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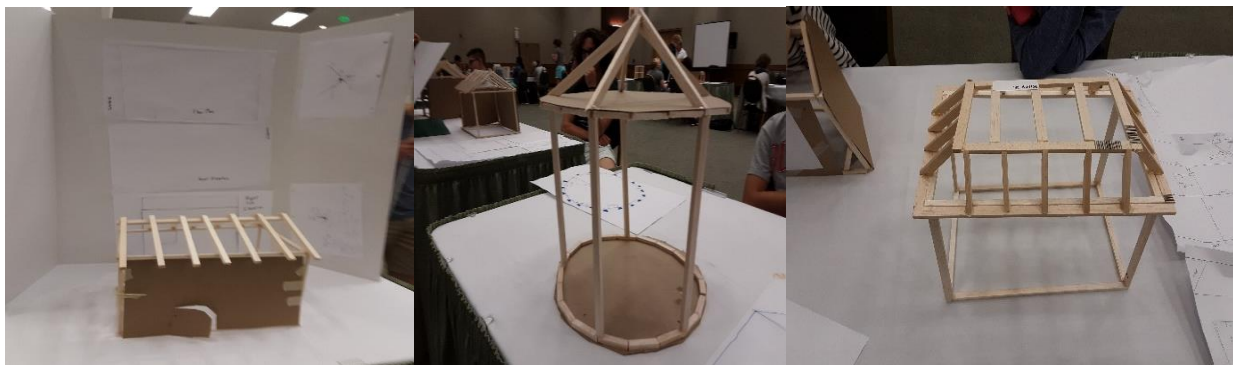
Spatial Ability Blind Engineering Research (SABER): NFB EQ (Engineering Quotient) Program

Year Two Evaluation

January, 2020

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Prepared for:
National Federation of the Blind



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Dear President Riccobono and NFB,

This email is just a small token of gratitude for my immense gratitude for the program that I participated recently. It has opened my eyes to areas that I thought were impossible and has shifted my attitude to what it means to be a blind man. I wholly enjoyed my time with the NFB where I have met the most amazing humans and also have formed life-long friends. Thank you for this experience.

-2019 NFB EQ Summer Program Participant

“I would like to express my gratitude for this program. I have learned so much about engineering and that it can be made accessible for the blind. In addition, I have met many amazing staff who have taught me about engineering as well as life skills, which are very important as someone who is visually impaired. Lastly, this program has increased my knowledge with accessibility and given me a network of people I can reach out to.”

-2019 NFB EQ Summer Program Participant

“I am the only blind person at my school, and this week was so inspiring meeting and talking with so many other blind people like me. It was amazing. This program allowed me to engage in, gain a better understanding of, and apply real engineering concepts. It was so satisfying to learn these concepts and then do something using the concepts.”

-2019 NFB EQ Summer Program Participant

Executive Summary

Introduction

The National Federation of the Blind (NFB), in partnership with scholars from Utah State University and educators from the Science Museum of Minnesota (SMM), has developed the Spatial Ability and Blind Engineering Research (SABER) project to assess and improve the spatial ability of blind teens in order to broaden their participation in STEM fields. The goals of the project include:

1. Contribute to the knowledge base of effective practices regarding informal STEM education for the blind, particularly relating to the development of spatial reasoning abilities.
2. Educate families, blind youth, and museum personnel about the techniques, tools, and instructional practices rooted in problem solving to effectively develop spatial ability skills in blind youth in informal STEM-learning settings.
3. Incorporate promising techniques, tools, and instructional practices from the developed interventions into ongoing programming for both blind and sighted learners.

In June 2019, 30 teens who had just completed 9th to 12th grade arrived at the National Federation of the Blind (NFB) Jernigan Institute in Baltimore, Maryland to attend the 2019 NFB EQ Summer Program. As with the previous year, this second year of the NFB EQ summer program was primarily composed of two types of sessions: 1) instruction, and 2) building, in an intense STEM-based program where each individual teen participant designed and created a PMO (Place of My Own) personal retreat space model building. Teens developed a portfolio that included graphic artifacts (front elevation, side elevation, structural column-beam plan, floor plan), narrative artifacts (final design brief, self-reflection), algorithmic artifacts (load calculations, column justification, rafter justification, truss analysis), and a scale model. A third type of session involved several blind engineers sharing their successes and challenges of navigating various engineering fields. The program also included a field trip to the nearby Jerusalem Mill and Village.

The Lifelong Learning Group (LLG), now the Center for Research and Evaluation (CRE), at the Center of Science and Industry (COSI) in Columbus, Ohio conducted an evaluation of the NFB EQ program during the first year of implementation. This second year evaluation focused on perceptions of process and measures of efficacy around key themes including drawing and drafting, measurement, and building and construction.

Methods

Evaluators collected data from the 2019 NFB EQ program teen participants using three different methods:

1. Passive observations throughout the program, comparing these notes with the goals of the program. The evaluator used these notes to facilitate daily staff debriefing discussions.
2. Brief open-ended, semi-structured interviews conducted with participants pre- and post - program.
3. A pre- and post-program web-based questionnaire.

The interview and questionnaire focused on the teens' interest in STEM, future career intentions, and the impact of the NFB EQ program. Themes related to interview responses emerged from the data itself rather than being prescribed. LLG analyzed quantitative data using Excel and the Statistical Package for the Social Sciences (SPSS) and used descriptive statistics to present overall patterns in the data.

Findings

A future evaluation report, in consultation with the research team, will more fully answer how the NFB EQ program contributes to participants' development of spatial reasoning and ability. At the same time, post-program interviews indicated that by the end of the 2019 NFB EQ program several teens indicated they felt they had gained a better understanding of spatial ability and were able to describe fundamental concepts.

The majority of teens attended the 2019 NFB EQ program because they were interested in some aspect of STEM (specifically science, math, physics, and/or engineering) and/or wanted to learn more specifically about engineering. Teens expressed an interest in STEM for several reasons, including a desire to develop technology to support the blind and a desire to solve problems. While most participants had taken classes in school to support their STEM interests (including robotics, mechanical engineering, and computer programming), others shared they wanted to have this NFB EQ program STEM experience due to limited access to engineering and skill-building opportunities within their current school environment.

Responses to the pre-program questionnaire showed that most teen participants look forward to science and math classes at school and were already interested, to very interested, in pursuing a career in a STEM-related field.

A few teens indicated during their post-program interview that the 2019 NFB EQ program did motivate them to explore the possibility of a career in engineering. However, for most teens,

post-program questionnaire responses indicated about the same level of interest in pursuing a career in STEM as their pre-program responses. At the same time, post-program interviews found that the Program reinforced interest in pursuing a career in engineering, physics, or math of teens who were already interested in such a career.

The 2019 NFB EQ program teen participants said they most enjoyed the hands-on approach to the week and the skills they learned. These skills included constructing and testing a structure to help cross a river, drawing and drafting skills they practiced and used to design their PMO (Place of My Own) model structure, measuring and wood-cutting skills, calculating and testing of potential forces on their PMO model buildings, and the actual construction of their models. A few participants said they appreciated being able to hear from, and talk with, many people about their experiences being blind. In some cases, this person was a professional working in a STEM-related career or a peer with the Program about how they are meeting the challenge of designing and building their PMO model structure.

When asked during the post-program interviews what teen participants valued about their 2019 NFB EQ program experience, several talked about the friendships they had built with other blind teens their age, hearing how these new friends have adapted to their blindness, and recognizing they could find support for their life experiences from people like them. One teen expressed wanting to become more involved with the state youth group of NFB. Other teens talked about the opportunity they had to do something new in a new location. For one teen, attending the 2019 NFB EQ program was a valued opportunity to travel for the first time without an adult. One teen expressed a perspective, echoed by other participants, that the 2019 NFB EQ program reminded her that “being blind does not make things impossible”.

Conclusions

Based on the evaluation findings, LLG concludes the following about the NFB EQ program.

How the NFB EQ program contributes to teen participant’s development of spatial reasoning and abilities.

