students how to critically evaluate data

and the ethical use of information (digital citizenship) were also mentioned by many participants. Teacher librarians need the skills to teach students about digital information – locating it, accessing it, evaluating it, and utilizing it in all areas.

Staying current on emergent technologies. A common thread through the various responses of the participants was their implicit and explicit references to their concern to stay current on emerging technology. The interview responses demonstrate participants' beliefs that it is the responsibility of the teacher librarian to stay on the cutting edge of emerging technologies so they can introduce them to students and teachers. One participant expressed this saying that "it is like a full-time job just to stay up-to-date – it seems like every day there is some new digital resource." Another participant stated that while you are in your preparation programs it is easy to stay current with information from courses and from other classmates, yet "when I got out into practice I felt like I was falling behind - it was hard to keep up." Other teacher librarians shared how they strive to stay current: reading journals, webpages/blogs, social media (Twitter was mentioned by every participant), going to conferences, and attending trainings. The participants also spoke of learning from other teacher librarians through informal channels, but also through professional organizations. This echoes previous research which found professional organizations as an enabler for teacher librarians acting as leaders in technology integration (Johnston, 2012).

Resources

Participants all mentioned providing resources as a way that they supported STEM education in their schools. Though participants expressed that this was seen as a basic level of support and that it had to go beyond this. "Providing an up to date collection that includes print and nonprint resources is one of the most basic ways I feel that I can support the STEM areas in my school." In regards to the print collection focusing on the materials "especially the 500s" or the Dewey classification that deals with the natural sciences and mathematics, was frequently mentioned, but so were "biographies of important scientists," "fiction materials on STEM subjects," and "STEM career books." The school library can provide a place for students to connect with various aspects of STEM learning through their collection and the resources provided (Mardis, 2014, 2015). Purchasing and "bulking up" the eBook collection was also suggested by 8 participants and 3 mentioned interactive augmented reality books. Participants talked about seeking out more review sources for science and math books to assist them in ordering. This was yet another area where participants stated that their lack of knowledge on STEM areas could be a challenge.

Digital resources. Most of the focus was on digital resources. Participants discussed purchasing a variety of technology equipment to support STEM, everything from iPads to log observations on science projects, to poster printers to create data charts and diagrams. Other equipment mentioned by participants included digital microscopes, 3D printers, circuit sets, drones, and codable robots (i.e., Sphero, Osmo), all in order to support STEM learning. A plethora of digital resources were mentioned by participants, such as a variety of apps that are utilized for teaching and learning, apps for content creation, database subscriptions, digital video subscriptions, and free services.

Yet, noticeably absent was the specific mention of open educational resources (OER). Even though there is "increasing evidence that effective use of OER… improves student critical outcomes— everything from test scores to college enrollments, … only ten percent of K-12 educators are using OER, [which] means 90 percent still are not" (Kramer, 2015). Classroom teachers are confused or unsure about OER and the licensing governing their use (Shear, Means, & Lundh, 2015) and teacher librarians can serve as a resource to assist teachers in utilizing these valuable resources. Indicating that teacher librarians need further education on what OER are, how to find them,

licensing governing their usage, and how to adapt and use these valuable resources for teaching and learning.

Digital video was mentioned by all participants as important in supporting STEM areas, especially using "snippets or segments" to show students "real examples." The issue of staying up-to-date on these resources and how to effectively use for teaching and learning was frequently mentioned and most of the teacher librarian participants spoke of taking the initiative to teach themselves how to use the various digital tools. They also spoke of partnering with the instructional technologist and STEM coordinators at their schools, as well as other teacher librarians in their district, as ways they are "consistently learning."

Funding resources. A particularly interesting finding was the variety of ways that the teacher librarian participants were funding the purchasing of resources on limited budgets. Participants mentioned applying for grants, setting up Go Fund Me sites and Donors Choose pages, and working with community partners. Twenty two out of 26 participant spoke about writing grants. When asked if they had formal education on how to write a grant proposal or felt they had they knowledge needed to apply for grants, 20 out of the 22 said no. For the most part, participants spoke of learning as they went along and three mentioned attending some sort of professional development on grant writing, indicating a need for more education in preparation programs on grant writing and methods for advocating for funding and resources.

Community resources. The rural teacher librarian participants also spoke about the importance of community resources and how making community connections and utilizing local resources to help students establish connections between their learning, communities, and possible future career opportunities available to them. Participants spoke of "targeting people in my own community that could come bring a real-world perspective for the students." Several of the teacher librarians identified themselves as a liaison to the community. "I am always approaching businesses, parents, and whoever I can find that has expertise to offer our students." And this was noted in the observation data, with many parents and other "experts" in the library working with students and pictures of previous events. This finding indicates that another need for teacher librarians is coursework that teaches about partnering with community organizations.

