

Research Article

Karla Steege Krueger*, Joan Bessman Taylor

Discerning users of information: A qualitative analysis of student inquiry

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Abstract: School Librarians are poised to lead a shift in information and digital literacy instruction with a growing emphasis on the evaluation of information sources, a need precipitated by widespread societal sharing of mis- and disinformation. What does the inquiry learning process look like when a team of students creates an innovative solution to a problem they identified through project-based research? And does such research enable students to practice the skills necessary to be discerning across information contexts? The information literacy instruction woven throughout the project contributed to the visible successes in student inquiry-based learning. And the skills necessary to be a discerning user of information were enabled through inquiry-based learning and would benefit from collaborative librarian instruction. Implications for school librarians point to teaching components from this project that are recommended for similar units (project scenario, process rubric, librarian background research packet, time to do research, librarian-led group discussion of focus, teacher prompts, teacher and mentor arranging expert visits, and a panel of judges) and those needed for future collaboration (scaffolding for searching for and tracking relevant sources, teaching complex note taking to decipher credible authors and sources, categorizing notes and sources by points of view, and citing sources to corroborate evidence).

Keywords: inquiry-based learning; digital literacy; information literacy; school librarian; misinformation.

1 Introduction

1.1 The Need for More Information Literacy Instruction

The world is facing a crisis of information misuse and misunderstanding. In times of crisis, societies turn to their younger generations in search of change and promise. But digital natives are not as savvy and equipped as their frequency of technology use would lead society to expect.

“Young people’s ability to reason about the information on the Internet can be summed up in one word: bleak” (Weinberg et al., 2016, p. 4). So concludes the study, *Evaluating Information: The Cornerstone of Civic Online Reasoning* from Stanford (CA) University’s Graduate School of Education. In their study of 7,804 student responses, they found that students in middle school, high school and college had a hard time distinguishing advertisements from news articles or identifying where information came from. Students recognize that they have these deficiencies in evaluating information as corroborated by the research of SSRS (Robb, 2017) for Common Sense Media. *News and America’s Kids: How Young People Perceive and Are Impacted by the News*, reporting on a survey of 853 children ages 10 to 18 living in the United States, indicates that children have difficulty determining whether a news story is fake; less than half (44%) of children feel “they can tell fake news stories from real ones,” and, among children who have shared a news story online in the last six months, 31% say they “shared a story that they later found out was wrong or inaccurate” (p. 5).

***Corresponding author: Karla Steege Krueger**, Associate Professor. School Library Studies Program, Curriculum and Instruction Department, 610 Schindler Education Center, University of Northern Iowa, Cedar Falls, IA 50614 U.S.A, E-mail: karla.krueger@uni.edu

Joan Bessman Taylor, Associate Professor. School Library Studies Program, Curriculum and Instruction Department, 611 Schindler Education Center, University of Northern Iowa, Cedar Falls, IA 50614 U.S.A

Recent studies show that teachers and school librarians alike see a need for more teaching of information literacy and news literacy skills to help students learn to evaluate the quality of information sources. These same studies show that some school librarians have too little time with students to support this instruction and that they have minimal curricular support for it (Crary 2019; Farmer, 2019; Phillips & Lee, 2019). Organizations have shared news and media literacy resources for teachers of history, civics, and language arts to aid students in recognizing the characteristics of news and to identify misinformation (Jacobson, 2017; Kletter, 2020; Valenza, 2016, Valenza, 2020), but these resource sites are not always tailored to school library programming.

Yet one concern regarding the teaching of fake news is that the topic may be taught or be perceived to be taught as inherently political, with the potential to distract from the instructional goals. Lazer et al. (2018) said educational efforts given on the topic of fake news have the potential for “unintended consequences” such as reducing the perceived credibility of all news among students (p. 1095). Likewise, Greenhill (2018) emphasized a preference for teaching about corroborating information sources, which could be done using sources about health, economics, and other topics outside of political news, which may serve to remove partisan overtones.

We should routinely ask the same set of questions any editor asks a reporter before something goes to press. Has it been corroborated? By whom? What is their agenda? Trust but verify—it requires extra work and it’s hard and unpleasant because it complicates our lives. To just say, *oh, this is a trusted news source, they must know what they’re doing*—we can’t do that anymore (para. 14).

These concerns about the inability of people to discern what is true and reliable information in a world saturated with “information” sources are ones that can be met head on through instruction in what librarians for decades have called information literacy, and more recently elaborated to include digital literacy, that is, those competencies necessitated by the evolution of ubiquitous technology. Best practices point to the advantages of teaching information and digital literacy through an inquiry-based learning process that includes the student asking a question of personal interest or need, conducting research using resources representing multiple perspectives on a topic or issue and synthesizing information to generate new understanding that they then share with others. Past research studies have established several things needed when teaching students research skills: adequate time for teaching how to assess the credibility of sources (Kavanaugh & Lenart, 2017; Metzger, 2007); close study of what works when students are engaged in guided inquiry research (Garrison et al., 2018; Todd, 2015); and articulation of student outcomes for deep knowledge and understanding of content (Todd, 2012). Further, Garrison et al. call for more studies of inquiry-based learning using the new AASL (2018b) standards and learner competencies. As such school librarians may begin to combat the perceived barrier of time by demonstrating a multitude of standards are taught *through* the student research process.

1.2 Purpose and Research Questions

This qualitative case study asks, What does the inquiry learning process look like when a team of students creates an innovative solution to a problem they identified through project-based research? And does such research enable students to practice the skills necessary to be discerning across information contexts?

2 Literature Review

2.1 Information and Digital Literacy

Information and digital literacy are central to the AASL (2018b) *National School Library Standards*, and they also encompass the more specialized literacies such as media and news literacy and the behaviors considered digital citizenship. An information literate learner knows “when and why information is needed, where to find it, and how to evaluate, use and communicate it in an ethical manner” (p. 277). Information literacy stems from more than 60 years of school library goals for students to “analyze, evaluate, and interpret” information (AASL, 1960, p. 19). Digital literacy echoes information literacy, but limits it to online use of “information and communication technologies to

find, evaluate, create, and communicate information, requiring both cognitive and technical skills” (AASL, 2018b, p. 275). Digital literacy does not include defining the information problem. The scholarly literature in the areas of school librarianship and literacy education is rich with references to a multitude of other literacies that fall within the umbrella of information literacy: media literacy, visual literacy, textual literacy (AASL, 2018b), critical information literacy (Brisola & Doyle, 2019), new literacies (Coiro, 2020), and news literacy (Farmer, 2019). For example, Farmer defined news literacy as a reasoning process: “the ability to consciously and critically analyze and evaluate mass media messages and only then decide how to respond” (p. 222). Phillips and Lee (2019) defined digital citizenship as the desired behaviors of information literate individuals as they pertain to an online context; that is, using the Utah State Legislature H.B. 213 definition of digital citizenship, “the norms of appropriate, responsible, and healthy behavior related to technology use, including digital literacy, ethics, etiquette, and security” (lines 54–55) (as cited in Phillips & Lee, 2019, p. 1). In this article the term *information literacy* is used as inclusive of other literacies that all aim to guide learners to recognize mis- and disinformation.

2.2 Misinformation and Disinformation

Lazer et al. (2018) in “The Science of Fake News” establish a definition, historical context, and analysis of characteristics of fake news. By definition, fake news is “fabricated information that mimics news media content in form but not in organizational process or intent” and without the news media’s ‘editorial norms,’” it extends beyond strictly news topics to areas such as “vaccination, nutrition, and stock values” (p. 1094). Historically, fake news has been utilized around the globe by governments from the most authoritarian to the most liberal, “to scare, persuade, mobilize and distract” (Greenhill, 2017, para. 9). The first of three key variables that determine belief in fake news is one’s worldview, or what one already believes about the world (Greenhill, 2018):

We all bring our worldviews to the table. None of us is neutral: our ideas, experiences, and values influence how we comprehend and interpret the world around us. Some individuals are more wed to verifiable empirical evidence—facts, as we traditionally understand them—than others, but we are all susceptible to falling victim to “truthiness” (truth that comes from the gut rather than books) (para. 4).

Lazer et al. (2018) note that people rarely check facts if the information is consistent with their preexisting beliefs. Bias works in several ways: a preference for information that confirms one’s beliefs is “selective exposure;” the view that information that fits preexisting beliefs is more persuasive is called “confirmation bias;” and the inclination to accept information that fits one’s beliefs is “desirability bias” (p. 1095).