Conclusion: The NFB EQ program helps to increase some blind teens’ understanding about the overall concept of spatial ability, as well as reasoning and abilities as demonstrated in their building designs, drawings, drafting, and construction of a 3-D model structure.

The extent that the NFB EQ program influences teen participants’ interest in STEM and intention to pursue STEM study and career

Conclusion: Most participants are already interested in pursuing a STEM-related career when they attend the NFB EQ program. While the program may not necessarily influence participants to pursue a STEM career when they were not already planning to do so, the NFB EQ program does reinforce and strengthen participants' intent to pursue such a career.

Factors that contribute to increasing NFB EQ program teens' interest to pursue STEM study and a career

Conclusion: Factors that contribute to increasing NFB EQ program teen participants' interest to pursue STEM study and a career include:

- 1) The engineering-specific knowledge and information they learn
- 2) Increased self-confidence with some of the skills needed to conduct engineering tasks non-visually, such as measuring, conducting mathematical calculations, drawing and drafting, orthogonal projection, repeated trial and error testing, and designing and constructing scaled models
- 3) Support and inspiration from peers who experience the challenges of being blind
- 4) Believing they can be engineers and/or have a STEM-related career by hearing from blind engineers about their experiences in the field
- 5) Having a chance to be an engineer by engaging in a hands-on project in which participants use multiple engineering skills to design and build a scale model structure.

Teens' perceived value of the NFB EQ program experience other than contributing to development of their spatial reasoning and abilities

Conclusion: Teen participants believe that the value of their NFB EQ program experience extends beyond increasing their knowledge and skills related to spatial reasoning and ability. This includes an increased sense of affinity with other blind youth their age and confidence in what they can do and accomplish as a blind person.

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Introduction

The National Federation of the Blind (NFB), in partnership with scholars from Utah State University and educators from the Science Museum of Minnesota (SMM), has developed the Spatial Ability and Blind Engineering Research (SABER) project to assess and improve the spatial ability of blind teens in order to broaden their participation in STEM fields. The goals of the project include:

1. Contribute to the knowledge base of effective practices regarding informal STEM education for the blind, particularly relating to the development of spatial reasoning abilities.
2. Educate families, blind youth, and museum personnel about the techniques, tools, and instructional practices rooted in problem solving to effectively develop spatial ability skills in blind youth in informal STEM-learning settings.
3. Incorporate promising techniques, tools, and instructional practices from the developed interventions into ongoing programming for both blind and sighted learners.

2018 NFB EQ program (Year 1)

Activities for the first year of the grant began the summer of 2018 with a week-long, residential engineering design program for 30 blind high school students called the NFB EQ (Engineering Quotient) program held at NFB headquarters in Baltimore, Maryland. This program is designed to contribute to teens' development of spatial learning through technical drawing experiences that include isometric and scale drawing, as well as iterative engineering design process, and through critical feedback from instructors. On the last day of the Summer Program, teens shared their work and what they learned throughout the week with each other and invited guests in a Student Showcase Expo.

The Lifelong Learning Group (LLG), now the Center for Research and Evaluation (CRE), at the Center of Science and Industry (COSI) in Columbus, Ohio conducted an evaluation of the 2018 NFB EQ program during the first year of implementation. It focused on perceptions of process and measures of efficacy around key themes including drawing and drafting, measurement, and building and construction. The Year 1 evaluation found that the majority of teens attended the NFB EQ program because they were interested in STEM, including a desire to develop technology to support the blind and to solve problems. Many NFB EQ program participants had taken classes in school to support their STEM interests, including robotics, mechanical engineering, and computer programming. Others voiced that they wanted to have the NFB EQ experience due to limited access to STEM within their current school environments.

While the data suggests the program had a limited effect on increasing participant's interest in studying STEM, this is most likely due to the number of participants (50%) that entered the program already with a desire to pursue careers in STEM, ranging from oncology to robotics. Those who were not interested in a STEM career had definite career goals. Teens not planning a career in STEM felt the drawing and building experience could support their creative outlets. They believed the tools they used (i.e., Sensational Blackboards, Braille rulers) would be helpful tools to use in the future.

The evaluation study concluded that the 2018 EQ Summer Program contributed to participant's interest and intention toward STEM. Teens who arrived with limited engineering experience left with "more knowledge about engineering." The program strengthened the curiosity of those who were already interested in engineering.

2019 NFB EQ program (Year 2)

In June 2019, 32 teens who has just completed 9th to 12th grade arrived at the National Federation of the Blind (NFB) headquarters building in Baltimore, Maryland to attend the 2019 NFB EQ program. As with the previous year, this second year of the NFB EQ Summer Program was primarily composed of two types of sessions: 1) instruction; and 2) building, in an intense STEM-based program where each individual designed and created a PMO (Place of My Own) personal retreat space model building. Teens developed a portfolio that included graphic artifacts (front elevation, side elevation, structural column-beam plan, floor plan), narrative artifacts (final design brief, self-reflection), algorithmic artifacts (load calculations, column justification, rafter justification, truss analysis), and a scale model. A third type of session involved several blind engineers sharing their successes and challenges of navigating various engineering fields. The program also included a field trip to the nearby Jerusalem Mill and Village.

Methods

Evaluators collected data from the 2019 NFB EQ program teen participants using three different methods:

1. Passive observations throughout the program, comparing these notes with the goals of the program. The evaluator used these notes to facilitate daily staff debriefing discussions.
2. Brief open-ended, semi-structured interviews conducted with participants pre- and post - program.
3. A pre- and post-program web-based questionnaire.

The interview and questionnaire focused on the teens' interest in STEM, future career intentions, and the impact of the 2019 NFB EQ program. Appendix A contains the instruments used in this study. LLG analyzed the data collectively. Themes to interview responses emerged from the data itself rather than being prescribed. CRE analyzed quantitative data using Excel and the Statistical Package for the Social Sciences (SPSS) and used descriptive statistics to present overall patterns in the data.

Findings

The 2019 NFB EQ Program Participants

Twenty-three of the 32 teens who participated in the 2019 NFB EQ program agreed to participate with the evaluation study. They completed a pre- and post-program web-based questionnaire of which they shared information about themselves, as well as additional information about their “blind identity” and tools they use to access written materials and computers. They also participated in a pre- and then a post-program face-to-face interview with the evaluators.



The questionnaire data for the 2019 NFB EQ program include those teens who participated in the evaluation and are presented in tables that, in most cases, also include responses from 2018 NFB program participants. This is for purposes of comparison.

Half the 2019 NFB EQ program participants self-reported as female, slightly less than half as male, and one as non-binary (Table 1). The majority of teens had just completed the 10th or 11th grade in high school (Table 2), and these participants represented a diverse group of race and ethnic backgrounds (Table 3). The 2019 NFB EQ program participants were similar to the 2018 participants, regarding race/ethnicity and grade level.

Table 1. Gender identification

Gender	2018 Participants N=26	2019 Participants N=22
Female	53%	50%
Male	47%	47%
Non-binary	0%	3%

Table 2. Grade during previous school year

Grade	2018 Participants N=30	2019 Participants N=21
9	7%	14%
10	30%	38%
11	40%	33%
12	23%	14%

Table 3. Race/ethnicity self-identification

Race/Ethnicity	2018 Participants N=30	2019 Participants N=22
White	50%	55%
Asian	17%	8%
Black or African American	10%	14%
Pacific Islander	3%	5%
White and Other	3%	5%
Black or African American, White, and Other	3%	8%
Other	10%	5%
Prefer not to answer	3%	0%

More than half of the 2019 NFB EQ program participants self-identified as having low vision or being visually impaired (Table 4) compared with less than half who self-identified as being blind. The majority of participants shared they were blind since birth (Table 5). The majority of participants also indicated they know Braille (Table 6). These characteristics of the 2019 NFB EQ program are similar to those of 2018.

