White Paper

Identifying Factors Influencing Individuals Who Are Deaf or Hard of Hearing Becoming Interested in Pursuing a STEM Career

(TERC Project #44115)

TERC
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PROJECT DESCRIPTION

With this *Identifying Factors Influencing Individuals Who Are Deaf or Hard of Hearing Becoming Interested in Pursuing a STEM Career* project, TERC conducted a small preliminary study to examine influences that contribute to the interest of middle grade and high school students and STEM professionals who are deaf or hard of hearing in STEM and in a STEM career. Outcomes will provide new knowledge that will be used to determine directions for a larger more robust study and to identify strategies to incorporate into educational materials and informal learning experiences for increasing the interest of deaf or hard of hearing students in pursuing STEM careers. We have chosen to focus on middle and high school because research shows that students who commit themselves during these grades and also have opportunities to take high school or vocational courses in science and mathematics do pursue a path (Hossain 2012).[1]

OBJECTIVES and GOALS

1) Survey middle and high school students who are deaf or hard of hearing to identify
   - degree of interest in pursuing a STEM career;
   - reasons for interest or lack of interest;
   - persons, classroom, virtual, and/or out-of-school experiences that influenced their interest or lack of interest in STEM;
   - persons, classroom, virtual, and/or out-of-school experiences that might help them maintain or increase their interest.

2) Survey persons in STEM who are members of the workforce and are deaf or hard of hearing to identify
   - degree of interest in pursuing a STEM career in the middle grades and in high school and careers of interest;
   - reasons for interest;
   - in and out-of-school K-12 experiences that might increase interest of students who are deaf or hard of hearing in a STEM career and those that might decrease interest.

3) Survey teachers of students in grades PreK-12 who are deaf or hard of hearing to identify
   - what they do to create awareness and interest in STEM careers;
   - what resources and activities would help them be more effective in creating awareness and interest in STEM careers.
   - how they might integrate stories from STEM professionals into their teaching
   - what materials and supports they need to help them incorporate stories from STEM professionals

4) Survey parents of students in grades 5-12 who are deaf or hard of hearing to identify
   - what they do to create to create awareness and interest in STEM careers;

[1] Hossain, M. (2012). How to motivate US students to pursue STEM (science, technology, engineering and mathematics) careers. *Online Submission*.

- what resources and activities would help them be more effective in creating awareness and interest in STEM careers;
- what might schools do to be more effective in creating awareness and interest in STEM careers.

METHODOLOGY

Six research questions guided the study: 1) How interested are students who are deaf or hard of hearing in pursuing a STEM career? 2) What contributed to students' interest in STEM? 3) What contributed to members of the STEM work force who are deaf or hard of hearing choosing a STEM career? 4) What barriers do members of the STEM workforce encounter and how do they deal with them? 5) What can teachers of children who are deaf or hard of hearing do to help them become interested in STEM or a STEM career, how might they integrate stories from STEM professionals into their teaching, and what materials and supports do they need to help them incorporate stories from STEM professionals? 6) What can parents of students who are deaf or hard of hearing do to help them become interested in STEM or a STEM career?

A mixed-measurement within-subjects design (Cresswell & Plano Clark 2007; Johnson, Onwuegbuzie & Turner 2007)[2] was used to answer our research questions. It combined qualitative methods in the form of open-response items with quantitative methods in the form of fixed-response items. Instruments included STEM career interest surveys for students, members of the workforce, teachers of students who are deaf or hard of hearing, and parents of children who are deaf or hard of hearing. The instruments were developed off line and then entered into NoviSurvey and tested to ensure they worked as intended and provided data that would allow us to answer our research questions. Appendix A provides copies of the instruments used for the study.

Requests for students, professionals, teachers, and parents were solicited online using organizations and contacts that had previously provided subjects for work done in conjunction with our Signing Math & Science initiative (https://signsci.terc.edu/) and were known to be reliable sources of participants. After volunteering and prior to giving students and adults the link to the survey, requirements for working with human subjects were finalized. For students under 18, parents were sent an informational letter about the study along with the link to the student survey to share with their child if they agreed to allow their child to participate. Adult teachers, parents and professionals volunteered to participate after being informed about the study

RESULTS

The study sample included a survey sample of 6 students representing grades 5-11, 18 STEM professionals, 22 teachers of students who are deaf or hard or hearing, and 3 parents with at least one child who is deaf or hard of hearing. The Surveys provided information about the demographics of participants. This information is provided in Tables 1-4.

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[2] Creswell, J., & Plano Clark, V.L. (2007). *Designing and conducting mixed methods research.* Thousand Oaks, CA: Sage.

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L.A. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research*, *1*, 112-133.

Table 1: Student Demographics (N=6)

Participant #	Grade	Gender	Hearing Status	Communication Preference	School Type
1	5	Female	Deaf	ASL	School for the Deaf
2	6	Male	Deaf	ASL	School for the Deaf
3	8	Female	Hard of Hearing	ASL	School for the Deaf
4	8	Female	Hard of Hearing	ASL	School for the Deaf
5	10	Male	Hard of Hearing	ASL	School for the Deaf
6	11	Female	Hard of Hearing	English	Private School

Table 2: Demographics of STEM Professionals (N=18)

Number	Age Range	Gender	Hearing Status	Communication Preference	Highest Degree	Current Job
1	18-25	Female	Deaf	English	BS	Student/Intern
2	18-25	Female	Hard of Hearing	English	Bachelors	Subsystems Engineer
3	18-25	Female	Hard of Hearing	English	Bachelors	Software Engineer
4	18-25	Female	Hard of Hearing	English	Undergraduate	Environmental Researcher
5	18-25	Female	Hard of Hearing	Signed English	Bachelors	Researcher
6	26-35	Male	Deaf	ASL	Masters	Ph.D Student/GTA
7	26-35	Male	Deaf	ASL	Masters	Ph.D Student
8	26-35	Female	Hard of Hearing	English	Ph.D	Scientist
9	36-45	Female	Deaf	English	Masters	Systems Engineer
10	36-45	Female	Deaf	Signed English	Ph.D	Professor
11	36-45	Female	Deaf	English	Masters	Aerospace Engineer
12	36-45	Female	Deaf	ASL	Masters	Software Engineer
13	46-55	Female	Hard of Hearing	English	Ph.D	Professor
14	46-55	Female	Hard of Hearing	English	Ph.D	Associate Professor
15	46-55	Female	Hard of Hearing	English	Masters	Engineer/Analyst
16	46-55	Male	Deaf	English	Bachelors	Program Manager
17	56-65	Female	Hard of Hearing	English	Ph.D	Professor/Senior Scientist
18	65+	Male	Deaf	ASL	Ed.D	Professor (retired)

Table 3a: Demographics of Teachers of Students Who Are Deaf or Hard of Hearing [Cohort 1] (N=10)

Number	Gender	School Type	Communication Preference	Subjects Taught	Grades Taught
1	Female	Public	English	Math Science. Technology, ELA, Social Studies	5
2	Female	Public	English	Math, Science	5
3	Female	Private	ASL	Math Science. Technology	6, 7, 8
4	Female	School for the Deaf	English	Science, Reading	6, 7, 8
5	Female	Public	ASL	Math	6, 7, 8
6	Female	School for the Deaf	ASL	Science, Reading	5-12
7	Female	School for the Deaf	English	Math	5-12
8	Female	Public	English	All Subjects	6-12
9	Female	School for the Deaf	English	Science	9-12
10	Female	Private	English	Math, Science	9-12

Table 3b: Demographics of Teachers of Students Who Are Deaf or Hard of Hearing [Cohort 2] (N=12)

Number	Gender	School Type	Communication Preference	Subjects Taught	Grades Taught
1	Female	Public	ASL	Math, Science, ELA	K-3
2	Female	School for the Deaf	English	Science, Social Studies	7-12
3	Female	Public	English	ELA	10-12
4	Female	Public	ASL	Math, Science, Technology, ELA	Pre K
5	Female	Public	English	Technology	6-12
6	Female	Public	English	Math, ELA	2-5
7	Man	Public	ASL (School); English (Home)	Science	9-12
8	No Response	School for the Deaf	ASL	ELA	9-12
9	Female	Public	English	Severe sub-separate special education	6, 8
10	Female	School for the Deaf	ASL	All subjects	8, 10
11	Female	Public	English	Science	K-5
12	Female	Public	English	Math, Science, Technology, ELA	K-1

Table 4: Demographics of Parents of Children Who Are Deaf or Hard of Hearing (N=3)

Number	Gender	Communication Preference
1	Female	English
2	Female	English
3	Female	English

We organized our results around our six research questions as described below. The Surveys for Students provided information about Questions 1 and 2. The Surveys for Members of the Work Force provided information for Questions 3 and 4. The Surveys for members of the Workforce and for teachers and parents provided information for Questions 5 and 6.

Research Question 1*: How interested are students who are deaf or hard of hearing in pursuing a STEM career?*

As noted in Table 1 above, six students provided responses to the Student Survey, four middle school students and two high school students. The following tables summarize their responses to the survey questions.

Table 5: Summary of all students' responses (N=6)

How interested are students who are deaf or hard of hearing in pursuing a STEM career?