The second variable that determines belief of fake news is threat perception, or the amount of fear a person perceives related to the issue. Lazer et al. (2018) note that political polarization in the U.S. over the past 40 years creates an environment of fear in which fake news can attract a larger audience (p. 1095). The third variable is repetition, or the number of times a claim is repeated. Whether verifiable or not, the repetition of claims, even if debunking them, can further set them in memory. Thus Lazer et al. note that even repeating false claims for fact checking purposes could cause greater acceptance of the claim, due to the familiarity factor. Greenhill (2018) clarifies that educational level and political affiliation do not make anyone less susceptible to fake news: “If the information on offer fits with what we already believe about the world, if it speaks to our fears and desires, and if we’ve heard it before, we will be more likely to treat it as plausible or true, irrespective of our political leanings, level of education, or socio-economic status” (para. 5). These understandings suggest a need for careful study of best practices in school librarians’ information literacy instruction.

Farmer’s (2019) survey showed that while 41 responding California middle and high school librarians said they had a clear understanding of what fake news is, they reported perceptions of their students’ skills as low for the 10 news literacy tasks they assessed. The tasks they perceived their students to do moderately well were (1) determining *News versus opinion* and (2) identifying an *Ad on news website*. Whereas the tasks they believed students had the least skill with were *Photo trustworthiness* and *Sponsor reliability*. When asked what skills they taught, these school librarians reported teaching traditional information literacy skills: “critical thinking; evaluating sources, including determining accuracy, reliability, authorship, and bias; identifying reliable sources such as databases; and distinguishing between fact and opinion” (p. 229). Two librarians specifically said they gave instruction about fake news. However, nine

respondents mentioned teaching no lessons in the area. Farmer concluded that students need instruction in how to “access, interpret, evaluate, and respond to news in its various forms” and that educators themselves are in need of instruction in these literacies to build their competence (p. 231). Thus an implication for teachers is to aim for inquiry-based instruction that results in news literate digital citizens and to seek the highest standards and competencies of information and digital literacy. Competencies for student information literacy exist within current standards from AASL (2018a) and the Common Core (NGA, 2010).

2.3 AASL and Common Core Standards

The current *Standards Framework for Learners* (AASL, 2018a) lists 68 competencies for students that include finding, using, and assessing information within a collaborative, inclusive environment of inquiry learning. The pedagogical practices school librarians use to teach information literacy research skills are ever-changing. A shift is occurring in response to widespread societal sharing of misinformation and disinformation largely related to political news (Lazer et al., 2018; Vamanu, 2019). The mis- and disinformation is further amplified by the politicizing of scientific understandings of a disease and the ensuing distrust of the messages of public health officials during the COVID-19 global pandemic. Historically information evaluation was largely focused on source relevance, as students often selected sources that had been vetted as they were added to library collections. However the increasing use of world wide web sources requires renewed emphasis on information evaluation of all sources’ authority, accuracy, publication type (e.g. a background, journal, or news source) and intent, especially where information becomes blurred with divisive and sponsored content masking as news. Vamanu shared ten types of misleading news from the European NGO, Media Literacy for Citizenship: propaganda, clickbait, sponsored content, satire and hoax, error, partisan, conspiracy theory, pseudoscience, misinformation, and bogus.

Notably, information literacy exists (although not by name) within the *Common Core State Standards* (CCSS) (NGA, 2010), creating a U.S. education requirement for information skills. The *Key Design Considerations* section in the introduction to the English Language Arts standards states that “research and media skills” are blended into the Standards as a whole: “students need the ability to gather, comprehend, evaluate, synthesize, and report on information and ideas, to conduct original research in order to answer questions or solve problems;” and further that this is “embedded into every aspect” of curriculum. Research is embedded within these CCSS Anchor Standards for reading 6, 7, and 8 and for writing 7 and 8, for example, CCSS.ELA-LITERACY.CCRA.R.7 *Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words*; and CCSS.ELA-LITERACY.CCRA.W.7 *Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation*.

2.4 Inquiry Learning and Collaborative Teaching

Having defined information and digital literacies and having placed them squarely within AASL (2018a) and CCSS (NGA, 2010), this section describes their presence in the pedagogical context of inquiry-based learning. *Guided Inquiry Design* (Kuhlthau, Maniotes, & Caspari, 2012) is a teaching approach to personalized research and learning. AASL (2018b) defines inquiry based on the work of Kuhlthau, Maniotes, and Caspari (2007) and *The Stripling Model* (Empire State Information Fluency Continuum, 2021), which support personalized inquiry described by AASL (2018b) as a “stance toward learning in which the learner is engaged in asking questions and finding answers, not simply accumulating facts presented by someone else that have no relation to previous learning or new understanding” (p. 277). Guided Inquiry Design furthers the inquiry stance by incorporating it into a teaching and learning model with an

innovative team approach to teaching and learning where teachers and school librarians, with other experts and specialists, join together to design and implement inquiry learning. It engages children in constructing personal knowledge while using a wide range of sources of information and creatively sharing their learning with their fellow learners in an inquiry community. (Kuhlthau, Maniotes, & Caspari, 2007, 1)

2.5 Information Literacy Skills and Middle School Students (ages 11-15 years)

2.5.1 Evidence about student skills for evaluating information sources

Past studies confirmed that information and digital literacy skills, especially for middle school (ages 11-15 years) students, are low and that teachers and school librarians have recognized the challenges inherent in teaching these skills. The Stanford History Education Group (Weinberg et al., 2016) studied young people's "ability to reason over information they found on the Internet," and the authors summarized their findings as "bleak" (p. 4). More than 80% of the 203 middle school students in the Stanford study failed to identify native advertising (an increasingly common form of advertising designed to look like news stories) even though it was labeled as sponsored content. Some students even explained that because it said 'sponsored content,' they believed it to be news. The authors concluded that the concept of sponsored content should be directly taught in elementary school.

Coiro and Kennedy (2011) similarly found 1000 seventh grade students (ages 12-13) struggled to critically evaluate information that had political and commercial messages. They created a protocol, the Online Reading Comprehension Assessment, to measure students' evaluation skills using an authentic task - to research whether energy drinks are dangerous to teen heart health. They found students were not skilled in evaluation but could benefit from practice. Coiro (2012) noted that students lacked skills to "critically evaluate, synthesize and communicate new understandings related to a self-generated task" and to "perceive, sort out, and respond to multiple agendas and perspectives represented (or missing) across a collection of online texts" (p. 413).

Researching students' willingness to put forth effort to evaluate the quality of information sources, Kavaunaugh and Lenart (2017) and Metzger (2007) agreed that students had to feel motivated in order to put forth the effort needed to verify the credibility of information. Metzger noted that people assign less importance to credibility of entertainment types of information than health related information. Metzger argued that each individual must determine when they need to assess trustworthiness or credibility and that this is in essence what it means to be literate (p. 2089). Understandings from Weinberg et al., 2016, Coiro and Kennedy, 2011, and Metzger point to the importance of planning and implementing information literacy instruction to help students achieve the skills and motivation needed to evaluate their sources of information.

2.5.2 Evidence about inquiry-based instruction to improve source evaluation skills

To better students' skills in evaluating information, it is important to understand students' feelings of success, satisfaction, and motivation because these propel them to greater levels of information literacy. Three studies using inquiry-based instruction found that students prefer to have a choice in their research topic selection but not so much that they lack structure or the ability to feel successful (Bilal, 2004; Garland, 1995; Garrison et al., 2018). Bilal found the success rate among the 22 seventh grade (ages 12-13) students was highest (73%) for those participating in the self-generated research task, which was above the success rate for those using the research-oriented (69%) and fact-based (50%) tasks. However, only 47% of students said they actually preferred the fully self-generated task, while 20% preferred the research-oriented, and 20% the fact-finding tasks. Those who indicated they preferred the self-generated tasks said they did so because they could find what they needed and had satisfaction with the results. Bilal suggested that the satisfaction and self-confidence factors may be even more important to students than selecting their own topic because students spent the most time and performed the most keyword searches for the fact-based search that required complex search techniques to locate prescribed sources.

