EXTERNAL EVALUATION OF THE BUILD A BETTER BOOK PROGRAM, UNIVERSITY OF COLORADO BOULDER

Funded by the National Science Foundation ITEST program

Heather Thiry, Ph.D.
Ethnography & Evaluation Research

Contents

Table of Figures

Executive Summary

The Build a Better Book program seeks to "iteratively develop, test, and refine a Tactile Picture Books curriculum suitable for library Makerspaces." In the past year, the program was implemented at school sites, libraries, university summer programs, and museums. Program formats ranged from a series of drop-in workshops to an extended multi-week museum internship. The project also offered librarian trainings, student outreach events, and one-time workshops. The external evaluation used multiple methods, including observations, embedded assessments, pre-post surveys, and focus group interviews to evaluate outcomes from the extended format programs offered by the Build a Better Book program in 2017-18. In particular, the evaluation focused on students' engagement in the design process, and changes in their career interest in STEM fields, technological self-efficacy, STEM interest, and concepts of accessibility and disability. Outcomes from the librarian training were also evaluated, as well as a needs assessment to gauge librarians' capacity to deliver makerspace programming to youth at their sites.

Key findings from the evaluation are as follows:

The Build a Better Book Learning Environment:

- The BBB program scored very highly on the "authentic making" measures of the observation rubric, including scoring the highest ratings for attention to audience, authentic design process, and use of a variety of tools and technologies.
- The BBB program scored relatively highly on student collaboration, although this varied by program site and implementation model. Students worked individually in some implementations, while students worked collaboratively in others.
- The BBB scored highly in teacher feedback to students, and student revision of work based on teacher feedback. Peer-to-peer feedback was observed less frequently.
- The BBB program scored very highly on general teacher items, including the highest marks for strong teacher-student rapport, inclusion of all students, and a learning environment that maximizes opportunities for creativity and learning. Almost all of the markers for teacher quality were very high, with the exception of curricular pacing. The pacing of student projects was challenging at most sites, as students often ran out of time, or nearly ran out of time to complete their products. On the other hand, at one implementation site, students finished too quickly, suggesting that those projects did not contain the same level of depth and detail as student work at the other sites.
- The BBB also received the highest scores for evidence of student engagement in authentic project-based learning, and student choice.

Student Outcomes:

Design Process

- The embedded assessment, program observations, and focus group interviews all demonstrated that students engaged deeply in a creative and iterative design process and had given thoughtful attention to their intended audience of blind or visually impaired youth. Students engaged in frequent problem solving and trouble-shooting throughout the project.
- Students were most proud of learning new technologies and helping people.
- Students found the focus on accessibility and disability to be the mot impactful part of the programs because it fostered a sense of empathy and helped them to understand the perspective of blind and visually impaired people.
- 88% of BBB students learned about accessible design from the BBB program, while 62% of students learned about accessible design from other engineering activities.
- In response to an open-ended question, 39% of students reported that their favorite aspect of the program was 3-d printing/modeling, while 30% of students reported their favorite part was helping people with disabilities.
- In interviews, students and librarians/educators commented that they appreciated that the BBB program had brought "humanity" into the engineering design process.

Interest in STEM and Careers

- Students showed a slight increase in interest in careers that use technology to help people.
- Students' increase in interest in careers that involve 3-d design was statistically significant ($t=-1.492$, $df=70$, $p=.70$).
- Student interest in an engineering career rose from 54% to 64% of students. In interviews, students mentioned that they were more "open" to an engineering career because of the BBB program.
- Students also were significantly less likely to feel that a technology career would be "hard" ($t=-2.162$, $df=85$, $p=.033$).
- Students who opted in to the program showed slight increases in interest in 3-d printing and modeling, while those who did not opt in showed slight decreases.
- 75% of students gained interest in engineering from the BBB program, while only 57% of students gained interest in engineering through other hands-on engineering activities.

Self-Efficacy

- Older students made strong gains in self-efficacy than younger students (e.g., 10th graders increased by +.83 out of 5 on feeling that they can get good grades in technology, while middle school students remained steady).

Librarian Outcomes

- 81% of librarians were interested in providing the Build a Better Book program, including 100% of attendees at the Colorado training.
- While the majority of librarians had prior experience in facilitating youth programming or STEM-oriented programming, the majority did not have prior experience in facilitating programs for disabled youth (77%), makerspaces (41%), or engineering design programs (61%).
- Only 5% of librarians had "a lot" of knowledge about designing inclusive makerspaces and only 12% had a lot of knowledge about issues related to accessibility
- Nearly ¾ of librarians felt they had the knowledge to implement a makerspace, but they lack expertise in 3-d printing, engineering design, and issues related to disability.
- Librarians cited a lack of space, funding, and staff as challenges to implementing makerspace programming
- Strong partnerships were essential to help libraries deliver STEM programming for youth, but 30% of librarians reported no partnerships in this area
- 85% of librarians plan to use what they learned in the BBB training
- The museum that implemented the program felt "fully supported" by BBB in their implementation of the curriculum
- In interviews, librarians discussed a shift in focus around disability from their work with BBB, from a passive approach focused on compliance with the law to an active approach of ensuring inclusivity and accessibility in all aspects of programming

Recommendations

Overall, the BBB provided an authentic making experience to many students traditionally underrepresented in STEM, including girls and underrepresented minority students. The most impactful part of the program appears to be the blending of engineering design with humanitarian purposes. The focus on disabilities and inclusive design fostered a shift in thinking about disability and society for many students. Librarians and educators also appreciated the inclusive focus of the program. If the program would like to enhance career interest outcomes, it might consider adding a more career-focused module or activities to the curriculum, especially for programs where students have not opted in to the program and may be entering BBB with less interest in STEM. Additionally, while the program reflected all of the attributes of an authentic making experience in inclusive design, there was less peer-to-peer feedback observed during the implementation. If the program would like to strengthen

peer feedback, the use of a structured protocol or guide, or structured activities to elicit peer feedback, may be considered. Finally, the challenge of working within time constraints is a real-world aspect of design experiences that is beneficial for students, yet the pacing of the programming and completion of work was an ongoing challenge. Perhaps a more structured approach to pacing and the work flow, without interfering with student creativity or choice in the design process, would help students to organize their time and to make appropriate choices for completing the product in the given timeframe.

Introduction

The Build a Better Book project funded through the ITEST program of the National Science Foundation aims to "iteratively develop, test, and refine a Tactile Picture Books curriculum suitable for library Makerspaces." This curriculum engages youth in designing and building multimodal, tactile books for blind and visually impaired youth using 3-d printing and other technologies. The program also employs high school near-peer mentors to assist with workshops and activities. The Build a Better Book program is offered in several different formats. In the past year, the program was offered through extended, drop-in workshops at Huron St. Library, extended camps and multi-day workshops at Boulder Library, an internship at the Boulder Museum, an extended, school-based program at Northglenn High School, extended, multi-week workshops at the Wings Over the Rockies Museum, and extended multi-week, outreach programs for middle and high school youth at the University of Colorado, Boulder. Additionally, multiple trainings, outreach events, and one-time workshops were held. This report will focus on outcomes from the extended, multi-day or multi-week programs.

Evaluation Design and Methodology

The primary goal of the evaluation is to: 1) collect outcomes data related to different extended program formats, 2) provide formative feedback to guide future implementation, and to 3) evaluate outcomes from librarian training, including librarians' resources, challenges, and needs in implementing STEM programming in libraries. The evaluation addresses the following questions:

- Has the Build a Better Book program achieved its goals to broaden participation in STEM and to increase student interest in STEM?
- Has the Build a Better Book program achieved its goals to broaden students' conceptions of STEM, especially the use of STEM tools and concepts to help people or society?
- Do outcomes differ according to demographic characteristics (e.g., gender, age, etc.) or program model?
- How might the program be modified to better serve youth and achieve its goals?

Evaluation Instruments

Through literature reviews and the STELAR resource center for ITEST projects, the external evaluator and project co-PI identified several relevant scales to evaluate student outcomes from the Build a Better Book program. Survey scales are a group of items that are clustered to measure student outcomes in a specific area, granting the array of items greater statistical power than a single item. The project leadership and evaluator also modified these survey scales with items related specifically to the Build a Better Book program to gauge

students' interest in accessible design, blending art and technology, and their interest in specific technologies that are used in the program. These survey items and scales were assembled into a survey that could be delivered in a pre-post format. The survey measured the following domains:

- Technological self-efficacy,
- STEM aspirations,
- Belief that technological skills will help in the future,
- Interest in engineering and design, and
- Belief that technology can be used to contribute to society

Additionally, the survey collected demographic information about participants, such as gender, race/ethnicity, parental education level, and grade level. The survey was administered at the beginning and end of program sessions. Students completed the survey on laptops through an anonymous web link, but had the choice whether to participate in the evaluation of not. Several groups of students completed a paper version of the survey which was then hand entered into the survey software.

To assess the extent to which the Build a Better Book program engaged in principles of engineering design, an observational rubric was used at a sample of sessions. The rubric was created by one of the project co-PIs from the School of Education. Because this was the first year that the instrument was used, all sections were completed during each observation, however, some sections may be edited or deleted in the future as they are not relevant for the Build a Better Book program. The rubric sections include "Authentic Making," "Collaboration," "Feedback and Revision," "Provide Multiple Means of Engagement" "General Teacher Items," and "Reflection." The reflection section is not reported here because the type of reflection criteria specified in the rubric was not observed (or was very infrequently observed) during the Build a Better Book sessions and is not a part of the curriculum of the program. Thus, the "authentic making," "collaboration," "multiple means of engagement," "general teacher items" and "feedback and revision" sections are reported. Each section of the rubric contains several items that are observed and rated on 4-point scales, such as: 0=not observed, 1=observed minimal attempts, 2=partially observed and 3=observed. The rubric was used for seven observations of five different programs: Huron St. Library, Boulder Library (two different programs), CU-Boulder Pre-Collegiate program, and CU-Boulder ACCESS program.

To capture student learning outcomes and understanding of the design process, an embedded assessment was used in a sample of five programs (Boulder Library, both programs, ACCESS program, Boulder Museum, Pre-Collegiate program). The embedded assessment allowed students to film themselves and their project as they responded to four questions:

1. What was your vision for your project and what features did you add to make it more accessible?
2. What challenges did you encounter and how did you overcome them?
3. What features are you most proud of and why?
4. What is your biggest take away from this experience? If you looked back on this 5 years from now, what will you remember?

In all, 32 students responded to the embedded assessment questions: 7 students from the Pre-Collegiate program, 7 students from the Boulder Museum program, 8 students from the ACCESS program, and 10 students from the Boulder Library program.

Two focus groups and one individual interviews were conducted at the Pre-Collegiate program held in Summer, 2018. The interviews were conducted during the second to last class session. Two groups of students who were far along on their projects were taken out of the session for about 10-15 minutes apiece to voluntarily participate in a focus group. The individual interview was conducted at the same session with a high school mentor who was a former participant in the Build a Better Book program and now serves as a mentor to participating students. The student focus group participants were asked about their project, how they designed it to be accessible, what they learned about designing for accessibility, their favorite aspects of the program, challenges they encountered in the design process and how they overcame them, and their advice for improving the program.

Librarian outcomes were documented through a survey offered to all librarians who participated in the librarian training in October. The survey documented outcomes from the training, elicited feedback about the workshop, and also gathered data on librarians' needs, challenges, and preferences in delivering STEM programming to youth. The survey link was sent to librarian participants of the training and 12 completed the survey. Additionally, a separate link was generated with only the needs assessment (needs, resources, challenges, etc.) and not the training items to gather formative data about the capacity of librarians to deliver makerspace and STEM programming. The survey also addressed librarians' knowledge of youth programming and programming for people with disabilities. The survey was sent to members of the International Society for Technology in Education (ISTE) and twelve librarians and teachers completed the survey. Finally, two librarians were interviewed in the past year. Four librarians were contacted for interviews, but one did not respond to repeated requests and another was on an extended leave and unable to complete the interview within the timeframe. Still, librarians/program coordinators from Boulder Library and Wings over the Rockies were interviewed. The interviews covered their background in makerspaces and youth programming, their experience with the Build a Better Book program, and the benefits to students that they observed from the program.

Additionally, one high school mentor was interviewed during the Pre-Collegiate program. He started as a participant in the Build a Better Book program and has risen to the

role of a mentor. The interview was brief but discussed his experience in the Build a Better Book program, how the program had benefited him, and the benefits that he has observed in student participants.

Data Analysis

Survey data were cleaned and merged into SPPS statistical software package. Descriptive and inferential statistics were conducted. Inferential statistics, such as chi-square, t-tests, and ANOVA were performed as appropriate to test for statistically significant differences in outcomes according to program format or students' background characteristics. The variables that were tested were gender, program format, and grade level. Significant results are reported. Qualitative data were analyzed using content analysis methods. Open-ended survey comments and transcriptions of student presentations were searched for units of meaning, called codes, and organized into taxonomies. Codes reflected patterns in librarians' or students' responses related to issues such as learning gains, motivation, or other aspects of their experience in the Build a Better Book programs.

Evaluation Findings

The findings section is organized according to outcomes for each participant group. First, student outcomes are described and reported. Next, outcomes from the librarian training workshop are reported. Finally, high school mentor outcomes are discussed.

Student Participation and Demographics

Student Participation

Overall student and librarian participation rates in the various program formats are as follows:

- One-time workshops: 94 students (34% girls)
- School programs (multi-session): 75 students (49% girls; 100% minority)
- Multi-day or week library/museum programs: 125 students (44% girls, 48% minority)
- Outreach events: 97students (48% girls, 69% minority)
- Librarian training: 65 participants

At least 400 students participated in the BBB program in the past year, as attendance data was not available for all program offerings. The following tables display demographic information and participation rates for one-time workshops, extended programming, and outreach events. Gender and race/ethnicity information was not available for all programs and events; however, the BBB program served nearly equal numbers of boys and girls. The female representation in the BBB program is higher than in STEM undergraduate majors and/or careers. Race/ethnicity data indicate that over 50% of BBB extended-program participants

were racial/ethnic minorities. The duration and number of sessions was not available for all implementations of multi-day or multi-week programming, but the BBB program delivered at least 104 hours of programming to youth through extended program formats.

Table 1. Participation in one-time workshops

Workshop topic	Age Range	# Participants	# w/ disability	# female	# male	# of underrepresented minority
Designing for Creativity and Learning class	University.	20	n/a			n/a
Inclusive Making	University	30	n/a			n/a
Making workshop with blind youth	Late elementary-middle school	7	7	4	3	0
BBB in Undergrad Children's Lit	Undergraduates	27	n/a	26	1	n/a
STEM workshop	Middle and high school	10	n/a	2	8	n/a

Table 2. BBB Extended Programs, AY and summer 2017-18

	Program Description	Age range	# of sessions	Session length	# of participants	# of female	# of male	# of minority
Fall 2017	Tactile Games	High school	4	1.5 hr	8	3	2	2 (1 American Indian, 1 Hispanic)
AY 17-18	Museum of Boulder project	Middle school	n/a	2 hr	12	8	4	2 (2 Asian)
Winter 2018	Tactile Aviation exhibits	Middle school	6	2 hr	13	5	8	1 (1 Hispanic)
Spring 2018	Tactile picture books	Middle school	n/a	n/a	11	1	10	2 (2 Black)
Spring 2018	Tactile picture books	Undergrad Internship (Eng + Ed)	N/a	n/a	n/a	n/a	n/a	n/a

Spring 2018	Multi-modal literacy	Elem student + pre-service teacher	3 hrs teachers/ 1 hr youth	15 sessions tchrs/ 9 youth	15 youth/ 10 teachers	8 tchrs. 7 youth	2 tchrs, 8 youth	2 youth (1 Asian, 1 Black)
Spring 2018	Multi-modal literacy	High school	n/a	n/a	75	26	27	53 (51 Latino, 2 Black, 1 Asian)
Sum 2018	BBB - ACCESS Camp	Middle school	5	3 hr	24	12	11	19 (2 Black, 2 American Indian, 15 Hispanic,
Sum 2018	BBB - Pre-collegiate	High school	9	3 hr	20	12	5	17 (1 Black, 1 American Indian, 3 Asian, 12 Collegiate
Sum 2018	BBB- Design Internship	High school	5	4 hr	16	7	9	14 (3 Black, 1 American Indian, 2 Asian, 11 Hispanic
Sum 2018	BBB - extra program	High school	5	3 hr	6	0	6	5 (1 Black, 4 Hispanic)

Table 3. Participation data for outreach events

Outreach Event	# Partic-ipants	# girls	# boys	# Hisp-anic	American Indian / Native Haw. , Alask.	Black or African American	Asian	White	Other
Classroom workshop STEM Launch K-8	50	24	26	29	0	3	3	13	2
PBL Showcase, STEM Launch K-8	47	23	24	27	0	2	3	13	2

Demographics for Student Survey

This section will report demographic results from student surveys administered to program participants. In all, 178 students completed a pre- or post-survey, however, 62

students in the Northglenn high school program were not included in the survey analysis or in this survey demographic reporting because they only completed a pre-survey. With no post-survey comparison, they could not be included in the analysis. Likewise, 13 students in the second iteration of the Wings over the Rockies program only completed a pre-survey, and therefore are not included in the survey analysis.

In all, 87 students completed a pre- and post-survey and are included in this report. Additionally, 14 other students completed a pre- or post-survey, but not both. Demographic information is reported for the 87 students who completed both surveys.

Girls were well represented in the Build a Better Book program.

- 54% female
- 46% male

Students ranged in grade level from 6th to 12th grade, although the majority of students were middle school or early high school.

- 1% were in 6th grade
- 28% were in 7th grade
- 22% were in 8th grade
- 17% were in 9th grade
- 8% were in 10th grade
- 2% were in 11th grade
- 21% were in 12th grade

Students were primarily from underrepresented minority groups. Some students reported two races.

