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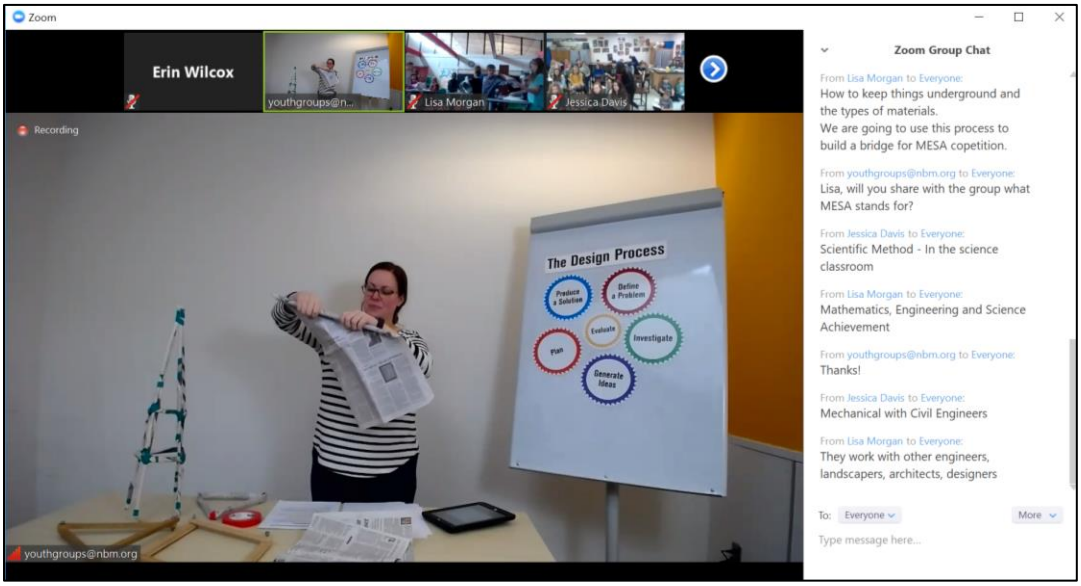

SUMMATIVE EVALUATION

WHY ENGINEERING? PROGRAM

Prepared for the
National Building Museum

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SUMMARY AND RECOMMENDATIONS

The National Building Museum contracted RK&A, Inc. to conduct a summative evaluation of the *Why Engineering?* distance learning program. The goal of this evaluation is to explore the extent to which the program is achieving its intended outcomes for students and teachers. The following summary presents the results from the program observations, student assessments, and teacher interviews, considering overall program operations and the following student and teacher outcomes:

STUDENTS WILL...

- Discover something new or interesting about engineering
- Learn how engineers collaborate with others in planning and designing buildings
- Increase awareness of the choices and variety of engineers involved in decisions that shape the built environment
- Value the National Building Museum as a place that offers meaningful experiences

TEACHERS WILL...

- Feel prepared to use the *Why Engineering?* program in their classroom
- Value the National Building Museum as a place that offers meaningful experiences

The findings presented here are among the most salient. Please read the body of the report for a comprehensive presentation of findings by methodology.

PROGRAM STRUCTURE AND OPERATIONS

Changing the tower-building for a sketching activity during the program has improved the program experience for students and teachers. For example, the version of the program evaluated during the formative evaluation included a hands-on tower building activity in the middle of the program, which students enjoyed, but teachers reported it also detracted from the remainder of the program because students wanted to continue constructing their building even after the facilitator had moved on to the next part of the program. The current version of the program replaced the tower-building activity with a shorter sketching activity, which the student assessment showed students still enjoyed, yet allowed for a smoother transition to the rest of the program. The facilitator still introduced and demonstrated the tower-building activity for students to try after the program, which several teachers indicated they completed as a post-program activity.

Pre- and post-program materials have increased teachers' feelings of preparedness for the program compared to formative evaluation results. In response to the results of the formative evaluation, where teacher interviews revealed teachers wanted more information or supplemental materials from NBM before the program, NBM added pre- and post-program materials that were emailed to teachers soon after they registered for the program. Interviews indicated that most teachers referenced the program materials provided by NBM before the program. Teachers who referenced the NBM materials reported that the materials helped them to feel prepared for what content the program would cover, helped them with lesson planning, or provided an activity they could complete with their students to complement the program experience.