I am interested in	Science	Computers	Technology	Math	No Interest
Grades 5-8 (N=4)	3	2	1	1	1
Grades 10-11 (N=2)	0	1	1	0	1

I like learning about	Science	Computers	Technology	Math	Does not like
Grades 5-8 (N=4)	3	2	1	1	1
Grades 10-11 (N=2)	0	1	1	0	1

Interest in studying STEM after HS	Definitely	Maybe
Grades 5-8 (N=4)	1	3
Grades 10-11 (N=2)	0	2

Areas of interest	Science	Computers	Technology	Math	Not sure
Grades 5-8 (N=4)	2	2	1	3	2
Grades 10-11 (N=2)	0	1	1	0	1

Three of the four middle school students expressed interest in STEM fields. All four noted that they may or are interested in studying STEM topics after high school.

Research Question 2: *What contributed to students' interest in STEM?*

Table 6: Summary of middle school students' responses (N=4)

What contributed to students' interest in STEM? (Grades 5-8, N=4)

What at school got you interested in STEM?	N	%
Doing experiments and labs	4	100%
Using computers and technology	3	75%
Reading books and articles	2	50%
Going on field trips	2	50%
Playing games and video games	1	25%
Discovering new things	1	25%
Fixing a car	1	25%

What outside of school got you interested in STEM?	N	%
Exploring outdoors	2	50%
Reading science books	2	50%
Clubs and camps	2	50%
Visiting museums, zoos, aquariums, etc. with family and friends	1	25%
Playing games, video games, computer games	1	25%
Using computers, technology	1	25%

Did a person get you interested in STEM?	N	%
Yes	4	100%
Parent or relative	2	50%
Classmate or friend	1	25%
Famous person	1	25%

Are you interested in a job that involves STEM?	N	%
Yes	4	100%

What else might get you interested in STEM?	N	%

I take pictures, and that makes me interested in computers because I can edit them and make them look cooler.	1	25%
I am not sure	1	25%

What challenges do you encounter in STEM?	N	%
Math is very hard for me	1	25%
I do not know	1	25%

All four of the students indicated that hands-on science experiences at school got them interested in STEM; it was another person that got them interested in STEM (parent, classmate or friend, famous person); and they are interested in a job that involves STEM.

Respondents' comments were as follows.

What at school got you interested in STEM?
- Doing experiments and labs (4)
- Using computers and technology (3)
- Reading books and articles (2)
- Going on Field Trips (2)
- Playing games and video games (1)
- Discovering new things (1)
- Fixing a car (1)

What outside of school got you interested in STEM?
- Exploring outdoors (2)
- Reading science books (2)
- Clubs and camps (2)
- Visiting Museums, Zoos, Aquariums, etc. with family and friends (1)
- Playing games, video games, computer games (1)
- Using computers/Technology (1)

Did a person get you interested in STEM?
- Yes (4)
- Parent or relative (2)
- Classmate or friend (1)
- Famous person (1)

Are you interested in a job that involves STEM?
- Yes (4)

What else might get you interested in STEM?
- I take pictures, and that makes me interested in computers because I can edit them and make them look cooler.
- I am not sure. (1)

What challenges do you encounter in STEM?
- Math is very hard for me. (1)
- I do not know. (1)

Research Question 2: *What contributed to students' interest in STEM?*

Table 7: Summary of high school students' responses (N=2)

What contributed to students' interest in STEM? (Grades 10-11, N=2)		
What at school got you interested in STEM?	N	%

Doing experiments and labs	2	100%
Award from ASPIRE, a Tennessee initiative	1	50%
Use of computers and technology	1	50%
Science fair	1	50%

What outside of school got you interested in STEM?	N	%
Playing games, video games, computer games	1	50%
Hummingbirds and sharks	1	50%
After school and summer club and camp activities	1	50%

Did a person get you interested in STEM?	N	%
No, I study myself	0	0%
Parent or relative	1	50%

Are you interested in a job that involves STEM?	N	%
Yes	2	100%

What else might get you interested in STEM?	N	%
Maker fairs and fab labs	1	50%
I am not sure	1	50%

What challenges do you encounter in STEM?	N	%
I have a hard time reading	1	50%
Not hearing directions	1	50%
I do not know	1	50%

As was the case for the middle school students, high school students indicated that hands-on science experiences at school got them interested in STEM and they are interested in a job than involves STEM.

Respondents' comments were as follows.

What at school got you interested in STEM?
- Doing experiments and labs (2)
- Award from ASPIRE- a Tennessee initiative (1)
- Use of computers/and technology (1)
- Science Fair (1)

What outside of school got you interested in STEM?
- Playing games, video games, computer games (1)
- Hummingbirds and sharks (1)
- After school and summer club and camp activities (1)

Did a person get you interested in STEM?
- No-I study myself (1)
- Yes-Parent, relative, and teachers (1)

Are you interested in a job that involves STEM?
- Yes (2)

What else might get you interested in STEM?
• I am not sure. (1)
• Maker fairs and fab labs (1)

What challenges do you encounter in STEM?
• I have a hard time reading. (1)
• Not hearing directions (1)
• Being slower (1)

As mentioned previously, the surveys for members of the workforce provided information about Questions 3 and 4. Eighteen members of the STEM workforce who are deaf or hard of hearing responded to the survey. Their responses are summarized in the tables below.

Research Question 3: *What contributed to members of the STEM workforce who are deaf or hard of hearing choosing a STEM career?* (N=18)

Table 8: Summary of all workforce members' responses

***What contributed to members of the STEM workforce who are deaf or hard of hearing choosing a STEM career?* (N=18)**

When did you become interested in STEM?	N	%
Elementary School	5	28%
Middle School	7	39%
High School	6	33%

Overall, members of the STEM workforce report that they became interested in STEM during formal schooling.

Table 9: Summary of experiences that sparked interest in STEM

***What contributed to members of the STEM workforce who are deaf or hard of hearing choosing a STEM career?* (N=18, one person provided two ideas in the response)**

What sparked your interest?	N	%
I've always been interested in STEM subjects and was good at those subjects	6	33%
Teachers and family members sparked my interest	3	17%
I became interested in health and medical issues	2	11%
I became interested in solving environmental issues	2	11%
I was interested in computer games and in programming	2	11%
Visiting informal STEM venues like nature centers sparked my interest	1	6%
Other deaf people in STEM fields inspired me	1	6%
I wanted to solve deaf accessibility issues	1	6%
Drawing maps got my interested in STEM fields	1	6%

A third of the STEM workforce members noted that they were always interested in STEM topics and did well in these subjects at school. Although other experiences sparked their interest, they were mentioned less frequently.

The respondents' actual comments on the survey follow.

What sparked your interest?
• Learning about other deaf people who had entered STEM fields. After learning about a few, I actively sought other information.
• Wanting to solve accessibility issues was something I've always wanted to work on.

- My family has always been interested in public health.
- The environment and health issues.
- There was a polluted creek in my backyard, and I wanted to help clean it up.
- I grew up around yard projects and Legos, and when I was in Middle School I was fascinated with the medical field and how it was all just a big puzzle.
- My love for the unknown fascinated me. When I was 14, I wanted to study astronomy to see alien planets!
- I don't remember ever not being interested in math. My interest in science came relatively later (high school). As for engineering, while I pretty much always expected I'd go into engineering, I don't think I truly appreciated engineering as a profession until I actually did it.
- Math and sciences were always favorite subjects from early on.
- I was good in science and math. I liked the possibilities of problem solving.
- We used computers in elementary school, and I enjoyed playing games on them. We also had a personal computer at home which I played with.
- Learning BASIC in a computer class and doing programming in math class. I was always interested in science and humanities - a curious child - so I point to this as the beginnings of my interest in computer science.
- I was placed in an advanced science class with an awesome teacher.
- My 6th grade science teacher.
- Drawing maps
- Science Museums & Nature Centers

Table 10: Summary of experiences that maintained interest in STEM

***What contributed to members of the STEM workforce who are deaf or hard of hearing choosing a STEM career?* (N=18, although some provided more than one idea in their response)**

What maintained your interest?	N	%
High school and college courses and readings	7	39%
I love problem-solving and STEM topics	5	28%
I'm naturally curious	4	22%
Encouragement - from parents, teachers, and others	3	17%
I seem to have an innate ability in STEM fields	2	11%
Working with computers keeps me interested	1	6%

A range of factors contributed almost equally to workforce members having a propensity toward STEM. These included: problem solving, being naturally curious, and having an innate ability in STEM fields. Nearly 40% mentioned that their courses and readings in high school and college maintained their interest in STEM.

Respondents' comments were as follows.

What maintained your interest?

- Four years in undergraduate study in physics helped me to develop a passion for the field.
- Math is a satisfying and challenging field of study. I frankly don't understand why other people dislike it. There's nothing better than the feeling of solving a challenging problem, especially a difficult proof. It's also a decades-long experience in delayed gratification - seeing how the little pieces you learned 5-15 years ago fit together is incredibly satisfying and rewarding. Same thing for engineering - it is basically problem solving as a career.
- I've always loved puzzles, and the logic involved with STEM topics always kept me interested even though I did shift over to engineering in early high school.
- Curiosity and innate ability.
- My love for math & science.
- I was good at math
- Seeing how engineering has continuously pushed boundaries and brought us technology that we thought wasn't possible at one time maintained my interest.
- Took more classes to expand my knowledge. I actually took extra science and math classes in high school.
- We continued to use computers throughout my life, both at home and at school.

