Knology

STEM Student Reporting Labs

STEM Engagement through Journalism

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Executive Summary

Existing research indicates that engaging and sustaining youth interest in STEM subjects past elementary school remains challenging (Adelman, 2006; AAUW, 2010; University of the Sciences, 2012). This is especially true for girls, students of color, and economically disadvantaged individuals. Strategies for expanding and diversifying pathways for individuals to pursue STEM and STEM-adjacent careers could approach the issue by helping students connect their existing interests with STEM concepts and situate STEM in the context of their daily lives.

Seeking to use narrative and media creation as a vehicle for getting more young people interested in STEM, the National Science Foundation supported a WETA/PBS NewsHour initiative to adapt their Student Reporting Labs (SRL) curriculum to feature a focus on STEM content in 2015. Building on earlier research about student-led science journalism (e.g. Polman & Hope, 2014; Nicholas, 2017), this project suggests that having students develop and produce narratives about complex STEM topics may make these topics far less intimidating and serve as the impetus for greater involvement in STEM learning. Specifically, this initiative sought to understand how project-based learning that integrates socially relevant media *and* STEM content might increase youth interest in STEM learning, promote STEM and media literacy, and motivate young people to pursue careers in STEM and STEM communication. It also investigated how engaging young people in producing STEM-focused news stories could impact their social networks and increase demand for quality STEM reporting.

Using a guided curriculum that includes examples of NewsHour reporting and story prompts related to current social issues, NewsHour's general SRL program has helped middle and high school students visualize themselves as journalists by engaging in journalistic practices under the direction and mentorship of an established media organization. In addition to exposing youth to media careers that they may not otherwise have considered, NewsHour's efforts amplify youth voices by providing a platform for sharing their perspectives with a national audience. Many of the students' final stories air either on the PBS NewsHour or a PBS affiliate. In some cases, stories are shared as part of national conferences and festivals. In addition, the focus on video, camera, lighting, and editing further developed students' technology and problem-solving skills.

Students … find it difficult to watch videos or films without a critical eye after learning the skills required of video journalists.

The STEM iteration of the SRL initiative shares the mandate of increasing media literacy, empowering teenagers as civically-engaged media creators, and showcasing youth voices. It has the added goal of diversifying the STEM workforce through increasing participation from groups that have largely been excluded. Part of this process involves connecting students

with professional mentors that look like them in terms of gender and ethnicity. But equally important to increasing access to STEM work is demystifying the subject matter and stories. A story about the effects of climate change on the water supply in students' communities may be more useful for motivating young people to study the underlying science and consider engineering careers than reading the same concepts in a textbook. Moreover, encouraging young people to do the investigative work required for good reportage gives them the chance to practice many of the same skills needed for rigorous scientific inquiry and study.

Independent evaluation of the four-year initiative by Knology demonstrated that in addition to increased technology, media literacy, and critical thinking skills, the STEM SRL program helped students connect concepts learned in class to the world outside. As a result, students reported gaining a more expansive view of what STEM encompasses and a deeper understanding of the civic role of journalism. By the end of their learning year, we frequently heard students say that they find it difficult to watch videos or films without a critical eye because of their experiences as video journalists. Furthermore, STEM SRL increases the breadth of available STEM news content that specifically targets young people. Our evaluation showed that participants' peers were able to see the value of stories their fellow students produced. Access to this information may encourage more young people to take active roles in addressing issues within their communities that some of these stories address.

Accomplishments & Impacts

The STEM SRL program provided students with important awareness of the variety of STEM-linked career options and built confidence in their ability to understand STEM concepts. Through the program, participants gained interest and expertise in their particular story topics, as well as a better understanding of professionals' day-to-day activities. Students cultivated professional skills such as effective strategies for communicating with authority figures in work environments, and made valuable connections with mentors and potential future employers.

The evaluation showed that teachers availed themselves of professional development opportunities provided by the SRL team including an annual workshop as well as in through training provided over the course of the program years. Teachers asked questions, reviewed the proposed curriculum, and discussed strategies for using the resources provided in classrooms with members of the SRL team. They also helped select topics that were used during program years. Lastly, three teachers worked closely with the project team to produce a publication for peer review.

Students had a platform for sharing their perspectives on issues of importance to them and their communities. Their stories were disseminated through the SRL and NewsHour websites, local and national news broadcasts, social media platforms, and some conferences and festivals. Across all four years, the Labs produced 98 STEM news stories. These stories contribute to the existing body of resources designed specifically for youth audiences. In the final two years of the evaluation, students participated in a film festival that engaged their peers, teachers, and members of their communities in deliberating on the quality of the

stories and their featured topics. In 2018, five STEM Labs and two Health Labs participated in the film festival. Their audiences ranged from 30 people to over 300. In 2019, six STEM Labs participated in the film festival. Their audiences ranged from 18 people to over 100.

STEM Student Reporting Labs helped students connect STEM concepts to situations outside the classroom and increased their confidence in their abilities to understand and talk about complicated topics. The transdisciplinary nature of the program helped students connect their STEM content knowledge to skills in other areas like technology and storytelling. Simultaneously, participating teachers—who typically had backgrounds in disciplines outside of STEM—gained a better understanding of science and the basics of scientific research through the Labs.

Interactions with media and STEM professionals, as both mentors and sources, exposed students to more career choices than they may have considered previously. These interactions helped students visualize themselves in different jobs, understand motivations for pursuing them, and have more realistic expectations of different career paths. Students also cultivated transferable interpersonal and professional skills, including working collaboratively towards shared goals and responding professionally to feedback.

The STEM SRL initiative has also produced various educational resources that can be used after the end of the official project period, including curricula, teaching aids, and worksheets for teachers and students. Several SRL Master Teachers are continuing to run their Labs as STEM Labs in the 2019-2020 school year and plan to do so for the foreseeable future.

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Introduction

Between elementary school and high school, a disproportionately high number of girls, minority students, and students from low socio-economic backgrounds choose not to pursue STEM-related coursework for various reasons. The University of the Sciences (2012) reports that by high school, 61% of students of color are not interested in pursuing a career in science or healthcare. Moreover, only a quarter of STEM jobs are held by women although they make up about half (48%) of the total workforce (the American Association of University Women, 2010). Other studies correlate low socio-economic status with fewer opportunities for advanced STEM classes, systematically placing those students at greater disadvantages (Adelman, 2006). These statistics suggest that previous strategies for engaging young people in STEM and STEM-related careers may be ineffective for reaching groups of individuals that have historically been excluded from STEM workforce.

Seeking to get more young people interested in STEM, in 2015, the National Science Foundation supported a WETA/PBS NewsHour experiment to adapt their established Student Reporting Labs (SRL) initiative to include a STEM focus. The SRL initiative provides teachers with digital media curriculum to train middle and high school students to develop video journalism news reports about societal issues from their perspective. Since its launch in 2009, the program has reached over 200 schools in 48 states and over 15,000 students. The program includes opportunities for teacher professional development through training workshops and frequent communication with the SRL project team to discuss curriculum and plan implementation.

Previous evaluation of the broader SRL model shows that participants in the program become more media literate, intellectually curious, have stronger communication skills, and are better able to work in teams (Hobbs & Donnelly, 2013; Marshall, 2015, 2019). Using a similar strategy, STEM SRL was designed to guide students to develop broadcast-worthy news reports about STEM topics. Research goals were to determine if a STEM-focused video journalism curriculum could increase middle- and high-school students' STEM and media literacies, as well as their interest in STEM-related careers. Given the focus on creating pathways for historically underrepresented groups, the experiment focused on partnerships with Title 1 schools serving minority youth.

The project focused on four expansions to the SRL model:

- A new STEM SRL curriculum, aligned with the Next Generation Science Standards and Common Core Standards;
- Connections to STEM professionals to serve as content mentors;
- Partnerships with organizations with a strong commitment to producing high-quality STEM media; and
- A film festival model that helped students and teachers broaden the reach of their videos.

The goals for this expanded program are:

- To empower youth to synthesize and communicate science information accurately and in ways that resonate with them and their communities;
- To increase youth interest, engagement, and skills in STEM and media fields through interdisciplinary and multimodal approaches;
- To expand the STEM and STEM communication career pipelines; and
- To inform new methods for delivering STEM news and increasing STEM literacy among members of the public by centering a youth perspective.

Knology (formerly New Knowledge Organization Ltd.) served as the evaluation partner to assess the impacts of the curriculum on students' knowledge of and interest in STEM and STEM-related careers. The evaluation focused on helping stakeholders better understand how well the program met its goals and working with the project leadership team to identify areas for potential improvement and expansion.

Over the four years of the evaluation, Knology used a mixed-methods approach, employing quantitative surveys in parallel with qualitative observation, case studies, focus groups, and engagement with students, teachers, mentors, members of students' social networks, and project leadership [Year 1 (Roberts, Norlander, Flinner, & Fraser, 2016), Year 2 (Roberts, Norlander, & Flinner, 2017), Year 3 (Fraser, et al. 2018)]. To compare outcomes of STEM SRL and general SRL, we gathered data from experimental sites that used the STEM SRL curriculum, and compared these results with data gathered from control sites that used the main SRL curriculum and produced stories about humanities, language arts, or civics topics. We evaluated differences between the groups to identify the unique contributions of the STEM SRL program to STEM learning.

This Report

This final summative report outlines the results of the four-year research project based on the final year's data and a retrospective assessment of the preceding three years of data. It is organized into six content chapters. The first, "Methods," outlines the approaches we took to this evaluation over the four years. The second chapter, "Baseline Results," summarizes our Year 1 findings. The third and fourth chapters focus on student outcomes. The third chapter presents aggregate results from surveys and focus groups with current and former Lab participants that provide evidence of growth over time. Meanwhile, the fourth chapter provides a detailed case study of a single school. The fifth chapter, in turn, addresses teacher and mentor outcomes by aggregating findings from surveys, focus groups, and interviews with program teachers and mentors. This research focused on program implementation, perceptions of growth, and suggestions for improvement. The sixth chapter, "Discussion," summarizes our findings in terms of the program's goals, discusses *how* the program met its goals, and provides suggestions for future implementation and research.

Project History

During the pilot year (2015-2016), the new experimental STEM SRL curriculum ran for a single spring semester based on one curriculum unit. Teachers had access to lesson plans, worksheets, information about NGSS standards, and example stories for their use. The evaluation team used this year to test instruments intended for use in data collection over the life of the project. The project was designed with longitudinal tracking in mind, and SRL made changes to the program each year. As a result, the evaluation strategy included an assessment of emerging questions each year, and opportunities for using data to refine the design through each evaluation cycle.

Figure 1. Students visit a construction site to capture B-roll for their report.

In Year 2 (2016-2017), participating Labs received a more comprehensive full-year STEM SRL curriculum with expanded opportunities for social media-related activities. Teachers received the STEM SRL curriculum including information on relevant activities and worksheets at the beginning of the school year. The evaluation for this more comprehensive curriculum employed separate pre- and post- student surveys and a set of site visits / interviews to verify findings. During the Year 2 program, mentors were identified through multiple customized searches after students had finalized their story topics.