Environment

The third theme that emerged from the data was the importance of designing an environment that supports discovery inquiry-based learning that is at the heart of STEM education. Every participant was eager to show their library space and what they were doing to create an environment conducive to support this type of learning. With the current focus on makerspaces in school libraries, it was not surprising that all of the libraries visited had some sort of makerspace area. What was surprising was that their makerspace was how many of them said they were "doing STEM." While others had STEM centers or stations with different activities tied to science and math concepts. Most of these makerspaces were about technology with codable robots, circuit kits, video equipment, iPads and apps, coding and gaming apps, and 3D printers. There were some less technical ones too, with constructing with recyclable materials, knitting, Legos, homemade playdough, and even one had biographies of scientists to learn about.

Overall though there was a big focus on "stuff." A concern mentioned by participants was obtaining and replenishing items for their makerspace. Another focus was on furniture that would support collaborative exploratory learning. Surprising was the lack of connection that was made for these makerspaces to supporting the curriculum, though a few participants were able to articulate how their makerspace was tied supporting content area standards. "I try to have research activities

that students can complete as part of their making" and "I work with teachers to come up with activities for the makerspace that are connected to all content areas, not just science and math." When asked why they had makerspace responses ranged from "because that is what everyone is doing now in the school library – you must have a makerspace," to "my principal said we must have a makerspace," to "the makerspace is a way I can support STEM learning." Though a couple did make the connection to having activities that promoted the engineering design process, inquiry based learning, and connected learning in a fun way. This research finds, as Bowler (2014) discovered, future teacher librarians need to be taught ways "to implement makerspaces that reflect the core mission and goals of the library" (p. 60) and how to "demonstrate benefits for students" (Fontichiaro, 2016). Most of the participants responded that this was another area in which they were self-taught and had taken the initiative to learn about makerspaces through reading journals and blogs, attending conference sessions and webinars, from other teacher librarians, and social media.

Conclusions and Implications

The overall findings signify a need for teacher librarian preparation programs to adapt to better prepare students for the expectations of today's teacher librarians. When asked if they felt that their preparation program prepared them to support STEM teaching and learning in their school, 100% of participants said no. Additionally, professional development/continuing education opportunities are needed for those teacher librarians already in practice on how they can support STEM education in their schools.

Programs need to focus on educating teacher librarians on the foundational concepts of the STEM areas of science, technology, engineering, and mathematics. This would include the core concepts and standards that guide each of these areas. An increase in the basic content area knowledge will bolster the confidence of the teacher librarian, and potentially lead to an increase in collaboration and communication with the teachers of these areas. This can have implications not only for instruction, but also for collection development.

Teacher librarians need to be able to support technology integration efforts in all curricular areas, but especially in STEM, where technology and media play such an important part in the teaching and learning of these subjects. Professors in preparation programs must stay up-to-date with the field, national initiatives that impact the profession, and design coursework that reflects this, in order to best prepare future teacher librarians to meet demands and expectations. Teachers continue to find locating appropriate resources to utilize for instruction challenging and still struggle with effective integration. Programs need to include educating teacher librarians various digital resources, including Open Educational Resources, and how they can be utilized in their schools. Teacher librarians need coursework that teaches effective integration of technology for teaching and learning. This type of coursework must include learning the skills necessary to teach students how to locate, access, evaluate, and utilizing digital information within an inquiry based learning framework. Providing this type of preparation and/or training will help teacher librarians better serve to support teachers in their STEM teaching efforts and in teaching students the skills they need to interact with and utilize digital information.

With the current popularity of makerspaces in school libraries, teacher librarian preparation programs must address the underlying foundations of the maker movement and teach future teacher librarians the "how and why" of having a makerspace, with a focus on the benefits to students. Teacher librarian preparation programs need to educated future teacher librarians on how to make the connection to STEM education so that they understand why a makerspace can be considered a way to support STEM learning. While makerspaces will be different for every school,

teacher librarians need to understand how to create these "exciting innovative spaces" for students where "ideas are valued and creativity flourishes" (Small, 2014). Therefore, coursework needs to include elements of design thinking, constructivism, and inquiry-based learning, and how makerspaces can provide students an opportunity to be innovative, problem solve, and interact with peers.