In keeping with the research studying students' choice in research topics, Garland (1995) surveyed a large group of 387 students ages 14-18 after they completed a research project and interviewed seven of their teachers to find out what makes a good research task. Garland identified five elements of research satisfaction that seemed to indicate what made students feel most successful: student choice of topic within the subject area, group work, topics clearly related to course content, clear teacher communication about goals and evaluation, and attention to process steps and final product.

While reaffirming that students preferred to have choice in research, Garrison et al. (2018) examined how Grade 9 students (age 14-15 years) used Guided Inquiry (GI), what they thought of using the GI process and the quality of

thinking in the process. They found that while almost all students appreciated the choice of topic in a Guided Inquiry unit, some students liked the independent nature of GI, while some did not. Some students appreciated the structure of a GI unit, while others would have preferred less restriction.

Given that students prefer a choice of topic and a feeling of success (Bilal, 2004), clear goals and teacher communications about inquiry (Garland, 1995) and clearly structured inquiry-based units (Garrison et al., 2018), two additional studies focused on best practices in teaching inquiry. Todd (2012) revealed considerable teaching of information literacy skills among 765 New Jersey school librarians surveyed. But while 80% reportedly taught the traditional tasks such as awareness of, choosing, and citing relevant sources; 70-80% taught evaluating information quality; and only 50-60% taught more challenging tasks of forming questions based on information need and synthesizing ideas. Similarly Crary (2019) found that among 109 North Dakota middle and high school teachers surveyed, over 90% had high expectations for school librarians to teach information literacy skills of awareness and access to print and digital resources, and how to locate, evaluate, and cite printed and online materials. This indicates that teachers and school librarians agree upon the importance of teaching information literacy skills including evaluating the quality of information. As such, innovative methods are needed to help students develop an inquiry perspective that can result in strong digital citizens with a discerning stance to all information.

3 Methodology

This qualitative case study (Stake, 2005) analyzed a group's inquiry process based on research with an academic extracurricular robotics club made up of six middle school students (three in grade 6, two in grade 7, and one in grade 8) and their volunteer coach, who was also an elementary teacher in their school district. The team of students was preparing for a competition through the *FIRST*® LEGO® League (FLL®, 2019) program that included a research project of the team's choosing to develop an innovative solution to a problem they identified within the topic area of communication, health, or transportation issues of senior citizens.

3.1 The FLL® Project

The project overview encourages students to use multiple sources to research a thematic engineering topic, identify a specific problem and develop an innovative solution, either by creating something that doesn't exist or building upon something that does. The overview suggests steps to students such as doing background research and interviewing multiple senior citizens about these issues and impacts on their lifestyle. Below are the nine rubric requirements:

- Clear definition of the problem being studied,
- Quality and variety of data/evidence and sources cited,
- Depth to which the problem was studied and analyzed by the team, including extent of analysis of existing solutions,
- Clear explanation of the proposed solution and description of how it solves the problem,
- Degree to which the team's solution makes life better by improving existing options, developing a new application of existing ideas, or solving the problem in a completely new way,
- Systematic process used to select, develop, evaluate, test, and improve the solution (Implementation could include cost, ease of manufacturing, etc.),
- Degree to which the team shared their Project before the tournament with others who might benefit from the team's efforts,
- Imagination used to develop and deliver the presentation,
- Message delivery and organization of the presentation. (FLL®, 2019, p. 2)

The Project resembles multiple learner competencies from the AASL (2018b) *National School Library Standards* and some standards from the CCSS (NGA, 2010), although the standards are not articulated by FLL®. In addition to the Project, student teams are also judged on their Robot Design and their overall Core Values. The Core Values specify appropriate teamwork, and importantly, one is that "Kids Do the Work," meaning there is "appropriate balance between

team responsibility and coach guidance” (FLL®, 2019, p. 1). Therefore the inquiry of the team described in this paper was self-directed with minimal guidance from the volunteer coach or the researcher participant observer.

3.2 The Participant Observer Role

One of the researchers was a team mentor with a role that resembled a volunteer librarian to help support the students in their project research. Wildemuth (2017) defines participant observation as the researcher being a participant in the setting in order to gain a better understanding of the processes that occur within that natural setting (p. 219). The team met in an unused classroom they called the “robot room” that was set up with a robot field, legos and other spare robot parts, whiteboards, and a table for students to meet and work. The team shared the robot room with several other robotics teams that met separately throughout the week. The researchers, based on the first author’s participant observation throughout the duration of the project’s completion, examined the activities of one FLL® team in relation to the project portion of their overall competition entry as a single case that would allow a robust examination of the students’ processes in completing the work.

3.3 Procedures

The researcher joined the team at their seven research meetings, each lasting between 30-90 minutes, occurring every two weeks from September through December and observed the team’s regional judging in December and state judging in January. This researcher served as a Complete Observer at three of their meetings and Observer as Participant at four (led the Background Research Packet discussion in September, led a Focus Group discussion to process their research at a mid-point in October, facilitated students generating questions for a senior citizen partner in November, and administered a reflective information literacy survey in January, several weeks after the final event). It should be noted that the team meetings had limited time for the project-related tasks. Although this was an extracurricular club, the same team also needed to design, build, program, and practice with a robot for the same competition. The robot competed for the team’s time and most members participated in numerous other extracurricular athletic and music groups, in addition to attending to their homework and family commitments outside of school.

3.4 Data Sources

The following data source descriptions flow chronologically along with the team’s project activities. The team followed a path suggested by the FLL® project overview and items in the scoring rubric. The rubric indicated three steps were essential: problem (clear definition of the problem being studied (which the team did through their background research packets, talking to senior partners and to each other, and by keeping track of their evolving research question on the whiteboard); clear explanation of the proposed solution (which they did through drawings and a development of a prototype); and the degree to which the team shared the proposed solution with others (which they achieved with the doctor and in the presentation skit).

1. **Background research packet** (August - September) -students’ research work using their choice of one of two sample topics. At the coach’s request to help students improve their research in the upcoming year, the researcher participant created a research packet with inquiry activities for brainstorming, taking notes by source type, writing questions, and choosing the strongest evidence. Items were adapted from the *Empire State Information Fluency Continuum* (2021). The coach emailed students the packet and the FLL® project overview and judging rubric and asked students to read them and complete the packet on their own during several weeks prior to their first meeting.
2. **Group whiteboard notes** (September - November) - photos of the whiteboard filled with student notes and large post-it notes from team brainstorming sessions. The team often met sitting or standing near the large mounted whiteboard and was accustomed to drawing on it and writing big ideas or questions that were saved on the board.
3. **Senior partner interview** (October) - student-generated questions and notes from their conversation with a senior partner who had an inner ear disorder.

4. **Focus group conversation** (November) - a transcript of the researcher-led focus group that occurred while the innovation prototype was still in development, and before the team started their presentation plans. Questions were designed to help the team process their research in preparation for writing a skit.
5. **Doctor conference call (otolaryngologist)** (November) - a transcript of the conference telephone call between the team members and an otolaryngologist who agreed to talk with them and to fill the role of an outside expert, a role that was required by the FLL® project process guidelines. The senior partner assisted in making arrangements with the doctor, and the team mailed two prototype drawings to the doctor before the call.
6. **Presentation skit and judging** (December - January) - includes speaking parts for each team member (created by the students for them to practice and memorize), powerpoint slides, photos of the prototype model that was shared in the presentation, and a transcript of the judges' questions and team responses at the state-level judging.
7. **Final questionnaire and TRAILS** (January) - students' individual responses to a questionnaire developed by the researcher exploring information literacy and the TRAILS (Tools for Real Time Assessment of Information Literacy Skills, n.d.) were administered at a final meeting.

3.5 Data Analysis

The two researchers analyzed the data sources qualitatively using “directed content analysis” (Zhang & Wildemuth, 2017, pp. 319-320), in which they began by naming what the students were doing. Researchers took notes and marked items within the data (e.g. student work in their research packets, photos of the students' notes they kept on the whiteboard, and transcripts of a recorded focus group conversation and doctor conference call) that demonstrated information literacy skills that occurred in the students' work. The initial coding produced the following guiding questions: (1) what the students' task was and what they understood it to be, (2) what they demonstrated knowing how to do and what they didn't know how to do, (3) where they sought and found their information, (4) how they evaluated their information sources, and (5) throughout their information-dependent work and at its conclusion, what they made of what they were able or were unable to do.