Based on emerging results from Year 2, the Year 3 (2017-2018), program was expanded to present two scaffolding STEM prompts (as part of a two-phase curriculum design) rather than a single year-long prompt. The first phase of the program asked students to focus on skill-building, particularly shot lists, pre-production, interview technique, and development of B-roll material. The second phase focused on developing a more robust story that drew on the resources developed in the first phase. Activities for Year 3 also included testing of refined program products including a Welcome Packet and Road Map documents designed to help orient teachers using the STEM SRL curriculum. These documents helped teachers integrate content from the original SRL curriculum with the curriculum provided for the STEM iteration. This two-phase program modification seemed to help maintain motivation for teachers and students alike (Fraser, et al. 2018).

In Year 3, the SRL team began working with organizations, such as MIT's alumni association, to streamline the process of recruiting STEM mentors. The team also piloted a film festival and competition designed to increase the reach of students' stories beyond their personal networks. During the festival, students' news reports were shared with peers, members of their local communities, and other STEM SRL-participating schools.

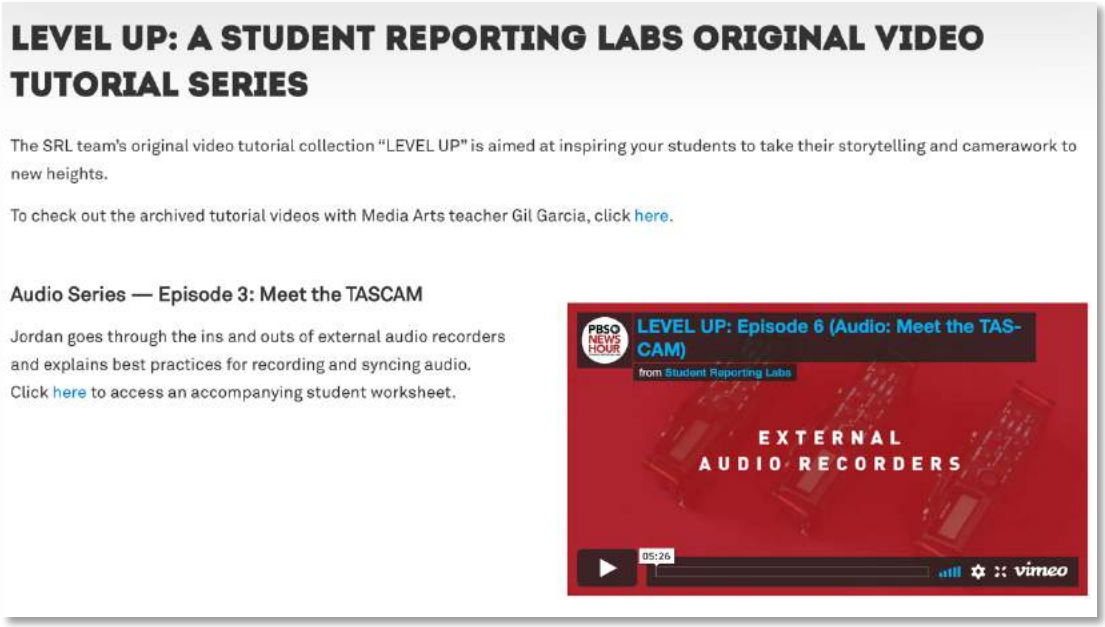

Figure 2. Example of an online tutorial created to support skill development.

Teachers in the experimental group received the STEM SRL curriculum at the beginning of each school year except for the Year 1 pilot group who received the curriculum at the beginning of the Spring semester. Curriculum materials included activities and worksheets that targeted specific student skills and culminated in story pitches related to several STEM-specific prompts (see Appendix A for story prompts).

Each year, sites submitted story pitches to the SRL project team for feedback on ideas, content, and approach.[i] Once students selected their topics, the SRL project team recruited scientists and engineers with relevant content expertise to serve as mentors for the experimental classes. Teachers in control group settings used the regular SRL curriculum and students in this group were also required to submit story pitches for feedback. In all cases, SRL staff assigned journalism professionals to both experimental and control classes to serve as public media mentors and provide hands-on technical guidance.

In the fourth and final experimental year (2018-2019), teachers received refined curriculum materials and more up-to-date examples and story ideas. The final year also saw changes in the mentor recruitment strategy. The project team prioritized working with organizations including one that connects young people with female STEM role models (FabFems) and those that prioritize connecting with low-income students (Letters to a Pre-Scientist). Across all four years, the evaluation team met regularly with the program team to share findings, interpret results, and discuss project evolution.

Methods

Our four-year evaluation was based on a quasi-experimental between-subjects design that compared outcomes in STEM SRL labs to control SRL labs (see Appendix B for a summary of all research activities and participants).

Seventeen experimental sites were selected for the one-semester pilot STEM SRL in Year 1, and seventeen control sites with a well-matched comparison group of students. In Years 2 through 4, returning SRL teachers were invited to apply to host STEM Labs. The team selected 20 experimental and 20 control sites in Year 2, 24 experimental and 25 control sites in Year 3, and 29 experimental and 26 control sites in Year 4.[ii] [iii] More schools were urban than suburban, and relatively few were rural. Over half of the participating schools were categorized as Title 1 with more than 50% of the student population eligible for free or reduced-price lunch (See Appendix C for details).

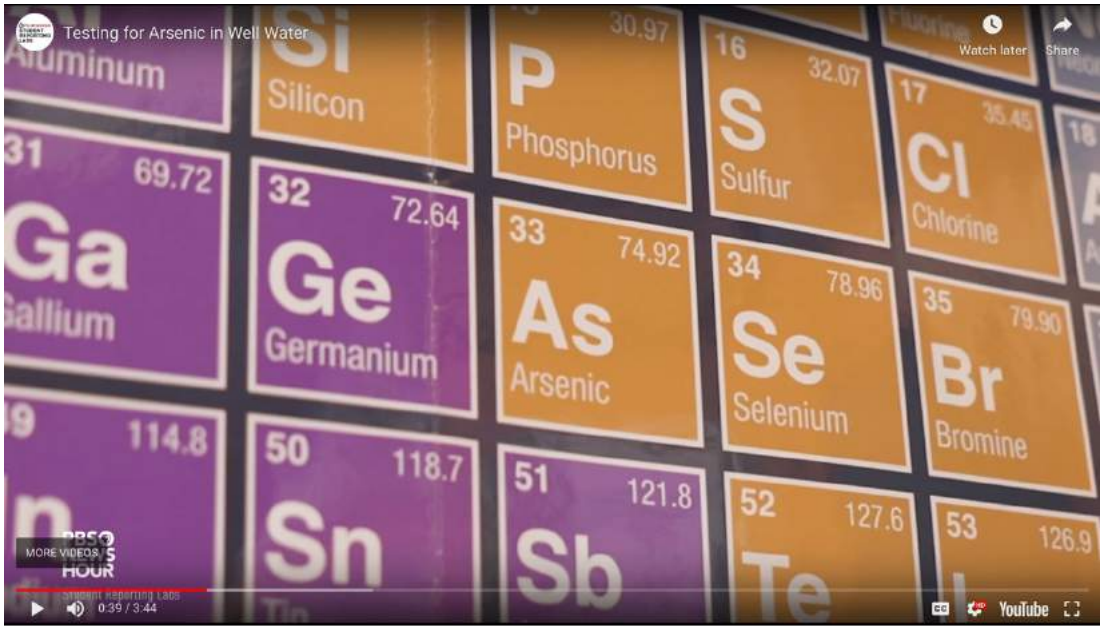

Figure 3. Screengrab from video in which Mid-Maine Technical High School students reported on dangerous levels of arsenic in local well water.

Note. Video: *https://studentreportinglabs.org/youth-reporting/students-help-with-citizen-science-study-of-arsenic-in-well-water/*

Research & Evaluation Activities

We used a mixed methods approach to gather data[iv] from students, teachers, mentors, and film festival audiences. All evaluation was conducted under the auspices of a federally registered IRB.[v]

Student Surveys

In Year 1, Knology developed and validated a pre/post survey to measure changes in students' science and media literacy as a result of program participation (Roberts, et al.,

2016). Teachers in the STEM SRL experimental and control group classes distributed the surveys to their students at the beginning and end of each program. There were small changes to the survey design between project years. The survey consisted of five modules reflecting: science literacy, STEM interest, STEM identity, STEM applicability, and career interest in STEM or STEM communication (Appendix D). The pre-SRL survey included additional questions about demographics, previous participation in an SRL project and STEM SRL in particular, and two open-ended follow-up questions about prior program experience. The post-SRL survey asked students to clarify the stories they worked on to help differentiate data, and included two open-ended questions asking students to identify their favorite and least favorite parts of the story creation process.

Analysis

We conducted cumulative quantitative analysis using data from student surveys from Years 2, 3, and 4. We used program year as a factor representing the increased implementation experience of teachers, mentors, and the SRL team.

We calculated Cronbach's alpha statistic to assess the scale reliability for each module. We assessed reliability by SRL year (for Years 2, 3, and 4) and by survey deployment time (pre- and post-SRL surveys), in addition to assessing overall reliability across SRL years and survey deployments. We judge a scale to be reliable if the standardized Cronbach's alpha was greater than .70 (Nunnally & Bernstein, 1994) and if all scales were reliable both overall and within each SRL year. For details on reliability, see Appendix E.

Beginning in Year 3, we combined the scale items using Principal Component Analysis (PCA). For each scale, the PCA confirmed a single underlying dimension that summarized the scale items. The PCA also provided numeric scores that represented the placement of each respondent on that summary dimension. We used the PCA scores to generate a pre-SRL value and a post-SRL value for each respondent on each scale.[vi] In previous years, we used mixed-effects regression models to understand the effect of various predictors, including enrollment in an experimental or control class and demographic variables, on the responses to each scale. These models included school identity as a random effect accounting for similar student profiles within schools. We found that the variation across schools was negligible, if apparent at all. Therefore, we removed the random effect in the summative analysis.

We focused instead on change over time using an Analysis of covariance (ANCOVA). We assumed post-SRL scores for each construct would have some relationship to the pre-SRL scores and used group (experimental vs. control) as the main between-subjects predictor. Our models controlled for cognitive development (Grade and Mother's Education), experience with SRL (whether the student was in SRL the previous year), Male Privilege (whether or not the student reported "boy" for gender), White Privilege (whether or not the student reported only "white" for race & ethnicity) and the year of the program (2-4; to account for the fact that each successive year may yield useful experience for teachers, mentors, and the SRL team).

A Knology researcher reviewed responses to all open-ended questions and developed a set of codes for describing response content. In cases where responses addressed multiple codes, we included all relevant codes. Only Year 4 student responses to open-ended

questions are reviewed in this report. Previous analyses are available in earlier project reports [Year 1 (Roberts, et al., 2016), Year 2 (Roberts, et al., 2017), Year 3 (Fraser, J., Barchas-Lichtenstein, et al. 2018)].