Technology remains a major obstacle to the program experience. There are many positive aspects of digital program delivery, such as increasing accessibility to resources for traditional and homeschool students who may not be able to visit the museum, integrating video interviews with real engineers who would not be able to participate in the program in-person, and creating a feeling of connection between students from classrooms across several different states. However, observations and teacher interviews indicate that audio issues (and to a lesser extent video issues) negatively impact the program experience for most participants. Audio issues are twofold—during the observed programs some participants reported issues with the facilitator's audio through the chat box, and during interviews several teachers reported significant audio issues with the engineering videos. This suggests two separate issues—one with the facilitator's microphone and another with the video playback. Both teacher interviews and student assessment responses indicated the poor audio quality affected students' ability to understand the information and instructions provided during the program, which means students are not getting a true opportunity to meet the program's intended outcomes.

STUDENT OUTCOMES

OUTCOME #1 – DISCOVER SOMETHING NEW OR INTERESTING ABOUT ENGINEERING

Outcome: Students will discover something new or interesting about engineering.	

Multiple aspects of the program were successful at helping students discover something new about the field of engineering or the work of engineers. When asked an open-ended question about something new they learned from the *Why Engineering?* program, nearly all students were able to name something new they learned. Responses varied broadly and connected ideas from many different parts of the program, from the work of engineers to comfort with failure. For example, one-quarter of respondents said they learned about the teamwork and collaborative aspects of engineering from the program, an idea that was interwoven into the facilitator's script and the engineering videos. The second most common idea respondents said they learned about was the engineering design process—this idea was emphasized by the facilitator with the design process stickers and the white board, as well as in the post-program materials which asked students to reflect on how they had applied the design process to their tower building challenge. Teacher interviews also indicated teachers valued the content about the engineering design process for their students because it complemented their own teaching of the design processes with their students.

CONSIDER THIS: While this outcome's achievement is promising, NBM may want to consider if there are more specific learning outcomes it wants students to achieve through participation in the program. Learning "something new or interesting about engineering" is broad, which allows students follow whatever sparks their personal interest. This may be suitable if NBM's intentions are for *Why Engineering?* to be a broad introduction to engineering. If the learning goals from the program are more specific (e.g., understand the parts of the design process), NBM may wish to refine and focus the program's content more narrowly.

OUTCOME #2 – LEARN HOW ENGINEERS COLLABORATE WITH OTHERS

Outcome: Students will learn how engineers collaborate with others in planning and designing buildings.	

Many students come away from the program with an understanding that engineers work together with many people to plan, design, and build buildings. In the student assessment, nearly all (98 percent) students correctly answered the true/false question about Dave, an engineer from one of the videos in the program, working in a team with others to design a museum. Moreover, the idea that engineers work in a team was the most common response to the question asking students something new they learned from the program. Although students were not asked to explain what part of the program brought out the concept of teamwork, it is likely that the video interviews with engineers helped communicate this idea, as all three videos talked about how teams of engineers came together to complete a particular project. The student assessment results indicated the videos of engineers were the second favorite activity from the program for students—the appeal of the videos may have made the concept of teamwork more memorable because it was interwoven throughout the videos.

CONSIDER THIS: It is very encouraging that students learned about how engineers collaborate to complete a project from participating in the program. NBM could consider ways to take this concept even further by providing an exercise where students experience the teamwork aspect of engineering firsthand before, during, or after the program.

OUTCOME #3 – AWARE OF VARIETY OF ENGINEERS

Outcome: Students will increase their awareness of the choices and variety of engineers involved in decisions that shape the build environment.	

The variety of types of engineers who shape the built environment was not top of mind for students following the program. When asked the open-ended question about something new they learned from the program, few students responded that they had learned about the different types of engineers (11 percent). Moreover, in the teacher interviews, some worried that the vocabulary used by the facilitator in the slide explaining the different types of engineers might be too advanced for elementary students. Indeed, it may be difficult for elementary students to distinguish between an electrical engineer (defined as "designs electrical and electronic systems") and mechanical engineer (defined as "designs physical and mechanical systems"), for example, because the descriptions provided lack a concrete example that would be familiar to an elementary student. The engineers in the videos also mention some of the different types of engineers that work on projects, but this is not a primary focus of their interviews.

CONSIDER THIS: Adding concrete examples of the work of engineers across various specialties that would be familiar to elementary students (e.g., designing the circuits in a gaming system; designing the mechanical system that makes your car run and the highways it drives on) may help students recall the diversity of engineering specialties. Moreover, the slides presenting the engineering specialties use tables and text to present this information. Perhaps adding icons or picture examples of the work of engineers would help make this information more memorable or relatable for students.