- 33% were white
- 51% were Hispanic/Latino
- 6% were Asian
- 8% were African-American
- 8% were American Indian/Native Alaskan/Hawaiian

Students' Motivation to Participate in Build a Better Book Programs

Students expressed several reasons for wanting to participate in Build a Better Book programs. Most students were intrinsically motivated to participate in Build a Better Book, but a fair number of students participated because the program was offered as part of another program they were enrolled in (e.g., ACCESS and Pre-Collegiate students engaged in other STEM and college-oriented programming during the day and BBB was only one aspect of the

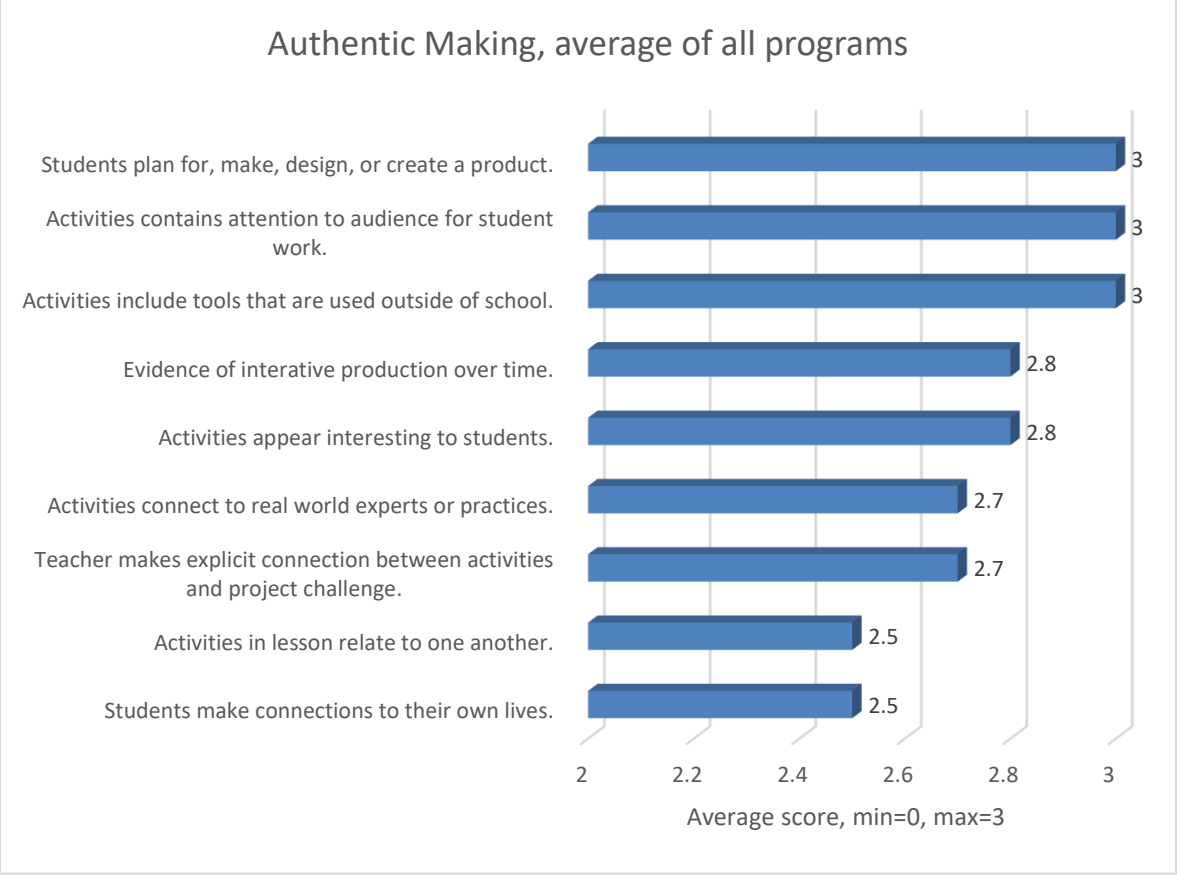
overall program). Still, the majority (71%) of students chose to participate because the program was interesting. About half (52%) wanted to design something, although this is a lower proportion than last year when more students opted in to the program. Some students (15%) participated because they wanted to be with friends and 18% reported that their parents had encouraged them to do it. Thus, most students were motivated because they thought the program was interesting, but a fair number of students did not opt in to it.

The Build a Better Book Learning Environment

Authentic Making

The Build a Better Book program provided a learning environment that fostered authentic making experiences. All of the observed programs allowed students to plan, design, and make a product for visually impaired people, thus, attention to audience was part of the design task. All observed programs also incorporated tools that are used outside of school, such as 3-d printers or Makey Makey kits. Almost all programs displayed evidence of iteration and students were highly engaged in the activities during observations. Often, the teacher made an explicit connection between the activities and the project task, thus reinforcing the design and audience aspects of the program. To a lesser extent, students made connections to their own lives in the tasks. Students often chose books or games that they enjoyed to re-design for visually impaired people, but the explicit connection to their own lives was not always verbalized. Nevertheless, the program still scored highly on connections to students lives.

Figure 1. Authentic Making, average of all programs



Across sites, the program scored consistently high in authentic making activities. However, the overflow room in the Boulder Library program was a meeting room, rather than a makerspace, and was organized and run slightly differently than the programs at the other sites. Students worked individually, were slightly less engaged than at other sites, and there was less evidence of ongoing iteration throughout the design process. Several of the completed products also did not have a real-world use (e.g. a 3-d representation of a soccer field with goal vs. a tactile book or game that could actually be used by a blind or visually impaired child).

Table 4. Authentic Making Scores, by program

Observation item	Huron	Pre-Collegiate	ACCESS	Boulder Library, Bldg 61 group	Boulder Library, Canyon room
Activities are connected to project challenge or final product.	2.5	3	3	3	2
Activities in lesson relate to one another.	2	3	3	3	2

Teacher makes explicit connection between activities and project challenge.	3	3	3	3	1
Students make connections to their own lives.	3	2	2	2	3
Activities appear interest to students.	3	3	3	3	2
Activities contains attention to audience for student work.	3	3	3	3	3
Activities include tools that are used outside of school.	3	3	3	3	3
Activities connect to real world experts or practices.	3	2	3	3	2
Students plan for, make, design, or create a product.	3	3	3	3	3
Evidence of iterative production over time.	3	3	3	3	2

In an interview, the Boulder librarian commented on the authentic aspects of the making experience in the Build a Better Book program, particularly how the open-endedness of the program differed from the traditional school curriculum. The design process of the program was appealing and interesting to teens. She commented on how the Build a Better Book program had recruited some new teens into their other library making programs.

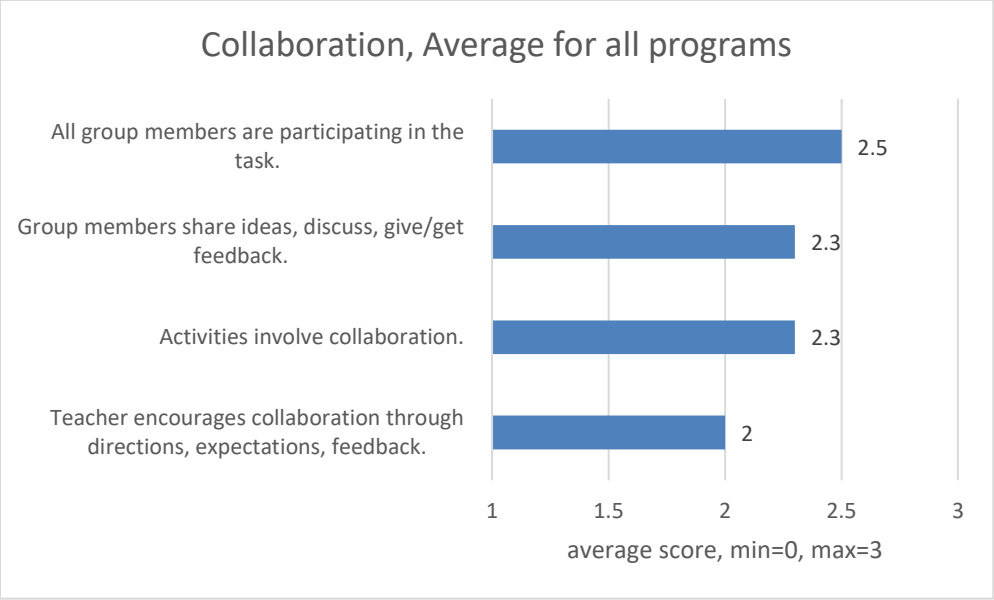
> *What keeps the teens coming back, so nobody's telling them that they have to come here and we have teens along with senior citizens every Wednesday and Saturday that we have open hours filling our space and coming back week after week. That was also true after the Build a Better Book project. After the internship we were seeing teens that came back to just about every program that we offered on the calendar after that and we had never seen them before in some cases. I think that this is creating a very welcoming environment that's very much about co-learning instead of being about you have a question, I've got an answer. – Boulder Librarian*

Collaboration

The Build a Better Book sites differed in the level of collaboration displayed among students. For instance, some of the summer programs at the university campus required collaboration among students, while other programs, such as the Huron library program or

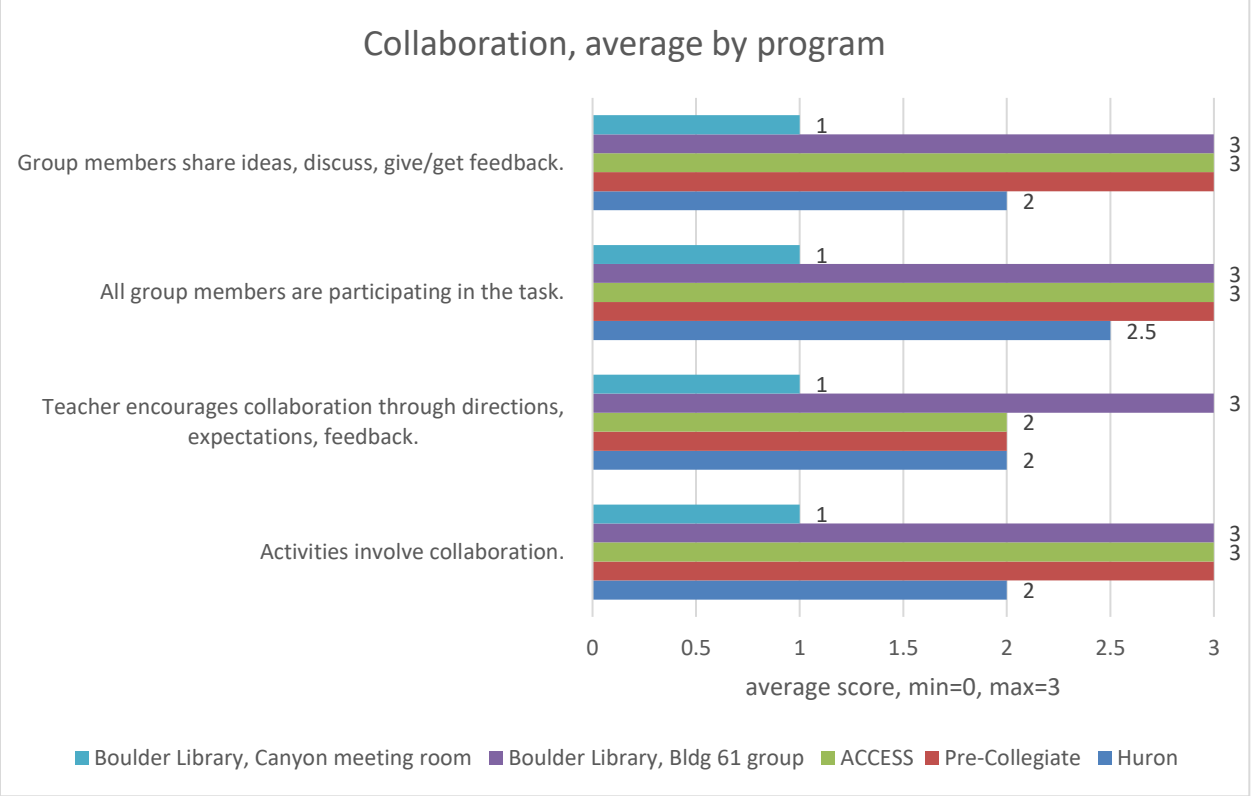
Boulder Library overflow program allowed student choice as to whether they worked individually or in groups. Therefore, the programs exhibited different levels of collaboration. Nevertheless, when students worked on teams, almost all were equally engaged and contributing to the task. Students also brainstormed and shared ideas. Less often, the teacher was observed encouraging collaboration, but this was not necessary at several of the observed sites (especially the university programs) because the students were collaborating effectively on their own.

Figure 2. Collaboration, Average for all programs



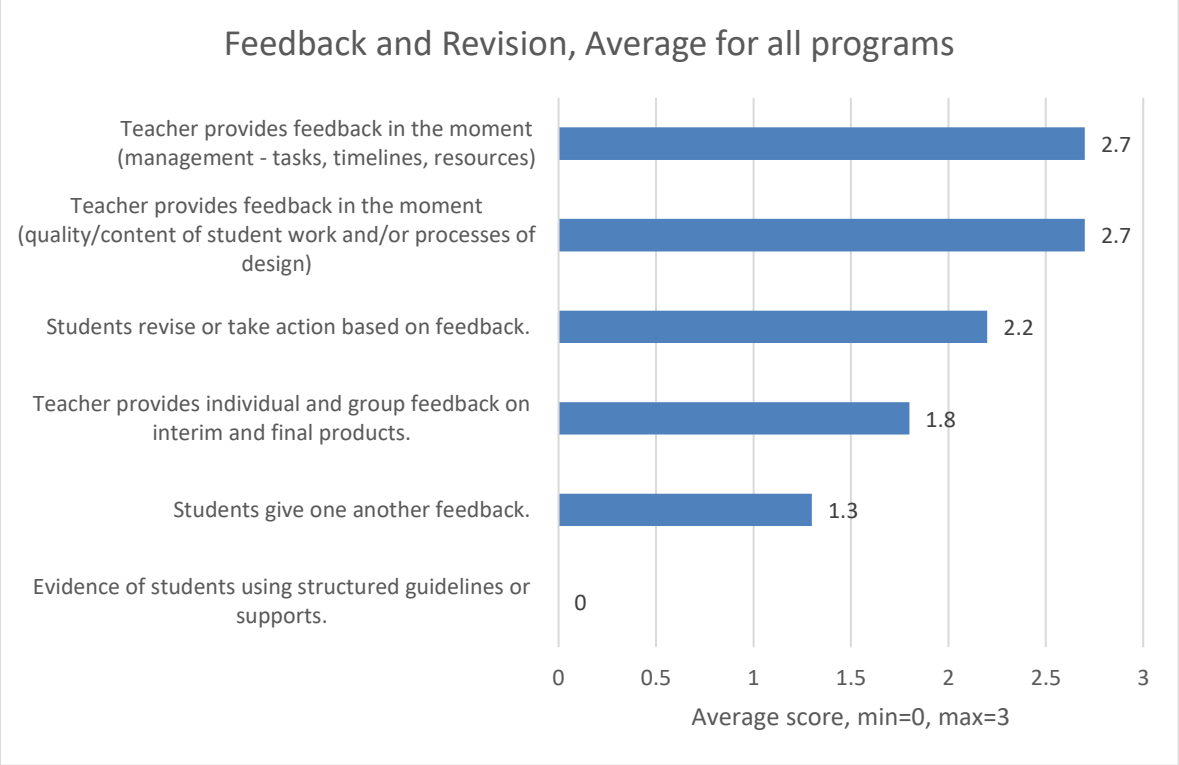
Because sites differed on whether students worked individually or in groups, they demonstrated varying amounts of collaboration according to the observation rubric. Noticeably, the Huron St. Library program and Boulder Library overflow programs exhibited lower levels of collaboration because some, or all, students at those sites worked individually. Therefore, there are several models for implementing the Build a Better Book program and some use cooperative work while other models do not.

Figure 3. Collaboration, Average by program



There was a fair amount of feedback and revision observed at all sites. Teachers often provided several types of feedback to students as they circulated around the makerspace and assisted individual students or small groups. Teachers provided feedback to students about managing the tasks, meeting the timeline, or about the use of or access to resources, especially crafting materials. Teachers also were often observed providing feedback about the quality of the design (e.g., how well it work for blind or visually impaired students), or helping students to troubleshoot a challenge in the design process. Often, students revised their work based on this feedback, but sometimes they decided to go in another direction and try something different. Less often, the teacher provided summative, or more formal feedback, evaluating the overall quality of interim or final products. Students rarely gave one another the type of feedback provided by teachers. Students often brainstormed or solved a problem together, but they did not often give one another feedback on their ideas, the overall project, the design process, or the content of the project. The use of a structured guideline or prompt could facilitate more peer-to-peer feedback if this is a goal of the project.

Figure 4. Feedback and Revision, Average for all programs



Sites also differed in the amount of feedback provided to students. One of the sites, in particular, offered little feedback to students (Boulder library, Canyon meeting room). A "2" denotes that the element was partially observed (e.g., some students, but not all students, etc.), while a "1" denotes that it was minimally observed. A "0" would indicate that it did not happen at all.

Table 5. Feedback and Revision, by program

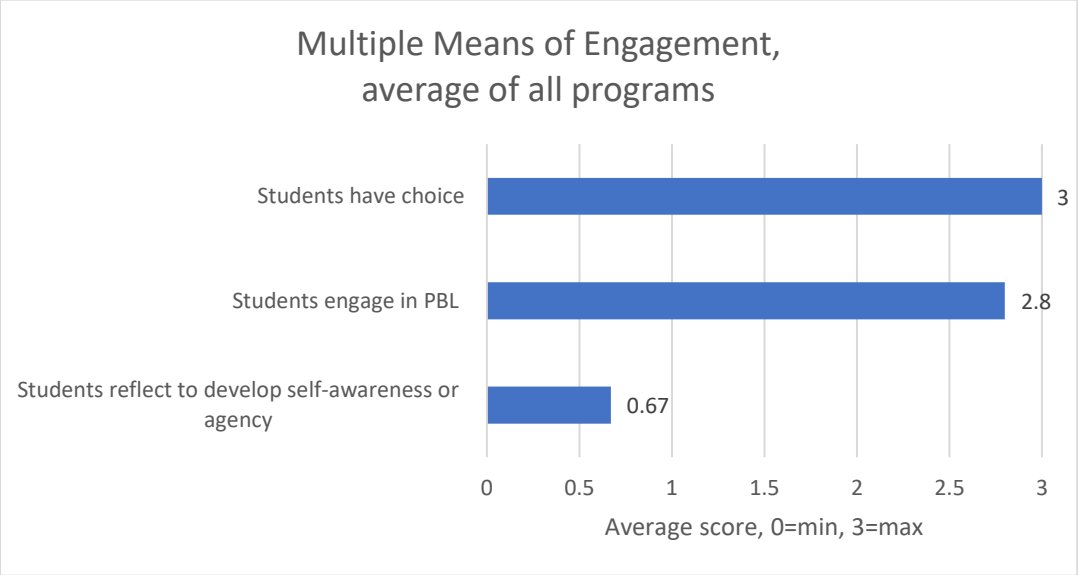
Observation Item	Huron	Pre-Collegiate	ACCESS	Boulder Library, Bldg 61 group	Boulder Library, Canyon meeting room
Teacher provides feedback in the moment (quality/content of student work and/or processes of design)	3	3	3	3	1
Teacher provides feedback in the moment (management - tasks, timelines, resources)	3	3	3	3	1
Teacher provides individual and group feedback on interim and final products.	1.5	3	2	2	1

Students revise or take action based on feedback.	1.5	3	3	3	1
Students give one another feedback.	0.5	2	2	3	0
Evidence of students using structured guidelines or supports.	0	0	0	0	0

Engagement

The Build a Better Book also used multiple methods to deeply engage students in the project, such as providing plentiful opportunities for student choice and input. All sites also actively engaged students in project-based learning design elements. Rarely, students reflected to develop self-awareness or agency. Similarly, the "reflection" scale of the rubric was not used in the evaluation because this type of reflection was not a program goal or built into the curriculum. In the future, this reflection item will be removed from the "engagement" part of the rubric as it does not necessarily align with the Build a Better Book curriculum as it is currently implemented. Nevertheless, all sites scored highly in project-based learning and student choice, key markers of authentic making.