Participating Students

Across Years 2-4, 741 students submitted both pre-SRL and post-SRL survey responses (Year 2 *n* = 170, Year 3 *n* = 402, and Year 4 *n* = 169). Most students were in high school, although we saw a decrease in the proportion of participating seniors each year. We had roughly equal numbers of boys and girls each year, with a small number of students (*n* = 14) who declined to respond, selected non-binary, or used a self-identified gender term. Students were racially and ethnically diverse, with similar distributions across years. More demographic information about student survey respondents across years is available in Appendix F.

Figure 4. STEM SRL students from Dalton, GA.

Teacher Surveys

Knology developed a reflective survey that was administered in spring of each year for both control and experimental group teachers to capture information related to teachers' experiences with implementing both the broader SRL and STEM SRL curricula. It included questions that addressed teacher motivations for participation, class and student descriptions, program delivery process, perceptions of student outcomes, teacher competencies, and school and class demographics (Appendix G). In addition to the survey questions, experimental class teachers received an open-ended prompt that asked them to compare the regular and STEM SRL curricula. Year 1 teachers were offered the option of

identifying themselves so that we could connect their responses with other datasets, while all other responses were anonymous. We adapted the survey slightly in each project year to address questions that emerged from our analysis of the data from previous years.

Analysis

All analysis was descriptive because the sample size was insufficient for statistical analysis. We report frequencies where appropriate.

Participating Teachers

In Year 4, 17 STEM SRL teachers and 10 control teachers responded to teacher surveys. Most taught at public schools, and participating teachers were distributed evenly across urban (6 experimental and 4 controls) and suburban (6 experimental and 4 controls) areas. Two control teachers and three experimental teachers worked in rural settings. Two experimental teachers selected "other", indicating that their school includes students from multiple settings. Almost all teachers mentioned wanting to provide their students with an *"authentic audience"* or an applied*, "first-hand,"* or *"real-world"* experience as reasons for participating, while a few were interested in professional development.

Almost all Year 4 teachers used the SRL program in journalism or media classes. One experimental teacher used the materials in a science class, and one teacher in each group used them in English/Language Arts courses. Four experimental teachers used the materials in production and film making courses. Five STEM teachers said the program gave students opportunities to engage with science in a different way.

Mentor Survey

A separate survey asked public media and STEM mentors to anonymously reflect on their experiences working with teachers and students. The survey, which was refined slightly in each project year, included open-ended and closed-ended questions that addressed motivations for mentoring, types of interactions with the students, comfort answering students' questions, time commitment, and perceptions of support from the SRL team, partner teacher, and employers (Appendix H). Some public media mentors worked with multiple classes and could compare their experiences.

Analysis

As with the teacher survey, data analysis was descriptive because sample sizes were too small for statistical comparison. We present frequencies where appropriate.

Participating Mentors

In Year 4, most media mentors (n = 7) were participating for the second or third time, with only one first-time mentor. Because STEM mentors were recruited for topical expertise, we did not ask STEM mentors about prior SRL participation. As with the teacher survey, we reviewed responses to the open-ended questions to identify themes that provided insight into the mentor experience.

Case Studies

Each year, Knology researchers and SRL staff identified six experimental sites for case studies. In the first three years, the project team visited the selected sites towards the end of the program year to observe and discuss STEM stories with the students, their teachers, their peers, and in some cases, parents (Appendix I). In Year 4, the project team interviewed the teacher, the STEM mentor, and the public media mentor. Questions focused more on professional backgrounds, professional challenges, capacity building through STEM SRL, and recommendations to support other teachers and mentors (Appendix J). Several teachers participating in the final year of the project served as participant researchers and co-authors of a research paper (Barchas-Lichtenstein et al, in preparation), and all teachers had the opportunity to review comments attributed to them.

Graduate Survey

In Year 4, we distributed a survey to former SRL students,[vii] using a snowball sampling methodology through both SRL teachers and SRL social media. We collected historical information about the students' schools, the years they participated, and their specific stories. We also looked at their current college major (if applicable), career interests, and demographic information that paralleled the questions asked during the SRL program.

Participants

In total, we received 31 complete surveys, 11 came from individuals who had participated in STEM SRL for between one and three years, and 20 who had experienced the regular SRL classrooms for one to four years. Twelve were men and eighteen women, ranging in age from 18 to 22. Three were employed full-time and thirteen were employed part-time. Eight respondents were still in high school, seventeen were full-time college or graduate students, and one was attending college part-time.

Film Festivals

In Years 3 and 4, the SRL team created a film festival and competition for STEM (and Health) school sites to increase the reach of student videos. The survey design was created as a voting ballot (Appendix K) to:

- To determine the film that taught audiences the most STEM content, as determined by self-report;
- To cement learning by asking attendees to reflect about what they learned; and
- To provide evidence of the festivals' impact.

We counted each audience member's first-place vote. If they voted for their own school, we used their second-place vote instead. That allowed us to control for the different numbers of votes at each school, particularly since several schools voted overwhelmingly for their own film. Schools were permitted to opt out of participation in research without opting out of the film festival and judging.

Participating Schools

In Year 3, five STEM labs and two Health labs participated in the film festival. Their audiences ranged from 30 people to over 300. In Year 4, six STEM labs participated in the film festival. Their audiences ranged from 18 people to over 100.

Other Evaluation Activities

Between Years 2 and 3, we conducted concurrent teacher focus groups with teachers in both STEM and general SRL to understand their experiences and gain insight into how to reach more students through SRL. In Year 4, we conducted a survey of SRL teachers overall to solicit teacher opinions about peer mentorship. As both of these activities focused on implementation rather than outcomes, findings are not reported here.

Baseline Results

The baseline studies in Year 1 indicated that students performed well in the program's target outcomes. Teachers in both control and experimental classes reported improved STEM and media skills in students resulting from program participation. They described the pilot program as particularly effective for ***increasing research and technology skills***. A regression analysis of students' post-program self-perception revealed that those who reported on science concepts had ***higher STEM self-efficacy*** following the program. Younger students and girls whose mothers had higher levels of education attainment also demonstrated higher levels of STEM self-efficacy after participating in the program. After Year 1, we moved to measuring science literacy both pre- and post-SRL for comparison, rather than treating it as a covariate.

Many students involved in pilot testing already viewed themselves as science people, even though some admitted to feeling STEM topics were *"scary"* or "intimidating." Some students were concerned about the open-ended nature of science or worried that they would not be able to produce compelling stories. In spite of these reservations, all participants were engaged with the assignment, especially once they identified personally relevant topics. A regression model revealed that students who (1) valued STEM before the program, (2) reported that their story included science or engineering concepts, and (3) were younger, all valued STEM more highly after the program. The Year 1 student survey also revealed greater interest in all four STEM disciplines after participating in SRL than was present before, but the difference between control and experimental groups was not statistically significant.

Following the Year 1 pilot STEM SRL program, several participating students said they were interested in careers in STEM and media. Almost all students who participated in focus groups said that they were interested in filmmaking though their interest in STEM topics varied. Because the pilot year focused only on instrument and construct validity, we could not use the results to determine prior interest. Students' responses to science literacy survey questions indicated that science literacy in both experimental and control groups was high. While students in the experimental group scored significantly higher on science literacy than control group students, that result could be a result of prior interest that led to them choosing to take part in the program.

Most teachers had a background in journalism or video production. Thus, they likely had the skills necessary to deliver the program, and were uniformly confident in their abilities to teach and provide feedback to students. Experimental group teachers found the STEM SRL curriculum accessible and valuable for helping students to craft effective stories. They described the curriculum as flexible and adaptable to their classroom contexts. In addition, teachers felt the curriculum helped students strengthen certain skills and pay attention to issues in their local communities.

Teachers found the pilot STEM SRL program focused on climate change to be well-suited to student engagement in STEM because of the real-world relevance of the topics and the potential for broader reach than some other possible science stories.

Cumulative Results: Student & Graduate STEM Learning

STEM SRL brought together three different types of disciplinary knowledge. ***Technology skills*** through the use of all hardware and software necessary for video journalism. Teachers most frequently described ***STEM content knowledge*** as scientific, but several teachers brought a more interdisciplinary or transdisciplinary understanding of STEM to their classrooms. While technical skills were specific to video, teachers generally described ***storytelling skills*** as medium-agnostic: structure, argumentation, and emotion (see Barchas-Lichtenstein et al, in preparation). In our evaluation of STEM SRL Labs, we looked for evidence of growth in all three areas.

Multi-Year Participation

In the final year of the evaluation, we asked students at returning Labs if they had previously participated in SRL. If their school had been a STEM or Health Lab in the past, we also asked if they had worked on a STEM or Health story in the past. A total of 91 students reported prior participation in SRL, and 18 of them had worked on a STEM or Health story.

"By working on the STEM story last year, I have become more aware of STEM careers in my community."

Students attributed changes in their perspectives to previous work on the news stories in Labs. For instance, some students with prior SRL experiences credited the program with improving their storytelling in different ways. Others noted that SRL had taught them new technical skills that they incorporated into their storytelling, such as using B-roll to *"actually [tell] someone's story, not just [repeat] it."* Other students noted that SRL helped them realize the importance of multiple perspectives. One student wrote, *"SRL has opened my eyes to the varying stories that are floating throughout our world. Each person has their own unique story to be told, whether STEM-related or not. I now have a better understanding of how to interact with people to create a story that can be told."* Students also noted that SRL taught them to think like journalists, to see the importance of journalism in civic life, or helped them realize new career possibilities. As one student wrote, *"By working on the STEM story last year, I have become more aware of STEM careers in my community."* They noted that their definition of STEM jobs became broader when they realized how much many businesses incorporate technology, for example.

Figure 5. SRL Fellow Colten Birkland filming a story about the effects of the oil drilling jobs on the Turtle Mountain Band of Chippewa Indian Reservation in Belcourt, North Dakota.

Some participants said that they had learned about STEM's applicability to daily life, while others observed that working on the story taught them that STEM is broader than they initially realized. Several students reported gaining a much better sense of STEM careers as a result of working on the story.

Student STEM & Media Communication Skills

Across all four years of the evaluation, case study teachers and mentors highlighted student growth. Teacher results were remarkably positive and generally consistent across all project years. We saw some small variation that was likely due to changes in circumstances from year to year. For example, individual teachers were new to STEM SRL in each project year, and some prompts may have been more logistically difficult to carry out than others.

Overall, teachers felt that the applied nature of SRL was an important motivator for students to keep working on their projects, and were consistently impressed by students' learning outcomes and the quality of their final projects. Both experimental and control teachers generally reported in surveys that they found SRL resources effective at increasing their students' research, writing, and technology skills (Figure 6).