OUTCOME #4 – VALUE NBM AS A PLACE OFFERING MEANINGFUL EXPERIENCES

Outcome: Students will value the National Building Museum as a place that offers meaningful experiences	

Students somewhat enjoyed their program experience with *Why Engineering?*, but there is room for improvement. Students were asked to rate how much they enjoyed the *Why Engineering?* program on a scale from "I did not enjoy it at all" (1) to "I enjoyed it very much" (4), and their mean rating was moderate at 2.8. Assessments indicate students most enjoyed the tower sketching activity and the engineering videos, both of which are uniquely suited to NBM's focus on "inspiring curiosity about the world we design and build." Notably, statistical analysis revealed younger students (age 9-10) were more likely than older students (age 11-12) to report that the chat box was their favorite part of the program. It may be that younger students are more excited about the opportunity to use technology in the classroom than older students, or that older students are more self-conscious about contributing responses to the group, as is typical around age 11 or 12.

While the student assessment did not solicit feedback about what parts of the program could be improved, teacher interviews and observations suggest issues with technology, mainly poor audio and video quality, may have had a significant effect on students' program experience because it was distracting and made some information hard to hear and understand. Moreover, teacher interviews and observations suggest that the program facilitators did not appear at ease in front of the camera or completely comfortable with the script for the program, which may have negatively affected students' perceptions of the facilitators' credibility to lead the program.[1]

CONSIDER THIS: Continued troubleshooting of the audio and video quality issues is recommended if NBM decides to continue the program or launch other distance learning programs using similar technology. NBM may also consider more rigorous training and practice sessions for program facilitators so that they are more comfortable leading distance learning programs with students.

[1] Several teachers (who also completed interviews with RK&A) provided similar feedback in the NBM's CILC program evaluation form—for example, one said the facilitator "read everything off of the table in front of her," and the students "picked up on this and did not think it was professional."

TEACHER OUTCOMES

OUTCOME #1 – FEEL PREPARED TO USE PROGRAM IN THE CLASSROOM

Outcome: Teachers will feel prepared to use the *Why Engineering?* program in their classroom.	

The program showed significant growth from the formative in helping teachers feel prepared to use the program in their classroom. The formative evaluation found that teachers wanted more information from NBM to help them understand the content and activities they should expect during the program. In contrast, teacher interviews from the summative evaluation found that many teachers used the new pre- and/or post-program materials provided by NBM to help them understand the program content, organize classroom activities, and lead discussions, consequently leading them to feel prepared.[2] While a few did not use the program materials provided by NBM, these teachers either did not want to review the materials because they already felt confident in their understanding of program content, or they did not have time to review the materials because they signed up at the last minute—in either case, these are circumstances outside of NBM's control.

CONSIDER THIS: Teachers who used the pre- and post-program materials generally found them useful for lesson-planning and preparing for their class to participate in the program; however, a few teachers did not use the materials provided by NBM. To encourage more teachers to use the pre- and/or post-program materials, it may be helpful to provide a more detailed description of the benefits of the materials when they are emailed out to teachers.[3] Moreover, instituting a registration cut-off time before the program begins could help make sure teachers have sufficient time to review the materials before the program begins.

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[2] Similarly, seven out of eight who completed the NBM's CILC program evaluation form selected "Agree" or "Strongly Agree" to the question: "If provided, was the supplementary material & resources provided for the program useful?"

[3] Currently, the email describes the materials as something "you can use to augment your students' experience with the program."

OUTCOME #2 – VALUE NBM AS A PLACE OFFERING MEANINGFUL EXPERIENCES

Outcome: Teachers will value the National Building Museum as a place that offers meaningful experiences.	 Program Achievement

Teachers found value in the Why Engineering? program both as a teaching resource and as a unique and beneficial learning experience for their students. Teacher interviews indicate teachers highly value the "real-world" connections that the program offers through the video interviews with engineers and appreciate that the program reinforces the engineering design process many had already begun discussing with the students prior to the program. In particular, teachers said the engineer videos and the interaction with other schools through the chat box feature were unique resources of the program they wouldn't otherwise have access to. While their overall experience was positive and most are interested in participating in similar programs in the future, teachers did indicate several areas that could improve the overall program experience—resolving the technology issues, improving the program facilitation to a more natural and engaging style, and making the experience more interactive (either through adding opportunities for students to connect with other participating classrooms or to ask questions to live professional engineers).