Table 4. Vision self-identification

Vision	2018 Participants N=30	2019 Participants N=21
Blind	40%	38%
Low Vision	10%	10%
Visually impaired	50%	52%
Sighted	0%	0%

Table 5. Duration of blindness

Duration	2018 Participants N=26	2019 Participants N=23
Since birth	81%	76%
Not since birth	19%	24%

Table 6. Knowledge of Braille

Knowledge of Braille	2018 Participants N=27	2019 Participants N=23
Yes	70%	72%
No	30%	28%

The 2019 NFB EQ program participants indicated they use a variety of mediums to access written material (Table 7). Slightly less than half preferred using electronic documents. Although more than half indicated knowing Braille, just slightly more than one-in-four prefer using Braille. The remaining participants prefer to use large print or audio. These preferences of the 2019 NFB EQ program participants are similar to those of 2018 with somewhat more preferring to use accessible electronic documents and fewer audio materials.

Table 7. Percent who ranked each as most preferred for accessing written material

Mode of Accessibility	2018 Participants n=30	2019 Participants n=23
Accessible electronic documents	32%	47%
Braille	22%	29%
Large print	19%	12%
Audio	23%	12%

More than half of the 2019 NFB EQ program participants indicated that they use a cane always or most of the time. About one-in-four indicated that they never use a cane. This is similar to those participants in 2018 (Table 8).

Table 8. Frequency of cane use

Frequency of Cane Use	2018 Participants N=27	2019 Participants N=23
Always	26%	46%
Most of the Time	33%	14%
About half of the time	11%	4%
Sometimes (i.e., at night, in unfamiliar environments)	4%	11%
Never	26%	25%

The majority of the 2019 NFB EQ program participants had taken STEM-related classes at their school. These included biology, geometry, algebra, and chemistry. About one-in-three had taken a pre-calculus and/or trigonometry class, and only about one-in-five had taken an engineering class (Table 9).

Table 9. Percent of classes taken by NFB EQ Program participants

Class	2018 Participants n=28	2019 Participants n=23
Biology	89%	96%
Geometry	86%	93%
Algebra I	86%	96%
Pre-Algebra	82%	96%
Algebra II	68%	71%
Chemistry	57%	61%
Geography	54%	43%
Trigonometry	43%	32%
Pre-Calculus	25%	32%
Physics	18%	25%
Engineering	-	21%
AP Physics	14%	7%
Computer Aided Design/ Drafting/Solid Modeling	14%	14%
Vocational Arts (Welding, woodworking, sewing, etc.)	7%	25%
Calculus	4%	21%
Anatomy	4%	14%

During the face-to-face interviews with the evaluators, almost half the youth said they do not, or have not, participated in any type of STEM-related extracurricular activities. For most, this is because their schools do not offer such activities. For those who have participated in STEM-related extracurricular activities, these included school-based Computer Science Club, Math Club, Robotics Club, and Tech Students Association. Outside of school, one youth talked about attending a Marine Biology camp and another participated in Science Olympiad.

Many of the 2019 NFB EQ program participants who were interviewed shared that they did something afterschool with technology, either on their own or in an organized school-sanctioned club such as Science Olympiad or Engineering Club. Several teens mentioned they liked to tinker or build things; one helped his grandfather build a garage and another helped her uncle who ran an auto repair shop. Teens also shared that they participated in organized sports and music, both of which have components that link to STEM.

In the pre-program questionnaire, (rating items from 1=Strongly disagree to 5=Strongly agree), teens indicated they looked forward to science and math class in school. They would rather solve a problem in science class by doing an experiment and felt more time should be spent on hands-on projects in science class. They did not think that Science is a difficult subject.

Table 10. Feelings regarding school science and math classes

Feelings About Specific Classes	Mean	Std. Dev.
I look forward to science class in school.	3.89	1.133
I look forward to math class in school.	3.33	1.468
I would rather solve a problem in science class by doing an experiment than be told the answer.	4.26	0.859
More time should be spent on hands-on projects in science class.	4.73	0.604
Science is too hard when it involves math	1.93	1.269
Science is a difficult subject.	2.00	1.074
Doing experiments in science class is frustrating.	2.22	1.368

*Rating based on a 5 -point scale, where 1 represents Strongly Disagree and 5 represents Strongly Agree
N varies from 20 - 23

The pre-2019 NFB EQ program questionnaire (1=Strongly disagree to 5=Strongly agree) data indicates these teens more frequently engaged in STEM-related play as a child compared with the 2018 participants. (Table 11). The relatively high standard deviation indicates the data could be bi-modal, where relatively equal amounts of teens selected responses above and below the midpoint.

Table 11. Frequency of STEM-related play as a child

Play	Mean	Std. Dev.	Mean	Std. Dev.
	2018 n=28		2019 n=23*	
Play with blocks, Legos, or other building toys/kits	3.21	1.34	3.13	1.01
Construct models	2.53	1.27	5.26	2.65
Build puzzles	2.50	1.30	4.30	1.59
Play with radio controlled toys	2.61	1.41	3.65	1.56
3-D video games	2.40	1.70	-	-
3-D tactile games	-	-	4.23	1.69
Doodle or draw	3.20	1.52	4.10	1.99

*Includes only youth participants who agreed to participate in the evaluation

The Overall 2019 NFB EQ Program Experience

Choosing to attend the 2019 NFB EQ program

Based on the pre-program interviews, the reasons why teen participants attended the 2019 NFB EQ program varied. Some (about 1 in 4) said they were interested in some aspect of STEM (specifically science, math, physics, and/or engineering) and/or wanting to learn more specifically about engineering. Some (about 1 in 4) indicated that they were encouraged to attend by a friend who knew about the program, a parent, a sibling who had attended the 2018 EQ Summer Program, or a school teacher/counselor. A few participants (about 1 in 10) talked about how their past involvement with an NFB event or program, such as attending an NFB Youth Slam event or starting a career mentoring program with NFB, motivated them to attend the 2019 NFB EQ program. For one teen participant, attending the Program was a chance to build a personal sense of independence, while another participant saw it as a possible chance to make professional and career connections.

Anticipated experiences

Several of the teen participants (about 1 in 4) said they were not sure, or did not know, quite what they hoped to experience or gain by the end of the NFB EQ program. A few talked about expecting they would learn and develop new skills, such as drafting and wood-working, and hoped to meet and get to know other blind teens who shared some of their interests. A few teens talked about looking forward to the Expo at the end of the week where they would be able to display or “showcase” what they had accomplished building during the week. One teen said he wanted to have some experiences that would have him doing something “outside his personal comfort zone”, while another commented that she wanted to experience the other blind teens being able to do some of the same things that sighted youth can do.

Teen Participant Comments

“I liked learning to use different tools to accomplish what sighted people do”

“The most exciting part of this week was the model-building process and being able to use a lot of mathematics and physics for the engineering design of the model.”

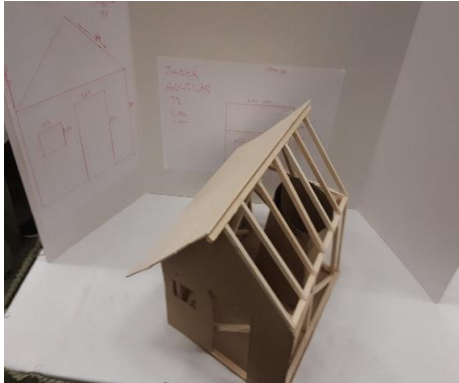
“The best part of the week was the social and cultural aspect. I learned that there are other blind people who share my experiences and share each other’s experiences and that being blind does not make something impossible.”

“The blind speakers who are engineers showed me that there are actually blind engineers successfully working in the field.”

Favorite part of the week

Teen participants’ favorite aspects of the 2019 NFB EQ program experience varied. Many (about half) said they most enjoyed the hands-on approach to the week and the skills they learned. These skills included constructing and testing a structure across a river (Engineering 101 activity) the drawing and drafting skills they practiced and used to design their PMO (Place of My Own) model building, the measuring and wood-cutting skills, the calculating and testing of potential forces on their model buildings (Fun with Forces activity), and the actual construction of the model. Some teens (about 1 in 6) said the recreational activities were their favorite part of the week. These included the evening exploring the Baltimore harbor, the field trip to the Jerusalem Mill and Village and the swimming. Some (about 1 in 6) spoke about

making new friends and learning from the other teens as their favorite part of the week. One teen especially enjoyed participating in the program research.