• Chemistry!
• Heavy encouragement from my mother, who wanted me to be an engineer like my father and grandfather.
• Desire to learn and adapt. Unique pathway of physics to earth science to geology (physic based) to geology with civil engineering.
• As I aged, I tended towards science as I preferred it to my other classes and found online articles very interesting. My high school did not offer many computer science opportunities, but I arrived at college, took the classes I was interested in, was able to compete and did well, and so it went from there.
• Being able to work outside and keep on learning new things.
• People liking the ideas I shared.
• Direct access to communication at Gallaudet.
• I would not necessarily say that it was maintained throughout high school, because I only had one true science teacher in high school. (Someone who literally majored in science as an undergraduate themselves.) The rest were trying to be science teachers.

Table 11: Summary of when workforce members began thinking about a STEM career

***What contributed to members of the STEM workforce who are deaf or hard of hearing choosing a STEM career?* (N=17, one person did not answer this question)**

When did you begin thinking about a STEM career?	N	%
High school	7	41%
College	5	29%
Middle School	2	12%
Elementary School	3	18%

As noted in Table 8, initial interest in STEM began during grades K-12. This related question elicited a different response. Nearly three-quarters of the respondents said their career interest in STEM began in high school (41%) or college (29%).

Respondents' comments were as follows.

When did you begin thinking about a STEM career?
• Childhood
• When I was 10 years old, I knew I wanted to be a scientist
• I began thinking about a STEM career in middle school after a surgery.
• Probably high school, when it hit me that people actually built everything for a living, and I was able to be around engineering mentors who helped me with engineering problems while in FIRST robotics. I also had the chance to tour NASA centers, and my fascination with space engineering grew.
• High school.
• High School/college
• In 11th grade, when I hit chemistry for the first time.
• High school
• At age 14
• In high school I got the sense I enjoyed computer-based activities more than the other sciences, and the sciences more than my other classes. I confirmed this in college and decided to major in EE+CS.
• Sophomore year in high school
• In my freshman year in undergraduate school. I had my heart set on research. When I graduated, I had difficulty as a deaf person finding a position in a laboratory. I was offered a physics teaching position at a recently established college for deaf students (NTID). I never planned to enter teaching and taking this offer was an important turning point that led to a very fulfilling career in STEM education.
• At Gallaudet.
• Freshman year of college.
• College
• During my undergraduate years

• I don’t remember ever thinking about any other sort of career. I did, in college, briefly flirt with majoring in English literature, but it wasn't the right choice for me.

Table 12: Summary of factors that supported interest in pursuing a STEM career

What contributed to members of the STEM workforce who are deaf or hard of hearing choosing a STEM career? **(N=18, although some provided more than one idea in their response)**

What activities, experiences, or people maintained your interest in a STEM career?	N	%
Teacher mentors in high school and college	11	61%
Doing science through clubs, internships, and fieldwork	9	50%
Courses and professional meetings	4	22%
Learning how to communicate science at Gallaudet	1	6%
Knowing the positive impact that engineering has on peoples' lives	1	6%
Meeting famous scientists	1	6%
Continued NSF funding	1	6%
Computer games	1	6%

More than one thing appears to have helped maintain interest of STEM professionals in a career in STEM. Six described the importance of having teacher mentors in high school and college. Half said that actually doing science maintained their interest.

Respondents’ comments were as follows.

What activities, experiences, or people maintained your interest in a STEM career?

• Becoming involved in the movement in STEM for people with disabilities after Public Law 94-142, I had the opportunity to meet many people with other disabilities who inspired me. Stephen Hawking in physics, Ballard and Cousteau (oceanographers), and many other STEM educators. I received, over the years, about a million dollars in NSF and other grant funding to pursue my professional interests in STEM education. The Classroom of the Sea project with UCONN and the National Undersea Research Center and American School for the Deaf in Hartford were each a huge boost in my interests.
• It’s difficult to be certain from my limited point of view, of course, but I don’t believe any external influences had any significant effect one way or the other. Although it probably did help that my mother had a BS in mathematics and was always happy to help answer my questions that went beyond the bare facts of the lesson. She never tried to push it on me, though.
• Mentors, my parents, tours of NASA and other engineering organizations, and a few women in STEM focused summer activities.
• Science club in high school helped me maintain interest and got me into college by paying me as a summer term. They were vital to kicking off my path in science - sadly these programs no longer exist.
• Playing strategic games on the computer really sparked and maintained my interest. There was a lot of debugging and troubleshooting involved. I broke a computer in middle school and almost broke the one at home. I was very curious and not afraid to try anything.
• College provided me with opportunities to apply engineering concepts and principals to actual projects, such as a robot car, or how to improve a turbine engine.
• Encouragement
• Doctors, professors, and emerging technology have maintained my interest in a STEM career.
• Chemistry teacher, a week-long engineering camp at Case Western Reserve University.
• I had an awesome structural geology teacher.
• My 8th grade science teacher; my advisor at the USGS that paid me to work while I went to school; a few friends and mid-career scientists helped me along the way.
• Great deaf professors at Gallaudet. Direct access to communication is so important!
• I can’t imagine any path other than engineering for myself. I do, of course, have other interests, including English literature and art history, but in terms of a career, I felt the best way for me personally to have a positive impact on people's lives was to pursue an engineering career."
• I had great undergraduate teachers. More importantly, I had incredible mentors at the graduate level.

• Excelled at science and math. Enjoyed going to the library to learn.
• I enjoyed my STEM courses more than any other course in college.
• As a geologist traveling the US and eventually the world was fascinating!
• Engaging classes, a makerspace with lots of tools and basic materials and knowledgeable people, a supportive community that helped me when I got stuck on academics and projects or commiserated with me.
• Being able to perform research, field work, attend meetings and workshops.
• Reading articles, interactions with others, participating studies of interest.
• I'm sure there have been a lot of influences around me my entire life and I just didn't notice them!

Table 13: Summary of workforce members' suggestions for supporting students' interest in STEM

***What contributed to members of the STEM workforce who are deaf or hard of hearing choosing a STEM career?* (N=16, two people did not answer this question)**

What do you think are the most important factors in keeping students who are deaf or hard of hearing interested in STEM?	N	%
Encouragement from key people - mentors, role models, peers	11	69%
Personal persistence	2	13%
Show the practical applications of mathematics	1	6%
Make STEM learning fun	1	6%
Eliminate barriers that discourage learning	1	6%

Nearly 70% of the STEM workforce respondents suggested that personal encouragement from key people was the most important factor that kept them interested in STEM.

Respondents' comments were as follows.

What do you think are the most important factors in keeping students who are deaf or hard of hearing interested in STEM?

• Motivation and positive reinforcement. I failed my first physics test during my freshman year. Seriously, a counselor told me to "reach for the stars" and this was motivating. Around the same time, I bumped into a senior majoring in physics who was from Greece. He was an assistant to the physics professor and casually mentioned that I had submitted the best lab report for the first experiment we did. It made a huge difference in motivating me to go on and do very well after that first discouraging experience.
• The ability to persist when something becomes hard or challenging.
• Make STEM fun and easy to understand.
• When you're in the middle of algebra I, it can be hard to appreciate that everything you're learning serves a true purpose. My linear algebra prof observed that to many students who don't yet have a solid grounding in linear algebra, a typical course in differential equations comes across as a bewildering welter of magic tricks. I think that can be true at a lot of levels of math. Maybe giving students the opportunity to do hands-on work or hear from speakers who use the concepts they're learning would help.
• Support, access to information, and encouragement.
• I personally believe that the Number 1 reason why many lose interest is because they feel like they can't do it, or they have just too much to handle. Persistence and encouragement are very important.
• Vertical peer mentoring.
• Having awesome mentors along the way.
• Role models!
• Access to role models who are Deaf/Hard of Hearing.
• Great teachers who pay attention to inclusiveness. Available accommodations, preferential seating, subtitles on all movies/videos, note-takers, technology (i.e. induction loop).
• Direct communication access. I did not fare well using interpreters. Not many interpreters are good with STEM, so they do not translate well. Also, a middle man causes barriers. Deaf and hard of hearing students need role models.
• Resources and support.

• Classes that include access and support to put deaf and hard of hearing students on a level playing field.
• Not having barriers for opportunities, whether they be physical or cultural.
• I think the most important factors are the number of people realizing that there are a diverse group of people out there willing to participate and work in the STEM.