CONSIDER THIS: As previously noted, troubleshooting the audio and video quality issues and refining the facilitation style would greatly improve an already positive experience for teachers and students. NBM may also want to consider a way to make the program feel more interactive for participants, perhaps through a question that allows the participants to exchange ideas or an activity that encourages participants to work together.

STUDY BACKGROUND

The National Building Museum contracted RK&A, Inc. to conduct a summative evaluation of the *Why Engineering?* distance learning program, developed as part of a grant from the United Engineering Foundation. The program offers a real-time video lesson to students in traditional or homeschool classrooms around the country. The goal of this evaluation is to explore the extent to which the program is achieving its intended outcomes for students and teachers.

ABOUT THE PROGRAM

The *Why Engineering?* program is an exploration of engineering and the ways engineers affect the places we live, work, and play. Students hear engineers describe their design process and explain the engineering principles behind projects they have completed in D.C. Through several interactive elements, students learn about the importance of creative problem solving and careers in engineering. The program includes:

- A lesson about engineering from a museum educator facilitator
- Pre-recorded videos such as an introductory video to the National Building Museum and video interviews with engineers speaking about their careers
- Open-ended questions to encourage student participation through the chat box feature
- A hands-on sketching activity

ABOUT THE STUDY

The overall evaluation study examines both student and teacher outcomes through multiple methodologies with two different audiences: teachers and students.

RK&A used a developmental evaluation approach to conduct a formative evaluation of the *Why Engineering?* program in order to uncover the strengths and challenges related to the program, and provide NBM with real-time feedback to support the development and innovation of the evolving program. RK&A completed the formative study report in the spring of 2018 and facilitated a discussion to take the NBM program team through the process of thinking critically about and interpreting the formative evaluation results.

This report is the summative study, completed in the fall of 2018, to evaluate the program's impact on students and teachers and determine the extent to which the program achieved specific outcomes for each audience.

EVALUATION OBJECTIVES

The overall purpose of the summative evaluation is to examine the extent to which the program achieves outcomes, to explore the successes and challenges of the current program, as well as to inform future programming. More specifically, objectives include:

STUDENTS WILL…

- Discover something new or interesting about engineering
- Learn how engineers collaborate with others in planning and designing buildings
- Increase awareness of the choices and variety of engineers involved in decisions that shape the built environment
- Value the National Building Museum as a place that offers meaningful experiences

TEACHERS WILL…

- Feel prepared to use the *Why Engineering?* program in their classroom
- Value the National Building Museum as a place that offers meaningful experiences

METHODOLOGY

Three methods were employed for this study and are described in detail below. The outcomes detailed above guided the development of protocols and instruments and served as a gauge against which to assess the data in analysis.

OBSERVATIONS

RK&A used observations to gain a holistic understanding of how the program is implemented and to identify the program's strengths and weaknesses. Observing how the program facilitator presents information and interacts with students through the chat function provides an objective account of behaviors and practices and helps uncover the most successful and least successful aspects of a program from a procedural/behavioral perspective. RK&A conducted naturalistic observations of six live program sessions in October, November, and December of 2018.

STUDENT ASSESSMENTS

A written student assessment was designed to measure achievement of student outcomes. Questions include close-ended questions which generated quantitative data that were summarized statistically, and one open-ended question which generated qualitative responses that were coded and analyzed statistically for significant differences. All materials were printed and mailed to the teacher before the date of the program. The assessment was administered by the teacher to students in their classrooms immediately after the program was complete. In all, 137 students completed written assessments.

TEACHER TELEPHONE INTERVIEWS

To complement the student assessment data, RK&A designed an in-depth telephone interview guide for teachers and homeschool parents. In-depth interviews are open-ended and encourage interviewees to express their opinions and experiences in their own words. NBM staff notified program participants regarding the interview through the email confirmation for the program. An RK&A data collector then contacted participating teachers and homeschool parents to schedule a telephone interview at the convenience of the interviewee. Upon securing agreement, the interviewer conducted the interview using the guide and asked probing or clarifying questions to better understand participants' experiences. The interviewer typed notes during interviews to capture the conversation as close to verbatim as possible. A total of 9 interviews were conducted in October, November, and December of 2018.

DATA ANALYSIS AND REPORTING

OBSERVATIONS

Observations were naturalistic, meaning the observer unobtrusively noted the behaviors of the facilitator and participants as they occurred. The RK&A data collector took hand-written notes during each session and photographed the screen presentation. Observation data is summarized and treated similar to other qualitative data, meaning the evaluator groups (codes) the data looking for trends across sessions.