Model constructed by a 2019 NFB EQ program teen participant

Program Influence on Engineering and STEM Career Interest

Responses to the post-program questionnaire (1=Strongly disagree to 5=Strongly agree) indicated that the 2019 NFB EQ program helped teen participants gain a better understanding of engineering, increase their interest to study science and engineering, increase confidence in their ability to participate in engineering projects or activities, and have a better understanding of their own career goals (Table 12).

Table 12. Feelings toward science and engineering post 2019 NFB EQ Program

Feelings About Science and Engineering	Mean	Std. Dev
Helped me understand engineering better.	3.93	0.940
Led me to a better understanding of my own career goals.	3.33	1.177
Increased my interest to study science and engineering.	3.12	1.275
Increased my ability to understand geometric concepts and engineering drawings.	3.37	1.115
Made me think more about what I will do after graduating from high school.	3.30	1.353
Made me think about different classes I might take in school (including college) than I had planned.	2.82	1.331
Increased my confidence in my ability to participate in engineering projects or activities.	3.50	1.476

Teen Participant Comments

“I will use the knowledge and skills I gained from this week for my career in engineering.”

“This program helped me to see how engineering can tap into my creativity.”

“Being here this week has motivated me to take an engineering class at school that I probably would not have taken otherwise.”

The post-program interviews with the teen participants support these findings. Many of the teen participants (about half) talked specifically about how attending the 2019 EQ Summer Program influenced their thinking about a future career path. Several of them (about 1 in 4) began the week with the intention of pursuing an engineering career, and found that attending the Program either strengthened their interest in engineering and/or started them thinking about specific areas of engineering. For example, at least two participants said they were now considering structural engineering and another two are thinking about architect engineering. A few youth said they still plan to pursue a career in STEM, such as being a physicist but plan to explore ways to incorporate engineering concepts and skills with physics.

Perceived Value of the 2019 NFB EQ Program Experience

Teacher-delivered content and materials

Teen responses to the post-program questionnaire indicate that teacher-delivered content (lectures, instructions, etc.,) were accessible (\bar{x} =4.86 on a scale from 1=Inaccessible to 5=Accessible) as well as written materials (books, handouts, workbooks, other) were accessible (\bar{x} =4.86).

Teen Participant Comments

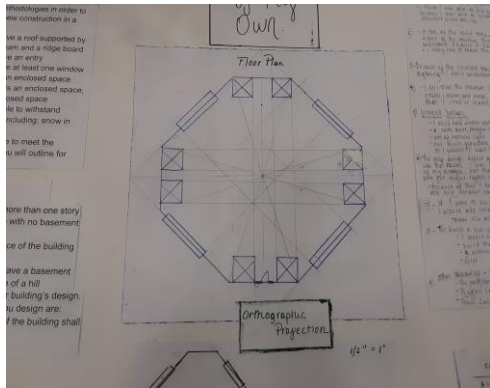
“I didn’t know anything about spatial ability before this weekend. I now understand that part of spatial ability for engineering is the presentation of a 3-dimentional object in a 2-dimentional space.”

“Part of what I learned about spatial ability is being able to use scales to represent objects larger or smaller than what they actually are.”

Engineering-related skills

Spatial ability

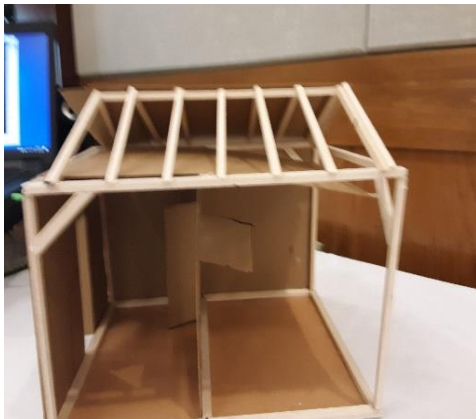
When the teen participants arrived at the 2019 NFB EQ program, most of them (slightly more than half) indicated during their pre-program interviews that they did not know anything about spatial ability. A few (about 1 in 6) said they had some idea of what it is but could not describe it. A few (about 1 in 6) commented on what they thought it was by describing or explaining it as “something to do with translating 2-D objects to 3D objects”, “ how pieces move in the physical world”, “all things are on an X and Y axis,” and “unfolding a cube into a 2-D object.” By the end of the week, several youth (about 1 in 3) said they thought they had gained a better understanding of spatial ability. Some described or explained spatial ability as “being able to represent a 3D object as a 2D drawing”, “ability to visualize shapes and understand the space an object takes”, and “the ability to define the face of a plane in a 3D object”.



Drawing of PMO model floor plan drafted by an 2019 NFB EQ Summer Program teen participant

Measuring

Developing measuring skills is fundamental to engineering, yet independently measuring anything can be challenging for blind teens when they do not have access to measuring tools and opportunities to practice the skills. Teens said during post-program interviews that the 2019 NFB EQ program provided them with the materials they needed to be independent, including tactile graphs and images, Braille caliper, Sensational Blackboard, etc. Teen responses to the post-EQ Program questionnaire indicate that the tools they used were accessible or would have been better with one modification ($\bar{x}=4.53$ on a scale from 1=Inaccessible to 5=Accessible).

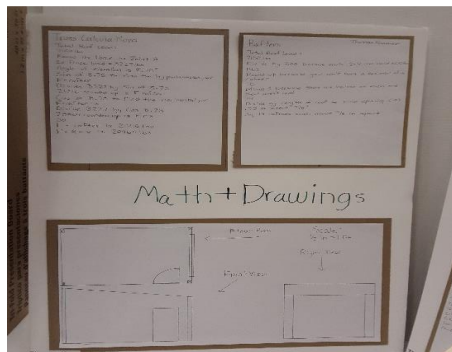


Example of a PMO model built by a 2019 NFB EQ program teen participant

Drawing and drafting

The 2019 NFB EQ program provided teens the opportunity to develop technical drawing skills so they could design a plan for their PMO personal retreat building model. They learned to create floor plans as well as elevation drawings (including front and side) to scale of their designed PMO models. Teen responses to the post-2019 NFB EQ program questionnaire indicate that accessible of materials (e.g. sensational blackboards, tactile drafting boards, etc.) they needed for drawing and drafting their PMO model were accessible (\bar{x} =4.53 on a scale from 1=Inaccessible to 5=Accessible).

Building and constructing



An example of the PMO model building process by a 2019 NFB EQ participant.

The challenge to design and build something, including learning about properties of wood, was the highlight for the majority of teens interviewed. Evaluators observed all teens in this program using tools to build their PMO personal retreat model. While the majority of these tools were common tools available at hardware stores, these teens had not had the opportunity to use them before their experience with the NFB EQ program.

Teen Participant Comments

“I felt safe, secure, and independent here. I value the support I got here from people like me.”

“I appreciated hearing how other students my age have adapted to their visual disability.”

“I value the friendships I made here.”

Feedback for Further Improvement

Teen Participants

For the second year of the 2019 NFB EQ program, teen participants were asked “If you were in charge, how would you change this workshop?” No primary themes emerged across most, or even several, of the interviews. At the same time, some of the teen participants recommended the following:

- Reduce the amount of information the teens are expected to digest and process (voiced by 6 participants). “At times I felt I was in mental meltdown.”
- Begin building the PMO model buildings earlier in the week (voiced by 6 participants). “It felt that building our models was crammed in to the end of the week.”
- Have more free time to work on their PMO models, engage in outdoor recreation activities, or just to digest the amount of information they receive during the week (voiced by 5 participants).
- Provide the day’s agenda first thing in the mornings so participants could have an idea of what will be covered and what they will be doing (voiced by 4 participants).