The students' tasks and deliberations throughout the project demonstrated the need for and application of information literacy-related skills. The use of AASL student learning standards as a coding protocol was a natural fit as the actions of the group and gave form to many of the learning objectives articulated through the professional school library standards. Therefore, the researchers' final coding (p. 319) utilizes the language of the AASL (2018b) National School Library Standards for Learners. The 68 AASL learner competencies provide a comprehensive view of inquiry. Initial and final coding revealed that this single project most directly addressed a subset of competencies from across the four Domains. Through analysis it emerged that the stages of the FLL® project reflected the same learning progressions described in each of the AASL Domains. In keeping with the purpose of this approach, the researchers allowed themes to emerge from the categorized data and used them to “validate or extend a conceptual framework or theory,” (Wildemuth, 2017, p. 320) in this case the AASL learner competencies.

4 Findings

The researchers acknowledge that the AASL (2018b) Standards are not a curriculum, but provide guidance for local curriculum (p. 17), that standards may be used as appropriate to the learning task, and that there is a progression through the competencies. AASL describes this *progression* in the section “structure and purpose” of the standards guidance indicating that learners and librarians may “first engage with the standards at the level of Think” and then “progress through Create, Share, and Grow” (p. 17). Given this AASL guidance, the researchers note their preferred way to view the progression is to use the AASL (2018a) Standards Framework for Learners that shows all 68 learners standards in a two-page grid. The researchers read across the grid so that all of the standards for Think, as the first layer of competence, under each of the six shared foundations (Inquire, Include, etc.) could be read across from left to right. For example, students are first engaged in inquiry under the Inquire foundation by learning the concept of engaging their curiosity and asking initial questions.

The researchers' first finding was recognizing the insight of this AASL guidance when they considered their data in this study. Instruction at the conceptual level is important to provide students with structure, but an isolated lesson would provide students only with a concept and without the ability to practice and experience it. Once the concept is achieved, it is only through the Domains of Create, Share and Grow that students will gain full mastery - as they create and design their projects (Create), share their projects to real audiences (Share), and then reflect on their processes and aim for growth (Grow). Therefore, it is through projects where students are immersed in activities of inquiry-based learning, such as the FLL® innovative solution project, where students can gain practice and experiences across the Shared Foundations and progress through the advanced layers of the Domains.

Findings are structured below by AASL Domain (Think, Create, Share, Grow) and the skills developed through each stage of the project (represented through the various data sources) progress chronologically parallel to each Domain. For example the first two stages of the project and their resulting data sources (Background Research Packets and Group Whiteboard Notes) address the competencies articulated in the *Think* Domain. Next the Senior Partner Interview and the Focus Group Conversation illustrate the objectives of the *Create* Domain being put into action. As the FLL® project called for demonstrating and communicating the student's learning through real-world engagement - seen in the corresponding data from The Doctor Conference Call and the Presentation Skit and Judging - learning met the goals laid out in the *Share* Domain, and the students' responses in the Final Questionnaire and TRAILS assessment align closely with the intent for mastery described in the competencies of the *Grow* Domain. These post-project assessments helped the students and researchers determine where growth in informational literacies had occurred and suggest areas in need of further enrichment.

4.1 Think Domain (AASL Standards Framework for Learners)

Through the student responses to the prompts in the Background Research Packet and the collective ideas summarized within the Group Whiteboard Notes, one can see the early engagement of the group in identifying prior knowledge, defining a question, and clarifying their task; key competencies of the AASL Standards' Think Domain. In late summer, anticipating the start of the new school year, the FLL® team coach emailed an invitation to attend an informal meeting to discuss team membership and participation to students who had participated previously or expressed interest in doing so. During this meeting they were introduced to the year's Project in which they would explore the FLL® Project topic: aging and issues involving health, fitness, communication and transportation. In this initial discussion students discussed their needs and concerns for the upcoming year, a major concern being the need for students to demonstrate commitment to the activities of the group. It was decided that one way a would-be participant could demonstrate their seriousness about the endeavor would be to begin the research necessary for the project. When asked what this initial research should take as its focus, taking into account the FLL® project guide, students discussed issues faced by seniors in their lives such as grandparents, family friends and community members. From this informal discussion of difficulties experienced by these known individuals, two general areas of difficulty emerged: difficulties involving sight and difficulties involving hearing. The coach then invited the researcher to provide scaffolding for the beginning research process resulting in the Background Research Packet. It guided them to choose one of the two practice topics, Macular Degeneration or Presbycusis, and to use a library online source, Britannica, and a government source (the website of the National Institutes of Health). The research packet asked students to read each source for background information on their chosen topic and to generate questions that emerged from their background reading. They were asked to write basic questions and more complex questions, to identify vocabulary and keywords, and to summarize the main ideas.

The Group Whiteboard Notes accumulated across their research process identified this team question: "Our problem is the loss of balance in the vestibular system in Seniors degrades the quality of life and increases the chance of falls." Surrounding it were notes that included a statement of rationale for investigating a solution such as, "the inability to drive makes it hard to stay connected." Also on the whiteboard, students listed "Reasons" [for their innovative solution] that include: Quality of life (scared to stand up, can't go outside by self, and Alzheimers); injuries; and money. Solutions were connected by a line to "artificial vestibular system, vestibular screen, vestibular vest, place it in your shoulder or chest." Such were the evolution of the notes to the point where they had a focused question. Residual notes from earlier in the process also remained expressing ideas from a senior citizen panel in which the seniors were asked to talk about issues in their lives, and they expressed concerns with finances and Medicare.

Students later added a list of potential “field trips/professionals” that included agencies they may need to contact for more information such as an audiologist, Aging and Disability Resource Center, and an area agency for the aging. Finally, a “To do” item on the whiteboard listed, “Maybe find senior w/ vestibular issue.” The Group Notes extended onto large post-it notes below the whiteboard. At one meeting, the coach provided these for students to collate their ideas and list major themes and questions and included space for students to write in the facts they found in their research. Themes included: cost of lost balance, and cost of hearing loss, and how many falls are related to this problem? Students wrote responses to these to indicate that in 2000, falls cost the U.S. healthcare system \$19 billion, in 2010 it was \$30 billion, and that 68% of falls are caused by this [inner ear disorders].

The first stages of the FLL® project, including conducting background research (Background Research Packet) and early brainstorming (Group Whiteboard Notes), align with the competencies summarized in the Think Domain of the AASL Standards. These activities show synthesis of several key aspects of information literacy. First, Inquire I.A.1. “Formulating questions about a personal interest or a curricular topic” was evidenced in the Background Research Packet because students identified what most interested them about the research topics and developed basic and more complex questions. For example, a basic question at an early stage from one team member’s packet read, “Where in the ear are the hairs located?” and the final team problem was, “Reasons why the loss of balance in the vestibular system in seniors downgrades the quality of life and increases the chance of falls.” Second, Collaborate III.A.2. “Developing new understandings through engagement in a learning group” was evidenced through the collaboratively generated lists of information and notes regarding what to do that were captured on the whiteboard.

Finally, Curate IV.A.3. “Making critical choices about information sources to use” was interesting to the researchers because it highlights a key aspect of their research focus - the ability to be critical about the sources one relies on for making decisions or forming one’s thinking on a topic.

The team exhibited a range of degrees of competency in doing so. Their ability to make critical choices was partially evidenced by the large post-it notes in which students made choices about the most important facts to list under each thematic topic. For example, the coach wrote several key questions on large post-it notes to collate various students’ research. In an earlier stage, the students kept their individual notes in their research packets. But as their topic evolved and their research progressed, students no longer used the notes sheets. When the coach asked them to compile these facts on the post-it group notes, one category was, “How many injuries are caused by a lack of balance?” Below this, four individual notes were added: “1 in 3 people fall each year,” “3000 = 1/3 were lack of balance,” “4/10 per 100 occurred in seniors,” and “68% of people fall due to lack of balance” -- showing that students had a mix of facts about falling. Students did not appear to have sources for their facts or a means to check various facts across the sources. Although the activity was intended to help them collate, sort, and prioritize their ideas, the activity may not have accomplished this at this stage.