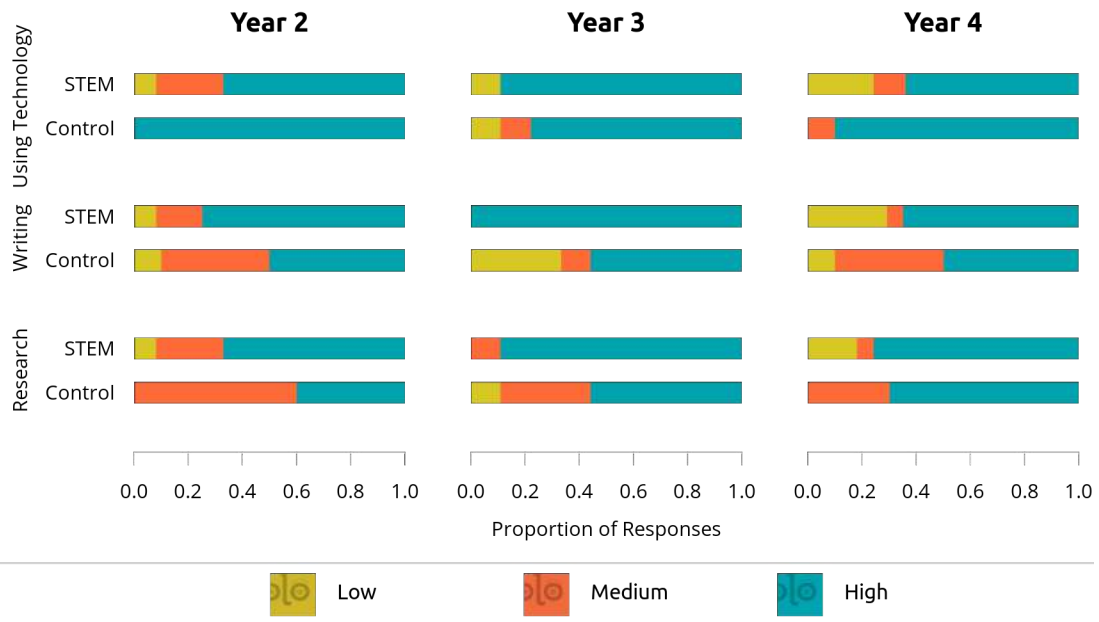

Figure 6. *How effective was (STEM) SRL at increasing your students' skills in the following **[technical]** areas?*

Notes. Year 2, Control *n* = 10 and STEM *n* = 12; Year 3, Control *n* = 9 and STEM *n* = 9; Year 4, Control *n* = 10 and STEM *n* = 17. Responses were on a five-point scale, collapsed here to three levels: *low* includes "not at all" and "slightly," *medium* includes "somewhat," and *high* includes "moderately" and "extremely."

They also reported that SRL resources were generally effective at improving students' collaborative and interpersonal skills (Figure 7).

Figure 7. *How effective was (STEM) SRL at increasing your students' skills in the following **[collaborative]** areas?*

Notes. Year 2, Control *n* = 10 and STEM *n* = 12; Year 3, Control *n* = 9 and STEM *n* = 9; Year 4, Control *n* = 10 and STEM *n* = 17. Responses were on a five-point scale, collapsed here to three levels: *low* includes "not at all" and "slightly," *medium* includes "somewhat," and *high* includes "moderately" and "extremely."

These results from teachers corroborate evaluation findings from James Marshall's (2019) study of SRL Fellows, who participate in an intensive summer workshop. Specifically, Marshall found that Fellows *"build interpersonal skills, including the ability to connect with others and work towards a shared goal"* and *"increase [their] comfort and confidence with technical aspects of production"* (Marshall, 2019, p. v). These results from teachers suggest that most students in SRL build these skills, not only the relatively small number of students selected as Fellows.

In survey text, teachers in both experimental and control settings reflected on the value of hands-on experience with journalism for increasing students' overall news literacy. One control teacher wrote, *"There were so many false, fake and misleading statements along with general misinformation perpetrated by the news [about a local story …] that PBS students were forced to find genuine sources for the truth. One student remarked that she understands the need for news journalist to be on top of their game and report fair and accurate news without opinion."*

Teachers also valued the opportunity for their students to learn professionalism from SRL mentors. Even instances where students did not complete their stories were teachable moments. In their survey responses, several teachers, wrote that these students learned to take responsibility, which is part of being a professional. As one teacher wrote, *"Understanding that the job must be done and that they are responsible, not their teacher, is starting to hit home."*

Most teachers from both groups reported that their students were at least *somewhat* motivated (Figure 8). This figure obscures some differences at the top end of the scale in Year 4: A plurality of Year 4 experimental teachers said their students were *extremely* motivated (n = 7), while no Year 4 control teachers ranked their students' motivation this highly. Among control teachers, the most frequent response was that their students were either *somewhat* or *moderately* (n = 4 each) motivated. Similarly, six of the seventeen experimental teachers said that their students were *extremely* engaged in the projects, while only two of the ten control teachers did.

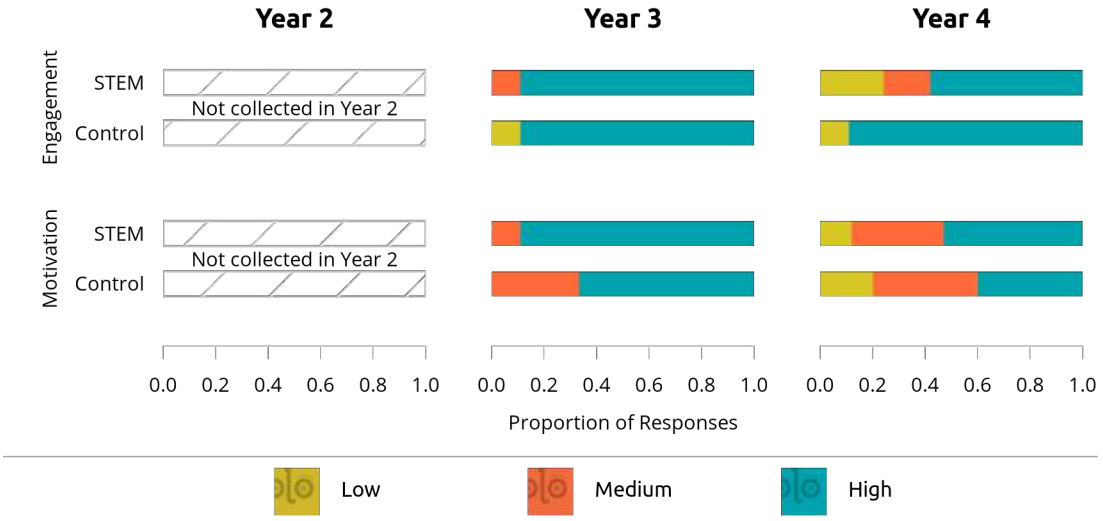

Figure 8. *How engaged were your students in the (STEM) SRL projects this year?* and *What is their level of motivation?*

Note. Year 3, Control *n* = 9 and STEM *n* = 9; Year 4, Control *n* = 10 and STEM *n* = 17. Responses were on a five-point scale, collapsed here to three levels: *low* includes "not at all" and "slightly," *medium* includes "somewhat," and *high* includes "moderately" and "extremely."

Teachers compared SRL students' interest in certain topics to the interest of their non-SRL peers. For the most part, teachers in both experimental and control groups agreed or strongly agreed that SRL students' interest in the local community and the news overall increased compared to their peers [Figure 9]. These findings also corroborate Marshall's (2019 findings for SRL Fellows and suggest that they are applicable to SRL students more generally.

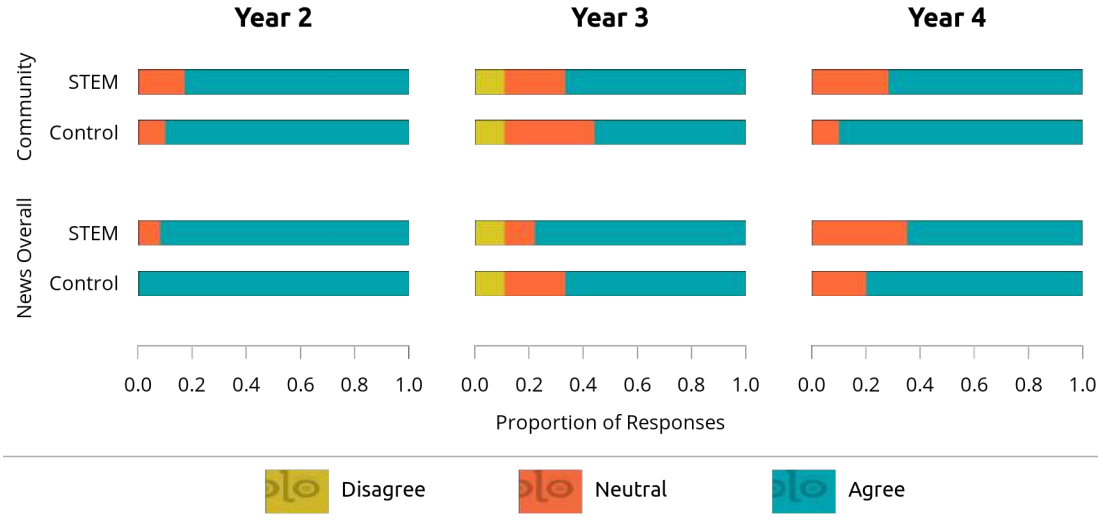

Figure 9. *(STEM) SRL increased students' interest in **their local community** and **news**.*

Notes. Year 2, Control *n* = 10 and STEM *n* = 12; Year 3, Control *n* = 9 and STEM *n* = 9; Year 4, Control *n* = 10 and STEM *n* = 17. Responses were on a five-point scale, collapsed here to three levels: *disagree* includes "strongly disagree" and "disagree," while *agree* includes "agree" and "strongly agree."

There was a larger difference between control and experimental teachers in terms of students' interest in STEM and health topics [Figure 10]. Most control teachers were neutral, while most experimental teachers agreed or strongly agreed that their STEM SRL students' interest in these areas increased more than that of their peers. From the teacher perspective, this appears to be a key difference between STEM SRL and the regular SRL curriculum.