Teacher librarian preparation programs must prepare students to go into practice with strategies on how to stay up-to-date on emerging technologies. Programs can teach students how to connect with other teacher librarians in the field and create a group of supportive colleagues or a community of practice. Pre-service teacher librarians can also be introduced to various professional organizations where they can meet other teacher librarians and experience professional growth opportunities through conferences, workshops, blogs, and journals. Introducing students to various ways to stay current, such as social media and how to develop strategies for effectively utilizing these various outlets should be a part of every teacher librarian preparation program. Yet, it is also important to teach students to move beyond just their own comfort zone of teacher librarianship, to expand their learning from other areas, for example using social media to follow STEM educators for the most current technologies for use in these areas.

Rural teacher librarians also spoke about the importance of making community connections and utilizing local resources to help students establish connections between their learning, communities, and possible future career opportunities available to them. Programs need to educate teacher librarians on making these community connections, whether it is with community organizations, local universities, museums, businesses, or parents, because STEM can mean something different based on the community where the school is located.

This study builds on the previous research to identify the specific needs of teacher librarians in supporting STEM education. Findings contribute to the exploratory purpose of this study to identify the specific needs of teacher librarians in regards to supporting STEM education. Implications demonstrate the need for teacher librarian preparation programs to adapt in order to better prepare pre-service teacher librarians to lead and address the needs of a new generation of learners.

References

Albertson, D., & Johnston, M. P. (2016). Individual differences of science teachers and interactive video retrieval. *The Electronic Library*, *34*(1), 42-57.

American Association of School Librarians. (2009). *Empowering learners: Guidelines for school library programs.* Chicago, IL: ALA.

American Association of School Librarians. (2018). *National school library standards for learners, school librarians, and school libraries.* Chicago, IL: ALA.

Bertram, V. (2014). *The most important resolution: STEM education*. Retrieved from http://edexcellence.net/commentary/ education-gadfly-daily/flypaper/the-most-important-resolution-stem-education

Bowler, L. (2014). Creativity though 'maker' experiences and design thinking in the education of librarians. *Knowledge Quest*, *42*(5), 58-61.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101.

Braun, L., & Visser, M. (2017). *Ready to code: Connecting youth to CS opportunities through libraries report*. Chicago, IL: ALA. Retrieved from http://www.ala.org/advocacy/ sites/ala.org.advocacy/ files/content/pp/Ready_To_Code_Report_FINAL.pdf

Delgado, A. J., Wardlow, L., McKnight, K., & O'Malley, K. (2015). Educational technology: A review of the integration, resources, and effectiveness of technology in K-12 classrooms. *Journal of Information Technology Education: Research, 14,* 397-416. Retrieved from http://www.jite.org/documents/Vol14/JITEv14ResearchP397- 416Delgado1829.pdf

Desilver, D. (2017). *U.S. students' academic achievement still lags that of their peers in many other countries*. Pew Research Center. Retrieved from http://www.pewresearch.org/fact-tank/2017/02/15/u-s-students-internationally-math-science/

Donovan, L., Green, T., & Hartley, K. (2010). An examination of one-to-one computing in the middle school: Does increased access bring about increased student engagement? *Journal of Educational Computing Research*, *42*(4), 423-441.

Dougherty, D. (2013). The maker mindset. In M. Honey and D. E. Kanter (Eds.), *Design, make, play: Growing the next generation of STEM innovators* (pp. 7-11). New York, NY: Routledge.

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods, 5*(1), 80-92.

Fontichiaro, K. (2016). Why data literacy matters. *Knowledge Quest*, *44*(5), 21-27.

Fontichiaro, K. (2016). Inventing products with design thinking: Balanced structure with open-ended thinking. *Teacher Librarian, 44*(2), 53-55.

Fu, J. S. (2013). ICT in education: A critical literature review and its implications. *International Journal of Education and Development Using ICT, 9*(1), 112-125.

Gilchrist, V. A., Williams, R. L. (1999). Key informant interviews. In B. F. Crabtree and W. L. Miller (Eds.), *Doing qualitative research* (pp. 71-88). Thousand Oaks, CA: Sage.

Gonzales, H. B., & Kuenzi, J. J. (2012). *Science, technology, engineering, and mathematics (STEM): A primer.* Washington, D.C.: United States Congressional Research Service. Retrieved from https://fas.org/sgp/crs/misc/R42642.pdf

Guzey, S. S., & Roehrig, G. H. (2009). Teaching science with technology: Case studies of science teachers' development of technology, pedagogy, and content knowledge. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 25-45.