Research Question 4: *What barriers do members of the STEM work force encounter and how did they deal with them?* (N=18)

Table 14: Summary of barriers members of the STEM workforce encounter

What barriers do members of the STEM work force encounter and how did they deal with them? **(N=18)**		
What challenges or obstacles did you find you had to overcome along the way?	N	%
Inadequate accommodations or lack of accommodations	6	33%
Being female in addition to being deaf or hard of hearing	5	28%
Learning tact and other soft skills	1	6%
Finding out about incidental learning activities in college	1	6%
Age discrimination in addition to being deaf or hard of hearing	1	6%
With my rural poverty background, I was the first in the family to go to college	1	6%
It's a challenge to do public speaking in noisy environments	1	6%
It's hard to understand topics that are brand new to me initially	1	6%
Finding a job	1	6%

One third of the respondents reported that insufficient or absence of accommodations hindered their careers. Five said that in addition to being deaf or hard of hearing, being female was an obstacle to their career success.

Table 15: Summary of how the STEM workforce respondents overcame obstacles

What barriers do members of the STEM work force encounter and how did they deal with them? **(N=14, four of the respondents did not answer this part of the question)**		
What challenges or obstacles did you find you had to overcome along the way? How did you overcome them?	N	%
Perseverance	5	36%
Self-advocacy	4	29%
Asked classmates to share their lecture notes	2	14%
I surrounded myself with role models	1	7%
I will retire early or do consulting (response to age-ism)	1	7%
I found a real-time transcription service in college	1	7%

Two-thirds of the respondents described their personal commitment to self-advocacy and not giving up as factors that kept them on the path to success in their STEM career.

Respondents' comments were as follows.

What challenges or obstacles did you find you had to overcome along the way? How did you overcome them?

• Primarily, access to sign language interpreters in some projects outside my college was problematic. Even in retirement it remains a problem. I am unable to attend meetings due to the cost of interpreters and the logistics of finding them. It is important to note that many of my deaf friends and myself chose mathematics or physics or engineering because we studied in undergraduate work in the days before Interpreting became a profession. Hence, we leaned toward math and physics and engineering because the professors in hearing colleges wrote more on the blackboards. Notetakers were rare, mostly a result of our asking classmates to share their notes. I was accepted to Gallaudet College, but they had no major in physics, so I took the risk of attending Bethany College, a

small college in West Virginia with a very nice physics program. This all worked out for me very well but understanding in classes was a MAJOR obstacle and at that time the professors did not know what to do with a deaf student. It required patience on my part and the professors' part.
- Using interpreters at college was very painful. I did not learn well through interpreting, but I learn well by reading.
- Entering RIT and learning how to work with interpreters and hearing people.
- Communication and meetings with people. When I was younger, I just tried to fit in, but that doesn't work out very well. As I got older and wiser, I've realized that when I set the rules, and explain to people what's the best way to communicate with me, people generally are very accommodating, and it's not a big deal.
- When I entered the workforce, my major challenge was learning tact and other soft skills
- I didn't become deaf until I started at University, where me hearing rapidly declined between the ages of 18-21 to the point of requiring a cochlear implant to remain a part of hearing society. This sudden impact on my life changed my outlook dramatically and has required me to start to stand up for myself more in conversation and work to figure out what's being said.
- Being a woman in engineering has always been a worry for me, but I was fortunate enough to be able to surround myself with amazing role models both in high school and college that have given me the confidence to succeed.
- Incidental learning opportunities-I either accepted I wouldn't get them or got them through chatting with classmates using instant messaging etc..
- Being a female aspiring-engineering student by 11th & 12th grade in 1980-81, no one took me seriously and fostered me into the highest levels of math courses such as calculus or drafting (which I could've taken in high school back then and needed for college) - it did make me stumble at first. But I persevered in college repeating classes where needed.
- Sometimes, being a female was an obstacle. Sadly, when I was an undergraduate, I was the only female student. As a graduate student, I saw the unusual treatment of females when it came to selections for field work, etc. In addition, I have also overcome attention difficulties during my PhD writing stage.
- Now, I'm in the fight of my federal career like never before - age discrimination has hit along with disability discrimination. So, if I have to, I'll retire early, and start another career or do consulting.
- I stopped wearing hearing aids at 14, because I thought they made me less attractive. Thus, I struggled to hear in many classes until my senior spring of college, when I got aids again. There were NO accommodations for hard of hearing besides hearing aids. One day in 5th grade, the school tried to put me in the one class they had for students with all types of disabilities including intellectual. I had to throw a fit to get put back with my intellectual peers.
- Coming from a poor, rural background and first to go to college much less get a PhD was the biggest hurdle. I was raised to not see my hearing loss as a disability, so I didn't start asking for help until much later for accommodations. Even with asking, institutions or agencies are underprepared.
- Public speaking is a bit of an issue in loud places."
- My high school was entirely discussion-based. I had good accommodations - an FM system - but they weren't quite what I needed. I went home, used the Internet to teach myself what my peers had heard from the teacher and from each other, and THEN began on homework. In college I got real-time transcription which saved me a lot of time and energy. I still look to the Internet to teach me many skills as in some cases it is hard to attend and follow a class or workshop.
- Sometimes it's hard to understand topics that are new. I overcame this by studying harder and making sure to take interest in the topic in everyday life.
- Finding a job

Table 16: Summary of the barriers that the STEM workforce respondents continue to face

What barriers do members of the STEM work force encounter and how did they deal with them? **(N=9, nine respondents did not answer this question)**

What challenges related to your job do you continue to have to overcome?	N	%
Inadequate accommodations resulting in poor communication	8	89%
Discrimination	1	11%

All but one of the nine respondents described a lack of accommodations as a challenge they continue to face.

Respondents' comments were as follows.

What challenges related to your job do you continue to have to overcome?

- Meetings are difficult to handle. I read lips, but I also use a captioner for telecons. However, people over talk each other, interrupt each other, use terminology that the captioner does not understand, or talk too far away from the microphone, so the captioning isn't that great.
- As someone with a cochlear implant, sometimes interpersonal communication takes extra efforts, and there can be frustrations both with myself and my team members. Everyone is different, and in a team meeting setting sometimes it takes more effort to follow everything or listen for a break in conversation to make myself heard.
- Poor communication.
- Most of the internal videos are not captioned and I have to personally require every individual one to be captioned. Also, not getting sent to customer sites or conferences, probably due to my deafness. I am not able to benefit from hall conversations. Team lunches are boring for me, too noisy.
- I struggle to hear in many environments - in class, in meetings, in informal situations.
- I asked for reasonable accommodations for captions on video for meetings or big town halls as well as an upgraded phone system to caption. I've been waiting 6 months and am still waiting.
- Arranging accommodations for events is a struggle as I am often informed of meetings and the like with too short notice to obtain a transcriber or arrange other accommodations.
- Sometimes it's hard to hear and communicate with clients via phone. Other times it's hard to communicate with my boss to make sure I understand the project correctly.
- Lack of culture of respect and dignity for people with disabilities and outright discrimination. Lack of understanding about or commitment to providing appropriate accommodations. A top-down approach that tries to tell us what we need, instead of listening to us, who are experiential experts.

Research Question 5: *What can teachers of students who are deaf or hard of hearing do to help their students develop interest in STEM or a STEM career, how might they integrate stories from STEM professionals into their teaching, and what types of materials and supports would help them make use of the stories?*

The results reported below result from the analysis of data that was collected from surveys of two different groups of teachers (Cohort 1 and Cohort 2). The survey administered to Cohort 1 occurred prior to development of a set of video stories that feature members of the STEM workforce who are deaf or hard of hearing. It was designed to gain insight from teachers about students' level of interest in STEM careers and about the kinds of materials and activities that might encourage their interest in STEM and STEM careers. The survey administered to Cohort 2 was administered after the stories had been developed. It was designed to gain insight from teachers about how they might integrate the stories into their teaching, and what materials and supports they would need to do so.

Table 17: Workforce respondents' suggestions as to what they can do to encourage STEM interest

What can teachers of students who are deaf or hard of hearing do to help them become interested in STEM or a STEM career? (N=18, 15 respondents made a total of 17 suggestions)

What do you think schools could do to help children and teens who are deaf or hard of hearing become interested in STEM or a STEM career?	N	%
More activities, labs, projects, field trips that engage the students	7	47%
Provide role models like deaf teachers and scientists	5	33%
Provide all possible accommodations	4	27%
Use real-world examples and applications in math classes	1	7%

All but one of the respondents mentioned the importance of having engaging learning activities, integrating role models, and providing accommodations as important for encouraging students' interest in STEM or in pursuing a STEM career.

Respondents' comments were as follows.

What do you think schools could do to help children and teens who are deaf or hard of hearing become interested in STEM or a STEM career?