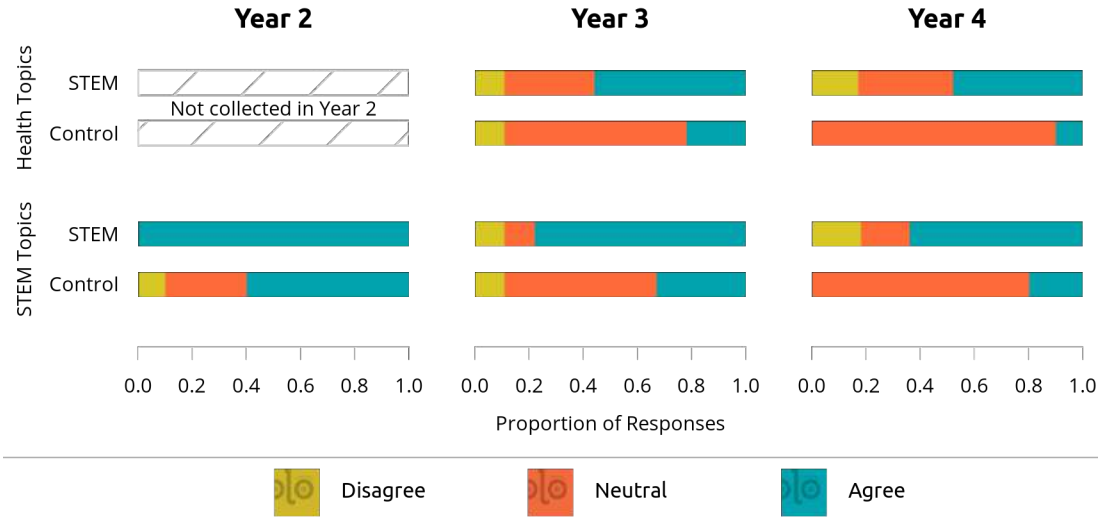

Figure 10. *(STEM) SRL increased students' interest in **STEM topics, including medicine/health science** and **Medicine/health science topics in particular**.*

Notes. Year 2, Control *n* = 10 and STEM *n* = 12; Year 3, Control *n* = 9 and STEM *n* = 9; Year 4, Control *n* = 10 and STEM *n* = 17. Responses were on a five-point scale, collapsed here to three levels: *disagree* includes "strongly disagree" and "disagree," while *agree* includes "agree" and "strongly agree."

Student Science Literacy, Self-Efficacy, & STEM Interest

Cumulative responses to four years self-assessment data on perceived growth in general science literacy revealed that students assigned to the experimental group had a statistically significant higher increase in this area than those in the control group. The effect, however, only explained 1% of the variance in the scores (Difference Control = 0.003, Difference Experimental = 0.05; F = 8.15, p < 0.01, partial eta^2 = 0.01). The qualitative analysis revealed more specific increase in topical science literacy based on the subject at the heart of their assignment, suggesting that topic competence may be sufficient to increase perceived self-efficacy, but might not have the ability to generalize these principles across STEM domains. Students' assignment to experimental or control group did not yield significant differences in STEM Self-Efficacy scores.[viii]

Survey responses from teachers in the experimental group suggests that STEM SRL students had a wide range of interests and experience with similar topics. At one extreme, a teacher wrote that *"They love science. They've loved getting to interview real working scientists and discover how broad the field is."* At the other extreme, another teacher wrote that students treat the computers as *"$2,000 iPhone chargers."* Despite this perceived variation, assignment to experimental or control group did not yield significant differences in STEM

Interest scores.[ix] Likewise, participation in either the experimental or control group did not yield significant differences in Value of STEM scores.[x]

Student Career Interest

Representation matters. Several teachers noted in surveys that interacting with STEM professionals – media mentors, STEM mentors, and interviewees – who looked like them had a major impact on students. One teacher wrote that when their students heard about STEM mentors' experiences, it *"turned on a lightbulb in all their heads."*

Figure 11. Screengrab of video in which students at Etiwanda High School in Rancho Cucamonga, CA interviewed the President and COO of SpaceX, an aerospace company developing re-usable rockets.

Notes. Video available at *https://studentreportinglabs.org/engineering-our-world/2018/10/03/new-race-space/*

Several case study teachers said that their schools focused on exposing students to STEM careers, and at least one SRL class was part of a vocational track in video production. Many teachers had a sense that students were interested in STEM, journalism, or both prior to participating in the STEM SRL program. For this reason, they felt that exposure to the day-to-day work of STEM and media professionals was one of the most important components of the program.

In teacher surveys, experimental teachers across years said that STEM SRL increased their students' interest in STEM careers more than control teachers did (Figure 10). Both control and experimental teachers saw approximately equal impact on their students' interest in journalism careers. In Year 3, experimental and control teachers saw approximately equal impact on interest in health and medicine careers, while Year 4 experimental teachers saw a larger impact.

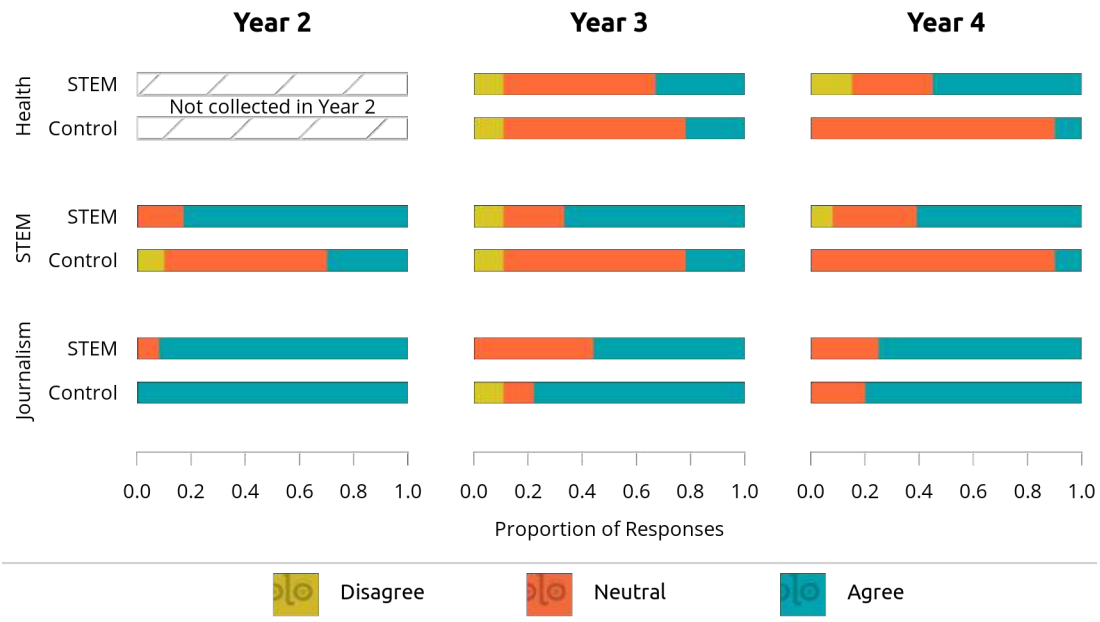

Figure 12. *(STEM) SRL increased students' interest in **journalism careers; STEM careers, including medicine/health science;*** and ***Medicine/health science careers in particular.***

Notes. Year 2, Control *n* = 10 and STEM *n* = 12; Year 3, Control *n* = 9 and STEM *n* = 9; Year 4, Control *n* = 10 and STEM *n* = 17. Responses were on a five-point scale, collapsed here to three levels: *disagree* includes "strongly disagree" and "disagree," while *agree* includes "agree" and "strongly agree."

For one teacher we interviewed, meeting engineers gave students a more concrete understanding of the field that they could not have gotten in the classroom: "*They got to [understand that], 'man, this is what engineers really do' because they get to see it in real life."* Similarly, another teacher said that students need to "talk to someone who does these kinds of things for a living [so] they can see themselves in that role." This teacher noted that *"A lot of times in school we teach [kids] concepts and [they] have a hard time seeing how that is going to transform into a job that gives you an income."*

Teachers also credited interactions with professionals with changing their thinking about career options for their students. For example, visiting with media professionals at a local PBS station helped one teacher visualize potential career opportunities for their students and see how SRL sets students up for the future.

In student surveys, we observed that group assignment (to experimental or control class) did not yield significant differences in STEM Careers scores. Psychological models of career development (e.g. Lent et al., 1994) often take knowledge about careers for granted. The availability heuristic (Tversky & Kahneman, 1973), or the idea that people remember things they have seen recently or often, suggests that *exposure* to careers is a prerequisite for *interest* in those careers. We further note that students' stated career interest may not be a good predictor of their ultimate career decisions, particularly since younger generations are shifting towards multiple careers (e.g. Chudzikowski, 2012).

Survey responses from former SRL students suggested some differences between students who spent at least one year in a STEM SRL classroom compared to those who did not. Our

qualitative analysis found similar numbers in both control and experimental groups interested in majoring in STEM fields, but this represented a larger proportion of STEM SRL graduates since fewer of those students took the survey. However, students who had been in a STEM SRL classroom scored higher, on average, on all three scales we used to benchmark these responses: STEM literacy, STEM self-efficacy, and STEM value. Many SRL graduates were interested in journalism careers, though this was more prevalent among the general SRL graduates then STEM graduates. Of the 14 SRL graduates, 11 were currently majoring in journalism or related fields, while of the seven STEM SRL graduates, only two were majoring in journalism or related fields.

Beyond the Student: Communities & Social Networks

Opportunities for connection to the community is an important benefit of participating in SRL (compare also Marshall, 2019). Equally valuable is encouraging young people to share their perspectives on societal issues that impact their lives and communities. As one teacher pointed out "*Youth today have some interesting things to say. [They are] often times idealistic, maybe not always realistic, but … more adults need to hear what they have to say.*"

"Youth today have some interesting things to say. [They are] often times idealistic, maybe not always realistic, but … more adults need to hear what they have to say."

Both control and experimental teachers wrote in surveys about the value of getting students out of their *"comfort zones."* One STEM teacher wrote, *"The opportunity to learn more about the impact of STEM on their community […] gave them a true connection to their place."* Similarly, all six teachers in the case study schools reported positive behaviors in their students, including increased motivation and a willingness to persevere. As a teacher noted *"It … drives them to do bigger and better stuff because they know that there's an audience and they know that other people are working on this as well."* For example, motivated by the chance have their work showcased during a NewsHour broadcast, one group of students kept working on their story, even after multiple rounds of feedback. According to their teacher, *"They were willing to put in all the work because they knew it was going to have an authentic audience."*

Students also commented on the importance of reaching this larger audience to both their motivation and their learning. As one student wrote in an email to staff and mentors: *"We did have frustrated, dejected moments, I think it was the constant improvement and feedback that at first frustrated and then gave us the push to do our personal best. … But we persevered, coming back to the drawing board, all the while learning the various nuances of story-telling and the editing skills. It all paid off in the end, because we learned a lot and grew by an order of magnitude as a team. The cherry on top of the cake was all of our videos getting published."*

Student videos reached a larger audience through NewsHour Extra and PBS Learning Media, which provide resources for teachers. Each year, several STEM SRL stories formed the basis of lesson plans and classroom activities, broadening their reach to classrooms around the

country. Over the last four years, more than a dozen stories were featured in this way. For example, one lesson plan featured a story produced by students at Hardin County Schools Early College and Career Center titled "College prep center in Kentucky introduces girls to programming, and some lucrative possibilities." This lesson plan included two components: (1) a series of comprehension and discussion questions, and (2) a design thinking activity asking students to propose solutions to the STEM gender gap. Between the 150,000 educators who use Extra each month, the 1.3 million unique users of PBS LearningMedia, the 1.5 million registered members of Share My Lesson, and the 15,000 Twitter users who see each PBS Education tweet, students' stories reach audiences far beyond their schools.