Henriques, L. (2016). Science teachers – In what ways have you partnered with your school librarian? *California Classroom Science*. Retrieved from http://www.classroomscience.org/science-teachers-in-what-ways-have-you-partnered-with-your-school-librarian

Heim, J. (2016). On the world stage, U.S. students fall behind. *Washington Post*. Retrieved from https://www.washingtonpost.com/local/education/on-the-world-stage-us-students-fall-behind/2016/

Hoffman, E. S., & Mardis, M. A. (2008). The status of technology, science and mathematics in U.S. middle school media centers: A national survey. In *Proceedings of the International Association of School Librarianship 37th Annual Conference*, Chicago, IL.

Johnson, L., Adams Becker, S., Estrada V., & Freeman, A. (2015). *NMC horizon report: 2015 K-12 edition*. Austin, TX: The New Media Consortium.

Johnston, M. P. (2012). School librarians as technology integration leaders: Enablers and barriers to leadership enactment. *School Library Research, 15*(1). Retrieved from www.ala.org/aasl/slr

Kaplan, C. (2013). The key informant interview. *The Research Review*, *3*(1). Retrieved from http://www.ctfalliance.org/research_savvypractitioner.htm#select

Kaufman, R., Rojas, A. M., & Mayer, H. (1993). *Needs assessment: A user's guide*. New Jersey, NJ: Educational Technology Publications, Inc.

Kumar, K. (1989). *Conducting key informant interviews in developing countries*. Agency for International Development. Center for Development Information and Evaluation. Washington, D.C: A.I.D. Retrieved from www.alnap.org/pool/files/conducting-key-informant-interviews-kumar.pdf

Kurti, R. S., Kurti, D. L., & Fleming, L. (2014). The philosophy of educational makerspaces. Part 1 of making an educational makerspace. *Teacher Librarian, 41*(5), 8-11.

Levin, B., & Schrum, L. (2013). Using systems thinking to leverage technology for school

improvement: Lessons learned from award-winning secondary schools/districts. *Journal of Research on Technology in Education*, *46*(1), 29–51.

Mardis, M. A. (2007). School libraries and science achievement: A view from Michigan's middle schools. *School Library Media Research, 10*. Retrieved from www.ala.org/aasl/slr

Mardis, M. A. (2014). Ready for STEM? A leading commercial multimedia database as a source for media-rich science, technology, engineering, and mathematics assets K-12 library collections. *Library Resources & Technical Services*, *58*(4), 250-264. Retrieved from https://journals.ala.org/lrts/

Mardis, M. A. (2015). *The collection's at the core: Revitalize your library with innovative resources for the Common Core and STEM*. Santa Barbara, CA: ABC CLIO.

Mardis, M. A., & Hoffman, E. (2007). Collection and collaboration: Science in Michigan middle school media centers. *School Library Media Research, 10*. Retrieved from http://www.ala.org/aasl/pubs/slr

Mardis, M. A., & Howe, K. (2010). STEM for our students: Content to co-conspiracy? *Knowledge Quest, 39*(2), 8–11.

Mardis, M. A., & Payo, R. (2007). Making the school library sticky: Digital libraries build teacher-librarians' strategic implementation content knowledge in science. *Teacher Librarian, 34*(5), 8-14.

McCawley, P. F. (2009). *Methods for conducting educational needs assessment: Guidelines for cooperative extension system professionals*. Retrieved from http://www.cals.uidaho.edu/edcomm/pdf/BUL/BUL0870.pdf

McIlvain, E. (2010). NSDL as a teacher empower point. *Knowledge Quest*, *39*(2), 54-63.

Montiel-Overall, P., & Grimes, K. (2013). Teachers and librarians collaborating on inquiry-based science instruction: A longitudinal study. *Library & Information Science Research, 35*(1), 41–53.

Moorefield-Lang, H. (2015). Change in the making: Makerspaces and the ever-changing landscape of libraries. *TechTrends, 59*(3), 107-112.

National Academy of Engineering and National Research Council. (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research*. Committee on Committee on STEM Integration. Washington, DC: National Academies Press.

The Organisation for Economic Co-operation and Development (OECD). (2015). *Programme for International Student Assessment (PISA) results: USA*. Retrieved from http://www.oecd.org/pisa/

Pandora, C. (2009). STEM - How libraries provide STEM information. *Ohio Media Spectrum*, *61*(1) 23-27.

Perrault, A. M. (2007). An exploratory study of biology teachers' online information seeking practices. *School Library Media Research, 10*. Retrieved from http://www.ala.org/ aasl/slr/

Perrault, A. M. (2010). Making science learning available and accessible to all learners: Leveraging digital library resources. *Knowledge Quest*, *39*(2), 64-68.