While one participant wanted to spend less time outside due to having allergies, others wanted to be outside more to balance more recreation time, including exercise, with learning. A few teens expressed they would have preferred to have heard from guest speaker engineers who are completely blind, versus speakers having some partial vision. These teens said, as a completely blind person, they had difficulty relating to the speakers.

Debriefings

At the end of most days during the program, the NFB EQ program coordinator, instructors, researchers, and evaluator met together to discuss the day's process and any issues that arose that needed addressed. They also identified several changes to make to the 2020 EQ Summer Program materials and instruction. These are included in the debriefing notes that are included in Appendix B).

Conclusions

Based on the findings of this evaluation study, LLG presents the following conclusions:

How the NFB EQ program contributes to blind teen participant's development of spatial reasoning and abilities.

Conclusion: The NFB EQ program helps to increase some blind teens' understanding about the overall concept of spatial ability, as well as reasoning and abilities as demonstrated in their building designs, drawings, drafting, and construction of a 3-D model structure.

When the teens arrived at the 2019 NFB EQ program, most of them indicated they did not know anything about spatial ability. A few said they had some idea of what it is but could not describe it. A few commented on what they thought it was by describing or explaining it as "something to do with translating 2D objects to 3D objects", " how pieces move in the physical world", "all things are on an X and Y axis," and "unfolding a cube into a 2D object." During the NFB EQ program most teens mastered some proficiency in measuring, math calculations, drawing and drafting, and building and construction.

A future evaluation report, in consultation with the research team, will more fully answer how the EQ Summer Program contributes to participant's development of spatial reasoning and ability. At the same time, post-program interview with participants indicated that by the end of the 2019 EQ Summer Program several teens indicated that they had gained a better understanding of spatial ability and were able to describe fundamental concepts.

The extent that the NFB EQ program influences blind teen participant's interest in STEM and intention to pursue STEM study and career

Conclusion: Most participants are already interested in pursuing a STEM-related career when they attend the EQ programs. While the program may not necessarily influence participants to pursue a STEM career when they were not already planning to do so, the program does reinforce and strengthen participants' intent to pursue such a career.

The majority of teens attended the 2019 NFB EQ program because they were interested in some aspect of STEM (specifically science, math, physics, and/or engineering) and/or wanted to learn more specifically about engineering. Teens expressed an interest in STEM for several

reasons including a desire to develop technology to support the blind and a desire to solve problems. While most participants had taken classes in school to support their STEM interests (including robotics, mechanical engineering, and computer programming), others shared they wanted to have this EQ Summer Program STEM experience due to limited access within their current school environment. Responses to the pre-program questionnaire indicated that most teen participants look forward to science and math classes at school and were already interested, to very interested, in pursuing a career in a STEM-related field.

Post-program questionnaire responses indicated a similar interest for 2019 NFB EQ program teen participants in pursuing a career in STEM as their pre-Program responses. At the same time, post-program interviews found that the Program reinforced most participant's interest in pursuing a career in engineering, physics, or math. For a few, it motivated them to explore the possibility of a career in engineering.

Factors that contribute to increasing 2019 NFB EQ program teen participants' interest to pursue STEM study and a career

Conclusion: Factors that contribute to increasing NFB EQ program teen participants' interest to pursue STEM study and a career include:

- 1) The engineering-specific knowledge and information they learned
- 2) Increased self-confidence with some of the skills needed to conduct engineering tasks, such as measuring, conducting mathematical calculations, drawing and drafting, orthogonal projection, repeated trial and error testing, and designing and constructing scaled models
- 3) Support and inspiration from peers who experience the challenges of being blind
- 4) Believing they can be engineers and/or have a STEM-related career by hearing from blind engineers about their experiences in the field
- 5) Having a chance to be an engineer by engaging in a hands-on project in which participants use multiple engineering skills to design and build a scale model structure.

The 2019 NFB EQ program teen participants said they most enjoyed the hands-on approach to the week and the skills they learned. These skills included constructing and testing a structure across a river, the drawing and drafting skills they practiced and used to design their PMO (Place of My Own) model structure, the measuring and wood-cutting skills, the calculating and testing of potential forces on their PMO model buildings, and the actual construction of the models. A few participants said they appreciated being able to hear from, and talk with, many people about their experiences being blind. In some cases, this person was a professional working in a STEM-related career or a peer with the Program about how they are meeting the challenge of designing and building their PMO model structure.

Teens' perceived value of the 2019 NFB EQ program experience other than contributing to the development of their spatial reasoning and abilities

Conclusion: Teen participants believe that the value of their 2019 NFB EQ program experience extends beyond increasing their knowledge and skills related to spatial reasoning and ability. This includes an increased sense of affinity with other blind youth their age and confidence in what they can do and accomplish as a blind person.

When asked during the post-Program interviews what teen participants valued about their EQ Summer Program experience, several talked about the friendships they had built with other blind teens their age, learned how these new friends have adapted to their blindness, and recognized they could find support for their life experiences from people like them. One teen expressed wanting to become more involved with the state youth group of NFB. Other teens talked about the opportunity they had to do something new in a new location. For one teen, attending the EQ Summer Program was a valued opportunity to travel for the first time without an adult. One teen expressed a perspective, echoed by other participants, that the NFB EQ program reminded her that "being blind does not make things impossible."

Appendix A: Data Collection Instruments

2019 NFB EQ Program Participant Pre- Interview

My name is _____ and I'm an evaluator for the NFB EQ program. To help the organizers of this program better understand your experience with the program, I'd like to talk to you for about 10 minutes. Your participation is voluntary and your responses are completely confidential. You can stop at any time. Do you have some time to answer questions?

1. Do you know your ID number for this program?
2. Were always curious, what made you want to sign up for this program?
3. What do you think will be the highlight of your week here?
4. Do you participate in any STEM based extracurricular activities, either through your school, scouts, etc.? If so, what are they? How did you get involved in them? (examples include First Robotics, JETS, Future City, Lego engineering, Botball, etc)
5. When you are 30 years old, what job would you like to be doing? How do you think this workshop might help you?
6. Do you have a role model, someone that you admire or someone that has encouraged you to pursue that career?
7. What do you know about spatial ability? (ask if they give answer--How do you think it might be important for you? How do you think it might be important for an engineer?)
8. Some of the things you are going to be doing in this program are what college students studying engineering do. It might be frustrating. How do you deal with frustration?

Thanks for talking with me. I hope you have a great time this week.

2019 NFB EQ Program Participant Post- Interview

Hi,

It's _____ again, and I'm still evaluating the NFB EQ program. Again, I'm working with the organizers of this program to better understand your experience with the program, I'd like to talk to you for about 15 minutes. Your participation is voluntary and your responses are completely confidential. You can stop at any time. Do you have some time to answer questions?

1. Do you know your ID number for this program?
2. What has been your favorite part of the week so far? Why?
3. How has the NFB EQ program impacted your interest in engineering?
4. How will this impact the courses you take at school?
5. When you are 30 years old, what job would you like to be doing? Why?
6. Did this workshop have any impact on what you plan to do when you are 30 years old?
7. Tell me about any skills or ways of thinking you acquired and/or enhanced during this program? (measuring, critical thinking, data collection or analysis, etc.) What are your big takeaways from this week?
8. What do you know about spatial ability? (ask if they give answer--How do you think it might be important for you? How do you think it might be important for an engineer?) Have you had any experiences that you believe improved your spatial ability before this workshop?
9. What did you think of the products you produced this week? How, if any, did these products help you develop your spatial reasoning abilities? Did they help you understand math and/or science?
10. Just one more question, if you were in charge, how would you change this workshop?

Thanks for talking with me. Have a great rest of your day.

NFB 2019 EQ Summer Program Participant Pre- Questionnaire

To help the organizers of the NFB EQ program better understand you and what you bring to this experience, please take 15 minutes to answer the following questions. Depending on your answers, you will answer as few as 15 or as many as 21 questions. To increase the contrast of the questions, it is recommended you access the survey with Chrome or Safari.