Figure 5. Multiple means of engagement, average of all programs

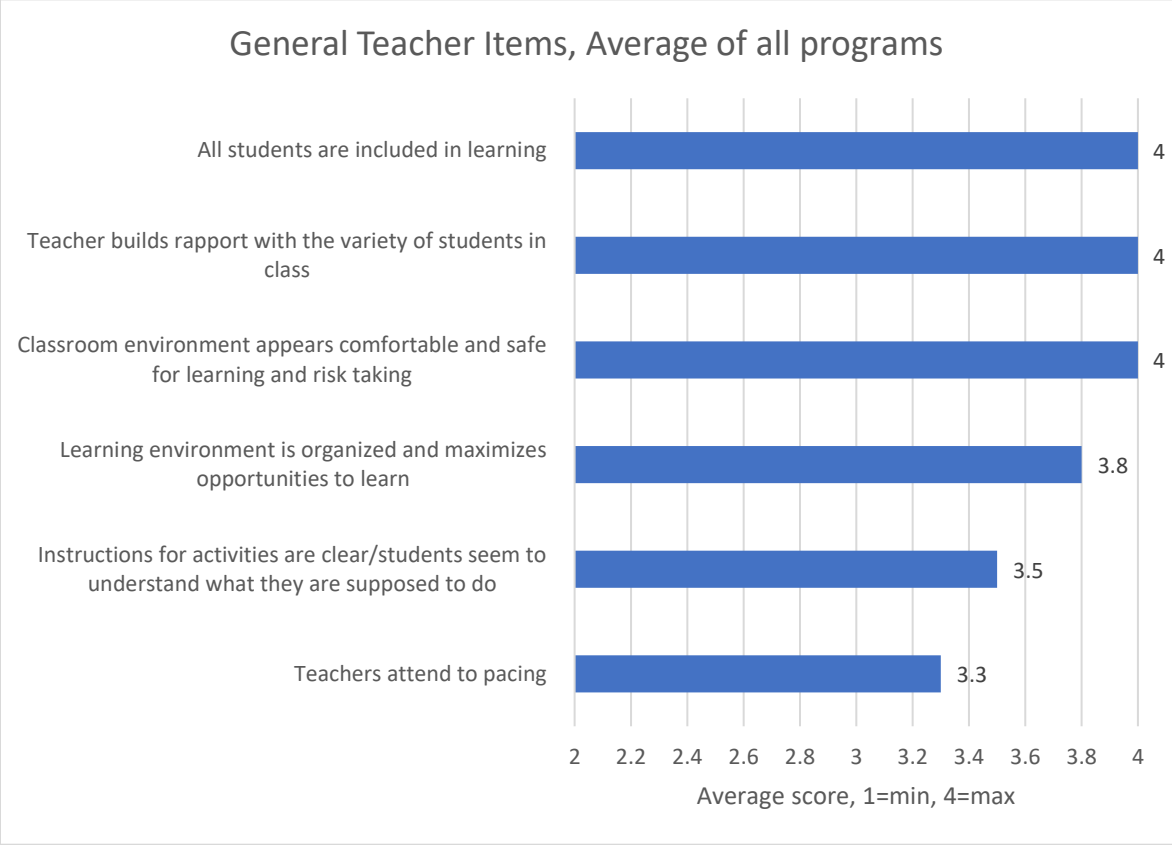


General Teacher Items

The Build a Better Book program scored highly on most of the items on the observation rubric related to teaching. For instance, at all sites, all students were included in the learning experience, including non-native English speakers and students with disabilities. Teachers ensured that all students were included and actively engaged in the learning experience, often giving individual attention and support to students who needed it. There was a strong rapport between teachers and students at all observed sessions and students seemed comfortable

seeking the teacher's support and help. All sites were organized with access to a variety of materials for students (e.g., crafting materials, 3-d pens, glue guns, etc.). With the exception of one site (Boulder Library overflow room), teachers clearly communicated instructions and expectations. At the Boulder overflow observation, students were largely finished with their projects and were uncertain about what they should be doing. Attention to pacing was observed slightly less frequently in all observations. Pacing was challenging in the program. At most sites, students were scrambling to finish their projects on the last day. On the other hand, the last-minute scramble generated some realistic design choices and trade-offs as students had to decide what they could reasonably accomplish with the minimal amount of time left. However, at the Boulder Library overflow site, the program had the opposite pacing challenge in that almost all students finished the project quite early and had nothing to work on in the last session.

Figure 6. General Teacher Items, Average of all programs



Student Outcomes

Students made several gains from their participation in the Build a Better Book program. Students' strongest outcomes were in a shift in their understanding of accessibility and how to design for accessibility. Students also gained interest in 3-d printing and modeling.

Students also gained interest in the BBB program in general and were more likely to state that they would participate in the program again at the end of the session. Students appreciated the opportunity to work on a meaningful product that could help people.

Student Learning Outcomes: Embedded Assessment and Interviews

Design Process

In their Recap videos and focus group interviews, students demonstrated that they had deeply engaged in the design process and had given thoughtful attention to their intended audience of blind or visually impaired youth. In fact, students designed for their audience using a variety of tools and resources. Depending on what was available at each site, some students used lasercut textures or crafting materials to augment their games or books. All sites used 3-d printed project to provide texture and relief to everyday objects in books and games. Many students also chose to add sound to their book. Students also added braille, especially for students working on children's books. Almost all students added craft elements and materials to also provide texture, relief, and function to their products, whether a book or game. In interviews, students described how they brought in the lens of disability into the design process, to understand how their products would be experienced by someone who is visually impaired.

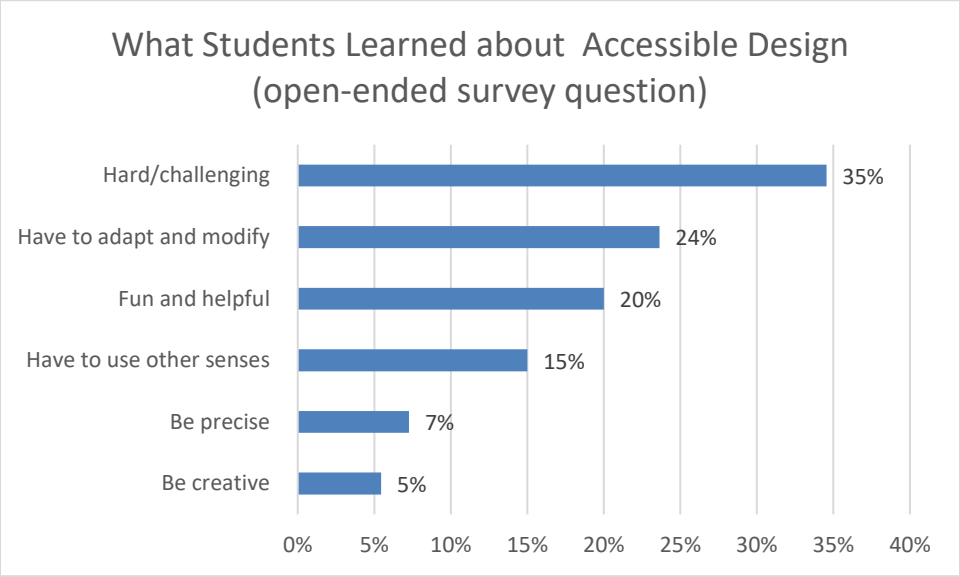
> *"I think we spent more time on how the animals were supposed to feel. Because I think it's just very difficult to explain to your child the story itself if you can't understand how the objects feel. And so we spent a lot of time understanding whether the feet should be smaller or bigger, and just thinking about those bigger attributes of an animal or a thing that you want to project for someone who has a different perspective than yourself." (Pre-Collegiate student, interview)*

In an open-ended question, students wrote about what they learned about designing for visually impaired people. Students' most common answer was that it was difficult or challenging, but these comments were usually qualified with "but it's worth it." Students also commented that they learned that they needed to adapt or modify existing or everyday materials to make them functional for visually impaired people. Many students also wrote

that the process was fun and that they learned that they could help people. Other students learned that they needed to use all of their other senses when designing for visually impaired people. A few students mentioned that it was important to be creative, use a variety of tools and resources, and to be precise in your work. Typical comments were:

- *It is hard and it takes time to build something with texture because it has to be accurate.*
- *It is hard, but a good thing.*
- *Its harder than I thought it would be and takes lots of thinking and time.*
- *That its hard to think about the world differently and erase how you grew up knowing the world for one minute, and how doing that can open your eyes and be a force for change inside of you.*
- *Common symbolism for us does not translate to those who are visually impaired so we have to think of creative ways to address these concepts without sight.*
- *I learned that it depends on a lot of sound, touch, and texture.*

Figure 7. What students learned about accessible design



Challenges

The challenges students encountered also demonstrated their immersion in the design process during the Build a Better Book program. For instance, most of the challenges experienced by students related to trouble-shooting or problem-solving. Students needed to learn the technology (especially Tinkercad) in order to manipulate the software to create their objects, whether by creating an original design or editing or modifying an existing object. Nevertheless, students found it challenging to design objects that would work within their real-world constraints (e.g., objects that are the correct size, would print correctly, etc.). Students also found it challenging to work within the time constraints of the program. This was affirmed in observations when most student groups were rushing at the end of the program to assemble their books and games and to add the finishing touches with crafts or other materials. Students also found it challenging to write in braille, especially because they

had to enter the letters in reverse order so that it would be readable to a blind or visually impaired student. Mastering braille was a tedious process for students but provided them with a sense of accomplishment. Students also found it challenging to decide which pieces, images, or elements could best represent their story, given the amount of space that they had to work with on their tactile page. Students needed to boil down the story to essential elements and word choice and this was often challenging for them.

> *"Challenges to overcome were making sure that everything fit on the page and making sure that it was big enough, cause when you're blind you can't really see it, so you have know what it is by feeling it. And the way we overcame that was by working together and asking questions." (ACCESS camp, recap video)*

Accomplishments

Students displayed a sense of pride, accomplishment, and mastery from their diligent work to produce tactile books or games. Students were most proud of learning about and creating braille text because it was something entirely new to many of them. Students also gained a sense of accomplishment through learning how to use technology, especially Tinkercad and lasercutting. Trouble-shooting challenges (especially technological challenges) and overcoming them also gave students a sense of accomplishment from the program. Students enjoyed the problem-solving process and were proud that they had overcome challenges to create their final product. Students also enjoyed working with peers to overcome challenges. Many students were also proud to have helped someone with a disability to enjoy books or games that they themselves had enjoyed as a young child. The thought of helping a young, visually impaired child was motivating and inspiring for many students.

The focus on inclusive design within the Build a Better Book program was the most impactful part of the program for youth. When asked what they will take away from the program, most students commented that they had gained a better understanding of disability and had learned to view the world from the perspective of someone with a disability. Students also appreciated the opportunity to help people through technology, as mentioned by Pre-Collegiate students: *"It's good to use STEM to help other people which I think is really powerful."*

Students developed a sense of empathy for people with visual impairment and gained a better understanding of the way society is organized to assist people with disabilities, as well

as an understanding of the ways in which people with disabilities could be better supported (e.g., a lack of tactile books and games for children). Students also appreciated that they were able to help somebody by using technology and recognized that it was challenging, but fun, to translate books into tactile formats.

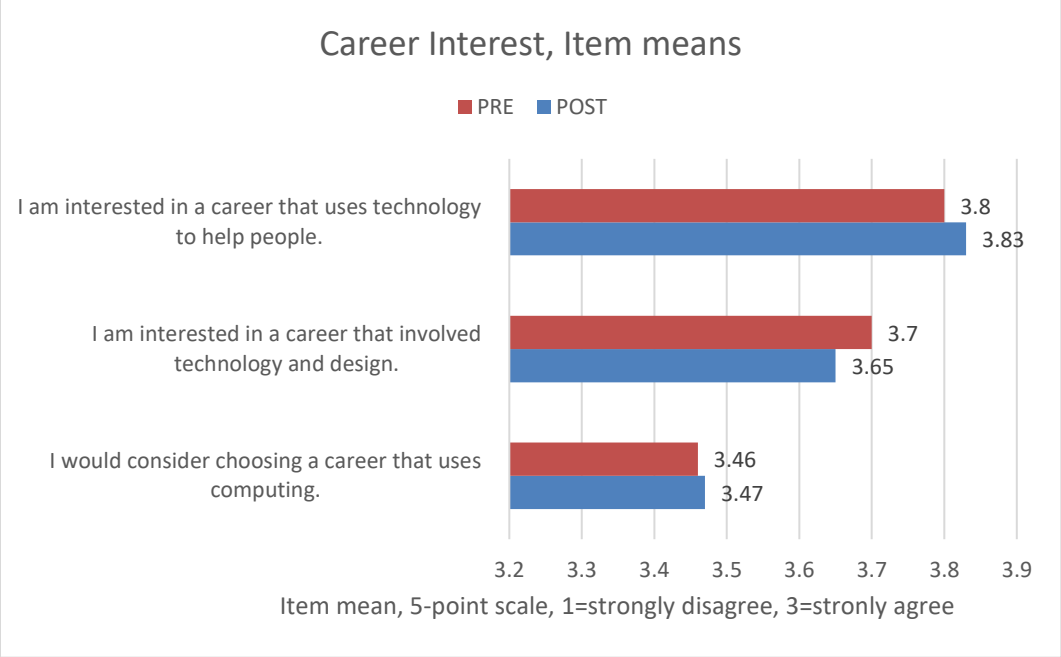
"Learning how to put yourself in other people's shoes. For example for people who can't see, we learned that they have to use all their other senses to recognize the world as we do. When I look at this back in five years, I will see this as something fun and interesting." (Boulder Library, Canyon room student, recap video)

"I really want to see this grow into a larger movement and I want people to become more aware and knowledgeable that this is an issue and we need to think about people that don't have the same level of accessibility that we do." (Pre-Collegiate student, survey)

Student Outcomes: Career Interest

Student attitudes toward and interest in careers that involved technology, engineering, or design did not change significantly over the course of the program. For instance, student responses on the survey items measuring career interest changed little from the beginning to the end of the program. There was a slightly uptick in the students who were interested in a career that uses technology to help people, but the difference was slight and not statistically significant.

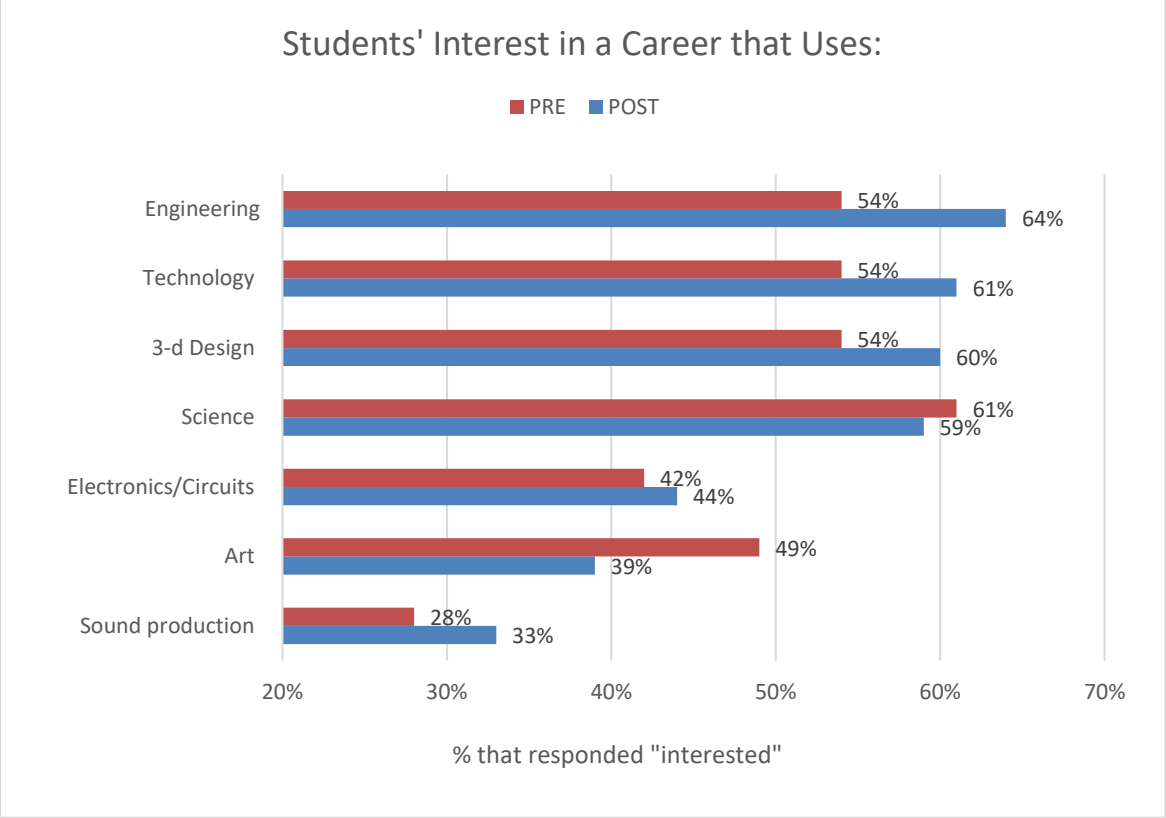
Figure 8. Career Interest, Item means



Career interest outcomes were similar across groups of students and across different program models. There were no meaningful differences in student responses by program model, program site, or by demographic groups of students, such as gender, race/ethnicity, grade level, or first-generation college students. The Boulder Museum internship, Boulder Library Building 61 summer program, and ACCESS summer program exhibited slight increases in career interest, while the other programs exhibited slight declines, though these differences were not statistically significant. Thus, long-term programs and programs where students opt in may be more beneficial in fostering increased career interest, yet these differences were minor.