- There are rich resources now in books and on the Internet, especially, with deaf women and men talking about their fields in STEM. Teachers should be familiar with Gardner's Theory of Multiple Intelligences and how to build upon students' individual interests and motivate them to think more about how they can relate their school work to STEM, even at an early age. Field trips to local museums, aquaria, laboratories. Invite STEM professionals to classes to demonstrate. Teachers can often introduce Discrepant Events, things that you don't expect, to motivate students toward involvement in subsequent discussions. Minds on (more than hands on) science can be motivating. Probably the least motivating approach is didactic lectures (teacher centered).
- There are resources and videos out there that show different deaf role models in various jobs.
- Deaf science camps and fun science games to play.
- They can provide opportunities to pursue existing interests
- There are probably opportunities for pedagogical improvement in various courses. I rarely enjoyed science experiments in any level of school because they were typically pointless; I could have learned the same material equally well by reading about it and working a few problems. Messing about with colored liquid in test tubes and pouring it all down the drain when you're finished serves no concrete purpose. Of course, there are students who do benefit from these experiments, so you wouldn't want to eliminate them, but perhaps there are opportunities for more variety. I remember one experiment where we made a snow globe - that one was pretty cool and resulted in a concrete result that I could hold in my hand. I also would have really enjoyed learning more about the history of science - my high school biology teacher did a great job with that - and the real-world applications of math. Complex numbers, for example, make the modern world possible, but you never hear anything about that in math class.
- Exposure.
- Add more STEM courses or projects.
- Introduce them early to science via science museums.
- Have great science teachers.
- Schools need to show extra interest in engaging students with disabilities.
- Foster interests and have the knowledge and access to assistive technologies to handle children who are deaf or hard of hearing (and everyone).
- Make sure that accommodations are proactively offered, rather than only available after protracted battle (during which content is lost).
- Provide live captions of teachers and hearing devices to loan.
- Have books and computers with Internet access, and engaging teachers (who may not know the answers but will work with the students to find them) It is important that the teacher be cooperative and provide outside time to answer students' questions regarding material they didn't catch in class, or listen to students' requests such as to write down exam dates. Otherwise the class becomes unnecessarily difficult and a negative experience that kills interest in the topic.
- Be willing to allow hard of hearing children a way get accommodations giving them ability to partake in STEM just like anyone else.

Table 18: Cohort 1 teachers' estimate of students' interest in STEM or a STEM career

How many of your students are interested in science, technology, engineering, or math?	N*	%
A few	4	40%
Half	3	30%
More than half	3	30%
*How many of your students are interested in a **career** in science, technology, engineering or math?*	N	%
A few	9	90%

None	1	10%

*- Teachers of Students Who Are Deaf or Hard of Hearing (N=10)

The fixed-choice nature of the questions precluded teachers from providing an estimate of the percentage of their students who they believe are interested in STEM or a STEM career. However, the data do show that some students were interested in STEM or in a STEM career. of some students. Only one teacher reported that none of the students were interested in STEM or in pursuing a STEM career.

Table 19: Cohort 1 teachers' suggestions for supporting students' interest in STEM

What can teachers of students who are deaf or hard of hearing do to help them become interested in STEM or a STEM career? (N=10)

What activities, resources, games, books, etc. that you have done or used do you think contribute to students' awareness and interest in STEM or STEM careers?	N	%
Hands on science labs and experiments	7	70%
Readings about science, science careers, and scientists	7	70%
Engineering design and build activities	6	60%
Field trips	2	20%
STEM and STEAM nights for families	2	20%
Guest speakers	2	20%
Pixar in a box (videos on the science behind animated movies)	1	10%
H&R Block budgeting challenge game	1	10%
Doing graphing with the labs and experiments	1	10%

Hands-on lab experiments, readings, and design and build activities were mentioned as most important for supporting students' interest in STEM or a STEM career.

Respondents' comments were as follows.

What activities, resources, games, books, etc. that you have done or used do you think contribute to students' awareness and interest in STEM or STEM careers?

- Science kits, experiments and labs, guest speakers, field trips, biographies, non-fiction how to books
- 3D printing
- STEM projects that include designing and building, videoconference with Deaf professionals in STEM fields, engineering activities integrated into science class
- Science fair, short stories about careers; inquiry activities that involve building a structure with a specific goal
- Engineering projects
- Investigating careers and opportunities in for the future, looking at college certification programs, research into future job trends.
- STEAM night for deaf and hard of students and their families
- Dissections, labs, graphs, tools, textbook sections that discuss careers in science
- STEM night, robots that students can use/program, Pixar in a Box, Kiwi Crate, field trips to various science museums and work sites, H&R Block challenge, Mystery Science Web site

Table 20: Cohort 1 teachers' ideas for supports to encourage students' interest in STEM

What can teachers of students who are deaf or hard of hearing do to help them become interested in STEM or a STEM career? (N=10, nine teachers responded)

What additional information, resources, tools, and/or activities would help you to support and encourage your students in STEM and potentially interest them to pursue STEM careers?	N	%
Technology to connect my students to deaf and hard of hearing role models in STEM	7	78%

Funding for students to attend STEM camps	1	11%
College visits	1	11%

Most teachers identified the need for their students to see deaf or hard of hearing role models. Some wanted technology to support their students' conversations with role models.

Respondents' comments were as follows.

What additional information, resources, tools, and/or activities would help you to support and encourage your students in STEM and potentially interest them to pursue STEM careers?

- Use of technology to connect students to Deaf, hard of hearing, and hearing individuals in STEM careers to provide information and exposure and to mentor/ and serve as role models
- Contact with Deaf individuals in STEM fields and use of interactive videoconferences
- Access to and interaction with deaf scientists and engineers for students to interact and use of videos
- Video series of deaf adults with STEM careers, explaining their jobs to create awareness of STEM careers and ~~and~~ view them as a viable goal.
- More access to Deaf adults who work in STEM fields!
- Guest speakers involved in STEM careers.
- Deaf and hard of hearing individuals already in STEM careers sharing their experiences about their jobs and what they did to get there.
- Funds for students to attend STEM existing STEM camps
- College visits

Table 21: Cohort 1 teachers' suggestions for families to encourage interest in STEM

What can teachers of students who are deaf or hard of hearing do to help them become interested in STEM or a STEM career? (N=10, nine teachers responded)

What do you think families could do outside of school to be more effective in creating awareness and interest in STEM and STEM careers?	N	%
Encourage activities that require active engagement	5	56%
Expose kids to STEM areas and careers	5	56%
Visits to informal science venues like museums and nature centers	4	44%

Teachers' suggestions parallel those shared in the context of responses to several of the previous survey questions. These include providing exposure to STEM topics and careers through engaging activities and visits to informal science venues like museums and nature centers.

Respondents' comments were as follows.

What do you think families could do outside of school to be more effective in creating awareness and interest in STEM and STEM careers?

- Encourage creative endeavors such as maker activities, hands on building toys, and technology that encourages active participation over passive engagement and problem solving
- Attend local museums and science centers
- Go to museums. cook together, participate in take your kid to work days, visit colleges
- Take advantage of free library passes to museums, encourage scientific curiosity
- Go to Science Museums and centers, expose children to different STEM areas
- Send children to camps focused on STEM themes
- Participate in STEM-based opportunities outside of school and after school clubs and activities that include interpreters to make them accessible.
- Point out what different people do to expose them to the broad range of STEM careers that are available.
- Discuss careers when the opportunity arises

Table 22: Cohort 2 teachers' strategies to introduce students to STEM careers

What can teachers of students who are deaf or hard of hearing do to help them become interested in STEM or a STEM career?

(N=12)

Is introducing students to STEM occupations and careers part of your teaching?	N	%
Yes	6	50%
No	6	50%

The results for this question show that half of the teachers surveyed include introducing students to STEM occupations as part of their teaching. The other half do not do so. Those that introduce students to STEM occupations report that they do this by incorporating it into their lessons; inviting guest speakers into their classes; doing research on Deaf professionals in STEM, and by watching videos about people in STEM fields.

Respondents' comments were as follows.

Why IS introducing students to STEM occupations and careers part of your teaching?

• I'm the tech teacher. I incorporate STEAM into everything I do. I use a fictional journey to Mars to teach middle schoolers about google docs & suite. I invite speakers to my classes - some Deaf some hearing all STEAM. Annual family STEAM events. Computer programming classes. Annual hour of code events.

• We research Deaf professionals in STEM. We are also involved in the WADE project (Watershed Stewardship in Action: Deaf Students on the Estuary) where my students interact with Deaf professionals using STEM.

• As I am an English teacher, introduction to STEM occupations and careers tends to come up as content when we read/view video about people in STEM fields, or when we do college-envisioning activities.

• Read alouds about scientists, introducing engineering fields (ie: civil engineer, biomedical engineer) when we tackle engineering design challenges.

The teachers that do not typically introduce students to STEM occupations report that they do not do so because of a lack of resources and lesson plans; lack of instructional time; age or ability of the students; and the need to focus on core content and concepts only, especially during remote learning.

Respondents' comments were as follows.

Why is introducing students to STEM occupations and careers NOT part of your teaching?

• Lack of resources and lesson plans

• I do not have information to do so and I teach language arts and there is no time in the curriculum

• I teach pre-k.

• I am focused on the content right now through remote learning, but it is something important to consider!

• My students are middle schoolers working on skills such as toileting, dressing, and recognizing their names. A career in STEM is not a reasonable goal for them at this time

• At this time, I am not addressing this.