You may decide to quit or skip any questions that you don't feel comfortable answering. This is not graded. There are no right answers.

For matching purposes, please write your ID number here.

This set of questions were designed to help us understand what you did in your free time when you were growing up. Tell us what you think by selecting the number that indicates how much time you spent doing these activities. Enter a 1 if you never did them, 2 if you did them less than half of your free time, 3 if you did these things about half of the time, 4 if you did them more than half of the time and 5 if you always did them in your free time.

In your free time as you were growing up, how often did you play with blocks, Legos?

- 1 Never
- 2
- 3 About Half of the Time
- 4
- 5 Always

In your free time as you were growing up, how often did you construct models?

- 1 Never
- 2
- 3 About Half of the Time
- 4
- 5 Always

In your free time as you were growing up, how often did you build puzzles?

- 1 Never
- 2
- 3 About Half of the Time
- 4
- 5 Always

In your free time as you were growing up, how often did you play with radio-controlled toys?

- 1 Never
- 2
- 3 About Half of the Time
- 4
- 5 Always

In your free time as you were growing up, how often did you play with 3-D tactile games?

- 1 Never
- 2
- 3 About Half of the Time
- 4
- 5 Always

In your free time as you were growing up, how often did you doodle or draw?

- 1 Never
- 2
- 3 About Half of the Time
- 4
- 5 Always

This set of questions focuses on experiences you might have with engineering-type activities. Tell us what you think by selecting the number that indicates how much experience you have with these activities. Enter a 1 if you have no experience, 2 if you have a little bit of experience with them, 3 if

you have some experience, 4 if you have a lot of experience and 5 if you believe you have a great deal of experience with these activities.

Before this workshop, how much experience did you have with woodworking, cabinetry, construction?

- 1 None
- 2
- 3 Some
- 4
- 5 A Great Deal

Before this workshop, how much experience did you have with welding, fabrication?

- 1 None
- 2
- 3 Some
- 4
- 5 A Great Deal

Before this workshop, how much experience did you have with electronics, building computers, computer coding?

- 1 None
- 2
- 3 Some
- 4
- 5 A Great Deal

Before this workshop, how much experience did you have with mechanics (small engine, automobile)?

- 1 None
- 2
- 3 Some
- 4
- 5 A Great Deal

Before this workshop, how much experience did you have with gardening?

- 1 None
- 2
- 3 Some
- 4
- 5 A Great Deal

Before this workshop, how much experience did you have with artistic painting/drawing?

- 1 None
- 2
- 3 Some
- 4
- 5 A Great Deal

Before this workshop, how much experience did you have with textile arts (sewing, embroidery, knitting, etc.)?

- 1 None
- 2
- 3 Some
- 4
- 5 A Great Deal

Before this workshop, how much experience did you have with cooking?

- 1 None
- 2
- 3 Some
- 4
- 5 A Great Deal

Before this workshop, how much experience did you have with sports (swimming, wrestling, track)?

- 1 None
- 2
- 3 Some
- 4
- 5 A Great Deal

Before this workshop, how much experience did you have with drafting (drawings for engineering, building)?

- 1 None
- 2
- 3 Some
- 4
- 5 A Great Deal

This set of questions focuses on your science and math classes in school. Tell us what you think about these statements by selecting the number that indicates how much you disagree or agree with these statements about your science and math classes in school. Enter a 1 if you Strongly Disagree with this statement, 2 if you Disagree, 3 if you Neither Disagree or Agree, 4 if you Agree, and 5 if you Strongly Agree. If you don't take one of these classes offered, please select N/A (not applicable).

I look forward to science class in school.

- 1 Strongly Disagree
- 2 Disagree
- 3 Neither Disagree or Agree
- 4 Agree
- 5 Strongly Agree
- N/A

I look forward to math class in school.

- 1 Strongly Disagree
- 2 Disagree
- 3 Neither Disagree or Agree
- 4 Agree
- 5 Strongly Agree
- N/A

I look forward to engineering class in school.

- 1 Strongly Disagree
- 2 Disagree
- 3 Neither Disagree or Agree
- 4 Agree
- 5 Strongly Agree
- N/A

I would rather solve a problem in science class by doing an experiment than be told the answer.

- 1 Strongly Disagree
- 2 Disagree
- 3 Neither Disagree or Agree
- 4 Agree
- 5 Strongly Agree
- N/A

More time should be spent on hands-on projects in science class.

- 1 Strongly Disagree
- 2 Disagree
- 3 Neither Disagree or Agree
- 4 Agree
- 5 Strongly Agree
- N/A

Science is too hard when it involves math.

- 1 Strongly Disagree
- 2 Disagree
- 3 Neither Disagree or Agree
- 4 Agree
- 5 Strongly Agree
- N/A

Doing experiments in science class is frustrating.

- 1 Strongly Disagree
- 2 Disagree
- 3 Neither Disagree or Agree
- 4 Agree
- 5 Strongly Agree
- N/A

Science is a difficult subject.

- 1 Strongly Disagree
- 2 Disagree
- 3 Neither Disagree or Agree
- 4 Agree
- 5 Strongly Agree
- N/A

If you indicated that doing experiments in science class is frustrating, can you tell us why that is?

These questions are about things you may do when you are working on school activities or assignments. Tell us what you think by selecting the number that indicates how often you believe you do these activities. Enter a 1 if you never do this, 2 if you not do this very often, 3 if you do this about half of the time, 4 if you do this most of the time, and 5 if you always do this.

How often do you design and build something?

- 1 Never
- 2
- 3 About half of the Time
- 4
- 5 Always

How often do you explain math or science to friends?

- 1 Never
- 2
- 3 About half of the Time
- 4
- 5 Always

How often do you find the information that you need to solve difficult problems?

- 1 Never
- 2
- 3 About half of the Time
- 4
- 5 Always

How often do you read books, magazines, or websites about science or math?

- 1 Never
- 2
- 3 About half of the Time
- 4
- 5 Always

How often do you learn about how something works?

- 1 Never
- 2
- 3 About half of the Time
- 4
- 5 Always

How often do you draw an object you plan to build before building?

- 1 Never
- 2
- 3 About half of the Time
- 4
- 5 Always

The next questions are about you.

What grade were you in during the 2018-19 school year?

Which of these classes have you taken (check all that apply)

- Pre-Algebra
- Geometry
- Algebra I
- Algebra II
- Trigonometry
- Pre-Calculus
- AP Calculus
- Biology
- Chemistry
- Physics
- AP Physics
- Anatomy
- Computer Aided Design/Drafting/Solid Modeling
- Geography
- Vocational Arts (Welding, woodworking, machining, sewing, etc.)
- Engineering

On a scale of 1 to 5, where 1 represents "No Interest" and 5 represents "Very Interested", how interested are you in pursuing a career in a science, technology, engineering, or mathematics-related field?

- 1 No Interest
- 2
- 3
- 4
- 5 Very

Do you identify as (check only one)

- 1 Blind
- 2 Visually impaired
- 3 Low vision
- 4 Sighted
- Other

If you chose other, write in the word or phrase that best describes your identity.

These statements are about mediums you may use for accessing written material. Please rank your preference with number 1 being your most preferred and number 5 being your least preferred.

- ____ Braille
- ____ Large print
- ____ Audio (5)
- ____ Accessible electronic documents
- ____ Other

Other than those listed in the previous question (Braille, large print, audio, etc.) what else do you use to access written material?

These statements are about assistive technology you may use when accessing a computer or tablet. Please rank your preference with number 1 being your most preferred and number 4 being your least preferred.

- ____ Screen reader
- ____ Screen magnification
- ____ Braille display
- ____ Other

Other than those listed in the previous question (Braille display, screen reader, screen magnification, etc.) what else do you use to access a computer or tablet?

Have you been blind/visually impaired since birth?

- Yes
- No

How old were you when your vision began to change?

Please describe how your vision has changed over the years. If it hasn't changed, skip this question.

Do you know Braille?