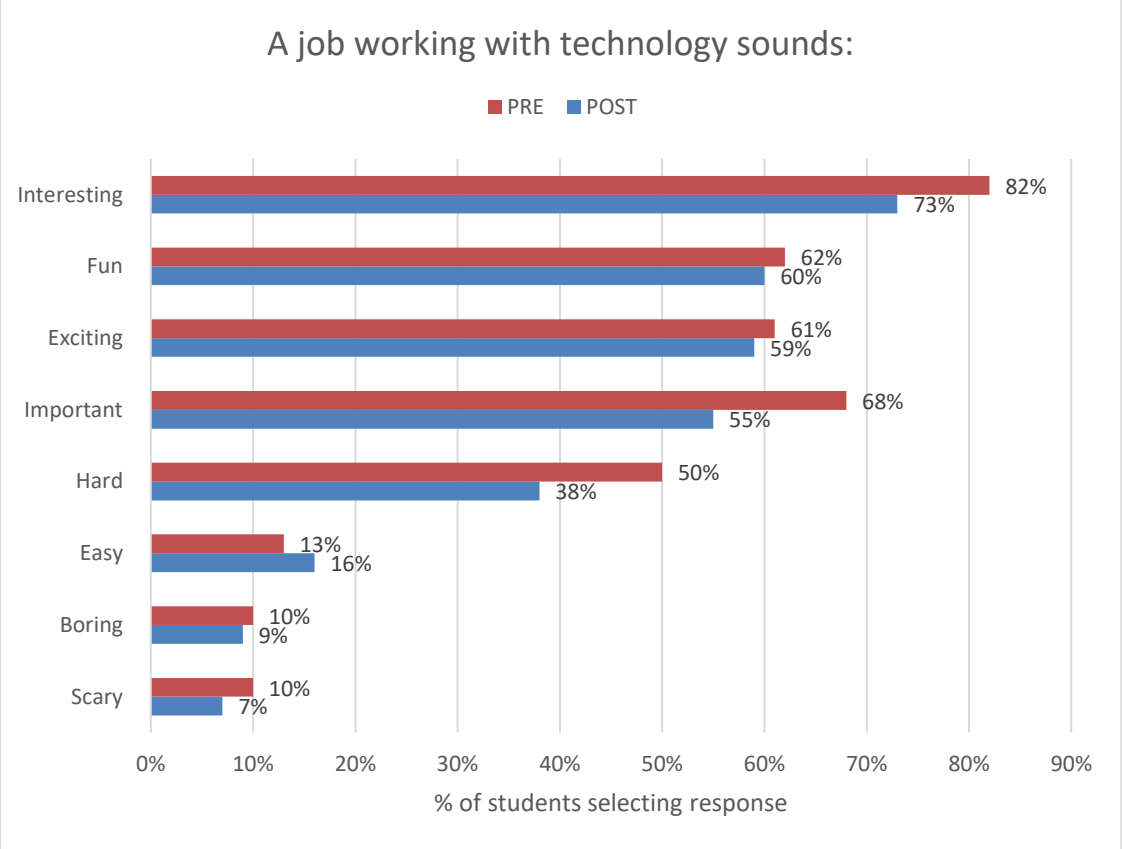
For the most part, students' interest in careers that use STEM remained steady or increased slightly. Students gained the most interest in careers that involve engineering. Students also gained some interest in careers that use technology or 3-d design. Students' interest in a career that involved art declined slightly. Students' increase in interest in 3-d design was statistically significant (t=-1.492, df=70, p=.70). Although students seemed to make a stronger increase in engineering, it did not register as significant because the rest of the students remained constant in their answers, whether "not sure" or "not interested" in engineering. However, almost no students (only 3%) responded that they were "not" interested in 3-d design in their career on the post-survey. Thus, when asked about specific technologies or aspects of STEM, students exhibited greater increases than when asked about general career interest questions. This suggests that students are interested in careers that involve STEM, or aspects of STEM, but their ideas and interests around careers are still not well developed.

Figure 9. Students' Interest in a Career that Uses:



Students' conceptions of a career in technology changed slightly. Students' perceptions that a career in technology would be exciting or fun held steady, with over half of students holding this attitude. Students were slightly less likely to believe that a technology career would be important or interesting, although nearly ¾ of students believed that a technology career would be interesting at the end of Build a Better Book. Therefore, students entered the program with strong beliefs that a technology career would be interesting or important, and most students maintained this belief throughout the program. Students also were significantly less likely to feel that a technology career would be "hard" ($t=-2.162$, $df=85$, $p=.033$). This result may indicate that students' successful production of 3-d designs and use of Tinkercad and other technologies may have lessened their belief that technology is difficult.

Figure 10. A Job Working with Technology Sounds:

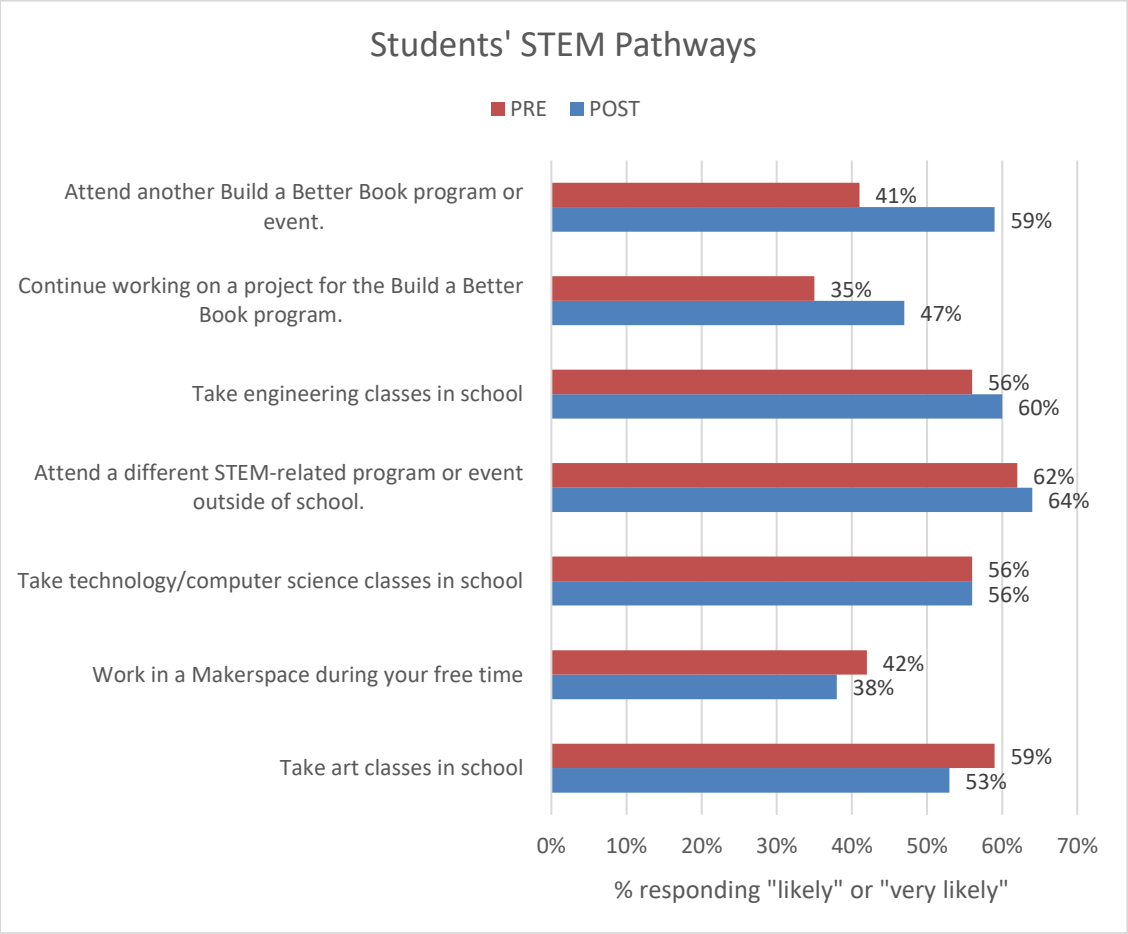


Student Outcomes: Career and Educational Pathways

Students reflected on their future intentions to continue with the Build a Better Book program, and to pursue STEM courses in high school or college. With the exception of technology and art, students' intentions to continue to engage in "making" experiences, engineering, and other STEM experiences increased. In particular, students were more interested in the Build a Better Book program after their experience in the program and were interested in continuing to work with the program. Students' intentions to attend another Build a Better Book program or event significantly increased as a result of their participation in the program ($t=-2.256$, $df=85$, $p=.027$). Students were also interested in continuing to work on a project with the Build a Better Book program. However, their interest in Build a Better Book did not always translate into increased interest in other STEM offerings. For instance, students' interest in taking engineering classes or participating in a different after-school STEM offering remained steady. Nevertheless, students' interest in the Build a Better Book program significantly increased, indicating that the program did spark their interest and enjoyment. Considering that a fair portion of students did not choose to enter the program, it seems that the BBB program sparked enough interest that students were interested in continuing with the program, which may then translate into participation in other STEM offerings in the future. The BBB program may be the first step in STEM engagement or

interest in design for some students who did not opt into STEM or hold other interests within STEM fields.

Figure 11. Students' STEM Pathways



There were slight variations in outcomes by program and grade level. For instance, younger students (ACCESS and Wings) were the most likely to want to continue working on a project for Build a Better Book (Wings mean on this item increased from 3.0 to 4.0 –from not sure to agree, and ACCESS mean increased from 2.87 to 3.25). Likewise, the students who did not opt in (ACCESS, Pre-Collegiate, Wings) were most likely to want to attend a Build a Better Book program or event, perhaps because they enjoyed it more than they expected. However, students who opted in to the program (Boulder Museum internship and Boulder Library summer students) demonstrated the largest increases in wanting to participate in other STEM-related activities, such as afterschool STEM programs or Makerspaces.

In interviews, students commented in more depth on the impact that the Build a Better Book program had on their career and educational paths, with many students remarking that they are now more open to an engineering pathway than they were before.

"Before the program, I never saw myself as an engineer or ever studying it, but being in [Build a Better Book], I thought it was really fun and interesting. And I can see myself being an engineer if I don't have anything else." – Pre-Collegiate student, interview

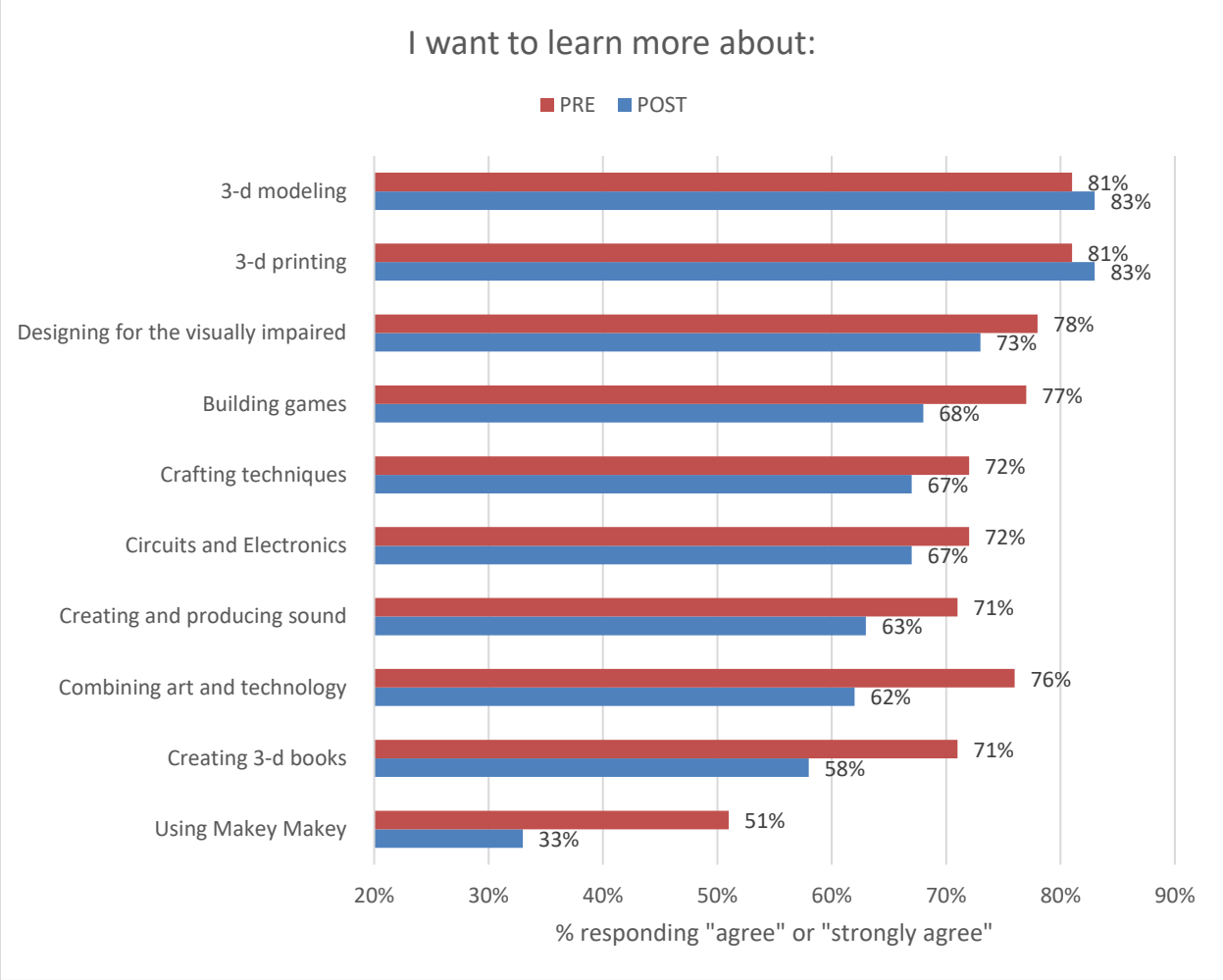
A student in a different focus group also mentioned how the program had opened her mind to engineering, a path that she had not considered before.

> *For me it did [influence my career path] just because I thought that it was interesting having to rearrange stuff and learning how to write the braille and learning how to do the Tinkercad stuff because I've never used Tinkercad before, so even though engineering is not what I wanna do, it did change my idea of well maybe I do wanna do engineering. But I haven't decided. – Pre-Collegiate student, interview*

Student Outcomes: Interest in Making

Students' interest in different technologies or making activities mostly held steady or declined slightly over the course of the Build a Better Book program. However, students' interest in the technologies most closely related to the Build a Better Book program (3-d modeling and 3-d printing) increased a bit. However, interest in these technologies was so high at the beginning of the program that it is meaningful that it was maintained throughout the course of the program. However, students' interest in using Makey Makey and producing 3-d books declined somewhat by the end of the program. Again, students who opted in to the program (Boulder Museum internship, Boulder library summer students) showed increases in interest in 3-d printing and 3-d modeling, while the students who did not opt in (Wings, ACCESS and Pre-Collegiate) showed slight declines (about -.1 to -.3 on the 5-point scale). Likewise, all programs held steady or showed very slight declines in learning more about designing for the visually impaired, while the Boulder Library Building 61 summer group was the only group that showed increases in this area. This group of students had chosen the program based on interest in this topic, and thus, their interest was piqued by the program.

Figure 12. I want to learn more about:



Despite lack of strong growth on the survey, observations indicated that students were deeply engaged in the making and technological aspects of the program. Also, facilitators observed deep student engagement and interest in the "making" aspects of the Build a Better Book program. Students were often motivated to put in extra effort on their projects. Students also needed to master a range of technologies and skills to create their products, as noted in a comment from a librarian.

> *The teams achieved incredibly creative and thoughtful projects. The one that really stands out was the group that did a game…That team's motivation was that they wanted to bring joy to others and for everybody. So their project was not only inclusive of any individuals who were sighted and unsighted but also there was instruction in Spanish and so that was probably the piece that the community resonated the most with. Which was really, really awesome to see. There was a lot that went into that. Not only design, understanding how to make a game and how to make a game cohesive but also the electronics and getting everything hooked up and wired up correctly. Then it was just*

really creative and fun too. So that was pretty awesome to see. The one student would stay after, after the workshop … I think he stayed after a total of four additional hours that week just to keep working on the project, which was pretty remarkable.- Boulder Librarian

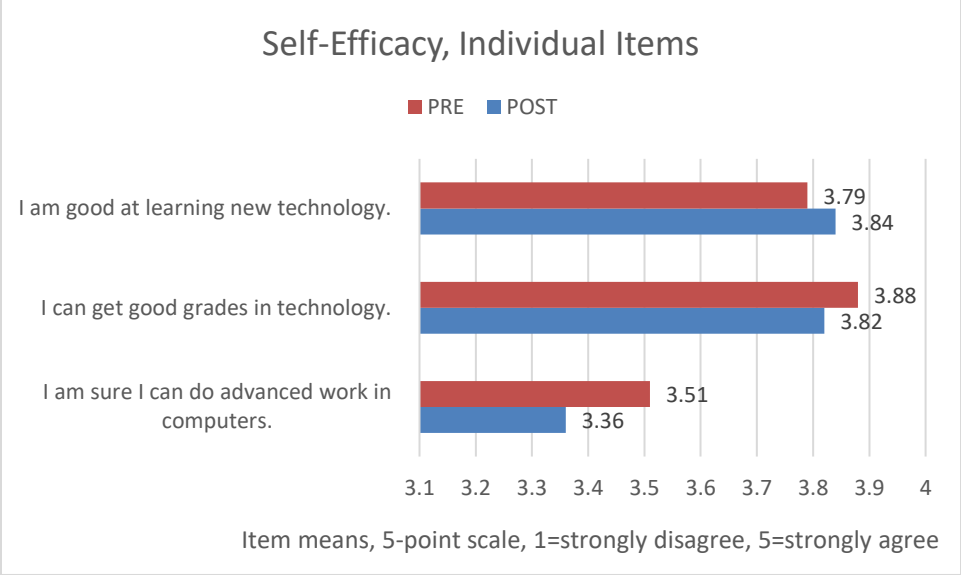
The educator from the Wings program also noticed that girls became more engaged in the project. She hypothesized that this increased engagement from girls was because of the social and humanitarian aspects of the BBB program.

Some students were a little more engaged, especially some of our female students. I know it's kind of a general stereotype that girls in STEM tend to be drawn a little more towards projects with a social component to it. And I saw that being the case too with my students who were there who were part of the program. – Wings Over the Rockies educator

Student Outcomes: Self-Efficacy

Students' self-efficacy in technology mostly remained consistent throughout the program. Students' beliefs that they are good at learning new technology increased slightly, but inconsistently, and their belief that they can do advanced work in computers declined slightly. There were no meaningful differences for different programs related to self-efficacy outcomes. However, there were meaningful, though not statistically significant, differences according to grade level. Middle school and early high school students generally declined in technological self-efficacy, while high school students increased their beliefs that they could learn and succeed in technology. For instance, 7th, 8th and 9th graders generally showed declines of about -.1 to -.5 on the 5-point scale, while 10th graders displayed a +.5 increase that they could do advanced work in computers (moving from not sure to agree) and +.83 increase in their belief that they can get good grades in technology (moving from not sure to agree). Likewise, 11th and 12th graders showed growth, but not quite as substantial (about +.1 to +.3 on a 5-point scale). Thus, older students appeared to gain more self-efficacy from Build a Better Book than younger students.