4.2 Create Domain (AASL Standards Framework for Learners)

The realizations arrived at through the Senior Partner Interview and Focus Group Conversation exemplified the competencies related to creating a plan for filling in knowledge gaps as represented in the Create Domain of the AASL Standards Framework. The Senior Partner Interview followed students’ completion of the Background Research Packets and compiling their group notes on the whiteboard. The FLL® project resources suggested students should find a senior partner and identify and learn about a problem faced by seniors. The group’s path to finding a senior partner included several phases. The group assigned each student to interview a grandparent, hosted a panel to ask questions of two seniors, invited one senior to be their partner, and met with that senior partner’s friend who talked in depth about difficulties associated with their Meniere’s Disease (a vestibular disorder). One student’s notes captured the following new understandings about one person’s experience living with this inner ear disorder:

Meniere’s Disease [has] no cure. [A] tube in ear and machine that puts pulses in their ear helps a little bit, they do it daily. Machines cost \$3500; Medicare does not pay any of it. Tube costs \$800. Meniere’s Disease causes people to hear voices and music inside their head. [A] machine called Meniett Micro Pressure Therapy [is used] up to 5 times a day - \$20 per doctor visit. [They] can’t have any sodium or chocolate. [The] hairs cause dizziness. Noise in head started before attacks. [They] had an inner ear infection 20 years before attacks. [They] use a cane when walking. [It] can come from a tumor in an ear. [They are] dizzy a couple times a week. Hearing aids don’t help at all. [It is] not [an] inner ear infection.

The Senior Partner Interview required the students to build more knowledge. They exhibited the AASL competency Inquire I.B.2. “Devising and implementing a plan to fill knowledge gaps,” as students gained understandings they had not encountered in their research because they heard first-hand about the experience of the disease, saw this senior’s meniett machine, and understood that it didn’t always help her symptoms. They used the interview to better understand one disease and current treatments. Then they discussed possible solutions - what is currently being attempted and the fact that it falls short and that they could potentially create an approach that would address some of the quality of life issues seniors face. Their “innovation” would need to assist with balance, quality of life, and cost.

At this phase their task was collecting as much first-hand information as they could from someone who knew first-hand the experience of having the disease. Although the coach encouraged students to meet with this senior and to take notes, the fact that only two students took notes during the interview with the senior partner may reflect that some students were unsure how one person’s lived experience would serve as a source of information. Or it may indicate that some students thought they would remember all that was said. Perhaps not considering the individual’s interview to be a valuable source could indicate a gap in the students’ fulfillment of the competence summarized in AASL standard Include II.B.3. “Representing diverse perspectives during learning activities.”

The Focus Group Conversation took place in mid-November, about 3 weeks before the group’s regional competition. The researcher, as participant observer, created questions for the team to reflect about their research process. However the coach asked that since students’ time was limited, it should also serve as a discussion to synthesize research so the team could start planning their presentation skit. In a prior meeting, the coach had students read the judging rubric and watch a video of a sample project presentation skit that was provided by the organization.

A focus group question asked, “How did the research you did change your opinion or direction from what you initially thought about this problem?” One student responded,

It made me actually think about the problem more because if you came up to any person. Just think of the person most in school. And if you went up to them and said, How would you find a solution to this problem? They’d say, well I don’t really care about it. But now that we’ve done a lot of research, now we really do care about our solution.

Having invested time and energy in the conduct of research changed their position from one of unknown interest to intensely caring about a topic. Exploring a topic more deeply and discussing it with their peers in their group made the topic more authentic and interesting. It made them want to come up with a solution and made them realize the importance of finding such solutions. By following a distinct process for their research - guided by the research packet they were given and following a rubric for evaluation of their end product - they were able to see the value of doing research.

Two focus group questions asked about the quality of the group’s information and their assessment of that quality. The researcher asked, “How did you know if you had good information?” One responded:

If it fits with everything else, and it came from a good source,” and “like with the problem of having the vestibular system being incurable, and then all these different processes that they’ve tried, and then if one of them has a large percent success rate, you know that one of the sources isn’t right, or it just is not a true source.

Another student added, “if you already know that it is incurable and then something says that, “we cured it,” then it’s... probably a scam.” To extend the discussion the researcher asked, “Did you find some information that you decided not to use, and if so, why did you decide not to use it?” One student responded, “most definitely,” while another elaborated, “one person found on Google that over 400 million people die from this every year in the U.S., and only 300 million people live in the U.S.” Another example given was that they left out information they had researched for earlier potential topics related to the eyes or hearing, which indicates that they knew those items were no longer relevant to their need for information about balance disorders

When asked for a list of steps of how to do research, one student replied quickly for the team, “Identify topic, Google topic, read Google, digest information, check other sources, come up with other sources. Find out if they’re plausible sources. ‘For example you’re not going to ask a monkey how bananas taste.’”

To understand students’ thinking about source attribution, a focus group question asked, “Why is it important that you list your information source in a bibliography? Several students replied, “So you can go back and expand” and “So it shows how much work we did. And also so we can go back and see if we got something wrong,” and “1 [you can] go

back; 2 you have to cite them, and 3.... Um it's important." Yet another student said, "You're deducted points if you don't do it. You need it if you need to go back to get more information from the website."

This is a strength and another example of students critical engaging with information sources and determining their validity and usefulness [Curate IV.B.3.] because it shows they did see citing sources as "important," as a means for demonstrating the amount of work and time invested in what they produced, and as a means for later expanding their thinking or information stating that it would allow them to "go back and expand" that is, to get additional information if needed in the future.

On the other hand, there is also a gap in that there is a lack of evidence for Engage VI.B.2 "Acknowledging authorship and demonstrating respect for the intellectual property of others," as the students could have discussed attribution or credibility but did not.

The focus group strands identified in this section showed evidence of several competencies articulated in the AASL Standards. First students showed that they connected with the topic and each other through Collaborate III.B.2. "Establishing connections with other learners to build on their own prior knowledge and create new knowledge." One student expressed that after researching and talking, now they really care about the problem and finding a solution. Another competency displayed in students' reflections about what makes a good source, or not, taps into students' connections and prior knowledge as described in Curate IV.B.3. "Systematically questioning and assessing the validity and accuracy of information," as students explained how to tell if a source is a good one, and suggest that a source that would make false claims and is not corroborated by other sources is probably a scam. On the other hand there is also a gap here as this shows the student sees assessing a source as a comprehensive rather than discrete determination. Their assessment that a reliable source "fits in with everything else" points to their understanding that if multiple sources lead to one conclusion and a single source contradicts all others, then that source must either be "not true" or "not right." [Though they don't acknowledge the factor of date/timeliness of when a source was created as potentially changing this assessment.] Also, one would compare a source to what they already know to be true. In this instance, the student recognizes that if they know something to be true, that is, has information that she already knows is reliable, then a source that contradicts that known fact would be considered questionable or even intentionally erroneous, "a scam." Again, the ability to assess validity [Curate IV.B.3. "Systematically questioning and assessing the validity and accuracy of information"] was demonstrated when the team did not use information from one website because they were able to determine immediately that the information on it was wrong because the site stated that more people die of the condition every year in the U.S. than even live in the U.S.

4.3 Share Domain (AASL Standards Framework for Learners)

During their engagement in the Doctor Conference Call and the Presentation Skit and Judging the students exhibited several competencies articulated in AASL's Share domain. In preparation for the November Doctor Conference Call, the team had researched the ear over several months, had interviewed a senior citizen who had an inner ear disorder called Meniere's disease, and worked with another of the team's senior partners to write to the doctor (an otolaryngologist) to arrange for a group phone call. They also mailed drawings of two possible prototypes the team was thinking about. Sharing their innovative solution and seeking feedback from experts in the field are part of the Project requirements (FLL®, 2019).

To begin the Doctor Conference Call, Robert described one potential prototype idea for an artificial vestibular system that would clip behind the ear and connect to the inner ear and the vestibular nerve. It has two spheres, one inside the other, with water in the outer ball to maintain gravity for balance and the inside ball has terminals that receive a current when the system tilts, to help maintain balance. The otolaryngologist said the idea was "intriguing" because it resembles the Cochlear implant and it was "interesting to apply that same principle to the vestibular system."

Next Carlos explained an idea for a hollow vest that a senior with an inner ear disorder would wear in order to maintain proper balance with "weights in the lower half and helium in the upper half" that would sense if one is leaning right or left and would move helium to that side. The otolaryngologist said he liked the theory behind it and was impressed with their "intuitive" understanding of the need to counteract something, of the fluid involved, and the position change involved. He also said they were doing a good job with thinking about something that is helping seniors in a way that "doesn't have to connect to their brain" as it is an "interesting" and "smart" way to look at things.