Professionalism

Case study teachers noted that the real-world nature of the program required students to learn professionalism and interpersonal skills, which teachers frequently described as *"problem-solving."* As one teacher explained in an interview, *"I try to instill in the kids [that] these are all very busy people with other lives besides us. … [W]hen we ask them questions [or] when we request their time let's be efficient with it. … [T]hat way, when we ask them something again, they're like 'oh, those people, they were easy to work with. Yes, I'd like to work with them again."* Empowering students to communicate directly with mentors and interviewees reduced the program burden on already overstretched teachers. It also gave students opportunities to cultivate workplaces skills including how to advocate for themselves and how to use appropriate strategies for handling disagreements with authority figures.

Program Implementation

In surveys, all but two Year 4 teachers described their course as an opt-in elective. One control teacher noted that their course is required for seniors in a particular major while another said that most students were placed by their vice-principal. One experimental teacher suspected that students had little to no control over their schedules. However, one control and three experimental teachers said that some of their students were placed in the class rather than actively selecting it. Three control and six experimental teachers noted that their Lab requires either a pre-requisite, an application process, or both.

Both experimental and control teachers said that students typically gravitate to one particular role although they encouraged participants in their Labs to learn, or at least try, every role. Both allowing students to specialize and requiring them to rotate had benefits for students. Some teachers reported that students who were more flexible sometimes discovered hidden skills from trying new roles. Other teachers noted that students showed considerable growth as a result of specializing in a single task.

Surveys asked students about their favorite and least favorite SRL activity. Editing, (field) production in general, interviewing, and filming were the activities students most commonly named as their favorite, while editing, selecting stories, transcribing, and pre-production in general were the most commonly listed least favorites (Table 1). However, more students said they had no least favorite activity than those who listed any single least favorite except for editing.

Table 1. Students' favorite and least favorite elements of the story creation process.

Activity	Favorite *n*	Least Favorite *n*
Editing	35	29
(Field) production	30	-
Interviewing	29	9
Filming	28	6
Choosing stories	19	18
Transcribing	-	18
Pre-production	-	17
Research	15	4
Teamwork	12	-
Post-production	11	7
Planning process	9	13
STEM focus	9	10
Deadlines	-	9
Lack of flexibility	-	6
Writing	6	13
Technology	4	-
Nothing	5	23

Notes: Favorite $N = 240$, Least favorite $N = 238$. Responses are not mutually exclusive. Table includes themes that came up in four or more responses in at least one of the two prompts.

Interestingly, there was much more consensus about some activities than others. Students were much more likely to enjoy than dislike (field) production, filming, and interviewing, while many more disliked transcription and pre-production than enjoyed it. Meanwhile, editing appeared as the most frequent item on both lists, and an almost equal number of students liked choosing stories as those who disliked this element.

Case Study: Southwest High School

Southwest High School[xi] serves one of the lowest socioeconomic status districts of a large Southwestern city. The city as a whole is majority Hispanic, and a plurality of the city's public-school students are bilingual speakers of English and Spanish.

Kiran has taught a CTE (career & technical education) video production course with Student Reporting Labs for several years. For Kiran, these classes offer an opportunity for students who might not have the means to attend college to develop skills that could help them obtain stable and well-paid careers. And videos also are a way to help change their school's undeserved bad reputation. *"The more things that we publish, the more that we show how awesome we are—our studio, our kids—then we're changing that perception [that this is a bad neighborhood] and that's amazing, because that's what I want to do,"* Kiran said.

Kiran applied to lead a STEM SRL Lab so that their students could produce PSAs and educate the rest of their school community about STEM and STEAM. They were also particularly interested in helping girls get more involved in STEM. Before working on their STEM stories, several of Kiran's students had internships producing short videos for the Southwest Science Agency. In fact, Kiran said a major reason they applied to become a STEM Lab was student excitement about the possibility.

Students in Kiran's class agreed that working on STEM stories had raised their awareness of and interest in STEM topics in the news, no matter where they started. Here's what two of them had to say:

"When I think of STEM, the first thing that really pops out to me is the technology part, and everything else kind of fades in the background for me, because that's just not my thing. But it's helped me learn that … the science, engineering, and math parts of it are important, too, and they can be interesting as well." – Carmen

"This is just me [but] I always thought it was kind of boring, math and science and all that. … [I learned that] it helps people out, and I think that's interesting." – Angel

Students in the class also reported developing advanced technical skills and they were eager to demonstrate what they have learned. They gave us specific interviewing, editing, and script development tips, such as not allowing interviewees to sit in chairs with wheels and putting interviewees at ease by asking them unrelated questions. The students felt a sense of pride about their work and the involvement of an established media organization in the SRL program. *"I feel like I'm important when I say I'm working for PBS,"* one of them said.

In the last few years, Kiran's students have received considerable recognition for their work. They have submitted videos for consideration for regional Emmy awards and received several grants from local funders. Shortly before our visit, the Regional Director of the Southwest Science Agency visited the school to thank the students for their video. As a result of that visit, one student, Carmen, now wants to make videos in both English and Spanish so that more members of their local community can learn about local STEM initiatives.

Cumulative Results: Teachers & Mentors

Teachers

Case study teachers noted that they, much like their students, had to combine three skillsets to be successful: ***technology skills***, ***storytelling skills***, and ***science content knowledge***. Most of them agreed that their initial comfort in each set of skills reflected their disciplinary training, and all teachers described growing in all three areas through their participation in the program. For these teachers, STEM SRL put them in a position to *learn alongside* students rather than *supervise student learning*, and they found this shift in their relationships valuable to both teacher and student growth (cf. Barchas-Lichtenstein et al., ms).

In surveys, most teachers in both groups either agreed or strongly agreed that the SRL materials and resources helped them to generate productive conversations with students, prepared them to answer students' questions, and reach students with various learning styles (Figure 13). Most teachers generally agreed that they had appropriate skills and knowledge to address most student needs and provide good feedback.

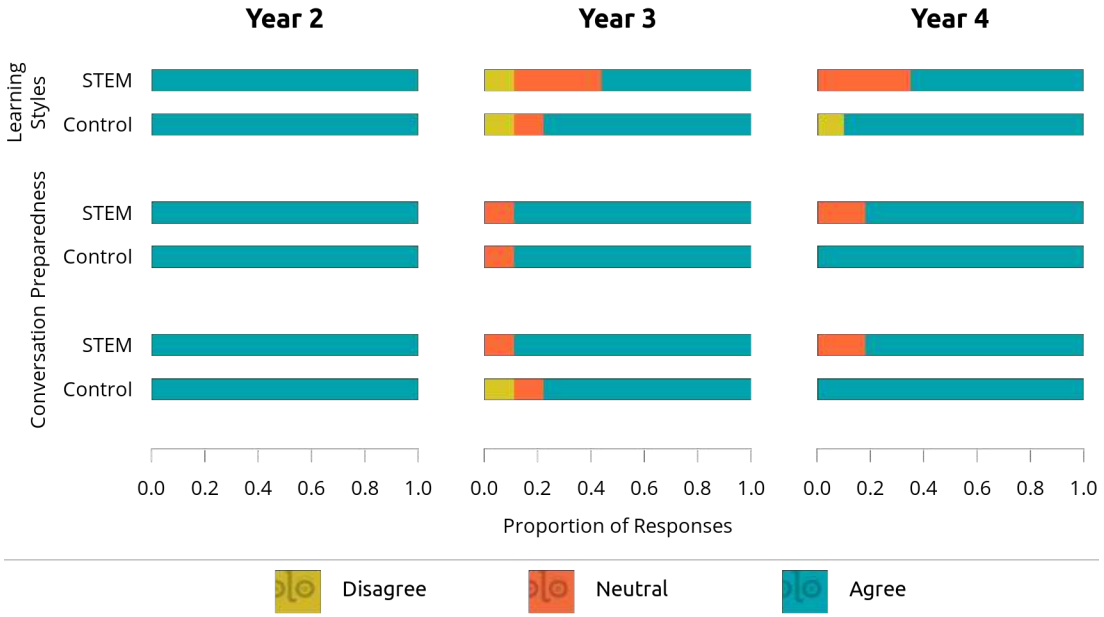

Figure 13. Teacher agreement with the following three prompts:
(STEM) SRL helped me to reach students with a variety of learning styles.
The (STEM) SRL materials and resources prepared me to answer my students' questions.
The (STEM) SRL materials and resources helped me to generate productive conversations with my students.

Notes. Year 2, Control n = 10 and STEM n = 12; Year 3, Control n = 9 and STEM n = 9; Year 4, Control n = 10 and STEM n = 17. Responses were on a five-point scale, collapsed here to three levels: *disagree* includes "strongly disagree" and "disagree," while *agree* includes "agree" and "strongly agree."

Program Resources

When asked to identify the most helpful resources, Year 4 teachers were most likely to mention video tutorials and lesson plans as particularly helpful resources for teaching students. Of the 15 STEM SRL teachers who responded to a survey question asking about helpful program materials, six mentioned the tutorial videos, while another six mentioned the lesson plans. In addition, two teachers mentioned mentors, two teachers mentioned Bill Swift by name, and two more referenced particular prompts. Of the nine control teachers who answered this question, five mentioned the tutorial videos and three mentioned the lesson plans.

Figure 14. The curriculum resources are now widely available for use by teachers across the country through the SRL website.

More details about SRL teachers' use of program materials and resources is available in Appendix L.

Successes

In surveys, three out of eight control group teachers identified growth in student motivation, pride, and engagement as a major success of the program. Several teachers identified growth in technical and storytelling skills as important successes, and one teacher noted that completing a story was their biggest success.

For their part, STEM SRL teachers cited completing their stories, introducing students to mentors and role models, and engaging with the real world as their biggest successes. Like the control group, these teachers also highlighted growth in student motivation, pride, and engagement.

Challenges

More than half of the STEM SRL teachers flagged either time management or integration with their curriculum as a challenge. There was much less agreement about other potential challenges. Only one or two experimental teachers mentioned a lack of equipment, finding stories that related to the topics, student motivation, technical or editing skills, and finding roles for every student.

In contrast, only one teacher in the control group said time management was a major concern. Other teachers in this category reported greater difficulties with finding equipment, relevant stories, and so on.

Recommendations from Teachers

Overall, teachers seem satisfied with the current structure of the SRL program. Of the 26 teachers who responded to the recommendation question, 15 said that they had no suggestions. Suggestions for improvement focused largely on Labs' relationships with their mentors. Some STEM SRL teachers asked for earlier and more consistent connection with STEM mentors. As one teacher stated, *"I strongly believe the students will buy into the SRL program and/or the STEM SRL initiative if they can begin … interacting and communicating with the mentors at the beginning of the year."*

Other suggestions include removing the transcription requirement, providing equipment training, and creating more opportunities for SRL teachers to interact with one another. Teachers also suggested making SRL a formal Career Technical Education course, and asked for more Rapid Response prompts as well as flexible timing between prompts and projects.

Specific resources or lessons teachers asked for were:

- Recordings of webinars so teachers can use them with students;
- Explicit lesson plans on:
  - Journalism and civics, or the role of journalists in society;
  - Credibility and the news;
  - Topical background for some of the prompts.
- Additional or more detailed tutorials on:
  - Adobe Premier;
  - Audio tools and techniques;
  - Cell phone journalism;
  - Using B-roll;
  - Operating cameras, differences between various brands of cameras, and care of cameras and other equipment;
  - Metadata and file management.