Figure 13. Self-Efficacy, Individual Items



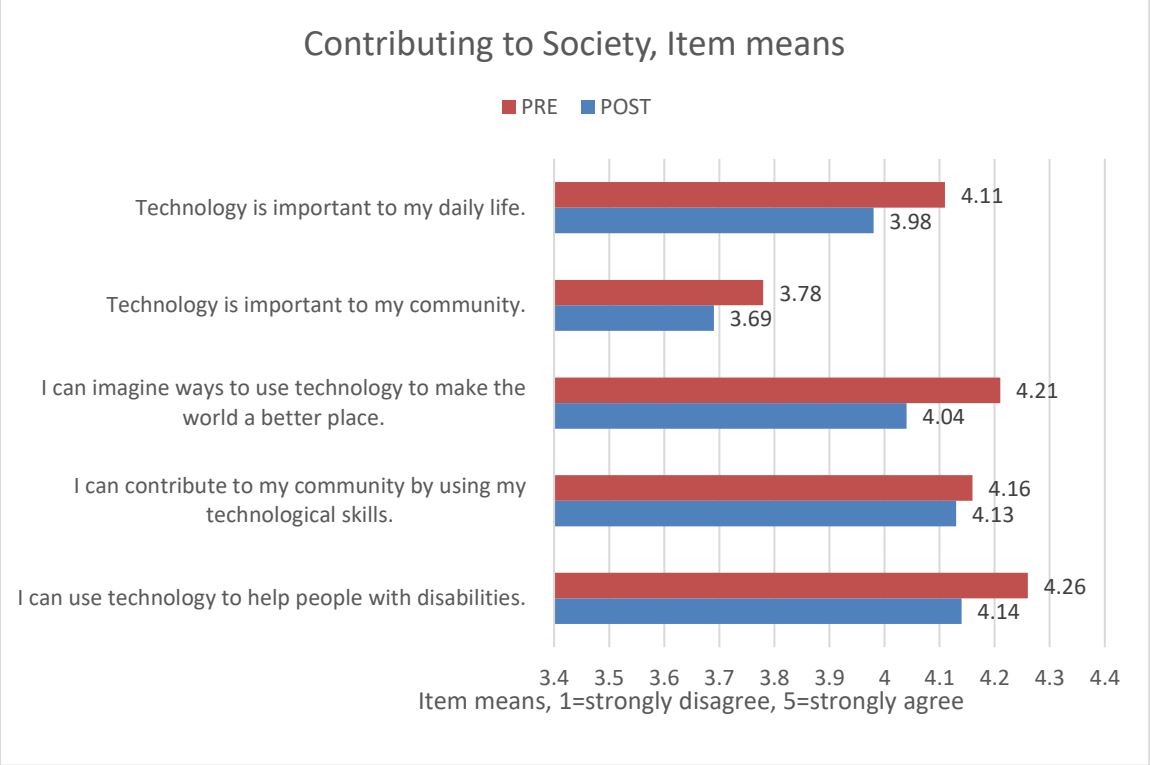
In interviews, students noted that they had gained skills that they can apply in numerous different areas. Many students remarked that they were proud to have learned Tinkercad because it was something entirely new to them.

I mean, I feel like for them and for myself, now that we have a good idea of how Tinkercad works and how QR works now we can apply it to other types of projects if we wanted to. And that's what we've been doing, I bet at least in some small way that all of us as students have used what we have learned in other classes besides just one. – Pre-Collegiate student, interview

Student Outcomes: Empathy and Contributing to Society

One of the most impactful outcomes for students was the ability to perceive the world as a blind or visually impaired person would, fostering empathy and awareness of difference and ability. Students spoke often in the Recap videos and in focus group interviews about the importance of taking another perspective. Despite this shift in perspective for many students, they did not demonstrate the same growth on the survey scale that measured their belief that they could help people and society with technology. Students' responses on the survey scales all declined slightly, including their belief that they could help people with disabilities by using technology, yet this was countered by their assertions in the Recap videos (previously discussed) and in focus group interviews. There were few programmatic differences on the survey items about helping people with technology, although the Boulder Museum internship program was the only group that consistently increased on almost all items. Therefore, an extended duration program such as the internship that spanned several months, may help to foster altruism more than shorter duration programs, such as week-long programs.

Figure 14. Contributing to Society, Item means



In contrast, in interviews, students remarked that the focus on disability and visual impairment and the opportunity to help someone with their project were the most impactful aspects of the Build a Better Book program.

> *I think the moral part of it is very interesting to me. What we're trying to do for people who can't see as good as us. And trying to innovate things that are better. I feel like a little bit like it's not the best book, but for them it's probably everything. – Pre-Collegiate student, interview*

Students also commented on how the focus on helping people through engineering had changed their ideas about engineering, especially as a possible career path. In the quote below, a Pre-Collegiate student mentions that she not only wants to continue to help people, but she wants to specifically continue to help people with visual or auditory impairments.

"For me, I got two big things from it. One, in the future, I hope whatever I do, I can somehow help out communities that are blind or deaf with what I can because learning from this, you can make a change. And the other thing is, it brought me back to the idea of maybe engineering as one of the fields I might go into." – Pre-Collegiate student, interview

Another student commented how she learned that engineering and technology can be used to help people and to make a difference.

> *It adds on to engineering that it isn't just the technical side, there is the humanity side of things, like you can do something with it to help the world. – Pre-Collegiate student, interview*

Finally, it was a powerful experience for many students to adopt the perspective of another and to think about the world in a different way. Not only did this foster a sense of empathy, but it required that student be deeply creative in their design work because they had to view the world from a completely different perspective, as shown in the following comment.

> *I think just kind of looking at like how we have these symbols that we're used to, like a stop sign or a teardrop and that just doesn't translate for them because they have no visual idea of that. How kind of just thinking about these things that are so normal for us and having to translate that into something, into a more abstract concept and just thinking about that and being more mindful of that. – Pre-Collegiate student, interview*

The Boulder Librarian also noticed the development of greater empathy and thoughtfulness about disability among teen participants. She described the conversations about disability that were facilitated by the Build a Better Book instructor:

> *I was unbelievably impressed with what the students did and the level of maturity that they brought to the table. Something that I've never really done before was facilitate a conversation about what questions we have. Like what uncomfortable questions we might have about working with people with visual impairments or who were blind. I think seeing Abby do that was really, really, really awesome to just see how respectful the teens were and what thoughtful questions they asked. I've not really done anything quite that direct before, but it certainly was awesome to just be in the room to experience it as a bystander. – Boulder Librarian*

Similarly, the educator from the Wings Over the Rockies museum commented that the greatest benefit to students that she observed was their ability to shift perspectives and to think about the world in a different way than they had before. The focus on helping people and the fact that the project was meaningful beyond simply making an object with a 3-d printer also sparked students' interest and enthusiasm.

> *Those students, it kind of opened their eyes to something that they hadn't really necessarily thought of before, so they really looked at things from a new perspective. A lot of students were really excited to be helping out other people through their projects. It wasn't just some random project. It was something that would actually become useful to somebody else. And I think that was probably the biggest effect right away. – Wings Over the Rockies educator*

She also observed a shift in perspective over time in some of the students as they more readily were able to take the perspective of another.

> *I had a few students, who at the beginning, some of them were kind of like, "Why are we doing this? What is this?" Just a little more skeptical. And to watch their opinions shift over the course of those eight weeks. I think we definitely had some students who were turned around.– Wings Over the Rockies educator*

Likewise, the high school mentor also observed that students' shifted their understanding of accessibility and disability issues and that this was one of the most impactful outcome for students. He commented:

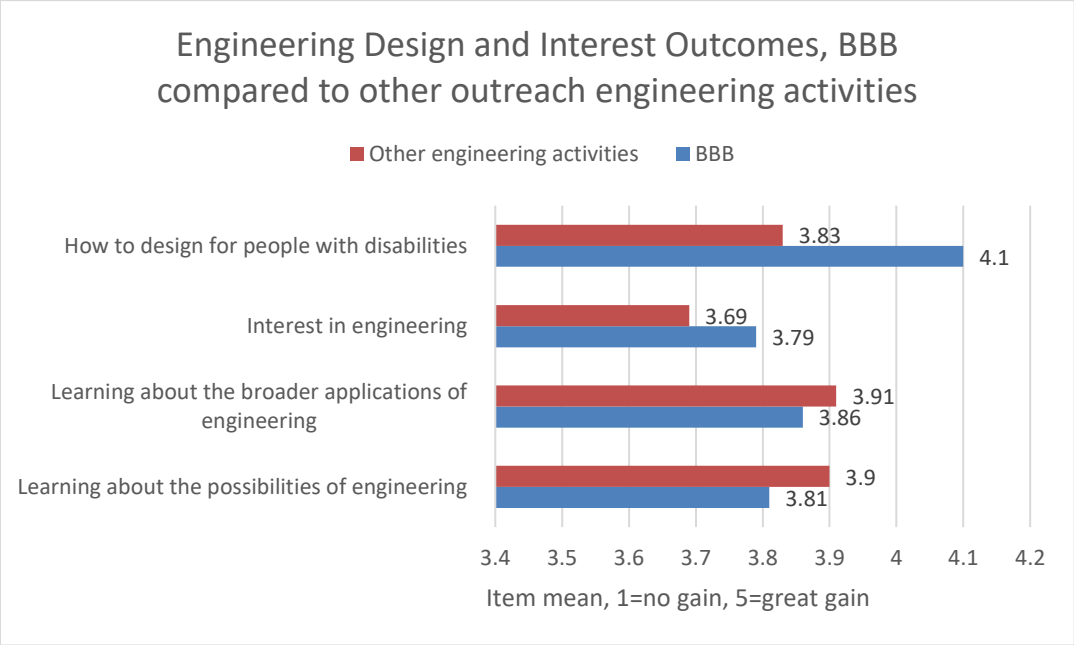
> *I have been talking to some students that say that this opened their minds. They hadn't considered the accessibility of some stuff for daily things for blind people. I think that was the same thing that happened to me when I first thought of doing something for blind people that was not accessible. I think that's pretty much the main thing that we heard from students. That now they think more about that. – High school mentor*

Outcomes from BBB Projects Compared to General Engineering Projects

Compared to other engineering programs or activities, Build a Better Book students gained a better understanding of how to design for people with disabilities and also gained more interest in engineering in general. Two of the Build a Better Book summer programs (ACCESS and Pre-Collegiate) were broader programs in which students spent part of the day on other STEM and engineering activities. When students were asked to reflect on their gains from the Build a Better Book program compared to these other general engineering activities in their summer program, they responded that they had gained a better understanding of inclusive design through the Build a Better Book program. For example, 88% students learned about inclusive design through Build a Better Book, while 62% also learned about it though

other engineering activities. Also, 75% of students gained interest in engineering through Build a Better Book, while 57% gained interest through other engineering activities. An additional 12% of Build a Better Book gained "some" interest in engineering, while 29% of students gained only "some" interest through the other engineering activities. Therefore, the Build a Better Book curriculum was more effective than other, general engineering projects in fostering a sense of accessible design and in enhancing students' interest in engineering.

Figure 15. Engineering design and interest outcomes, BBB compared to other outreach engineering activities



In interviews, students commented on the difference between the Build a Better Book programming and the general engineering activities that they had experienced in their summer programs. Students viewed the Build a Better Book program as a more authentic engineering experience because it was more open-ended in its focus than the other engineering activities they engaged in, as described by a student in the Pre-Collegiate program.

> *In the other [engineering] classes there's a specific way of doing things, while [in Build a Better Book], there's many different ways. Either we could have just done it on a flat platform, we could have done it 3D way, or maybe just words, or you know, now we're using sound. We had no idea of approaching it, but we tried. And I guess that's what engineering should be, is being able to come out of nothing to make something. – Pre-Collegiate student, interview*

Another student concurred that the Build a Better Book program allowed for more creativity and empathy than other engineering programs.

I think it was just fun how it integrated art into it because it wasn't just all "oh I do this to fill a purpose" it was like make it make sense in an artistic sense. Yeah. I just enjoyed that aspect that you were adding back in the humanism into engineering and 3D design. I liked that a lot. – Pre-Collegiate student, interview

Students' Favorite Aspects of Build a Better Book

Students' favorite aspects of the Build a Better Book program were also the fundamental aspects of the program, 3-d printing/modeling and the focus on people with disabilities. Students commented that it was fun to learn 3-d printing and they enjoyed learning a new skill. Students felt proud of the objects that they had produced and their ability to learn Tinkercad. For instance, a student commented:

[My favorite part was] when we received our 3D printings, because we spent so much time trying to perfect then. And so when we get it back we're like oh, either it's good or bad, or, you know, it's kind of rewarding to see that it turned out well., Pre-Collegiate student interview

Students also benefited from the focus on visual impairment and disabilities. Many students appreciated the opportunity to help someone by using technology and engineering. But, most of all, students benefited from and enjoyed the opportunity to take the perspective of a blind or visually impaired person, as shown in the following comments about students' favorite parts of the program:

The learning and understanding of how people with disabilities interact with things different from us. - survey

Learning how to better design for visually impaired people, thinking about how to get across complex thoughts or stories without visuals. - survey

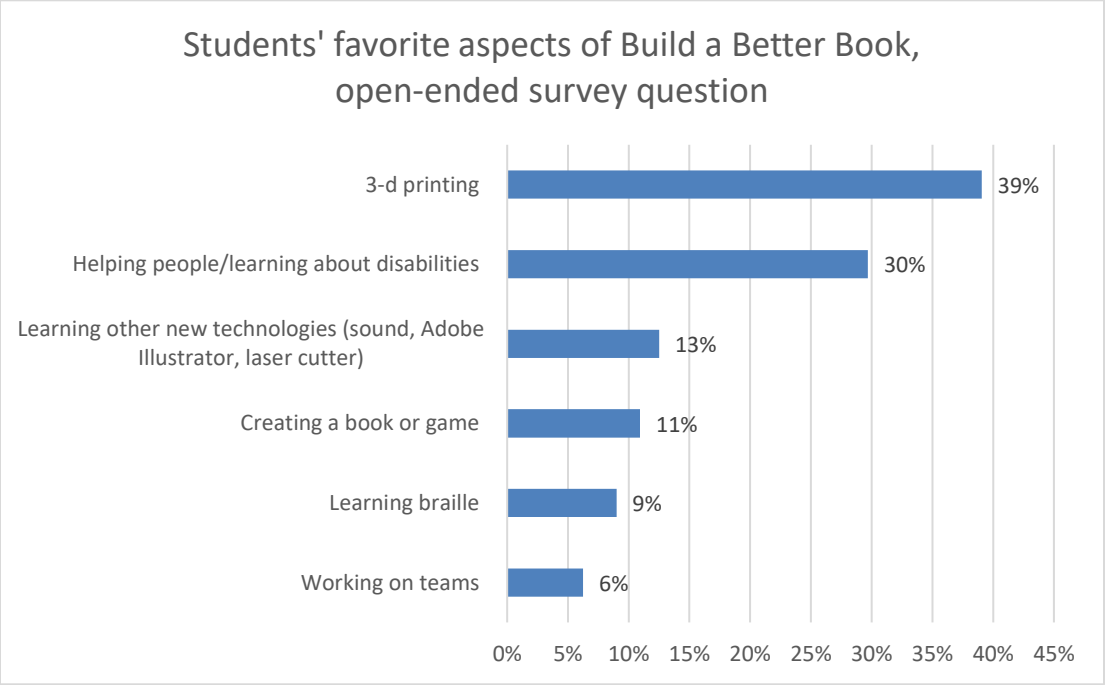
Making the books for the disabled because its meaningful. -survey

Probably the fact that at the end of the day, the effort we put in to making one small change to a museum can go a long way and help many people. Also that I am learning things that I will use in life while helping others.- survey

"I loved the feeling of helping the community and learning all of the technology was really interesting."

Students also mentioned that their favorite aspect of the program was the range of new technologies that they were exposed to, some students commented on learning to use a laser cutter, to produce sound using Makey Makey, and learning to use Adobe Illustrator. Students also benefited from learning braille and expressed pride that they might be able to now braille marking that they come across in their daily lives. For example, a student respondent on the survey: *Learning how to do the braille and write it because it was interesting to see how people who can't see read and use textures."* Finally, a few students also enjoyed the collaborative aspect of the program.

Figure 16. Student' favorite aspects of Build a Better Book, open-ended question



Student and Librarian Advice for Improving Build a Better Book

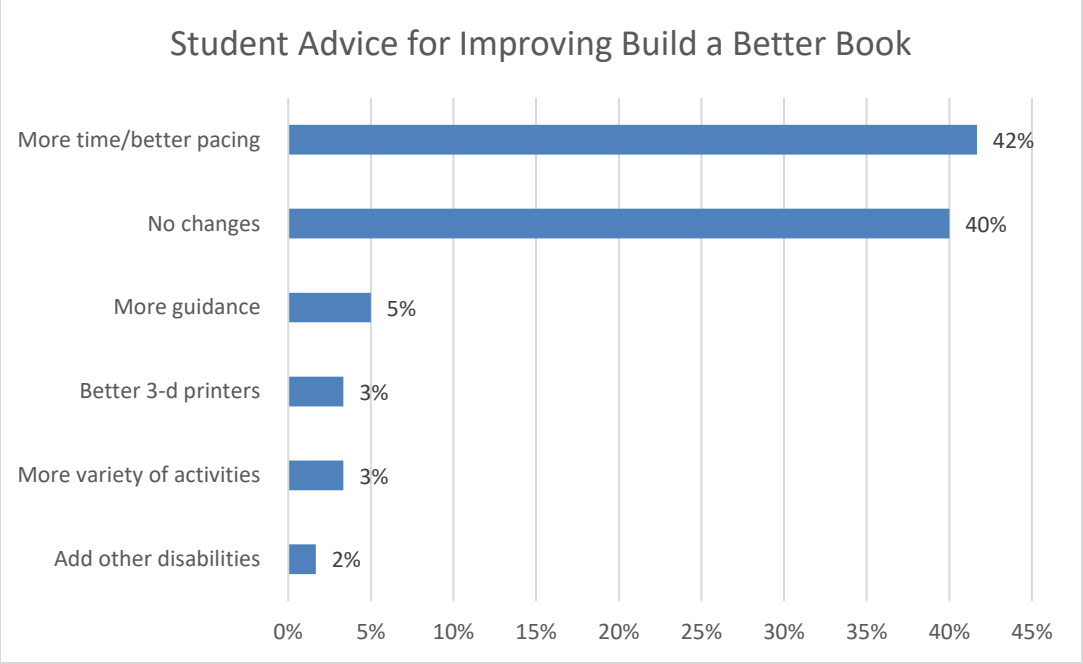
Many students had no advice for improving the program because they liked it exactly as it was presented. However, nearly half of students wrote comments about the need for more time to work on projects or more attention to pacing of the overall program. For instance, some students wrote that less time could have been spent on prototyping or the

activities at the beginning of the program in order to provide more time for the creation and assembly of the actual product. Typical comments were:

- *Give more time to work with Braille letters. We only had 1 hour.*
- *More time with the 3D printing.*
- *Maybe taking less time at the beginning for prototyping the objects that weren't our project and allowing more creation time for our actual projects.*
- *I felt like we spent a lot of time at the beginning before we even knew what our groups were, and I learned a lot in this time, but then I felt really rushed once we actually knew what we were going to do. I think it would be better if we spent a little less time at the beginning, and could work on our projects a little bit longer.*

Otherwise, a few students had other suggestions for the program such as working on a variety of different activities (e.g. expanding into other activities beyond creating a book), having more craft supplies and providing 3-d printers that can handle a higher output of objects.

Figure 17. Student advice for improving Build a Better Book



The educator from the Wings program also commented that they had struggled with pacing in their implementation and allowing enough time for the students to complete their projects. She commented that they had to provide more support and guidance to help the students to meet the deadlines, terming it "guided inquiry."