The doctor also reminded them to consider the weight of something the senior would have to wear as it would “probably be too heavy for them.”

After approximately 20 minutes, the doctor said that if they had more questions, he could give them a call back another time. However, the students had many questions, and they continued the call for 50 minutes. Carlos had a follow up question: “With the vest idea, what if you took out the weights and just had a series of compartments filled with lifting gas?” The doctor thoughtfully agreed that the fluid and gas in the vest could provide a lifting force, but also raised an issue about the gas bubble movement that may present a problem. Robert asked the doctor for the cost of the cochlear implant, noting he had read online that it could cost \$50,000- 100,000 to have the implant and return for 3-6 appointments to have it programmed. The doctor responded that it varied by person, but that he thought the \$20,000- 30,000 range was closer. Dawson continued the conversation asking, “Have you ever heard anything about otolith crystals getting out of the organ that they’re supposed to be in?” The otolaryngologist replied, “Yes, that refers to the 9th positional vertigo, and the vestibular system is responsible for both rotational and linear changes in acceleration. It was evident Dawson had been reading about this because he followed a long and enthusiastic explanation from the doctor with a new question, “Do you think it would be possible to make a screen so the crystals don’t get out of their spot?” After more detailed explanation, the doctor summarized some of the important ideas from the conversation and again complimented them saying, “I think just with you understanding how it works, you could certainly come up with ideas about how to keep those crystals from leaving their normal position.” The doctor later concluded with more compliments to the team for “looking at a particular system, understanding it, and trying to break it down, and trying to figure out methods to fix it.”

Throughout the discussion, the students enacted the skills articulated in Collaborate III.C.1. “Soliciting and responding to feedback from others. The back and forth about possible solutions to the seniors’ problem and whether the doctor thought they were feasible was a robust exchange of feedback that required the students to make connections between what they already knew and the information the doctor provided in response to the group’s prototype. The students made adjustments to their thinking as they asked the doctor follow-up questions being forced to continuously re-evaluate their approach to the problem.

The students did not simply send off their idea and get some expert commentary on it but rather were engaged in the discussion of continuous feedback based on their growth in knowledge on the topic. In so doing the students also exhibited Explore V.C.3. “Collaboratively identifying innovative solutions to a challenge or problem” which they did by creating prototype drawings in preparation for the call. During the Presentation Skit and Judging the students demonstrated, “Sharing products with an authentic audience” [Inquire I.C.4.] and “Disseminating new knowledge through means appropriate for the intended audience,” [Engage VI.C.2.]. The students wrote a skit with an intentional focus on answering the questions they anticipated being asked by the judges. They chose to organize their skit in the form of a newscast so that they could include specific questions and demonstrate how they would answer them so that no key information or steps of their process would get overlooked or left out. For instance, in the skit the newscaster asks, “Now tell me, why did you choose this topic?” to which the students responded (using back and forth commentary between four of the team members), “we chose this problem because after we talked to our senior mentors, they shared concerns about the cost of hearing aids. After we researched the inner ear and causes of falling, we saw the vestibular system, and we decided to look at that instead.” Then they reflected on how each of these activities formed their thinking - they talked to seniors to explore the range of possible concerns; they reflected on what the seniors told them and related it to their “assignment;” and they used what they heard from the seniors to shape their research and made several decisions as to what constituted a relevant topic. They also explained that, “We found that the loss of balance due to the failing of the vestibular system downgrades the quality of life and increases the chance of falls, is quite an interesting problem.” They then provided statistics about the cost that U.S. healthcare incurs as a result of loss of balance disorders, such as the failing of the vestibular system, as well the fact that 2 in 5 seniors fall every year due to balance disorders. By providing these statistics, they provided context for the problem they chose to explore as well as consequences of leaving the problem unsolved.

Immediately after the skit there was time scheduled for judges to ask questions. The judges asked several questions clarifying the function and connections in the vestibular system. They also asked the team to talk about whose idea this was and how the idea for the prototype was created. The team responded “it was all of us” and explained they started by researching hearing, researched costs, and saw problems with the vestibular system. A judge asked what the professionals the team spoke with had to say about how they thought it could be manufactured, and the team explained

their phone call and sending pictures to the otolaryngologist. Finally, the judges commented that the prototype was “a very effective tool for showing us how this works” and, “I don’t think it hurts to say, I think you are one of the smartest teams we’ve seen here today. This was very well done.” The team prototype and skit were clear enough for the judges to understand and to have authentic question exchange with the team about their ideas. In making decisions about the key ideas to include in their skit script, they were attending to the particular needs of their audience (the judges) in assessing their work as a team.

4.4 Grow Domain (AASL Standards Framework for Learners)

The Final Questionnaire and the TRAILS assessment were completed by students during a final team meeting in January after all competitions were completed and after having won first place for their Innovation Project at the state-level, the top award for the project at the highest level of competition available to teams. The team had a brief (and slightly hurried) meeting to hear positive comments from the coach and to turn in supplies. The researcher administered a paper questionnaire and provided them the online TRAILS assessment of 20 multiple choice questions. The paper questionnaire directions stated they were being asked seven questions to help the researcher and coach learn more about how middle school students do research in the FLL® project. It asked: how many years they have been in FLL®; why they joined; what their favorite part was; describe for future participants what makes a good brainstorming session (they were provided a list of their initial brainstorming ideas for projects); describe for future participants what makes a good research project question (they were provided a list of some of their questions); describe for future participants what makes a good keyword search and where is the best place to do research (they were provided a few of their keyword examples); and describe for future participants how you can tell if a source has good authority, bias, coverage, and has an appropriate date; and what they still wonder about artificial vestibular systems?

Responses showed two students had participated for 3 years, two participated for 2 years, and two were in their first year. The team’s reasons for joining included a mixture of responses from the suggested choices and one written in response. Three students circled almost all of the reasons both for joining and as their favorite parts: the robot, research, going to competitions, get to be with friends, get to choose a project, and get to come up with a solution. One student circled the robot, being with friends and going to competitions. One circled only the robot. And one first year student circled nothing for reasons to join, but indicated their favorite parts were research and all other choices except for the robot. One student wrote in a favorite part was the “coach was awesome, cool, and fun.”

Their descriptions for future participants about what makes a good research brainstorming session were “food, previous ideas,” “agreeing with others, not being rude,” “think about what the topic is and tell it to the group,” “listen to all, stupid ideas are the best ideas,” “write down all ideas,” and “the activity when everybody is quiet [to think] and then share ideas with the group.” Their descriptions of advice for future participants about what makes a good research project question included: “get questions from confusing brainstorming responses,” “something descriptive,” “it has to relate to the topic,” “ask what you don’t know and then for explanation,” “what is the cost? and how will you build or do it?, and “think about what you are researching, look at the situation, then brainstorm a question.”

What makes a good keyword, and the best place to do research were the next items on the questionnaire. Students responded with “something that sounds on your topic, Google, journals,” “brainstorming responses, main ideas, libraries, Google,” “it has to be for the topic, government sites,.edu sites,” “a main topic,” and “keywords= short with less complex words.”

When asked how they can tell if a site has authority, students responded “look for credentials of the author, doctors, PhDs, people with degrees, who wrote it, someone who writes it.” When asked how they can tell if a site has bias, students responded “it is an advertisement, do stuff you favor, what it is about, if they had any opinions, and doesn’t have ‘I like or ‘dislike’ or if it ever says ‘we’ or ‘I’ or ‘us.’” And when asked how to tell if the site has coverage with the information needed, students responded “good keywords, make sure it is relevant, does it cover all the things you need, facts about your topic, and details.”

Similarly, students’ scores on TRAILS, a free nationally-available information literacy assessment of multiple-choice questions, echoed their questionnaire results. The team completed the 6th grade level general assessment. The report identified areas of strengths and weaknesses in students’ understanding of specific concepts related to information literacy, which assists in targeting instructional efforts. As a group, the percent of correct responses within

that category, on average, were as follows: the highest score was 88% for “Evaluate sources and information,” next was 81% for “Develop topic,” next was 75% for “Develop, use and revise search strategies,” 70% for “Use information responsibly, ethically and legally,” and 69% for “Identify potential sources.” This shows that the same skills students demonstrated to be strengths in the questionnaire (evaluating sources and developing a topic) were also their highest scores on TRAILS. This is fitting because the project guide and judging rubric emphasized exploration of potential topics and developing ideas, and the researcher-created Background Research Packet included a section for students to complete for each source to evaluate its authority, bias, content purpose, and date. Although the project called for the use of a variety of sources, there was no direct instruction on how to use search strategies or identify books or databases. Likewise, students printed their sources to include in a binder that was handed to judges, no direct instruction about citations or ethics was provided to the team.