Mentors

While we interviewed relatively few mentors in Year 4, in general, the mentors we interviewed were impressed by the quality of student work and by the students' independence. Both teachers and mentors were able to articulate the value that mentorship

provides to students, and there were instances where mentors helped bridge expertise gaps in Labs.

Value of Mentorship

Case study teachers generally spoke highly of the mentors and thought the mentorship component added a lot to the program. In interviews, teachers noted that mentors provided two different kinds of value to their classes. First, they provided expertise that was often complementary to the teachers' own knowledge and this had implications for the teacher-mentor dynamic. For example, teachers who had less formal training in the technical aspects of filmmaking might rely heavily on media mentors to help their students work with cameras. Second, mentors provided insight into possible career choices and access to role models who could help students visualize themselves in different kinds of roles. One teacher was able to bring their students for a tour of the local PBS station and described this visit as an "incredible experience."

Conversations with two program mentors also reflected both kinds of value. One media mentor said their role was to give credibility to the teacher's advice and provide detailed feedback. One STEM mentor said that they saw the goal of mentorship as inspiring students to learn more about STEM careers and look into them. They described the SRL program as successful and said that they look forward to having more of an impact in future years.

Both STEM mentors that we interviewed discussed science career paths with the students, while media mentors generally said career questions were left more implicit. One media mentor said they thought it was important for students interested in media careers to meet working professionals. However, because their time with students was fairly constrained, mentor meetings with students were generally more project-focused than career-focused.

STEM mentors said that the students asked good questions and communicated clearly about scientific topics. For their part, media mentors said that students' technical skills developed over the course of the year; a mentor who had worked with a teacher for multiple years said they had watched students grow over time.

Mentor surveys and interviews were largely consistent with one another. Across both research activities, many mentors said they found value and gratification in seeing the students' interest and excitement about their field of practice. When asked about what they thought the best part of the mentorship was, most responses were about general engagement with the students. Mentors enjoyed having discussions with them, sharing their professional experiences, and responding to their questions.

Mentorship Process

In surveys, we asked mentors for both experimental and control groups what motivated them to participate in SRL. All six STEM mentors said that they were motivated to join because they looked forward to interacting with students. Two mentors indicated they were excited to educate students with real world insight and practices. Another two said that they wanted to inspire students to think about their future and consider pursuing careers in STEM. In contrast, most media mentors (n = 5) shared that participating was part of their job responsibilities, typically because their news program was paired with schools in the area.

Half of the media mentors (*n* = 4) said that they were motivated to mentor and educate students, and one was inspired to share their expert production knowledge.

STEM mentors generally met with classes only a small number of times. Of the seven STEM mentors who responded to the survey, three attended in person meetings with students, one corresponded through e-mail with the students, and one met the students through Google Hangouts. The remaining two indicated that the school never contacted them. Three of the four STEM mentors who met with classes said that during this meeting, they gave a presentation about their career. Two indicated that many students had follow-up questions during their visit about their experience in their STEM field and about their job specifically. Three out of four of the STEM mentors said they felt well-prepared for the meetings, while one felt poorly prepared and lacked any guidance or direction for the meeting.

Most media mentors engaged with the students in multiple ways, including in person meetings, e-mails with the teacher, and emails with the students (*n* = 5). The remainder met in person (*n* = 1), or did everything except for email directly with the students (*n* = 2). Most media mentors said that they shared their production expertise with students and helped them learn about the elements of video production, and that students also asked questions about the elements of story making. Three mentors said that they shared feedback with the students on the stories they were working on. Two went on field trips with the students, one of which included a tour of their news station. Five of the media mentors felt well prepared for their meetings. One mentor stated that the teacher was a great communicator and shared information ahead of time. However, one media mentor felt poorly prepared, but indicated that their employer was responsible, not the teacher or the program.

All but one media mentor reported feeling highly confident about their ability to provide good feedback to the students, and that they had the skills and knowledge to address the needs of the students. These mentors said that they felt comfortable addressing issues raised by the students and knew how to foster students' feelings of competence. Most STEM mentors also felt comfortable addressing most issues raised by the students, and felt that they had the skills and knowledge to address the needs of the students. Yet their agreement ratings were lower than the media mentors for the same questions. STEM mentors reported feeling only neutral in their confidence about their ability to provide good feedback to the SRL students.

Three of the seven STEM mentors reported devoting less than 3 hours per month to the mentorship. Two mentors said they spent 3 to 6 hours per month with the students, and two reported that they never ended up being called upon to mentor. Four STEM mentors reported that the time commitment ended up being less than expected, and two said that it was about what they had expected.

The time commitments from media mentors was similar to the STEM mentors, although most media mentors said the time spent was about what they expected (*n* = 6). Two media mentors said that the time was less than they expected. Four mentors reported spending one to five hours a month with the students. Of the four, three mentors worked with students for less than an hour, and one spent between five and ten hours per month with them.

Responses from STEM mentors about the support they received from their partnering teacher was mixed, spanning the full range of responses. Responses about support that STEM mentors received from the SRL team ranged evenly between disagree, neutral, and agree. STEM mentors were most satisfied with the support they received from their employer, with two strongly agreeing, two agreeing, and two neutral. Media mentors overall felt better supported, with over half agreeing or strongly agreeing that they felt supported by the SRL team, their partner teacher, and their employer.

Communication & Expectations

The program was not without its challenges and these largely centered on scheduling, time commitment, communication, and expectations. Logistical issues sometimes complicated the mentor relationship. For example, one mentor-teacher pair said that poor weather conditions caused a class to reschedule their filming trip, and the mentor was ultimately unable to meet with the students. Another mentor-teacher pair noted that the distance made it hard to schedule in-person meetings, so most communication took place by phone or email, which could be challenging for hands-on learning with the cameras, for instance.

In some cases, communication was the biggest challenge. One mentor said they expected more structure and they were surprised when the teacher didn't reach out. They were also disappointed that the students didn't thank them for giving feedback or ask any questions. Other mentors, however, said that though the relationship was *"loosely defined"* they were comfortable with the relative lack of structure. Meanwhile, one mentor said they didn't have a full understanding of the goals of either the mentorship in particular or STEM SRL as a whole. Overall, media mentors seemed more engaged than STEM mentors and had a better understanding of what was expected of them, perhaps because their employer often had an ongoing relationship with SRL.

Both teachers and mentors thought that adding structure and clear expectations to the mentor relationship would strengthen the relationship. In some cases, there was confusion about who was responsible for maintaining contact. As one teacher put it, *"If the mentor [said] 'You tell me when I can come in and I'll see what I could offer,' that would have been a lot easier. But it's one more person I have to call … That's tough."* Another teacher mentioned wishing their STEM mentor had invited their students for a college campus visit. Mentors, for their part, said they wished that teachers would reach out more and invite them to the classroom.

When given the chance to make suggestions, mentors focused on the importance of ensuring connection and better communication with the classrooms. Some mentors said that they could have been more helpful if Labs used them as a resource more frequently. They suggested that the SRL team either require classes to meet with their mentor a minimum number of times or develop a mentorship agreement that classes and mentors would fill out collaboratively. One mentor, who did not have much experience working with high-school students, asked for support in creating "educationally sound" and age-appropriate lesson plans.

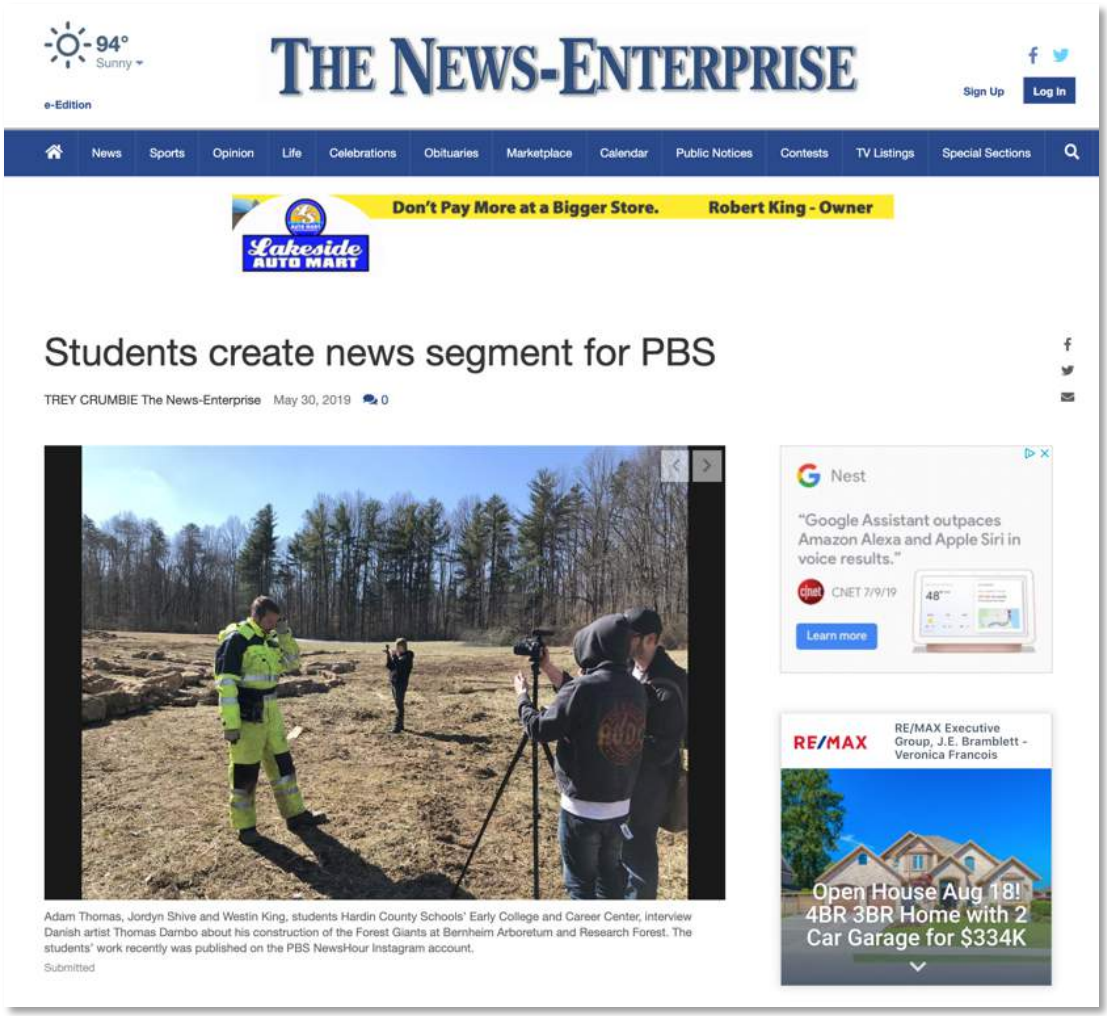

Figure 15. Local media coverage of Harding County School students' report on Forest Giants for PBS NewsHour.