> *Yeah, we did have some challenges. Some of it was the direct goal with our project where we were making things for the museum. We did have some issues with direction,*

like setting goals. If I'm making a book, I'm like, "Okay, I've got to set some timelines and some milestones. This is when you need this done by. This is when you need this done by." But we're creating materials that didn't exist yet at all into the format, so coming up with a solid framework ahead of time, saying, "Okay, this is what we need. This is when we need it by." We kind of approached it from, "Hey, we'll develop as we go along." But it needed more structure. So maybe guided inquiry would be a better way to put it. – Wings Over the Rockies educator

Librarian Outcomes

Librarians had high interest in the Build a Better Book program; however, they generally lack knowledge in 3-d printing and modeling and they have varied backgrounds and expertise in designing and facilitating makerspaces. Nonetheless, almost all librarians had extensive experience in implementing youth and teen programming, including STEM programming, although fewer librarians/teachers were knowledgeable about makerspaces or engineering design, in particular. Many librarians/teachers have the capacity and resources to implement technology-oriented or STEM programming for teens and they have a strong interest in facilitating programs that focus on inclusion and diversity in design, such as the Build a Better Book program. However, there is a demonstrated need to provide training and capacity-building for librarians/teachers in universal design, engineering design, makerspaces, and 3-d printing and modeling, as these are the areas in which they have the least expertise.

Demographics of Librarian/Teacher Survey Respondents

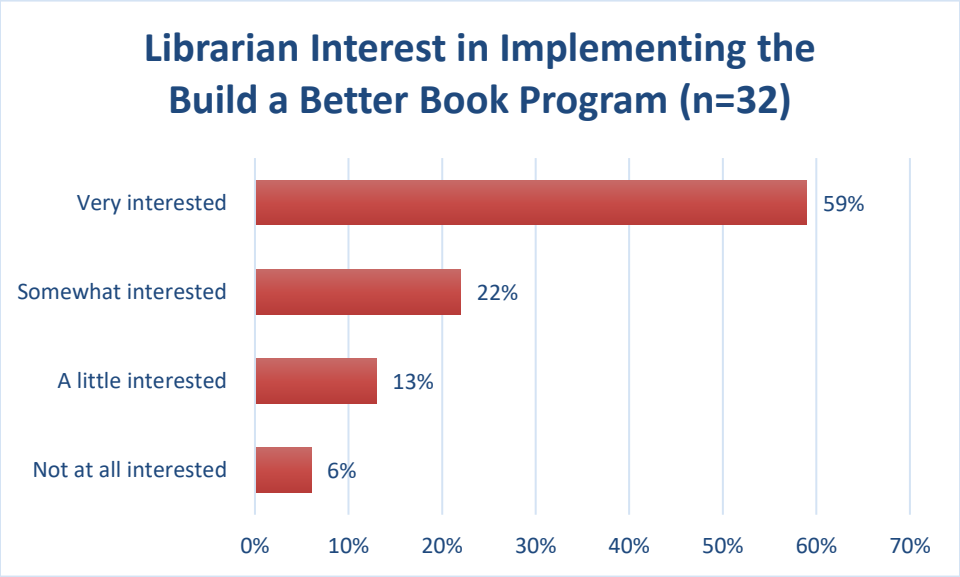
Survey respondents were recruited from the Fall, 2016 Build a Better Book training in Colorado, the Fall 2017 training in Colorado, and from the Summer, 2018 ISTE conference. In all, 44 librarians/teachers completed the survey. Almost all respondents were librarians, however, two were teachers and three were school librarians. Four others had unique positions, such as media specialist or library director. Respondents hailed from a variety of communities: 27% were from urban organizations, 33% were from rural organizations, and 40% were from suburban organizations. Therefore, respondents were relatively evenly distributed across different types of communities. Although the sample was relatively small, the geographic distribution of survey respondents indicates that these findings may be generalizable across different geographic regions or community types.

Interest in Providing the Build a Better Book Program

Librarians/teachers were highly interested in providing the Build a Better Book program at their site. In fact, 81% of all survey respondents were interested in implementing the Build a Better Book program. There was more variation in responses from the 2016 Colorado training as a few respondents from that training indicated that they were only "a little" or "not at all" interested. On the other hand, 100% of survey respondents from the more

recent Colorado training were "very interested" in implementing Build a Better Book. The figure below outlines the range of interest from respondents of both training surveys.

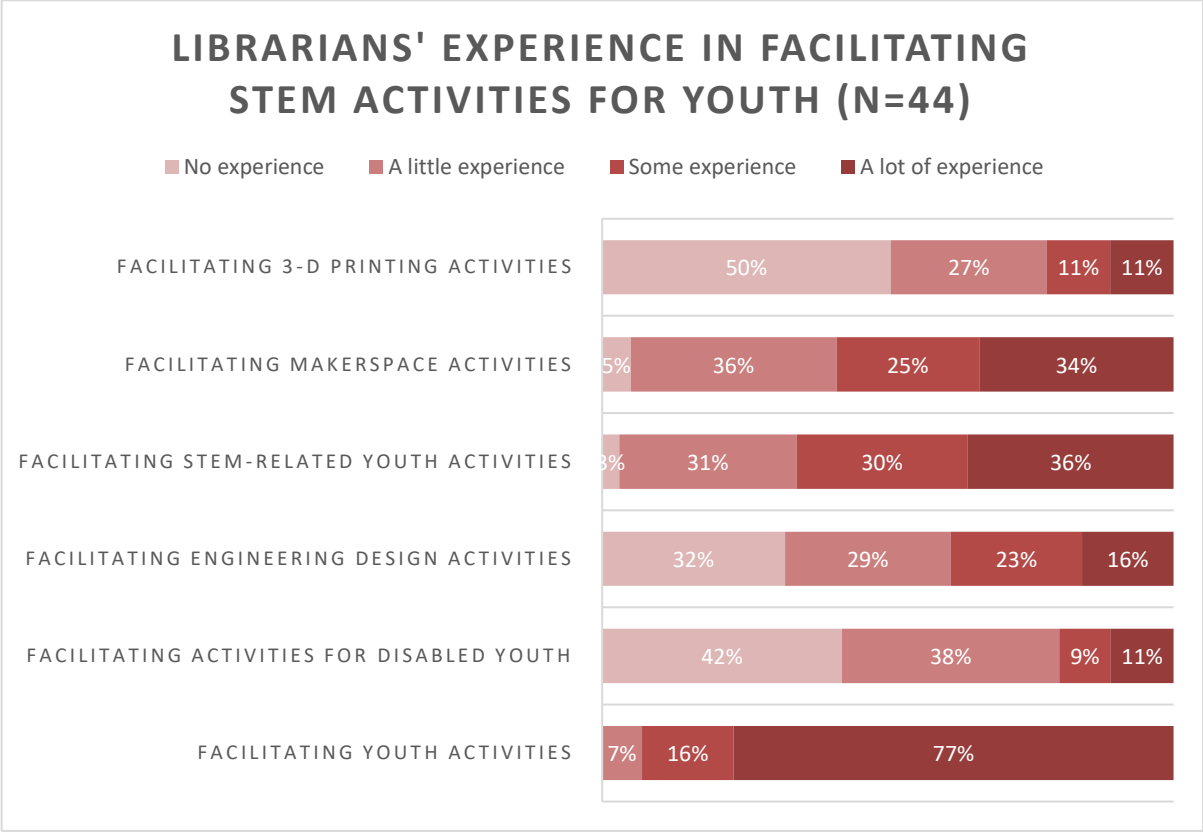
Figure 18. Librarian Interest in Implementing the Build a Better Book Program



Librarians' prior experience in facilitating youth or STEM programming

Almost all of the librarian and teacher survey respondents had experience in implementing youth programming but fewer had experience in implementing STEM-oriented youth programming. Most librarians had little to no experience in implementing programs or activities for youth with disabilities—only 20% of librarians/teachers had "some" or "a lot" of prior experience in facilitating activities for disabled youth. About half of librarians/teachers had prior experience in facilitating Makerspaces or "making" activities. Fewer librarians/teachers had experience in facilitating engineering design activities for youth; 60% had little or no experience in this area. Finally, most librarians/teachers (77%) had little to no background in facilitating 3-d printing activities. Thus, while librarians/teachers had some expertise in general STEM activities, they had less expertise in engineering design and little expertise specifically in 3-d printing programming and activities for youth.

Figure 19. Librarians' experience in facilitating youth activities (n=44)

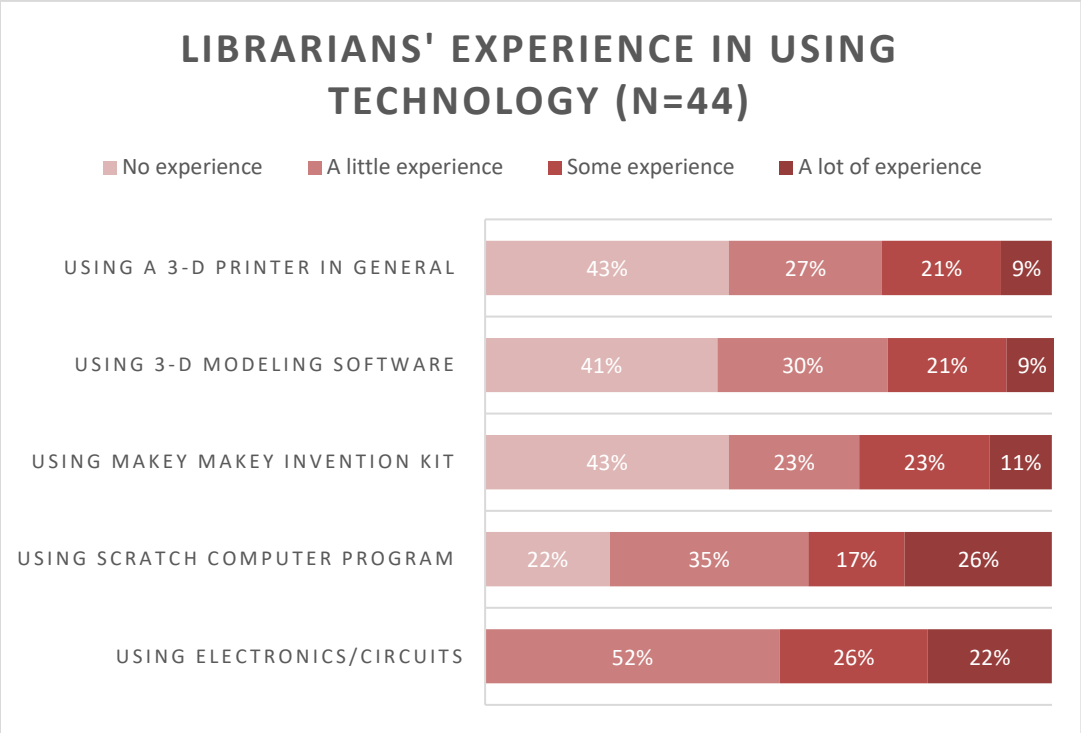


On the other hand, the librarian partners/facilitators of the Build a Better Book program in the local area have extensive experience in youth programming and makerspaces. The educator at Wings Over the Rockies, for example, had some prior experience with STEM programming for youth, but less experience with 3-d printing and modeling. The librarian at the Boulder Library, on the other hand, had been working with Makerspaces for many years—including 3-d printing—and had wanted to work with accessibility and design issues even before she was approached about the Tactile Book Project. Thus, the project was a great fit for her interests, skill set, and the resources provided in the Boulder Library makerspace. She also commented that her involvement with the program had shifted her perspective in how she thought about accessibility, especially in designing library programming. She noted that she had shifted from a "passive" perspective of viewing accessibility as complying with ADA requirements, to a more "active" approach of consciously and thoughtfully designing programs to include people with disabilities.

While librarians/teachers had some experience in facilitating STEM and makerspace programming, they had limited experience with specific "making" technologies, such as

Makey Makey or 3-d printers. Most frequently, librarians/teachers had experience in using electronics or circuits. A fair number of librarians/teachers (39%) had "some" or "a lot" of experience in using Scratch computer programming. However, librarians/teachers had much less experience in the technologies targeted by the Build a Better Book program, such as 3-d printing and Makey Makey. For instance, less than a third of librarians/teachers had "some" or "a lot" of experience with 3-d printing. In fact, nearly half of librarians/teachers had no experience in using a 3-d printer. Similarly, about a third of librarians/teachers had some experience in using Makey Makey, while nearly half had no experience at all in using Makey Makey. Therefore, librarians/teachers demonstrate a need for training and programming that will improve their skills and their capacity to deliver youth programs using 3-d printing or other technologies, such as Makey Makey.

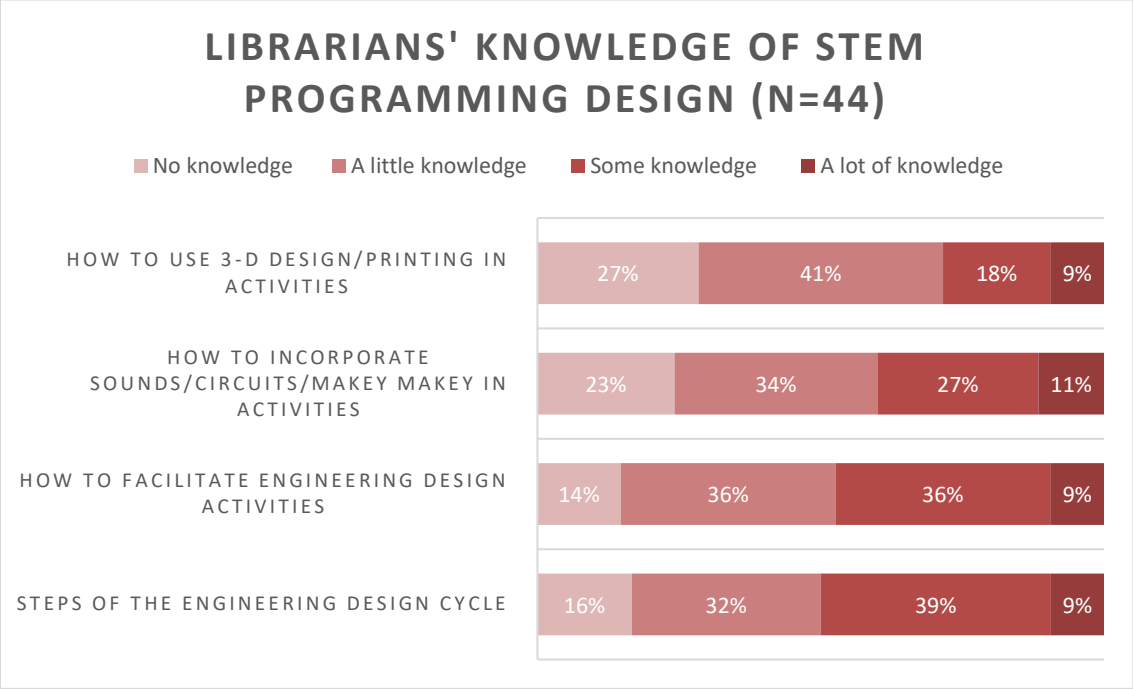
Figure 20. Librarians' experience in using technology (n=44)



Librarians/teachers had limited knowledge about designing STEM programming or activities. Librarians/teachers had the least amount of understanding of how to incorporate 3-d printing into youth programming or activities—over 2/3 had little or knowledge of how to 3-d printing in STEM programs for youth. Librarians/teachers also had little to no knowledge of how to integrate Makey Makey or circuits into youth activities. In keeping with their limited understanding of engineering in general, about half of librarians/teachers had little to no knowledge of how to incorporate the engineering design cycle into youth activities. Librarians/teachers also had a limited understanding of the steps of the engineering design

cycle. Overall, most librarians lacked the expertise to facilitate STEM programming—especially makerspace or engineering design activities—without training and support, suggesting a widespread need for training and support of librarians to implement design-oriented programming that uses 3-d printing and other technologies.

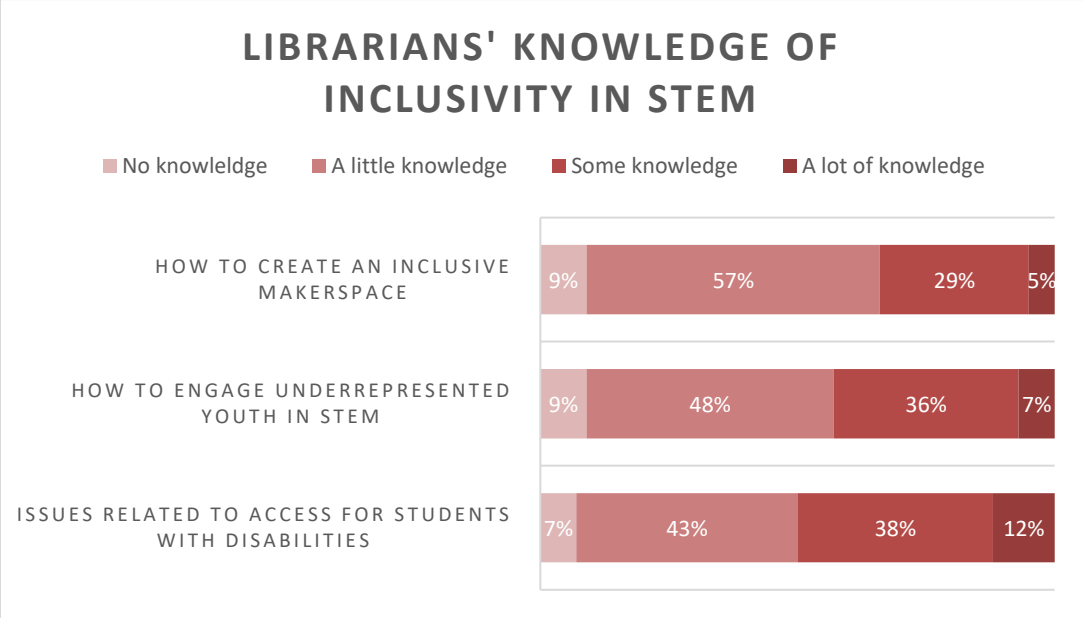
Figure 21. Librarians' Knowledge of STEM Programming Design



Librarians' prior knowledge of inclusive environments in STEM programming

Librarians had limited knowledge about issues related to designing programs for underrepresented youth, especially in terms of makerspaces or STEM programming. For instance, librarians lacked knowledge about how to create an inclusive makerspace for youth, as only 5% of librarians had "a lot of knowledge" in this area. In fact, two thirds of librarians/teachers had little to no knowledge about designing inclusive makerspaces. Librarians/teachers had more familiarity with issues related to general access for youth with disabilities; still, 50% of librarians/teachers reported little to no knowledge in this area. Therefore, librarians/teachers could clearly benefit from training and support in designing and implementing universal, inclusive technology or engineering design programming and makerspaces.