- Yes
- No

If yes, how long have you been reading Braille?

On a scale of 1 to 5, where 1 represents "Beginner" and 5 represents "Expert", how well do you read Braille?

- 1 Beginner
- 2
- 3
- 4
- 5 Expert

How often do you use a Braille slate and stylus?

- 1 Never
- 2
- 3
- 4
- 5 Always

In math and science class, how do you prefer to access diagrams, tables and figures? Please rank your preference with number 1 being your most preferred and number 5 your least preferred.

- ___ Someone describes it to me verbally
- ___ Read a written description of the diagram
- ___ Tactile graphics with Braille
- ___ Dual media graphics: graphics that include visual (high contrast/large print) and tactual (Braille, raised line) components
- ___ Large print/High contrast graphics

When do you use a cane in your daily life? (choose only one)

- 1 Never
- 2
- 3
- 4
- 5 Always

Thank you for your feedback. Have a great day exploring science, engineering, math, and technology in your daily life.

NFB 2019 EQ Summer Program Participant Post- Questionnaire

Intro To help the organizers of the NFB EQ program better understand your experience, please take 15 minutes to answer the following questions. There are 10 questions. To increase the contrast of the questions, it is recommended you access the survey with Chrome or Safari. You may decide to quit or skip any questions that you don't feel comfortable answering. This is not graded. There are no right answers.

For matching purposes, please share your ID number in the space below.

This set of questions focuses on how you feel about science and engineering now that you've participated in NFB EQ.

Just like the pre-questionnaire, tell us what you think about these statements by selecting the number that indicates how much you disagree or agree with these statements. Enter a 1 if you Strongly Disagree with this statement, 2 if you Disagree, 3 if you Neither Disagree nor Agree, 4 if you Agree, and 5 if you Strongly Agree.

The NFB EQ workshop helped me to understand engineering better.

- 1. Strongly Disagree
- 2. Disagree
- 3. Neither Disagree nor Agree
- 4. Agree
- 4 Strongly Agree

The NFB EQ workshop led me to a better understanding of my own career goals

- 1. Strongly Disagree
- 2. Disagree
- 3. Neither Disagree nor Agree
- 4. Agree
- 5. Strongly Agree

The NFB EQ workshop increased my interest to study science and engineering.

- 1. Strongly Disagree
- 2. Disagree
- 3. Neither Disagree nor Agree
- 4. Agree
- 5. Strongly Agree

The NFB EQ workshop increased my ability to understand geometric concepts and engineering drawings.

- 1. Strongly Disagree
- 2. Disagree
- 3. Neither Disagree nor Agree
- 4. Agree
- 5. Strongly Agree

The NFB EQ workshop made me think more about what I will do after graduating from high school.

- 1. Strongly Disagree
- 2. Disagree
- 3. Neither Disagree nor Agree
- 4. Agree
- 5. Strongly Agree

The NFB EQ workshop made me think about different classes I might take in school than I had planned, including college.

- 1. Strongly Disagree
- 2. Disagree
- 3. Neither Disagree nor Agree
- 4. Agree
- 5. Strongly Agree

The NFB EQ workshop increased my confidence in my ability to participate in engineering projects or activities.

- 1. Strongly Disagree
- 2. Disagree
- 3. Neither Disagree nor Agree
- 4. Agree
- 5. Strongly Agree

The NFB EQ workshop increased my interest in pursuing a STEM career.

- 1. Strongly Disagree
- 2. Disagree
- 3. Neither Disagree nor Agree
- 4. Agree
- 5. Strongly Agree

For this evaluation, accessible means that a given material or task was designed with blind/low-vision people in mind. The following elements are typically part of classroom learning. We want to know if these elements are accessible for you in your school. Tell us what you think about these statements by selecting the number that indicates how accessible you believe these elements are. Enter a 1 if you believe the element is inaccessible/can't be used at all, 2 if it's really hard to use but you can, 3 if it's ok to use with some modifications, 4 if you can use it, but it could be made better if there was one modification, and 5 if it's completely accessible/easy to use. If an element is typically not available for you, please rate it as 1-inaccessible.

Teacher-delivered content (lectures, instructions, etc.)

- 1. Inaccessible
- 2. Hard to use, but you can
- 3. O.K. to use with some modification
- 4. Can use it, but could be better with one modification
- 5. Accessible

Written materials (books, handouts, workbooks)

- 1. Inaccessible
- 2. Hard to use, but you can
- 3. O.K. to use with some modification
- 4. Can use it, but could be better with one modification
- 5. Accessible

Building tools (saws, hot glue guns, etc,)

- 1. Inaccessible
- 2. Hard to use, but you can
- 3. O.K. to use with some modification
- 4. Can use it, but could be better with one modification
- 5. Accessible

Drawing materials (sensational blackboard, drafting table)

- 1. Accessible
- 2. Hard to use, but you can
- 3. O.K. to use with some modification
- 4. Can use it, but could be better with one modification
- 5. Accessible

Now, we'd like you to use the same rating scale to rate the degree of accessibility for these elements in the NFB EQ program you attended this past week. Again, if an element was not available, please rate it as 1-inaccessible.

Teacher-delivered content (lectures, instructions, etc,)

- 1. Inaccessible
- 2. Hard to use, but I was still able to use it
- 3. O.K. to use, but needed some modification
- 4. Used it, but would have been better with one modification
- 5. Accessible

Written materials (books, handouts, workbooks)

- 1. Inaccessible
- 2. Hard to use, but I was still able to use it.
- 3. O.K. to use, but needed some modification
- 4. Used it, but would have been better with one modification
- 5. Accessible

Building tools (saws, hot glue guns, etc.)

- 1. Inaccessible
- 2. Hard to use, but I was still able to use it.
- 3. O.K. to use, but needed some modification
- 4. Used it, but would have been better with one modification
- 5. Accessible

Drawing materials (sensational blackboard, drafting board)

- 1. Inaccessible
- 2. Hard to use, but I was still able to use it
- 3. O.K. to use, but needed some modification
- 4. Used it, but would have been better with one modification
- 5. Accessible

On a scale of 1 to 5, where 1 represents “No Interest” and 5 represents “Very high interest”, how much interest do you have in pursuing a career in a science, technology, engineering, or mathematics-related field?

Interest in pursuing a STEM career

- 1. No interest
- 2. Low interest
- 3. Moderate interest
- 4. High interest
- 5. Very high interest

What is one thing your school has that NFB EQ could use?

What is one thing NFB EQ has that school could use?

Was there anything at NFB EQ that you found accessible that is typically inaccessible to you? If so, what was that?

If you were in charge, how would you change this workshop?

Is there anything else you'd like to share about your experiences this week?

Thank you for your feedback. Have a great day exploring science, engineering, math, and technology in your daily life.

Appendix B: 2019 EQ Summer Program Debriefing Notes

NFB EQ Project: Daily Debriefs

Monday 6/17/19

1. Dividing the full group into three groups with 10 students each (i.e., A, B, C) and then rotating them through the three Concurrent Sessions (i.e., Intro to Drawing, Engineering 101, and A Place of Our Own) worked well.
2. Intro to Engineering.
 - a. Having the students measure only 12 Cheetos instead of the whole bag worked better
 - b. Eliminate Step #25. Students started to improve on their own
 - c. Revise river maps so that there are bigger differences between the maps.
 - d. Use shelf liners or glue dots on trays to prevent soil containers from sliding on the trays.
3. PMO.
 - a. There was no need to have both the ideation handout as well as the architecture handout. The information was repetitive. Look at the two side by side and make one handout, or just pick one.
 - b. Include a stapler for construction
 - c. No need to have 2 TAs assisting
 - d. Possibly lay out the boards (i.e. 10' x 10') so students can get a sense of the size of the room they are building.
4. ID&D
 - a. Provide more room between tables (stations).
 - b. If possible, use bigger tables (i.e. 8' versus 6')
 - c. Have students put backpacks and other items away from tables to help reduce clutter.
 - d. Specific to the drafting class:
 - 1) Having the 3D wood cube for students to feel before starting their drawing was helpful. Guiding the students step by step using the drafting table and tools worked well.
 - 2) Orient the students to using the knobs on the drafting table horizontal straight edge before having them begin their drawing so that they know how to easily move this straight edge up and down.
5. General
 - a. Emphasize the need for students to bring their own bags for all the materials they receive and need to keep with them. Possibly designate a space (e.g., buckets, lockers) for students to put their backpacks and materials when they are not using them to help reduce clutter around work tables.
 - b. Assign one TA per table for all activities to help increase opportunities for personalized and on-on-one attention.
 - c. Avoid having two or more classes in the same space. Having three separate class spaces is best, even if the room sizes are smaller than this year.