Table 23: Cohort 2 teachers' perceptions of the value of including stories from STEM professionals in instruction

What can teachers of students who are deaf or hard of hearing do to help their students develop interest in STEM or a STEM career, how might they integrate stories from STEM professionals into their teaching, and what types of materials and supports would help them make use of the stories? (N=12, open response)

What do you think is or would be the most important value for students of including stories from STEM professionals into your instruction?	N	%
To motivate and inspire students to see themselves in these roles	5	42%

Expose students to STEM areas and careers	4	33%
Expose students to Deaf role models (from diverse backgrounds)	4	33%

Teachers' responses to this question indicate the importance of exposing students to Deaf role models and STEM areas and careers and to motivating and inspiring students in various ways to see themselves in these roles.

Respondents' comments were as follows.

What do you think is or would be the most important value for students of including stories from STEM professionals into your instruction?

• Teaching kids about why steam is important and what they could do with it as an adult
• It would help students picture themselves in these careers; they might see something that they hadn't thought about before; it would also clarify the careers so students understand it; they can see how what they are learning in class applies to life outside of school.
• Open their minds
• BIPOC Deaf and Hard of Hearing role models such as scientists, hand-on activity, background knowledge, and fully accessible language.
• Seeing Deaf & hard of hearing professionals and students from a rich diverse background - much like the demographics of our students.
• See role models, learn about professions they might have otherwise not known about, bring diversity into the field
• I want my students to see that they can do anything they put their mind to. Having them see Deaf professionals working hard out in the world is extremely important.
• I think it's great to spread out career information across the disciplines so that there is repeated exposure/deepened understanding.
• Attending to language output, whether the presenter signs or with an interpreter present, and encountering other people's signing styles. Also, exposure to new concepts and fields for the sake of curiosity.
• Special needs deaf in STEM roles
• So that they can see themselves as future scientists and engineers
• Students can make connections to these individuals or can aspire to be like them.

Table 24: Cohort 2 teachers' ideas about the kinds of questions stories from STEM professionals might answer

What can teachers of students who are deaf or hard of hearing do to help their students develop interest in STEM or a STEM career, how might they integrate stories from STEM professionals into their teaching, and what types of materials and supports would help them make use of the stories? (N=12, 8 teachers responded, open response)

What do you think is the most important question the stories should answer?	N	%
What it takes/How to get involved in this field/career	5	63%
How the professional became interested in the career	4	50%
What challenges the professional faced and how they overcame them	4	50%
Can students pursue this career/field when they grow up	2	25%
What does "daily life" at work look like for the professional	1	13%

Teachers' responses indicate the importance of the stories answering five major questions. These include: 1) How the professional became interested in the career? 2) What challenges the professional faced and how they overcame them? 3) What it takes to get involved in a certain STEM field or career? 4) Is it possible for students to pursue this field or career when they grow up? and 5) What does daily life at work look like for this field or occupation? Almost half of the teachers said that knowing what is involved and what it takes to pursue a particular STEM career is the most important questions that the stories could answer.

Respondents' comments were as follows.

What do you think is the most important question the stories should answer?

- How the person became interested in the career; what kind of training is needed; what is daily life like
- What were some challenges and how did you resolve them.
- The stories should answer the question, "What do I need to do to become a successful Deaf adult in the community working with STEM?"
- That STEM fields are great places for Deaf workers, and that women do as well as men in STEM fields.
- What does your daily life at work look like?
- "Can I do this?"
- What challenges did you face on your journey?
- From the perspective of the child the questing should answer...Can I do that when I grow up?

Table 25: How often Cohort 2 teachers would use stories from STEM professionals

What can teachers of students who are deaf or hard of hearing do to help their students develop interest in STEM or a STEM career, how might they integrate stories from STEM professionals into their teaching, and what types of materials and supports would help them make use of the stories? (N=12, eleven teachers responded)

If you used the stories, how often might you incorporate them?	N	%
Once a week	3	27%
Twice a month	3	27%
A few times a year	3	27%
Once a month	2	18%

Teachers' responses show the need for flexibility in use of the stories and would like to be able to use them as often as they wish depending on their situation.

Table 26: How Cohort 2 teachers would incorporate stories from STEM professionals

What can teachers of students who are deaf or hard of hearing do to help their students develop interest in STEM or a STEM career, how might they integrate stories from STEM professionals into their teaching, and what types of materials and supports would help them make use of the stories? (N=12, check all that apply)

If you used the stories, how might you incorporate them?	N	%
In class	9	75%
Into class discussions	8	67%
Into classroom/individual research	2	17%
Into hands on inquiry	2	17%
Into homework	1	8%

Teachers' responses indicate that using the stories in class is preferred. Many teachers said they would do this through class discussion.

Table 27: Strategies Cohort 2 teachers would use to incorporate stories from STEM professionals

What can teachers of students who are deaf or hard of hearing do to help their students develop interest in STEM or a STEM career, how might they integrate stories from STEM professionals into their teaching, and what types of materials and supports would help them make use of the stories? (N=12, check all that apply)

If you used the stories, what strategies might you use?	N	%
As a follow-up or extension to an activity	9	75%
As an illustration of how professionals use a concept or skill	9	75%

As an introduction to an activity	8	67%
As an opportunity to interact on-line with a professional	5	42%
As an opportunity to interact offline with a professional	3	25%
As an option during free time	2	17%
At home for homework	1	8%
Into a family night	1	8%

Teachers' responses show a preference for incorporating the stories as an introduction or as a follow-up to an activity. Many teachers said that they would use the stories to illustrate how professionals use a particular concept or skill. Several teachers said they would use the stories to provide opportunities for students to interact on-line with a STEM professional.

Table 28: Subject areas into which Cohort 2 teachers might incorporate stories from STEM professionals

What can teachers of students who are deaf or hard of hearing do to help their students develop interest in STEM or a STEM career, how might they integrate stories from STEM professionals into their teaching, and what types of materials and supports would help them make use of the stories? (N=12, check all that apply)

Into which subject area(s) might you incorporate the stories?	N	%
STEAM	7	58%
ELA	7	58%
STEM	6	50%
Social Studies	5	42%
Computer Science	3	25%
Technology Education/Instruction/Class or Program	3	25%
Afterschool/Out-of-School Programs	1	8%
Vocational	1	8%

Responses show that teachers would incorporate the stories into their teaching of a variety of different subjects or content areas including STEM, STEAM, ELA and Social Studies.

Table 29: Supports and materials Cohort 2 teachers would need to incorporate the stories

What can teachers of students who are deaf or hard of hearing do to help their students develop interest in STEM or a STEM career, how might they integrate stories from STEM professionals into their teaching, and what types of materials and supports would help them make use of the stories? (N=12, check all that apply)

What supports and materials would help you incorporate the stories into instruction?	N	%
Suggested activities, discussion questions, and prompts prior to viewing	9	75%
Activity sheets for students	7	58%
Suggested activities, discussion questions, and prompts after viewing	7	58%
Suggested activities, discussion questions, and prompts during viewing	3	25%
Determination of connections to STEM topics, skills, and standards	3	25%

Teachers' responses indicate it would be important to include activities, discussion questions and prompts prior to and following viewing a story. More than half would appreciate having activity sheets to give to students to use in conjunction with the viewing of the stories.

Table 30: When do Cohort 2 teachers believe integration of the stories should occur

What can teachers of students who are deaf or hard of hearing do to help their students develop interest in STEM or a STEM career, how might they integrate stories from STEM professionals into their teaching, and what types of materials and supports would help them make use of the stories? (N=12)

Where do you think integration of the stories should begin and why?	N	%
Early Elementary Grades	6	50%
Upper Elementary Grades	5	42%
Middle Grades	1	8%

Teachers' responses indicate that it is important to begin incorporating the stories in the elementary grades.

Respondents' comments were as follows.

• Early Elementary Grades should begin by noticing STEAM careers in their daily play activities. Upper Elementary Grades should begin to think about what makes a scientist and what do they look like. Middle school start to think about the future and what would be cool to study. High school is where they solidify their plans for college or trade. I'm happy to share that in middle school I already have 2 students that want to work at NASA.
• Start early!
• We have to start early to avoid the growth of misinformed beliefs that STEM is not a place for Deaf people or for women.
• Start early! I want Deaf kids knowing what's out there in the world for them!
• Earlier the better! And as kids grow, they can go deeper into exposure and interacting with the stories.

Teachers explained their responses further as follows.

• Younger kids are just developing language
• They are able to comprehend the topic
• It should START in elementary but should be ongoing throughout their school career.
• It is important for students to start learning about these at an early age.
• Middle schoolers are just beginning to think about the future; they would have the capability to understand the stories. Though I also think introduction at a young age is important; this helps students start thinking about science and peaks their curiosity.

Table 31: Cohort 2 teachers' ideas about accessibility features to incorporate into stories from STEM professionals

What can teachers of students who are deaf or hard of hearing do to help their students develop interest in STEM or a STEM career, how might they integrate stories from STEM professionals into their teaching, and what types of materials and supports would help them make use of the stories?
(N=12, eleven teachers responded, open response)

What are the most important accessibility features that you think should be included?	N	%
ASL	7	64%
Captions (printable and in multiple languages)	6	55%
Visuals (Pictures, Video)	5	45%
Reading Level Options	2	18%

Teachers' responses indicate the importance of including both ASL and captions as well as many visuals to keep students interested and engaged.

Respondents' comments were as follows.