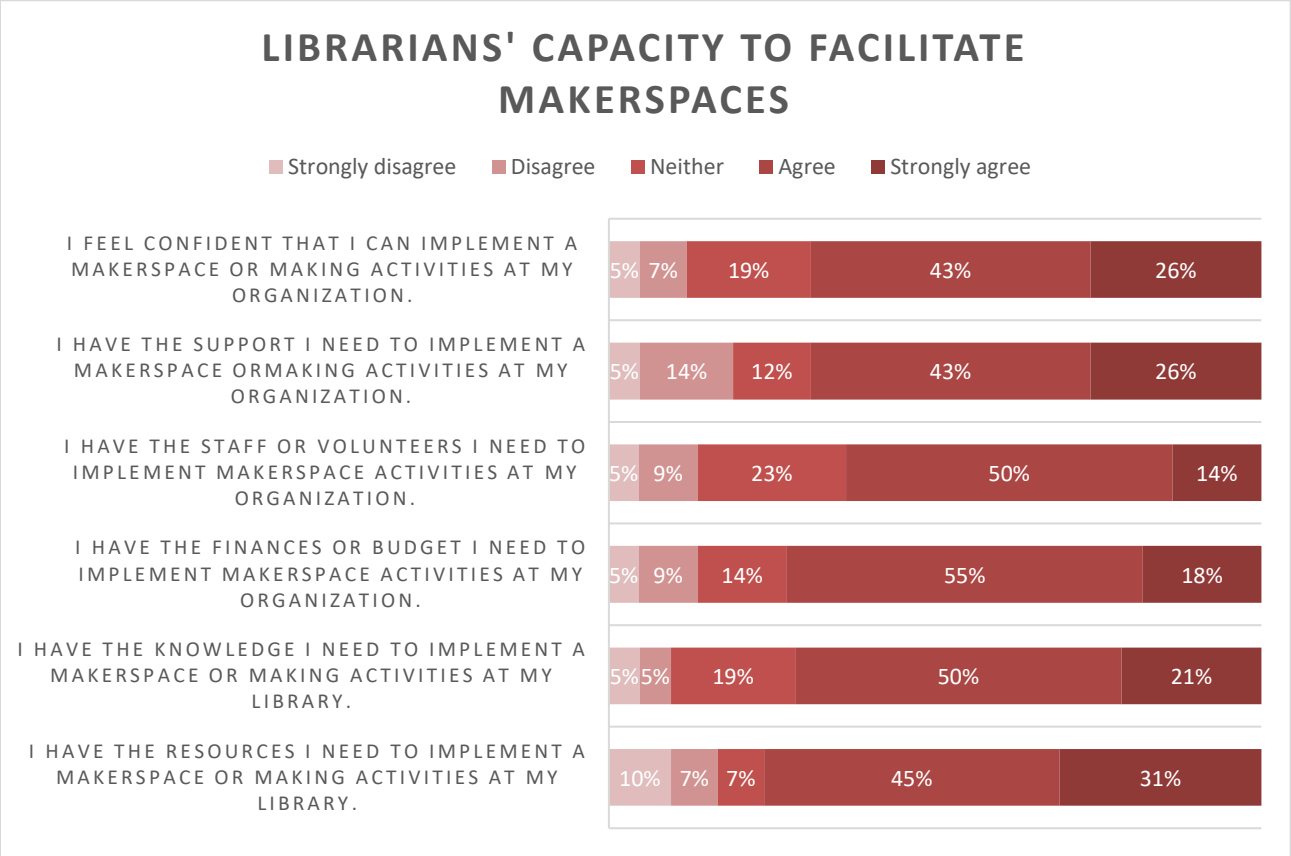
Figure 22. Librarians' Knowledge of Inclusivity in STEM



Librarians' capacity to implement makerspaces and STEM programming

For the most part, librarians/teachers have the capacity and knowledge to facilitate makerspaces or making activities within their organization. For instance, 86% of librarians/teachers felt that they have the resources to facilitate a makerspace, while 69% felt that they had the support they needed to facilitate a makerspace or to provide making activities. Nearly three quarters of librarians/teachers had the knowledge they need to implement a makerspace, although from their other survey responses, they clearly lack knowledge of some aspects of facilitating a makerspace. As noted in the section on challenges, librarians/teachers were somewhat less likely to have the finances or the staff/volunteers to facilitate makerspaces in their organization.

Figure 23. Librarians' Capacity to Facilitate Makerspaces



The Boulder Librarian also noted that librarians need to be comfortable with design and discovery processes and open-ended curricula that might be driven by youth more than the adult facilitator. Successful markerspaces and inquiry-based STEM programming are often driven by youth choice and interest and some facilitators may have varying comfort levels with that type of open-endedness. She commented:

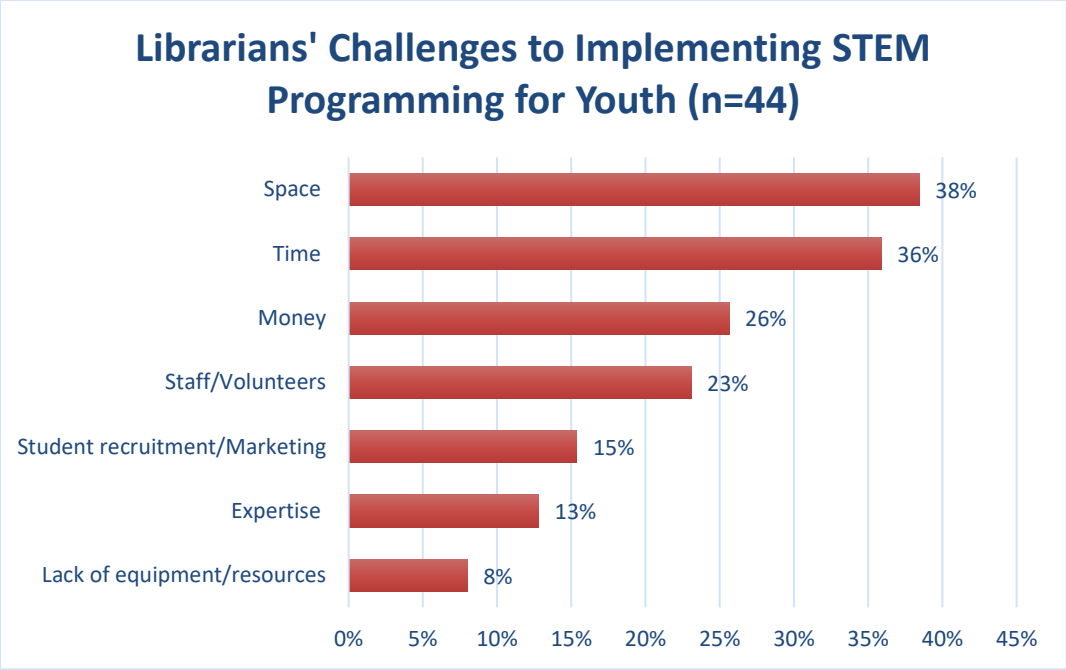
> *You do have to make sure you're working with facilitators that are comfortable with that approach. But I certainly was and I think that it was part of the success was that we let the students drive where the final projects went. – Boulder Librarian*

Challenges to hosting STEM programming libraries

A lack of physical facilities to provide programming and a lack of time to create and implement curriculum and activities are the primary barriers faced by librarians/teachers in providing STEM-oriented programming to youth. About a quarter of teachers/librarians noted a lack of financial resources to implement STEM programming at their sites. Likewise, a lack of staff or volunteers to implement STEM programs was an obstacle cited by nearly a

quarter of librarians/teachers. Some librarians/teachers (15%) noted that they would have difficulty in recruiting students or marketing a STEM program to the target youth audience. Interestingly, although librarians acknowledged that they had little expertise or experience in 3-d printing, technology, or STEM, most did not feel that their lack of expertise was a hindrance in implementing STEM programming. Finally, a few librarians/teachers (8%) noted a lack of technology, equipment or materials at their organization to run a STEM program.

Figure 24. Librarians' Challenges to Implementing STEM Programming for Youth (n=4)



Following are typical comments about challenges faced by librarians/teachers in implementing technology or makerspace programming. Many of the comments focused on lack of space, lack of expertise, and lack of staff to run the programs.

> *We have little space, and a very limited budget for purchasing laptops, 3-D printers, etc. smaller scale maker ideas are more probable.*

> *Depth of knowledge / comfort level of staff to facilitate*

> *lack of staff - lack of space - children in the area have a lot of options in lots of different areas so I end up competing with other non-profits for kids to come to an afternoon program*

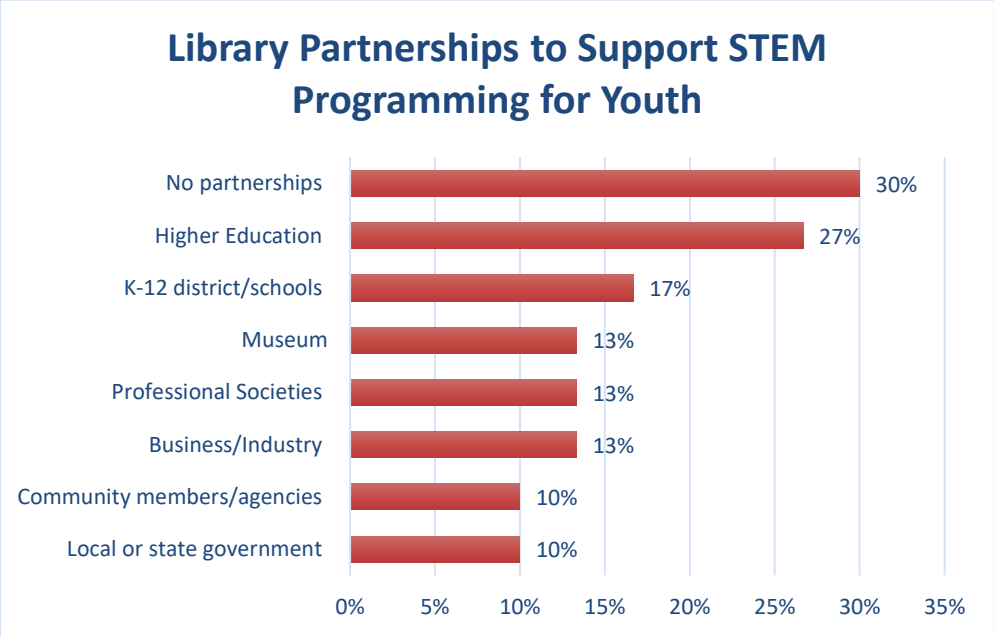
> *Staff time, money for materials, marketing and outreach opportunities to youth.*

Personnel. We are at capacity with our current staff. Reaching new audiences.

Partnerships

Partnerships are one way in which libraries can support STEM programming and makerspaces because partners can provide the technical expertise and, possibly, perhaps even materials and equipment. Indeed, 70% of librarians/teachers had existing partnerships to facilitate STEM-oriented youth programming at their library or site. However, several of these partnerships involved a paid organization that provided STEM programming at the library. Universities were the most common partner leveraged by libraries/schools to provide or support STEM programming. Other partners included STEM or library professional societies, community members, non-profits, local government agencies, and K-12 districts or schools. These organizations provide programming, training, curriculum and materials, volunteers, instructors, or support for library-hosted STEM programs serving youth. Therefore, partnerships are an essential aspect in building the organizational capacity of libraries to provide and deliver STEM programs and activities for youth. The majority of librarians/teachers reported one or two partner organizations, although some reported multiple partners. Additionally, a full 30% of respondents noted that they had no partners to assist with STEM programming for youth, indicating a widespread need for organizational partnerships to enhance the capacity of libraries to deliver STEM programming.

Figure 25. Library Partnerships to Support STEM Programming for Youth

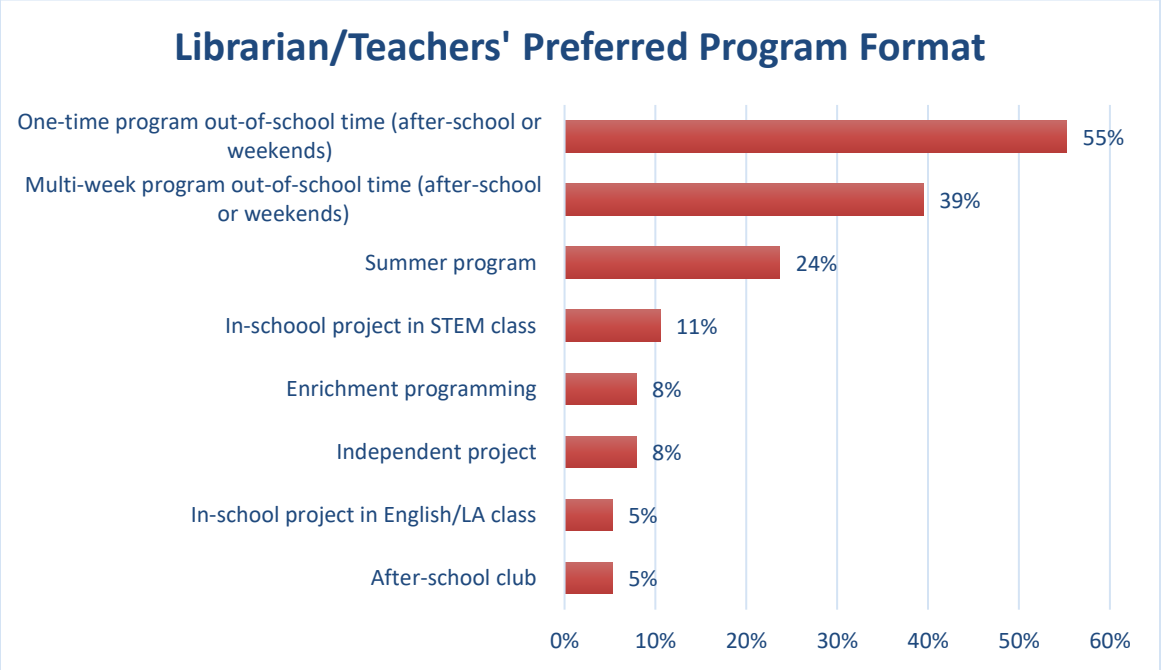


Librarians' preferences for formats for providing technology-oriented programming

Librarians (55%) preferred one-time workshops to extended programming for offering STEM programs for youth. Still, over one third of librarians preferred a multi-week format

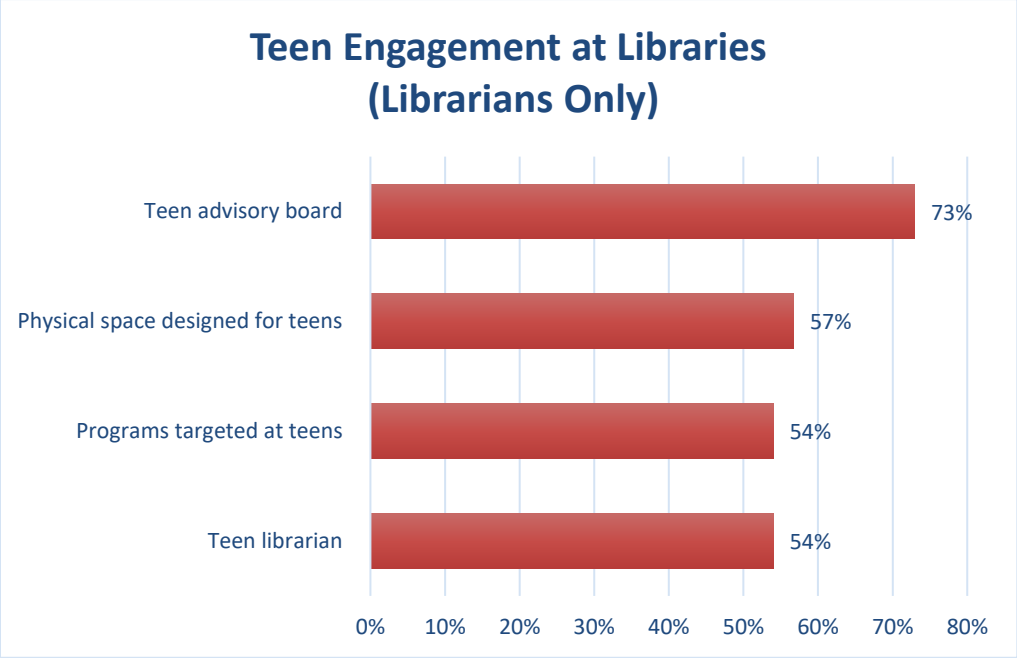
for out-of-school STEM programming, whether after-school or on weekends. Nearly one quarter of librarians preferred summer programs. Teachers overwhelmingly preferred in-school projects in STEM courses, although two teachers preferred to provide technology-oriented programming in English or Language Arts classes.

Figure 26. Librarian/Teachers' Preferred Program Format



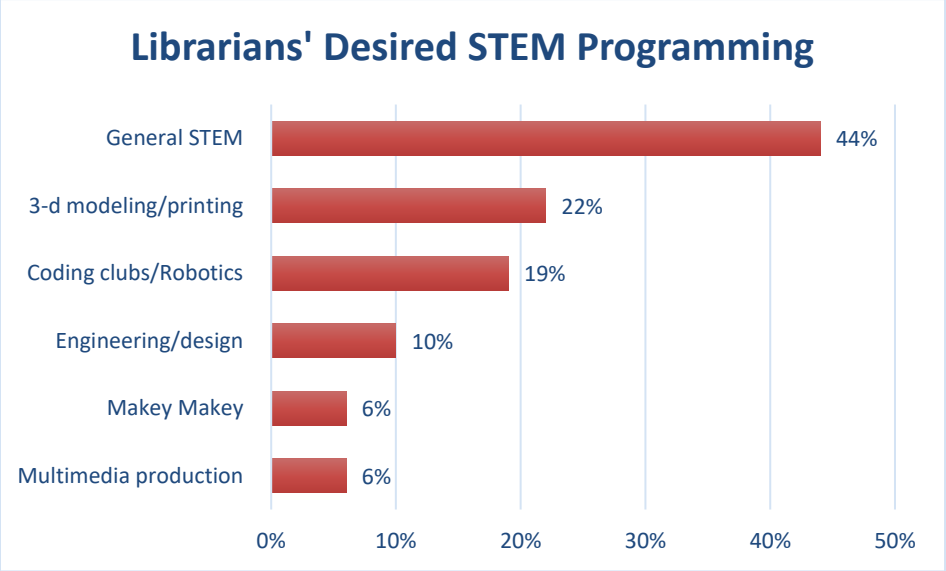
Libraries had various ways of engaging teens in their library programming, strategic planning, and other activities. All librarians reported that their libraries had at least one, if not multiple, ways of engaging teenagers. The most common way of engaging teens was to have a teen advisory board to advise the library on teen services, collections, and physical space. About half of libraries had a dedicated space for teens, a dedicated teen librarian, and/or specific programs targeted specifically at teens. Therefore, all librarian survey respondents worked at libraries that actively engaged teens in multiple ways.