Project Tomorrow. (2014). *The new digital playbook: Understanding the spectrum of students' activities and aspiration.* Retrieved from http://www.tomorrow.org/speakup/SU13DigitalLearningPlaybook_StudentReport.html

Project Tomorrow. (2015). *From print to pixel: The roles of videos, games, animations and simulations within K-12 education*. Retrieved from http://www.tomorrow.org/speakup/SU15AnnualReport.html

Randazzo, M. (2017). Students shouldn't live in STEM deserts. *U.S. News and World Report*. Retrieved from https://www.usnews.com/opinion/knowledge-bank/articles/2017-05-10/the-us-must-address-disparities-in-access-to-stem-education

Rawson, C. H. (2014). Every flower in the garden: Collaboration between school librarians and science teachers. *School Libraries Worldwide, 20*(1). Retrieved from https://iasl-online.org/publications/slw/index.html

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*. Retrieved from http://www.ala.org/aasl/slr/

Schultz-Jones, B. (2010). School librarians, teachers and optimal STEM learning environments. *Knowledge Quest, 39*(2), 12-18.

Schultz-Jones, B., & Ledbetter, C. E. (2009). Building relationships in the school social network: Science teachers and school library media specialists report key dimensions. *School Libraries Worldwide, 15*(2), 23-48.

Sharkey, J., & O'Connor, L. (2013). Establishing twenty-first-century information fluency. *Reference & User Services Quarterly, 53*(1), 33-39.

Shear, L., Means, B., & Lundh, P. (2015). *Research on open: OER research hub review and futures for research on OER.* Menlo Park, CA: SRI International. Retrieved from https://www.hewlett.org/wp-content/uploads/2016/08/ OERRH%20Evaluation%20 Final%20Report%20June%202015.pdf

Small, R. (2014). The motivational and informational needs of young innovators: Stimulating student creativity and inventive thinking. *School Library Research, 17*. Retrieved from www.ala.org/aasl/slr

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

Subramaniam, M., Ahn, J., Waugh, A., Taylor, N. G., Druin, A., Fleischmann, K. R., & Walsh, G. (2013). The role of school librarians in enhancing science learning. *Journal of Librarianship and Information Science, 47*(1), 1-14.

Subramaniam, M., & Edwards, A. R. (2014). The collaboration conundrum between school librarians and mathematics teachers. *International Journal of Libraries and Information Services* (LIBRI), *64*(2), 185-209.

Tremblay, M. A. (2003). The key informant technique: A non-ethnographic application. In R. G. Burgess (Ed.), *Field research: A sourcebook and field manual* (pp. 151-163). New York, NY: Routledge.

Tsupros, N., Kohler, R., & Hallinen, J. (2009). *STEM education: A project to identify the missing components*. Pennsylvania, PA: Carnegie Mellon.

USAID Center for Development Information and Education. (1996). *Performance monitoring and evaluation tips: Conducting key informant interviews.* Retrieved from http://dmeforpeace.org/sites/default/files/USAID_Performance%20Monitoring%20and%20Evaluation%20TIPS%20conducting%20Key%20Informant%20Interviews.pdf

U.S. Department of Education: Office of Educational Technology. (2017). *Reimagining the role of technology in education: 2017 National educational technology plan update*. Retrieved from https://tech.ed.gov/files/2017/01/NETP17.pdf

Vaughn, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.

Young, T. E. (2013). 24/7 STEMulation: Reinventing discovery. *Library Media Connection, 31*(6), 20–22.

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APPENDIX A

Needs Assessment of Southeastern Rural School Library Media Specialists Interview Guide

1. How long have you been a school library media specialist?

2. Have you worked at other schools as a school library media specialist other than the one where you currently are?

3. What is your background? Were you a teacher before you became a school library media specialist? In what content area?

4. You serve as the school library media specialist in a STEM focused school, if you have worked in another school before, can you speak to the differences in being a school librarian at a STEM focused school in comparison with other schools (those not STEM focused)? What do you find to be the major differences and/or similarities?

5. What do you feel in your preparation program prepared you to support STEM teaching and learning in your school?

6. Do you feel that there were areas that you could have been better prepared for in supporting STEM teaching and learning in your school?

7. In regards to technology and STEM education, can you give me some examples of digital tools you use and/or teach students?

8. How do you stay current on emerging and current digital tools? How do you advance your own professional growth in this area?

9. If you had to choose the number one thing that enables you to support STEM teaching and learning in your school, what would it be?