Regarding which AASL competencies appear to be evident in the Final Questionnaire and TRAILS assessment, selected from the Grow Domain, those that most resonate are from Curate: IV.D.1. “Performing ongoing analysis of and reflection on the quality, usefulness, and accuracy of curated resources” as the students reflected on their sources to inform their prototype ideas and suggested how future participants could do the same. There was also evidence of Curate IV.D.3. “Openly communicating curation processes for others to use, interpret, and validate” as they reflected on their own brainstorming and process of finding sources. One AASL competency addressed in the Final Questionnaire that revealed a gap in the students attainment was, Inquire I.D.1. “Engaging in sustained inquiry.” Only two students had new questions; one wondered whether their idea could connect to the nerve and another pondered if it would work. But overwhelmingly, students stated they had no more questions on the topic. The students had pursued a single topic over multiple weeks - sustaining a line of inquiry longer than most students have the opportunity to do - yet there were areas related to their topic that could have been pushed further had the students wanted to continue on their own. Students may have seen this as a time for celebration of their success and as the end of their project.

5 Conclusions and Interpretations

Having witnessed this inquiry-based learning project in which middle school students identified a problem and created an innovative solution that they then shared with others, the researchers formed two overarching conclusions. These conclusions are: (1) the information literacy instruction woven throughout the project contributed to the visible successes in student inquiry-based learning, and (2) the skills necessary to be a discerning user of information possessing successful strategies for combating misinformation are best enabled through inquiry-based learning and would benefit from more direct instruction from a collaborating school librarian.

5.1 Information Literacy Instruction Throughout the Inquiry Contributed to Successes

“Well I don’t think it hurts to say, I think you are one of the smartest teams we’ve seen here today. This was very well done. Congratulations!” -- This final comment from one of the judges indicated they were highly impressed by the students’ presentation. The judges were intrigued by and asked about their prototype design, and asked what various wires did, whose idea it was, how that idea translated into this prototype, and if they had asked the doctor about whether he thought it could be manufactured. The engagement displayed through the judges’ questions and reactions to the students’ statements and work indicated that they “saw” something in the group’s performance that stood out from that of the other teams. As a result, the team won the top award for the Innovative Solution project at the state competition, the highest level available to these students. Evidence of being on the path to this ultimate success, are other indicators of the team’s developing skills. The quantity of time (50 minutes) and the quality of the conversation with the doctor in the conference call revealed aspects of the team’s success as enabled by inquiry-based learning. The doctor listened to the team explain their ideas for two solutions: a type of artificial vestibular system implant for the ear, and a type of vest to wear to help maintain your balance. After 20 minutes of exchange, the doctor responded positively about their thinking, saying, “That’s a really interesting and smart way to look at things, too. If you have more questions for me, I can give you a call back tomorrow.” However, rather than ending things there, the team continued

the call with follow up questions including one about the vest related to the doctor's feedback about the weight of it, and one regarding the cost of a typical cochlear implant procedure. A question from another team member addressed otolith crystals in the inner ear and how they get displaced from the organ they're supposed to be in. After the doctor responded, the students asked if the doctor thought it would be possible to make a screen, "so that the crystals don't get out of their spot." After a 50 minute meeting, the doctor encouraged the team with comments such as, "You guys have done a great job of looking at a particular system, understanding it and trying to break it down, and trying to figure out methods to fix it." The doctor could have been exasperated by the further demand on their time but instead embraced the students' desire to develop their own thinking. The doctor encouraged the team to continue to think about all that goes on in the body, and acknowledged their potential as aspiring engineers:

This is what engineers do - is think about problems and solutions and they get data and try to think about how something works, and they try to figure out how they can improve upon that or make it better, or simpler, or faster...The systems are so balanced and work so well, it's fascinating. And you can be fascinated with almost anything when you start asking these kinds of questions. So I think you guys have done an excellent job of doing that with this system. This is a hard system. You've thought about it. You've learned about it. You understand it. And once you've had that understanding, you've come up with ideas of how yours is new or different. So I think that's wonderful.

As promising as the judge's and doctor's comments were, the researchers were heartened to find evidence that at least 13 of the 68 AASL (2018a) learner standards were addressed through the students' engagement in the inquiry-based research project. These are detailed in the descriptions of the seven data sources and the findings. The project did more than extend the students' knowledge about a particular medical concern but it also helped build critical skills and abilities that could be transferable to other information and professional contexts. Even the students acknowledged the role extended inquiry played in their success as articulated in one member's comment, "Now we really do care about our solution."

Yet these visible successes were made possible through the often invisible information literacy guidance delivered through the combination of the collaborative teaching role of the teacher/coach and the researcher participant acting in the role of a school librarian. Knowing school librarians teach information literacy skills and face great difficulty in articulating a scope and sequence for these skills aptly taught through collaborative, student-driven projects, the researchers offer a list of the skills and activities to assist in curriculum creation. The following information literacy instructional components were part of this project and are recommended for similar inquiry-based learning projects:

- **Project scenario.** This four-page project invitation written to students was provided by FLL in order to explain the competition requirements. It describes the basic process and several directions teams could take. The sections include *Think About It* [the topic], *Find a Senior Partner*, *Identify a Problem*, *Create an Innovative Solution*, *Share with Others*, *Present Your Solution at a Tournament*, and *More Resources*. This type of project scenario is common and may be found or adapted for numerous classroom teaching scenarios. This was sent out in advance, and the coach led a conversation about it at the first meeting.
- **Scoring rubric.** The nine FLL project requirements listed in the rubric are outlined in full in the methodology section of this article. This type of project rubric is common across many classroom projects. The project itself is founded on information literacy. You couldn't do it without having gained information literacy. Otherwise when the judges ask you questions (from the rubric) there would be little to say. So by nature, they do this project using inquiry-based learning for information literacy skills. This was shared with the team at the beginning of the project.
- **Background research packet.** The researcher participant created five pages of inquiry activities for brainstorming, taking notes by source type, writing questions, and choosing the strongest evidence. Activities were adapted from "assessments" of the *Empire State Information Fluency Continuum* (2021). The packet was emailed to the team for information literacy practice utilizing two sample topics prior to the beginning of the project.
- **Time to do research.** Several group meetings were designated for all members to research their topic individually or in pairs or small groups. They were also asked to do individual research at home various times and to bring with them an idea to talk about at the next meeting.
- **Group discussion.** The researcher participant led a 30-minute group conversation that helped to raise awareness of information literacy skills that were overtly written or implied in the project overview and the scoring rubric such as the quality and variety of evidence and sources cited and the degree of analysis of previous solutions. The conversation invited students to reflect on these questions: (1) What stands out that you're most proud of in

learning about this problem, (2) How did the research you did change your opinion or direction from what you initially thought about this problem? (3) How many types of sources did you use to find information? (4) Whose idea was it to use these sources? (5) How did you know if you have good information? (6) Did you find some information that you decided not to use, and if so, why did you decide not to use it? (7) Why is it important that you list your information source in a bibliography? (8) What kinds of questions did you have that you looked for information about? and (9) Now that you've completed your project, what new questions do you wonder about?

- **Coach prompts.** The team coach helped build a passion for research by showing interest in what any team member had found and by casually talking about it among other team members before, after, or during meetings. The coach facilitated a session to help the team collect and collate information they had located. She wrote topics based on what team members had been discussing over several weeks such as, “how many injuries are caused by lack of balance” and “how many falls are caused by this problem” on large post-it notes and put them on tables. Team members walked around the room and contributed their notes to various topics. Then the teacher hung the post-its in the room for future reference.
- **Coach and senior partner assistance arranging a doctor conference call.** One of the project requirements was for the team to share their ideas with an expert in the field prior to the tournament. As the team's idea evolved into developing a prototype of a medical device that could help to treat Meniere's Disease in the inner ear, they brainstormed with their coach and senior partner who to contact. The senior partner offered to make a contact to the otolaryngologist who had treated a friend for this issue, and the doctor agreed to meet with the team. The coach prompted the team to make sure that they were prepared for this meeting and that they would be respectful of the time this professional would take to talk with them. The coach asked the team to make drawings of their ideas and the senior partner mailed them to the doctor so that they would have the drawings in-hand during the phone conference call with the team.
- **A panel of judges.** It is no small commitment that there was a panel of volunteer judges and an organized competition for the culmination of the hard work the team did on their project. The team won the top award for their innovative solution. Even outside of this coordinated activity, many schools arrange similar activities within their school or classroom through various ways of incorporating volunteer panels who do things like judge debates to art shows. A similar structure could be put in place for a classroom application of this type of project.