What are the most important accessibility features that you think should be included?

• Visual
• ASL; most students are not able to read captions and understand what is happening- the message is more engaging if offered in ASL directly or through an interpreter; many visuals- students disengage when just watching a person talk; they need lots of action"
• Closed captions for any videos

• Communication access. Deaf & hard of hearing asl users.
• Closed captions, stories in ASL by BIPOC Deaf community members, clear visuals
• It must include all languages. Ideally, it would be in ASL with narration AND closed captions. That way each student can access the material according to their preferred method.
• Direct instruction by skilled Deaf signers. Open captions.
• ASL, captions, accessible and multi-leveled activities to accompany the stories
• ASL interpreter, Pictures, and Video clips
• Story available at different lexile levels, video of scientist or engineer talking about their work or in the field, story read aloud in ASL (interactive storybook)
• Printable, Captions, Leveled reading

Research Question 6: *What can parents of children who are deaf or hard of hearing do to help them become interested in STEM or a STEM career?*

Table 32: Summary of STEM workforce members' suggestions for parents to support STEM interest

What can parents of children who are deaf or hard of hearing do to help them become interested in STEM or a STEM career? (N=18, fourteen respondents made 16 suggestions)

What do you think parents could do to help their children and teens who are deaf or hard of hearing become interested in STEM or a STEM career?	N	%
Provide opportunities for exposure to STEM in school and out	8	57%
Introduce students to role models: deaf scientists in STEM fields	3	21%
Know about and use assistive technologies	2	14%
Advocate for your deaf children	2	14%
Give them a computer	1	7%

More than half of the respondents' answers focused on the importance of parents providing opportunities for children to experience STEM topics and activities both inside and outside of school. They also emphasized the importance of exposing children to deaf STEM role models and mentors.

Respondents' comments were as follows.

What do you think parents could do to help their children and teens who are deaf or hard of hearing become interested in STEM or a STEM career?

• Share with them the several books I have written several books that are biographical in nature and reveal how some of the great contributions to STEM by deaf women and men began with parents. For example, Konstantin Tsiolkovsky, the Father of Astronautics, was given a colloidal balloon by his mother when he was a young boy. He dreamed of space flight and actually sent passengers (insects) in small buckets attached to his kite strings. Annie Jump Cannon, a distinguished astronomer at Harvard, when young, studied the stars with her mother through a skylight in their attic. Robert Weitbrecht, who brought access to the telephone to deaf people after 90 years, was inspired by his science teacher who, during field trips, showed him various electrical gadgets.
• Earlier exposure to deaf role models.
• My mom was VERY encouraging and also understood that I will have difficult times. She was very supportive and just pushed me through those times. I didn't really have any deaf STEM mentors growing up, but I personally can see that it encourages kids to see a deaf aerospace engineer. I would expose the kids to as many deaf role models who have a variety of jobs. They are out there!
• Speaking as a parent myself, trying to get children (regardless of hearing status) interested in something when they're not already is a fool's errand. The best you can do is provide plenty of opportunities. It also helps to recognize that STEM is not a homogeneous field - just because someone likes biology doesn't mean they like physics. For example, despite being an engineer, I have zero interest in building a go-cart. But my husband (also an engineer) would have LOVED that as a child (and has plans to do it with our sons once they're old enough to use the requisite tools).

- I think exposure is the most important thing! Being able to explore is a wonderful part about being a child that should never be squashed. Curiosity and fascination lead to learning that the children WANT to do and will be more likely to pursue something if it feels less required. I think a big thing nowadays there are so many assistive technologies out there that anything is possible. If parents feel restricted and stressed, I think information about such assistive technologies would have a huge impact.
- Allow children to experiment. That my parents supported me when I was young if I wanted to make non-Newtonian fluid or read about bugs was crucial. If they had not done so my interest would have been squashed due to learning that science was a hassle or inaccessible.
- Parents have to allow their children an opportunity and not limit them or think they are less. Allow them to participate. Allow them the chance to figure out what they like and dislike.
- Expose children to a number of STEM-related fields during middle and high school to see if they have skills or passion in specific areas.
- Get them a personal computer. Have them play with it.
- Tutor them, if they can. Expose them to science museums and free learning activities at national parks, state parks, local parks, libraries, museums, arts centers, etc. Let their kids explore the natural world and interact with it. Learn about NTID & Gallaudet University, and Hearing Loss Association of America. These are organizations and institutions with programs, resources, and outreach to help them help their kids excel.
- Read to children
- Make sure to get them great, inspiring teachers who are supportive of students with disabilities.
- Advocate for their kids. Get the right devices or help to get them.
- Support children before they are able to self-advocate. Because my parents went to battle for me continually until I was old enough to stand up for myself (and even then they stepped up if I needed a higher authority to speak for me) and demand specific resources and accommodations, I was given what I needed to do well in classes from an early age until I graduated.

Table 33: Summary of parents' ideas for supporting their children's STEM interest

What can parents of children who are deaf or hard of hearing do to help them become interested in STEM or a STEM career? (Parents, N=3)

What persons, activities, resources, games, books, etc. do you believe may have contributed to your child's awareness and interest in STEM and STEM career?	N	%
Provide computers, apps, technology	3	100%
Subscribe to Kiwi Tinker Creates, provide microscope	2	67%
Go to science museums	1	33%
Provide workbooks	1	33%

All three respondents emphasize the importance of providing access to hands-on STEM activities.

Respondents' comments were as follows.

What persons, activities, resources, games, books, etc. do you believe may have contributed to your child's awareness and interest in STEM and STEM career?

- Science museum exhibits, workbooks, and some apps
- Extreme interest in the computer and in the technology for hearing aids and Cis, playing various interactive games on the computer, and using the computer as her main mode of communication.
- Microscope, using Tinker Crate, and using the laptop.

Key Findings and Implications

Three key findings emerge from the survey responses across all sub-groups. First, and most frequently stated, is that doing active, hands-on, and engaging activities fosters and sustains

interest in STEM topics for K-12 and college students and for members of the STEM workforce. Second, early exposure to role models and mentors, especially when they are also deaf or hard of hearing, is important for students believing that they might pursue a STEM career. Third members of the workforce often state that insufficient accommodations or a total lack of accommodations is a serious roadblock to their success as STEM professionals. The findings also indicate that engaging students in a broad range of hands-on labs, experiments, and activities is important. This will not, however, in itself necessarily create an interest in STEM. In the words of a STEM professional, who is also a parent: "[T]rying to get children (regardless of hearing status) interested in something when they're not already is a fool's errand. The best you can do is provide plenty of opportunities. It also helps to recognize that STEM is not a homogeneous field - just because someone likes biology doesn't mean they like physics. For example, despite being an engineer, I have zero interest in building a go-cart. But my husband (also an engineer) would have LOVED that as a child (and has plans to do it with our sons once they're old enough to use the requisite tools).

Implications of these findings suggest the importance of exposing K-12+ students who are deaf or hard of hearing to STEM activities that incorporate intellectually engaging hands-on activities and to STEM professionals who are deaf or hard of hearing. They also suggest the importance of incorporating accessible stories into formal and informal teaching experiences. These stories provide unique opportunities to see that it is possible and realistic for someone like them to pursue and be successful in a STEM career, to identify individuals to serve as examples and careers that might be of interest to them, and to recognize the need to self-advocate and persevere as students and throughout their careers.

Appendix

STEM Career Interest Survey for Students

Tell us about yourself:
Name:
Codename:
Age: (10-18)
Grade: (5-12)
I attend a public, private, specialized school for the deaf.
I am male, female, other (specify):
I am deaf, hard of hearing, hearing.
I prefer to communicate in: English, ASL, Signed English, Cued Speech.

Tell us what subject areas interest you now and what you might like to do after you graduate from high school:
I am interested in (check all that apply)

_Science
_Technology
_Computers
_Engineering
_Math
_None of the Above

I like learning about: (check all that apply)

_Science
_Technology
_Computers
_Engineering
_Math
_None of the Above

Please indicate your level of interest in studying science, technology, computers, engineering or math after you graduate from high school:

__ I *might* like to study science, technology, computers, engineering, or math after I graduate from high school

__ I would *definitely* like to study science, technology, computers, engineering, or math after I graduate from high school.

__ I am *not* interested in studying science, technology, computers, engineering, or math after I graduate from high school.

[Both "might" and "definitely" choices go to the questions below]

Which area(s) are you interested in studying? (check all that apply)

_Science
_Technology
_Computers
_Engineering
_Math
_I'm not sure
_Other (please specify)

Why are you interested in studying science, technology, computers, engineering, or math? Please be specific.

What are the three things that got you interested in science, technology, computers, engineering, or math?

1.
2.
3.

What do you do *in school* that got you interested? (check all that apply)
__ Experiments or "labs"
__ Watch Videos
__ Use Computers/Technology
__ Play Games (can be video games)
__ Read books or articles
__ Learn about scientists, mathematicians, etc. and their careers
__ Class discussions
__ Research (on or offline)
__ Science Fair
__ Field Trips
__ Other (please specify)

What do you do *outside of school* that got you interested? (check all that apply)
__ Explore/Play outdoors
__ Visiting Museums, Zoos, Aquariums, etc. with family/friends
__ After school or summer clubs, camps, or activities
__ Computers/Technology
__ Games (can be video games)
__ Other (please specify)

Did a person get you interested?
__A famous person in the field
__A mentor
__A parent or relative
__A teacher
__A classmate or friend
__Other (please specify)

Are there any other activities, experiences, or people that might get you interested in science, technology, computers, engineering or math?