Figure 27. Teen Engagement at Libraries (Librarians Only)



There was some consensus in respondents' written answers to an open-ended question regarding STEM-oriented programming that librarians would like to implement if they had the resources and the capacity. General STEM or makerspace programming was the most common response, suggesting that some libraries have little existing STEM programming or have a need to expand general STEM offerings. Some librarians/teachers also expressed a desire to implement 3-d printing, 3-d modeling or Build a Better Book programs. About one fifth of librarians/teachers would also like to implement coding or robotics if they had the expertise and resources to do so.

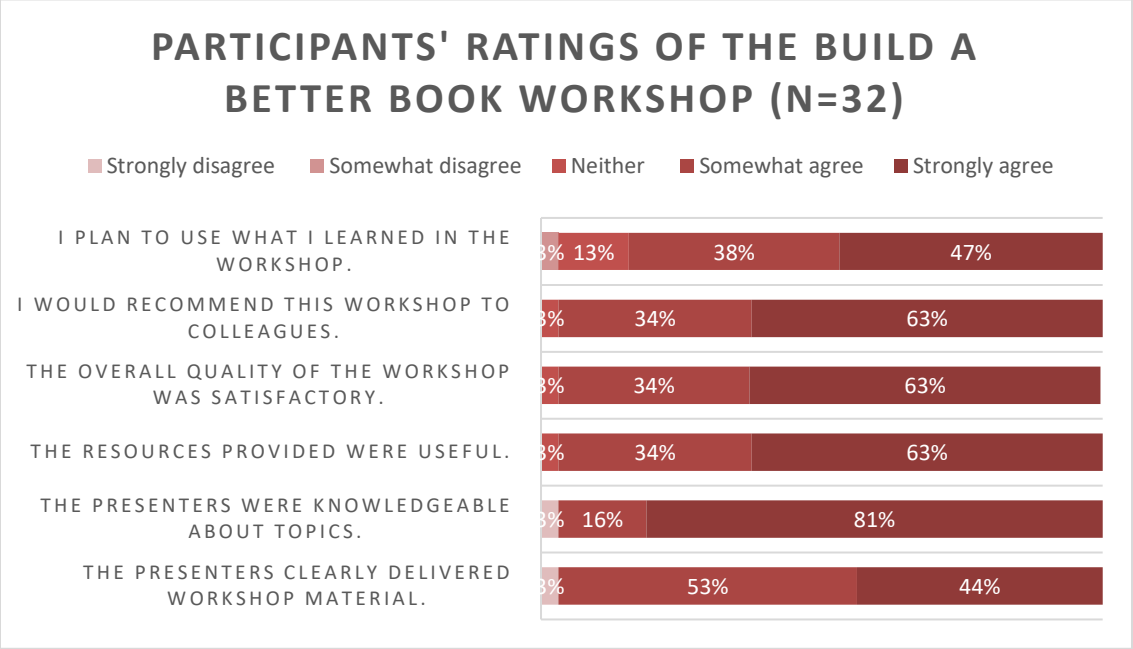
Figure 28. Librarians' Desired STEM Programming



Workshop outcomes

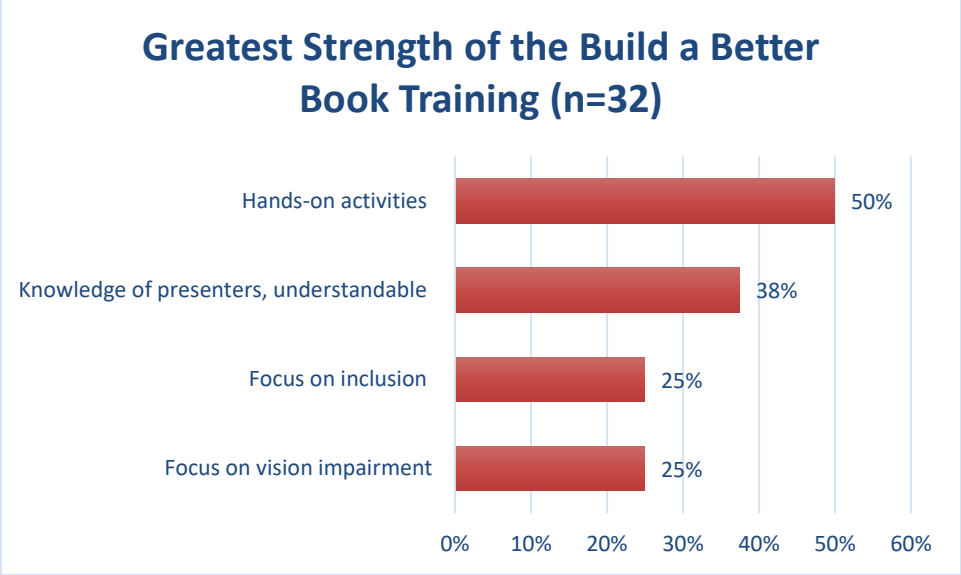
Librarians/teachers clearly have a desire to facilitate the Build a Better Book program, and a need to boost their knowledge and skills in implementing makerspaces, facilitating inclusive programs, and to gain expertise in specific technologies, such as 3-d printing. The Build a Better Book training boosted librarians' skills in these areas. Overall, librarians thought that the Build a Better Book workshop was useful and informative. There was strong agreement (97%) that the workshop presenters were knowledgeable and the content was clearly delivered. Librarians/teachers (100%) also found the resources provided to be useful. Indeed, 97% of the attendees would recommend the Build a Better Book training to a colleague.

Figure 29. Participants' Ratings of the Build a Better Book Workshop



Librarians benefited from the experiential nature of the workshop, particularly the hands-on activities in the workshop. Several attendees highlighted the impact of the blindfold activity where they could experience the world as a blind or visually impaired person would. Attendees also benefited from the workshop facilitation by a visually impaired person which deepened their understanding and sense of empathy, according to several of the workshop participants. Attendees also appreciated the way in which the presenters clearly and knowledgeably delivered the training. Additionally, attendees also noted the large amount of resources and information shared during the training and appreciated the focus on customizing the Build a Better Book program to meet their organization's capacity and needs.

Figure 30. Greatest Strength of the Build a Better Book Training



Librarians' comments about the workshop echoed their thoughts about its greatest strengths. Most of the comments related to the focus of the workshop, such as the focus on inclusion, universal design, and understanding the needs of visually impaired people. However, attendees also noted the importance of the hands-on activities and resources available during the workshop. Some of the comments related to specific activities—such as the blindfold activity or the opportunity to make a tactile book—that deepened their understanding of technology and inclusion. Librarians also appreciated the focus on disabilities which helped to shape their understanding of inclusion in their libraries programming and in their own lives.

> *"I really liked having the blindfold experience before we started making our tactile pages. It really helps us "see" how those with blindness or low vision might view the world. Helps create empathy. Makes us think beyond a flat, colorful page and how we could make that page come alive for someone with these challenges."*

Participants also appreciated the opportunity to learn from someone who is visually impaired, as noted in the following comment.

> *"The hands on and the testimonials were great. It was also very important to have the voice of someone who is vision impaired involved."*

Attendees liked the merging of human concerns with the engineering design process which was one of the main draws of the Build a Better Book program, as shown in the following comment.

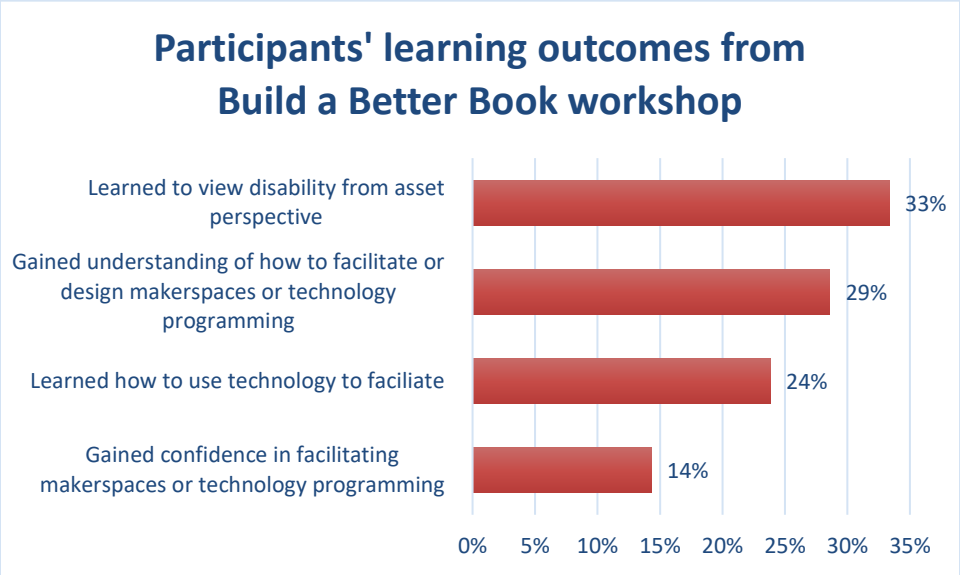
"Bringing in the empathy piece to the design process."

Finally, as mentioned previously, librarians appreciated the opportunity to customize or adapt the program slightly to work for their student population and organizational needs, as highlighted in the following comment.

"How the content was all there, but we have a lot of freedom to make this work for our students in our space."

In an open-ended question, librarians commented on their learning from the workshop. The most common responses are highlighted in the figure below.

Figure 31. Participants' Learning Outcomes from Build a Better Book Workshop



The primary learning gain cited by workshop attendees related to their view of disability. In fact, 33% of librarians learned to view disability from an inclusive and assets-based perspective.

"That you need to consider perspectives that are different from yours. Understanding how others access the world."

Additionally, 25% of librarians commented that they gained a better understanding of how to use technology to facilitate learning experiences for youth with disabilities. And nearly a third of attendees gained a general understanding of how to design or facilitate makerspaces or technology programming. Thus, attendees gained an overall view of how to facilitate Build a Better Book and gained facility with the technology and resources that they would need to implement it at their site.

"There are so many new technologies that can help make experiences more accessible to people with diverse needs."

Participants also gained confidence that they could use the technology involved in the Build a Better Book program. Overall, increased comfort with technology and familiarity with resources contributed to participants' confidence that they could facilitate a Build a Better Book program within their organization.

"My knowledge base increased based on this training, and I feel so much more comfortable planning to facilitate programming like this."

Workshop attendees had a few suggestions for improving the workshop. The majority of participants wanted the workshop to be longer to provide more opportunities to work with the technology. On the other hand, some participants requested more time to talk about inclusivity and how to facilitate STEM programming around disability, especially about how to facilitate conversations with students about universal design, disability, and inclusivity. Typical comments are as follows:

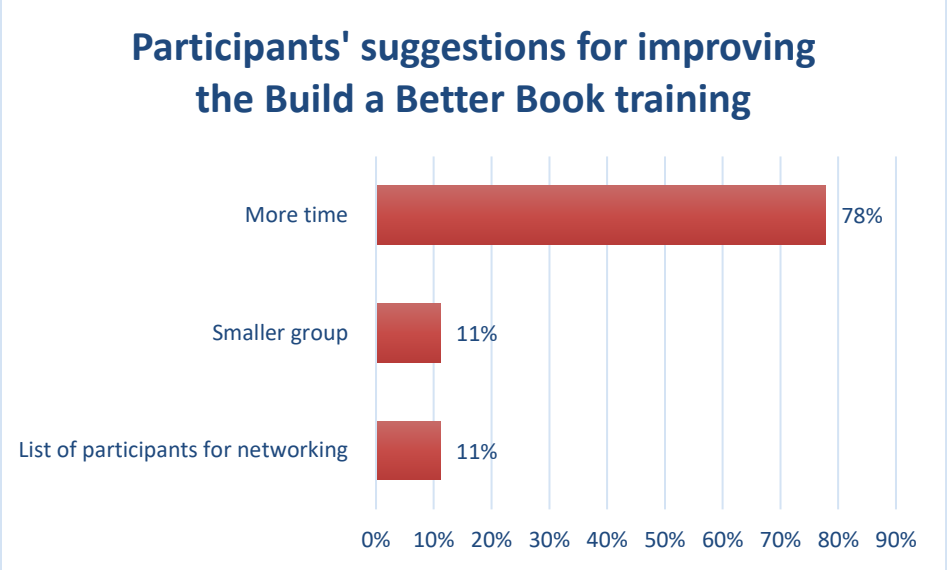
"More time to learn some of the skills and techniques needed to create the most effective books. For example, an actual lesson and hands-on experience with the Makey Makey for those of us who are unfamiliar."

"I would love to have a little more time talking about how to engage students in the inclusivity conversation. What to say, how to facilitate etc. "

"More time on tools and also on blindness so I can feel comfortable and competent finding people and resources in my community. "

A few participants recommended that the workshop be offered to a smaller group of participants to allow more time to practice hands-on activities. A few participants also requested a list of participants, so they could network and share program resources and ideas with one another.

Figure 32. Participants' Suggestions for Improving the Build a Better Book Training



Implementation of Build a Better Book

One site that participated in the Build a Better Workshop training (Wings Over the Rockies) implemented the curriculum after participating in the workshop. The museum implemented the program twice, once with direct support from Build a Better Book facilitators, and one implementation on their own. The educator from Wings felt fully supported by the Build a Better Book program, saying they were "always available when needed" and that she "felt completely supported the whole way." She also asserted that the training had "definitely" prepared them to implement the BBB program at their site. She commented that many aspects of the training had prepared them run the program on their own:

> *So, I think the most helpful components of the training were the hands-on, actually building a page. The other part was hearing from some speakers who were visually impaired to hear their insights into their needs and what we can do. But I think really the hands-on, using the technology, building a book page of our own, something like that was incredibly helpful. And then, for sure, receiving the materials to help us implement us, so the actual box of things we can use was definitely helpful too. – Wings Over the Rockies educator*

In conclusion, librarians were highly satisfied with the Build a Better Book workshop training. They appreciated the introduction to the technology and resources that they would require to facilitate the program. Additionally, attendees felt that the workshop broadened their perspective on issues related to the inclusion of people with disabilities.

High School Mentor Outcomes

The mentor interviewed this summer first became involved with the BBB project through the six-month BBB internship program offered through the Boulder Museum in 2017-18. He enjoyed the internship so much that he looked for other opportunities to be involved with the Build a Better Book program and became a mentor. He noted that the mentor position had built his confidence, especially when he realized that he was younger than the Pre-Collegiate program students that he was mentoring:

> *It was surprising for me that the students weren't younger than me. They're older than me, so, for me, that was like "wow". I think it's great for another reason too. I can share some things that I've been learning through these other programs I've been participating in [museum internship] and show some of the abilities I've learned. To be a mentor you have to be willing to share what you learned. It was pretty cool for me to do.*

He commented that being a mentor had not changed his career path because he had always planned on being an engineer, so it helped maintain his interest in that path. Also, he had been exposed to some of the tools and technologies used in the BBB programs, so it served to reinforce his existing skills, rather than introduce new skills. However, he noted that being a mentor had impacted his confidence and his social skills, as shown in this comment:

> *[it helped me to] Be more sociable, because I wasn't that much assertive. The first day I was not so sure how would be a relationship with mentor and student. As the project was done I think I gained confidence to talk to the students. And share what I know.*

Conclusion

In its second year of implementation, the Build a Better Book program implemented several extended program models, including in-school, after-school programs at libraries, multi-week programs at museums, and multi-week summer programs. The program clearly provided an authentic making experience for students, focused on design, student choice, creativity and problem-solving, and the use of a variety of tools and resources. For one, the program scored highly on all of the markers of authentic making on the observation rubric, including the highest marks for attention to audience, student design, and use of out-of-school tools. The program also scored very highly on teacher-student rapport, student choice, use of project-based learning, and inclusion of all students. Thus, the program has been implemented at multiple sites with multiple instructors and all programs have reflected the curriculum's focus on accessibility, design, and student choice within a making environment. Although, one iteration of the program (Boulder Canyon meeting room) scored lower on these design factors and was not quite as focused on function, use, and accessibility in design, highlighting that instructor training and support in these areas is very important. On the other hand, some

program models generally scored slightly lower on collaboration because students worked individually at some sites and in cooperative teams at other sites. Additionally, the BBB program in general scored slightly lower on feedback and revision of student work. For the most part, teachers provided student feedback and individualized instruction at almost all observed sites, but students were less likely to provide feedback to each other. If the BBB program would like to encourage more peer-to-peer feedback, the program might consider the use of structured protocols for providing peer feedback at intermittent points throughout the program, or conducting gallery walks or similar activities where students can provide structured, summative feedback to their peers.

Students demonstrated that they had deeply engaged in the design process and had given thoughtful attention to their intended audience of blind or visually impaired youth. Students described how they brought in the lens of disability into the design process, to understand how their products would be experienced by someone who is visually impaired. Students were most proud of learning new technologies, such as Tinkercad, and problem-solving any challenges that arose during the design process. However, one of the most impactful outcomes related to the design process was students' ability to adopt the perspective of a blind or visually impaired person. Most students had never considered how a visually impaired person experiences the world and their exposure to this perspective through the BBB program fostered a sense of empathy and understanding of the experiences of others. Students also found the most rewarding part of the program to be the opportunity to help people and to work on a meaningful project. Compared to a traditional, hand-on engineering curriculum that some students experienced in a concurrent summer program, students reported that the BBB program brought the "humanity" into engineering. Students also found the BBB program to be more creative and open-ended than their other engineering activities.

Students' interest in STEM careers largely held steady over the program, although there was a very slight uptick in the number of students interested in a career that uses technology to help people. Multi-week programs, especially summer programs, were more effective than shorter-term programs in fostering career interest, although the differences among programs were slight. The greatest change in career interest from the program was a statistically significant increase in students' interest in a career that uses 3-d design or modeling. Students' general interest in an engineering career also grew during the program. In interviews, students clarified that they had not necessarily altered their career plans because of the BBB program, but they were much more open to a career or a major in engineering than they had been before the program. Because many students in the past year did not opt into the program, there were a fair number of students without pre-existing interest in engineering. Nevertheless, some of these students had become more open to and interested in an engineering career than they were at the start of the program. Students' interest in different kinds of making activities stayed constant or declined slightly over the program, yet observations and interviews indicate that students were highly engaged in and invested in

their projects. Students who opted in to the program showed larger increases in interest in making activities than students who did not opt in. Likewise, older students (10th grade and above) showed greater gains in technological self-efficacy than did younger students (middle school or early high school).

Librarians benefited greatly from the training provided by the Build a Better Book team. Librarians came to a new understanding of accessibility and disability and increased their awareness of the need to include people with disabilities in their programming. The majority of librarians were interested in providing the Build a Better Book program at their site, including 100% of librarian participants at the recent Colorado training. The educators who implemented the program (Wings museum) felt fully prepared from the training and supported in the implementation. Most librarians had prior experience in facilitating youth or STEM-related programming, but few had experience in programs related to accessibility or 3-d printing. Few librarians had knowledge about developing programming for underrepresented students or facilitating inclusive Makerspaces. Additionally, a lack of space, time, staff, and funding served as challenges to most librarians in offering more making or STEM-related programming for teens. Nonetheless, there is strong interest in providing the BBB program, yet a lack of specific expertise in accessibility and 3-d printing, suggesting a need for ongoing training and support for librarians who might adopt the program.