Discussion

Our four-year evaluation of STEM SRL indicates that the program is achieving its goal of engaging students with STEM through the vehicle of narrative. To demonstrate the gains made in the last four years, we have structured the discussion section of this report around the specific goals of the project grant. Each section includes a brief description of our findings and places them in a broader context. This section also includes a brief discussion of the implications of the evaluation and suggests some directions for future program implementation and research.

Empowering Youth as STEM Communicators

Over the last four years, we have been struck by the similarities between the scientific method and the journalistic method, even as we recognize important epistemological differences between science and journalism (cf. Figdor, 2017). Like scientists, journalists must conduct research and weigh evidence to draw conclusions; for that reason, the SRL team considers journalism to be a form of STEM inquiry.

Our evaluation revealed comparable numbers of STEM SRL students interested in journalism and STEM careers. These results suggest that there is value in continuing to make both the parallels and the differences explicit for students. For example, helping students see that both journalists and scientists use examples and analogies to summarize considerable complexity. However, journalists typically rely on others' expertise rather than direct observation, juxtaposing multiple sources with primary knowledge but not themselves gaining this type of knowledge.

One exercise that might be helpful in drawing out these parallels is to compare a science news story with a news story that is not about science. Thinking through the "journalistic method" in parallel with the "scientific method" as it relates to these contrasting topics might ultimately lead the students into a deeper understanding of the relationship between these two modes of inquiry.

Youth Engagement in STEM & How to Measure It

The evaluation suggested that the STEM SRL model contributes to expanded STEM literacies and career awareness or interest. It helped students that had not previously perceived STEM as relevant to their lives find STEM knowledge practical and useful. Across project years, we've seen evidence from students and teachers that "applied," "hands-on," or "in-context" STEM was more meaningful for them than learning concepts in science and math classes.

The results of the student survey would suggest that STEM SRL yielded little to no improvements in the areas assessed by the survey. However, we caution against this interpretation for several reasons.

First, our quantitative results only include students whose pre- and post-program responses were able to be matched. These students may differ systematically from students whose responses were not analyzed. In particular, considerable evidence suggests that interventions are likely to have the largest effect on low-performing and less diligent students. These students may be less likely to have completed matchable surveys for a number of reasons, including absence on either survey date, incomplete parent consent forms, and mislabeled surveys.

Moreover, we saw consistent improvements in the qualitative results. This mismatch may represent a limitation of surveys as a research method: in pursuit of standardized questions for all SRL participants, the survey was designed to assess general aspects of science literacy, STEM efficacy, etc. Meanwhile, the SRL program was designed to prompt student to pursue specific paths through specific topics. As we have observed, assessing whether these specific paths promote general improvements yields null results. For example, students who film a story about local bird species may be able to expound at length on what they learned about bird migration yet struggle to identify what they learned about the field of zoology as a whole, or science even more generally. Such a result does not lessen the impact of their learning but rather points to the specificity with which students understand it.

Future studies of such individualized STEM programs will need to explore standardized methods for tracking individual paths to improvement in the program-wide target areas.

Expanding Pathways to STEM & STEM Communication Careers

Teachers frequently noted that developing students' professionalism was an important benefit of SRL participation. Programs like STEM SRL, which require students to interact with adult professionals on their terms, are one of the few ways that students are explicitly instructed in the norms of professionalism. Many of these skills, from networking to responding appropriately to feedback, constitute a *hidden curriculum*. Teaching them explicitly can help level the playing field between students from more and less privileged backgrounds: those whose parents work in professional jobs – and have internalized those norms – typically have better access to learn such norms.

Teachers across program years highlighted the opportunity for students to meet working scientists, journalists, and other professionals as an important aspect of the STEM SRL experience for students. Middle- and high-school students may only have a vague sense of what jobs exist, or what the day-to-day reality of different jobs entails. Hearing directly from a range of adults about their career choices and daily tasks provides new awareness of the skills and capabilities needed to pursue those paths. Furthermore, teachers frequently mentioned that the racial, ethnic, and gender diversity of program mentors helped students envision themselves in those roles.

Meanwhile, STEM mentors across project years have asked for a deeper level of involvement with classes. In Year 4, the SRL team took an important step in that direction by connecting classes with these mentors earlier in the school year, setting up mentors to provide more generalist knowledge about the nature of scientific inquiry, rather than simply feedback on

student stories. However, the lack of institutional relationships, and the fact that most mentors are only involved for a single year, means that these relationships would be even stronger if mentors received more information about program logistics and expectations.

Delivering STEM News

Over the four years of the evaluation, students researched and produced 98 STEM stories. Program participants had the opportunity to share their stories with national and local audiences as part of NewsHour broadcasts as well as through local news affiliates. Students also had opportunities to share their stories as part of national conferences and festivals as well as through an SRL-organized film festival and competitions. Knowing that their stories would be shared with a broader audience, motivated students to keep working on their stories sometimes through multiple rounds of feedback. In addition to sharing their perspectives, these forums also offered opportunities for students to connect with the wider community outside of school.

Empowering Teachers

Program teachers felt that they had to combine three skills, storytelling skills, and science content knowledge in order to successfully run the Lab. Most of them agreed that their initial comfort in each set of skills reflected their disciplinary training – for example some teachers had backgrounds in journalism and media. All teachers described growing in all three areas through their participation in the program. Teachers in both groups also felt that the SRL curriculum and resources were easily adaptable to their classrooms and prepared them to answer students' questions, address issues, and offer feedback. Overall most teachers felt that they had the appropriate skills and knowledge to work with the materials and that the curriculum helped them reach students with various learning styles. They also felt that the professional development opportunities available to them through training workshops and meetings with the SRL project teams were helpful in helping them run the labs.

Media mentors typically saw their role as complementing teachers' guidance with hands-on knowledge of technical skills. They led workshops and provided feedback on student work, typically focusing on both physical and aesthetic aspects of using camera equipment, lights, microphones, and editing software. Because most media mentors came to SRL through their employer, they benefited from institutional support for their mentorship. In particular, even new media mentors had some institutional knowledge to draw on regarding expectations for their role.

Teachers were generally positive about both the program and their students' performance across years. However, we note that differences in the difficulty of story prompts between Years 3 and 4 may have had a disproportionate impact on teachers as compared to students, since each teacher is often coordinating multiple student groups each with their own separate set of logistics. In Year 3, the main story prompt was *How are engineers and engineering shaping our future?* This broad prompt was full of possibilities that could be filmed at any time and in a wide range of locations, leaving students and teachers with considerable scheduling flexibility. Meanwhile, the corresponding prompt in Year 4 was

Citizen Science to complement a 3-day PBS initiative called Spring Live and provide more opportunities for student stories to air nationally. However, many schools struggled to find a citizen science project close to their school, and thus to pitch a story. Compounding this difficulty, most citizen science trainings and outings take place only on very specific dates and times, which may not have been convenient to the students or teachers. Missing a meeting date could delay a story considerably. In addition, the bulk of the shooting was happening during the winter, and many citizen science projects take place outdoors, disadvantaging schools in certain climates.

Implications & Future Research

Though students readily applied STEM concepts to real-world concerns, teachers recognized that they struggle to directly connect the abstract learning that takes place in classrooms to application (cf. Barchas-Lichtenstein et al., ms). One way to make this transition more seamless may be to design prompts that explicitly encourage students to incorporate concepts from all four STEM fields. For example, pitch sheets or other worksheets might ask students to deliberate how the research they report on might inform predictions (T, E, M), or new technological developments (S, T, E)

SRL's transdisciplinary structure supports an exploratory approach to careers by encouraging students to try out different roles in STEM media production and connecting them to working professionals to understand what their jobs entail. Many interventions targeting this age group seem to expect middle and high school students to have explicit career interests that relate to their ultimate career trajectories. We argue that such an approach is unrealistic and places undue pressure on young minds. SRL's approach is more fruitful, as it focuses on greater career awareness through exposing students to a range of subjects and allowing them to determine their paths over time. A future research initiative could focus on developing better measures of career knowledge and awareness among middle and high school students, rather than career interest.

Conclusion

STEM SRL successfully helps students engage with STEM as well as envision themselves in careers that they may not otherwise have considered. Connections with media mentors and practicing scientists not only offered opportunities for students to observe STEM and STEM communications careers in practice, but also allowed them to meet professionals that look like them in terms of gender and ethnicity. If the goal is providing pathways for greater participation in STEM from historically underrepresented groups, then creating space for interactions with people that students can relate to is crucial.

Through this experiment, students cultivated their story telling and technology skills as well as increased their understanding of STEM content and its connection with real world problems. The project also proved fulfilling for teachers and mentors who, for the most part, felt equipped to guide students' stories, answer questions, and provide helpful feedback. Some logistical challenges complicated the mentor relationships with teachers and students including scheduling issues, limited time, and unclear expectations. But overall, mentors enjoyed engaging with students and discussing their professional experiences. Overall teachers were satisfied with the structure of the SRL program although they asked for more training and suggested that earlier and more consistent connections with mentors would be valuable.

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Endnotes

[i] Each year, between 8 and 20 of these classes produced at least one STEM story. Many experimental sites also submitted stories for one or more of these assignments in addition to their STEM assignments.

[ii] In Year 2, 10 of the 20 schools selected to participate in the program were part of the Year 1 STEM Lab cohort. Twelve of the 24 schools selected in Year 3 had been STEM Labs in program Year 2. In Year 4, 13 experimental teachers had previously run STEM Labs and 3 had run Health Labs, while the rest had either been Control Labs or were new to STEM SRL altogether.

[iii] Most groups involved in the summative evaluation were from public schools, 55 control and experimental Labs included 2 private schools, 3 charter schools, and 1 afterschool program.

[iv] In conformance with Solutions IRB review, only data from students whose parents provided consent for their participation in these studies was used in these analyses.

[v] All data and research protocols for this project were conducted in accordance with the evaluation team's Federal-Wide Assurance (FWA#00021378) to ensure the protection and safety of human subjects participating in research. These studies involved children under the age of 18 and those from low socio-economic status considered to be protected classes. All protocols were reviewed by Solutions IRB (IRB00008523, IRB Type: OHRP/FDA) with project identification number 1MAR15-67.

[vi] In Year 2 of this project we summarized the scale items using the average rating for each respondent on each scale. PCA scores possess statistical qualities that make them preferable to arithmetic means and other average scores. The change from average scores to PCA scores enables more reliable analyses, without changing the overall pattern of results observed in SRL Year 2.

[vii] We refer to these students as 'graduates' as a gender-neutral alternative to 'alumni.'

[viii] Difference Control = 0.05, Difference Experimental = 0.13; F = 0.29, p = 0.59, partial eta^2 = 0.001.

[ix] Difference Control = -0.12, Difference Experimental = -0.03; F = 0.04, p = 0.84, partial eta^2 < 0.001

[x] D_Control = -0.01, D_Experimental = 0.07; F = 1.60, p = 0.21, partial eta^2 = 0.003

[xi] All proper names in the section are pseudonyms, including the names of schools and locations.

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