Tuesday 6/18/19

1. Engineering Drafting

- a. Use of the fill size constructed doghouse really helped the students apply the concepts and make their learning real
 - b. Some of the students worked quickly to accomplish the tasks of the activities, while others took longer. Possibly have more differentiated tasks to challenge those who accomplish the tasks easily
 - c. Snap Cubes: Have students begin with the front of the cube structures rather than starting with the top view. This may mean that students will need to hold the cube up directly in front of their face. It could be helpful to remind students that sighted people cannot see around objects, compared with feeling all sides of an object. This is especially the case for students who have never had any vision
 - d. Especially for the orthographic task, begin by providing the context for the lesson (e.g. this is what we will be doing) and then have a TA at each table provide one-on-one help so that students can work at their own pace accomplishing the tasks for the lesson
2. Woodworking
- a. Assigning a different cutting tool to each table and having them work with that tool for some time before rotating the tools to different tables allowed time for the students to explore and try a variety of tools in-depth rather than merely defaulting to a tool they felt most comfortable using or liked best
 - b. Having youth construct something out of the pieces of wood they cut extended their engagement
 - c. Watch the timing of the class. Time ran out a little early

Wednesday 6/19

1. Fun with Forces
- a. When introducing (or for some students reviewing) concepts of Mass and Force, it might be helpful to use examples where the students can visualize the concepts
 - b. The use of googly eyes as reference points on the page made it difficult to draw the vectors. Maybe in the future use punched holes instead of the googly eyes.
 - c. 8d (?) tell students to assume that straight up to be 0 degrees and move vector clockwise when drawing the 225 degree vector.
 - d. When demonstrating the tug-of-war, (don't call it "Tug-of-War" but rather "Human Vectors") have a TA narrate what is happening with the rope. Involving all students worked. The activity has been redesigned to have three-way leaning back of the rope. This will engage students in feeling different forces; a lessening and increasing of the forces as the vectors change. Show the students some vector drawings (graphics; shapes) beforehand of how the vectors will look to help the students conceptualize the shapes. For example, where vectors 1 and 2 are closer together, etc.
 - e. Possibly use rubber bands and a peg-board to illustrate the concept of decomposition of vectors (?)
 - f. When drawing the vectors tail-to-tail, include an example in the workbook.
 - g. For one of the pages in the notebook (11?) the pages need to be rotated one way for the braille version and the other way for the large print version. Or switch print graphic; place holes are punched.
 - h. Watch the timing of the class. Overall it took a little longer than planned.

2. Forming Foundations
 - a. Students said that checking out the 10' by 13' and the 10' x 10' wood frames on the floor was very helpful with them getting a better sense of the real-life size and space of the projects they are working on. One student said it helped her to change and reshape what she was planning to build. Possibly move to PMO session.
 - b. Blackboards had to be taped together to accommodate the paper size. Was not a problem? There are 10 drafting boards.
 - c. Constraints versus conditions. Students did not quite know the difference
 - d. Need a sliding glass door architecture figure
3. Defining Disability
 - a. Engagement in the discussion varied by table
 - b. Most students indicated they liked to TED Talk video of Stella Young
4. Columns of Calculation
 - a. Need more weights for next year, specifically more 25lb weights
 - b. Decrease size of balsa columns (width), shifting range of sizes down
 - c. Need to have safety glasses for students and have them wear them
 - d. Remind students that they need to stand when conducting the testing to avoid potential eye injury
 - e. The team will be redesigning the top of the column crushing apparatus to help improve stability and reduce wiggling
 - f. Need to buy balsa wood locally and test it because balsa differs by location of where it is sold. Possibly buy extra sizes.
 - g. Connect the testing with science
 - h. Eliminate 9 and 10. Establishing the range and subtracting it. It is valuable to communicate why starting with the lowest average weight is needed.
 - i. Include question "Which length of wood do you think is stronger?"
 - j. Just do the calculations at the tables, instruct by table rather than whole group.
 - k. Having a full group explanation and discussion on the factors was helpful. This can help to re-engage the group. This is a part of classroom management.
5. General Comments
 - a. Filing boxes are AWESOME (Wade)

Thursday 6/21/19

1. Model Building
 - a. Cutting tools
 - 1) Miter box: Most liked using it. Most challenging aspect of using it is aligning the saw/blade in the box groves or slots. Once students learned how to do this they said using the box was easy. Some thought the miter box helped to secure the saw blade that resulted in the cleanest cut. The metal box was easier to use because it had wider groves/slots (so that the saw blade fit easier) and there were fewer of them (groves/slots). However, some students commented that the plastic box does not squeak when cutting wood.
 - 2) Winged Sheer: Students liked that it was easy to use, especially when cutting angles. Some thought it made cleaner cuts than using the other tools, while others did not agree.
 - 3) Chopper: Good to use when wanting to cut wood quickly.

- 4) Jig: Students who used this liked it. They said setting the angles to make the cuts was a little challenging, but once the angles were set the jig was easy to use. They said the jig allows them more options for angles. Some felt they were able to better secure the wood for cutting by using their fingers to hold the wood to the jig.
 - b. Some students cut their wood with 45 degree angles for joining base corners. Might want to mention this to students that it is an option. Talk with students about measuring peak-to-peak when using this approach.
 - c. The 10' by 10' or 10' by 13' are outside (exterior) measures. For those who do not cut the ends of their wood pieces 45 degree angles for the base corners, mention to those students they need to subtract the width of two parallel pieces of wood from the length of the two others to account for this measure.
 - d. Mention that students can cut several pieces of wood at the same time (i.e. 3 or 4) by clamping them tightly together and then cut them at the same time together.
 - e. For next year, replace small orange clamps with Irwin quick release clamps.
2. Drafting
 - a. 10 people at a time was too many students when the student designs were complex.

General Comments

- a. Having a teacher/facilitator available to work with students one-on-one in a separate location is helpful.

Discussion Items for Saturday 6/22/19

1. Binders and handouts
2. Vector M&B2 (Braille and large print instructions were not similar)
3. Materials for Lesson 4
4. Lesson 4 methodology, calculation sheet
5. Lesson 5 hand-outs and notebook (sequence) . Does Lesson 5 need to be more than a cushion lesson? (i.e. Trig).
6. Sheathing test modifications
7. Number of tools needed for drafting
8. Number of jigs; need to increase number
9. Jig: angle double (Peter?)
10. More key feature sheets for drafting
11. Flexibility with staff to be able to work with students individually
12. Handling individuals and handling groups
13. PMO designs and projects. Creativity and complexity of the designs. Do we want students to learn more engineering versus construction? Is it more drafting and engineering than construction? How does this help to improve spatial ability?
14. Economizing the adhesives. Glue dots versus other? In addition to other? Need to teach students how to apply glue dots.
15. Fixtures to help assemble joints
16. Revisit the workstation set-up from last year

Materials Needed for Next Year 2020

1. Revised river maps so that there are bigger differences between the maps. (Introduction to Engineering)
2. Stapler for construction (PMO)
3. Rubber bands (Fun with Forces)
4. Peg boards (Fun with Forces)
5. Safety glasses (Columns of Calculation)
6. Balsa wood bought locally (Columns of Calculation)
7. Bic Medium Point Ball Point Pens. NOT retractable pens. (Drawing)