5.2 Successful Strategies Against Misinformation Enabled by a Collaborating School Librarian

Despite the compliments from the adults supporting the project such as the judges and the doctor providing expertise, and even though the highest team score for information literacy on the TRAILS assessment was in the area of source evaluation skills, showing that the students are approaching the designation of discerning users of information, the researchers found some noticeable gaps in the team's ability to evaluate information. Although existence of a gap is consistent with findings of past studies (Coiro & Kennedy, 2011; Robb, 2017; Weinberg et al., 2016), this raised new questions about why the team was successful even though they had some obvious gaps in their information process. To illustrate this point and to suggest how to rectify the situation, researchers interpreted the data about what students know and don't know about being a discerning user of information possessing successful strategies against misinformation. The example also shows how these skills are best enabled through inquiry-based learning and that more direct instruction from a collaborating school librarian may be needed.

What students know about being a discerning user of information may best be summed up in this statement from one team member who said one needs to find “plausible sources,” illustrated through the sentiment, “for example you're not going to ask a monkey how bananas taste.” The same student and a second team member contributed their understandings adding that information is quality “if it fits with everything else, and it came from a good source.” They said information was poor quality if it was untrue, “like with the problem of having the vestibular system being incurable, and then all these different processes that they've tried, and then if one of them has a large percent success rate, you know that one of the sources isn't right, or it just is not a true source.” The second student added even more clarity with the following example, “if you already know that it is incurable and then something says that, “we cured it,” then it's... And the first student finished their sentence for them, “probably a scam.” To further the point, two more

students added their understanding to the next point, which was that they had “most definitely” made critical choices about information not to use. Their elaboration showed that this fourth student had also internalized the importance of evaluating information with this example of incorrect information, “one person found on Google that over 400 million people die from this every year in the U.S., and only 300 million people live in the U.S.”

Although the team said that they judged information accuracy, there were also evident gaps in what they know about being a discerning user of information possessing successful strategies against misinformation. This was revealed when they provided an explanation of why it is important to list your information source in a bibliography, “So it shows how much work we did. And also so we can go back and see if we got something wrong,” and “it’s important,” and “you’re deducted points if you don’t do it.” Although their reasons focused on the utility of keeping track of sources to check correctness and not losing points are very important, students didn’t talk about the fact that using sources as evidence to support their ideas adds to the credibility of their own work. In keeping with these responses, the TRAILS assessment showed students’ scores were the second lowest (70% correct) for questions about using information “responsibly, ethically and legally.” Although they knew *what* to do at one level, it was difficult for them to apply the principles in practice.

Additionally they wrote four different statements on the large post-it note about how many injuries are caused by a lack of balance, but seemingly had no way of referencing any source to “go back and see if we got something wrong,” And in the presentation skit, they introduced a statistic that had not entered into previous discussions stating that “2 in 5 seniors fall each year.” This differed from the four variations of estimates related to falls experienced by seniors that they kept as part of their notes on the post-it. The fact that the students could state rules or benefits of certain information literacy-related practices but did not actually incorporate those practices into their procedures indicates that these students require more support and scaffolding.

Similarly, as successful as students were in conversing with the doctor about their possible solutions, the doctor encouraged the team to think harder saying, “The theory behind it is interesting, but the hard part is that you got to think about especially in older people that a system they would have to wear like that would probably be too heavy for them.” In another instance, the doctor pushed students to do more research about otolith crystals to learn what’s happening when they move out of their correct organ, “that’s a very focused thing, and I’m sure somebody’s done research looking at that...you could certainly come up with ideas about how to keep those crystals from leaving their normal position.” This shows that these students need to continue their research and that it may include reading more about body systems and their functions. However, student responses in the final questionnaire showed little understanding of what makes a good keyword or the best place to do research because students’ responses were vague, “something that sounds on your topic, Google, journals.” Again, the TRAILS assessment supports what the qualitative analysis showed the team needs. The team’s third lowest score was 75% correct for “Develop, use and revise search strategies,” And their lowest score was 69% for “Identify potential sources.” The team had no occasion for information literacy instruction in search strategies during their seven research meetings.

The second conclusion identified gaps in information literacy learning both specific to being discerning users of information with successful strategies against misinformation and encompassing related skills that enhance these strategies. The following information literacy instructional components were not part of this project but were determined to be essential and are recommended for any future inquiry-based learning projects:

- Searching for and tracking the most relevant sources. Scaffolding is needed that a school librarian may facilitate an ongoing system for both individual members and the team as a whole to develop methods to plan search strategies and to subsequently track all sources they find and decide to use in some way. This would allow students to track sources.
- Teaching complex note taking skills to decipher credible authors and sources. Another layer of source scaffolding needs to capture students’ important notes from each source and bring these notes together in a document format that will make it easier for students to compare notes, details and facts across various sources obtained by various group members. This would allow students to determine if a source has the right depth, relevance, author credibility, and perspective shared.
- Labeling and categorizing notes by points of view or perspective. Another layer of source scaffolding facilitate categorizing and labeling their notes so that an individual or group may compare notes on the same topic across

multiple sources to see different perspectives and points of view in order to make determinations about whether diverse opinions are included

- Citing sources to corroborate evidence. This is used to allow one to go back to the source to check details and to provide stronger credibility of the information included in the project. This would allow students to check the facts and details across a group of sources that are currently being cited.

Growth mindset would say that though the students did not satisfy the full competencies in some cases, having an instance to point to where things fell apart a bit or could have gone differently, helps envision success the next time around. Progress happens in stages, sometimes incrementally rather than in leaps and bounds. There is therefore a need for repeated practice across learning contexts (Todd, 2012) taught through the library but also embedded in the content areas schoolwide. Students need practice, practice, and more practice. Not just learning about vetting sources for instance but engaging in a continuous process of evaluation, reconsideration, and repositioning will demonstrate their competence in discerning information.

5.3 Implications for Future Practice

This research results in three implications for future practice of school librarians. First, it makes a case for doing project-based learning across the curriculum, in a prolonged and enriched way. Using this one project allowed the teaching of more than 13 AASL Standards as opposed to an individual unit for each one. Although this research observed middle school students engaged in an extracurricular project, it should be noted that it was an academic project that resembles curricular scenarios for inquiry-based or project-based research. The timeline is conducive to the classroom and/or library instructional contexts; notably this project spanned 4-5 months, and students met only seven times for their research component.

Second, this research makes a case for connecting information literacy instruction and student practice to as many curricular topics and as many grade levels as possible in order to create information users who are able to transfer their skills across the varied contexts of school and life. Lazer et al (2018) argue this “great need for rigorous program evaluation of different educational interventions” that can improve individuals’ “evaluation of the quality of information sources” (p. 1095). This will help students be more prepared to recognize Fake News later in life while avoiding the “unintended consequence” of students becoming skeptical of all information sources (p. 1095). A third implication of this research makes a case for a school librarian teaching inquiry-based learning in collaboration with a classroom teacher. This responds to prior studies (Crary, 2019; Farmer, 2019; Phillips & Lee, 2019) that identified barriers to information literacy instruction and sought to identify the roles of those best situated to teach it. The conclusions of this study point to teaching components that were part of this project and are recommended for use in similar units (project scenario, scoring rubric, background research packet, time to do research, group discussion of focus, coach prompts, coach and mentor arranging expert visits, and a panel of judges). It also recommends teaching components identified through the analysis that are recommended for future collaborative instruction (searching for and tracking the most relevant sources, teaching complex note taking to decipher credible authors and sources, categorizing notes and sources by points of view, and citing sources to corroborate evidence). This study has elevated the professional school librarian’s instructional goal of helping all students become competent, discerning users of information empowered with strategies to dispel misinformation in whatever context they may encounter it.

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