Are there any activities, experiences, or people that you think might keep you interested in science, technology, computers, engineering or math?

What challenges do you encounter in science and/or math or computer classes or when using computers?

["not interested" choice go to the questions below]

Why are you *not* interested in studying science, technology, computers, engineering, or math? Please be specific.

What challenges do you encounter in science and/or math or computer classes or when using computers?

What *are* you interested in studying?
_Art
_Music
_History
_Religion
_English Language and Literature
_Business/Economics
_Government/Politics
_Psychology

_None of the Above
_Other (please specify)

Why are you interested in studying this? Please be specific.

What are the three things that got you interested in studying this?
1.
2.
3.

Are there any activities, experiences, or people that might get and keep you interested in science, technology, computers, engineering or math (even though you are not currently interested in them)?

Are there any activities, experiences, or people that might keep you interested in science, technology, computers, engineering or math (even though you are not currently interested in them)?

Tell us about your job and career interests.

Are you interested in a job that involves science, technology, computers, engineering or math?
_Yes
_No

["yes" answer above goes to the questions below]

Which areas are you most interested in working in? (Check all that apply.)
_Science
_Technology
_Computers
_Engineering
_Math

Why are you interested in a job that involves science, technology, computers, engineering, or math? Please be specific.

Do you have a particular career in mind?
_Yes
_No

If yes, what is it? _____

["no" answer above goes to the questions below]

Why are you not interested in a job that involves science, technology, computers, engineering, or math? Please be specific.

Which areas *are* you most interested in working in? (Check all that apply.)
_Art
_Music
_History
_Religion
_English Language and Literature
_Business/Economics
_Government/Politics
_Psychology
_None of the Above
_Other (please specify)

Do you have a particular career in mind?
_Yes
_No
If yes, what is it? _____

STEM Career Interest Survey for Members of the Workforce

Tell us about yourself.
Name:
Age: (choose:18-25; 26-35; 36-45; 46-55; 56-65; 65+)
I am male, female, other (please specify), prefer not to answer
I am deaf, hard of hearing, hearing.
I prefer to communicate in: English, ASL, Signed English, Cued Speech.

Education
Middle School (choose: Public School, Private School, Specialized School for the Deaf)
High School (choose: Public School, Private School, Specialized School for the Deaf)

Did you attend? (Check all that apply)
2-year College ___Yes___No
4-year College ___Yes___No
University___Yes___No
Technical School Yes___No

Highest Degree Obtained: _____

Current job: _____

Tell us about your current job.
Please tell us a little bit about your current job.

What is your job title? How long you have had this job? _____yrs.

What are your responsibilities?

What do you do? What tasks do you perform?

What experiences did you have that led up to your current job?

What do you like about your current job?

What do you dislike?

What is your degree of satisfaction with your current job?
__Very Dissatisfied
__Dissatisfied
__Satisfied
__Very Satisfied

Please tell us about any challenges related to your job that you face?

Tell us how you became interested in STEM and in a STEM career.

When did you become interested in STEM?
____Elementary School
____Middle School
____High School
____After High school

What sparked your interest?

What maintained your interest?

When did you begin thinking about a STEM career?

What activities, experiences, or people maintained your interest in a STEM career?

What challenges or obstacles did you find you had to overcome along the way? How did you overcome them?

What do you think parents could do to help deaf/hh children and teens become interested in science, technology, engineering and mathematics or computers?

What do you think schools could do to help deaf/hh children and teens become interested in science, technology, engineering and mathematics or computers?

What do you think are the most important factors in keeping deaf/hh students interested in STEM?

What do you think are the most important factors in interesting students in pursuing a STEM career?

Additional comments

STEM Career Interest Survey for Teachers of Students Who Are Deaf of Hard of Hearing [Cohort 1]

Tell us about yourself
I am male, female, other (please specify), prefer not to answer
I am deaf, hard of hearing, hearing.
I prefer to communicate in: English, ASL, Signed English, Cued Speech.

My students are in grade 5, 6, 7, 8, 9, 10, 11, 12 (check all that apply)
I teach in a Public School, Private School, Specialized School for the Deaf
I teach math, science, technology, other (please describe)

How many of your students are interested in science, technology, engineering, or math? none, a few, half, more than half

How many of your students are interested in a career in science, technology, engineering, or math? none, a few, half, more than half

1. In the space below, please provide examples of activities, resources (human and non-human), games, books, etc. that you have done or used that you believe contribute to students' awareness and interest in science, technology, engineering and/or math (STEM) and STEM careers.

2. What additional information, resources (human and non-human), tools, and/or activities would help you to support and encourage your students in STEM and potentially interest them to pursue STEM careers?

3. What do you think families could do outside of school to be more effective in creating awareness and interest in STEM and STEM careers?

STEM Career Story Integration Survey for Teachers [Cohort 2]

Tell us about yourself

I identify as a man, woman, non-binary, prefer to self-describe, choose not to respond
I identify as White/Caucasian, Middle Eastern, Black/African American, Hispanic/Latinx, Asian, Native American, Pacific Islander, choose not to respond
I am deaf, hard of hearing, hearing.
I prefer to communicate in: English, ASL, Signed English, Cued Speech, Simultaneous Communication, other (please describe)
I teach in a Public School, Private School, Specialized School for the Deaf
I teach math, science, technology, ELA, other (please describe)

Tell us about your students

My students are in grade K, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 (check all that apply)
Number of students who are: White/Caucasian, Middle Eastern, Black/African American, Hispanic/Latinx, Asian, Native American, Pacific Islander
Number of students who are: deaf, hard of hearing, hearing
Language of communication of instruction: English, ASL, Signed English, Cued Speech, Simultaneous Communication, other (please describe) (check all that apply)
Do your students rely on an interpreter during the school day? Yes, No

1. Is introducing students to STEM occupations and careers part of your teaching? Yes/No

2. If you answered "No" to Q1 what are your reasons for not doing so? and If you answered "Yes" to Q1. how did you incorporate them?

3. What do you think is or would be the most important value for students of including stories from STEM professionals into your instruction?

4. What do you think is the most important question the stories should answer?

5. If you used the stories, how often might you incorporate them? once a week, twice a month, once a month, a few times a year, other (please describe)

6. If you used the stories, how might you incorporate them? in class, into homework, into class discussions, into classroom/individual research, into hands on inquiry (check all that apply)

7. If you used the stories, what strategies might you use? (check all that apply)
__ as an introduction to an activity
__ as a follow-up or extension to an activity
__ as an illustration of how professionals use a concept or skill
__ at home for homework, as an enrichment activity
__ as an option during free time
__ as an opportunity to interact on-line with a professional
__ as an opportunity to interact offline with a professional
__ into a family night
__ through the PTA
__ as a community event
__ other (please describe)

8. Into which subject area(s) might you incorporate the stories? STEM, STEAM, ELA, Library/Media, Afterschool/Out-of-School Programs, Social Studies, Computer Science, Technology Education/Instruction/Class or Program, Other (please describe) (check all that apply)

9. What supports and materials would help you incorporate the stories into instruction? (check all that apply)
__ suggested activities, discussion questions, and prompts prior to viewing
__ suggested activities, discussion questions, and prompts during viewing
__ suggested activities, discussion questions, and prompts after viewing
__ activity sheets for students
__ sheets for students to make notes
__ determination of connections to STEM topics, skills, and standards
__ integration of story use into professional development
__ materials for families
__ other (please describe)

10. Where do you think integration of the stories should begin and why?
__ Early Elementary Grades
__ Upper Elementary Grades
__ Middle Grades
__ High School
__ Please explain your choice:

11. What are the most important accessibility features that you think should be included?

STEM Career Interest Survey for Parents of Children Who Are Deaf or Hard of Hearing

Tell us about yourself
I am male, female, other (please specify), prefer not to answer
I am deaf, hard of hearing, hearing.
I prefer to communicate in: English, ASL, Signed English, Cued Speech.

Tell us about your child
My child is deaf, hard of hearing, hearing
My child prefers to communicate in: English, ASL, Signed English, Cued Speech.
My child attends: Public School, Private School, Specialized School for the Deaf
My child is interested in science, technology, engineering, math (check all that apply)

1. In the space below, please provide examples of persons, activities, resources, games, books, etc. that your child knows, knows of, or has used at home or outside of school that you believe may have contributed to your child's awareness and interest in science, technology, engineering and/or math (STEM) and STEM careers.

2. What people, information, resources, tools, and/or activities would help you to support and encourage your child in STEM at home/outside of school?

3. Is there anything that your child has done or been exposed to at school that you think may have contributed to his or her awareness and interest in STEM and STEM careers?

4. What do you think schools could do to be more effective in creating awareness and interest in STEM and STEM careers?