STUDENT ASSESSMENTS

The student assessments produced mostly quantitative data generated from multiple-choice questions and one rating scale question. Quantitative data are analyzed statistically, using SPSS 2.0 for Windows, a statistical package for personal computers. A standard 0.01 level of significance was used to preclude relationships bearing little or no practical significance.[4]

- **Descriptive Statistics:** Frequencies were calculated for the data.
- **Inferential Statistics:** To examine the relationship among variables, analyses include the following:
  - Cross-tabulations to show the joint frequency distribution of the variables, and the chi-square statistic (X^2) to test the significance of the relationship (e.g., age

[4] A 0.01 level of significance (p) was employed to preclude findings of little practical significance. When the level of significance is set to $p = 0.01$, any finding that exists at a probability (p-value) ≤ 0.01 is "significant." When a finding (such as a relationship between two variables) has a p-value of 0.01, there is a 99 percent probability that the finding exists; that is, in 99 out of 100 cases, the finding is correct. Conversely, there is a 1 percent probability that the finding would not exist; in other words, in 1 out of 100 cases, the finding appears by chance.

was tested against program activity preferences to determine whether there are preferences according to age).

- Analysis of variance (ANOVA) was performed and the F-statistic was used to test the significance of the difference. For example, mean ratings of experiences were compared by gender.

Consistent test variables include gender and age. Only one statistically significant relationship emerged from the analysis, and is reported in the findings section.

INTERVIEWS

Interview data are qualitative, meaning that results are descriptive. In analyzing the data, the evaluator studied the interview notes for meaningful patterns and grouped similar responses as patterns and trends emerged. The objectives of the study, as well as our professional experience, informed the analysis. Findings are reported in narrative, supplemented with exemplary quotations from participants. Trends and themes in the data are presented from most- to least-frequently occurring. Quotations from interview notes (edited for clarity) illustrate participants' thoughts and ideas as fully as possible.

Qualitative methods typically produce a wealth of data from a smaller number of people. In thinking about qualitative data, one should consider trends relative to one another. That is, more weight should be given to comments made by many individuals versus those made by a few individuals; however, the reader could consider the comments made by a few individuals when thinking about findings, as one person might offer valuable insight. When describing the findings, this report uses qualitative data terms such as "most" and "several," as is appropriate for the sample size and the type of data collected. Proportions, such as one-half or one-third are used where appropriate. Such descriptive language is intended to provide readers with a sense of the general trends. Readers should regard the trends as general categories rather than rigid numerical counts.

REPORT ORGANIZATION

Data in this report are presented by method—first, program observations, followed by student assessments, and teacher interviews.

FINDINGS: PROGRAM OBSERVATIONS

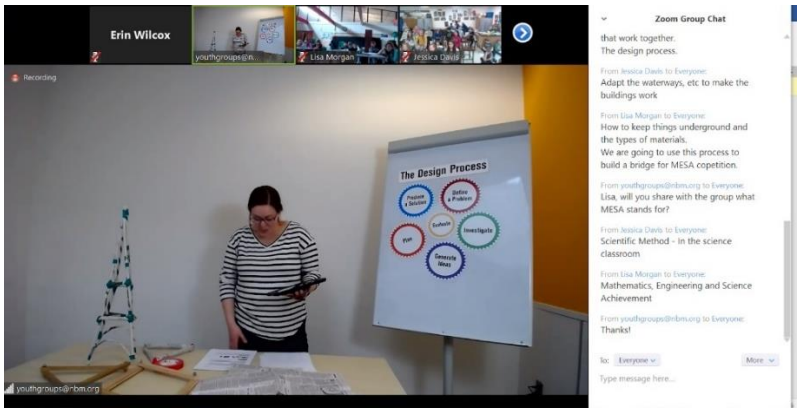
RK&A conducted six unobtrusive observations of the *Why Engineering?* program in October, November, and December of 2018. All observations were conducted on a computer as a participant during live sessions. The following results describe trends that emerged across all six observed sessions, with differences noted when relevant.

CHARACTERISTICS OF OBSERVED PROGRAMS

A few different facilitators led the six programs observed. Each program lasted approximately 45 minutes and included between zero[5] and 11 participating groups. The six sessions observed included:

- A lesson about engineering from the museum educator facilitator which included an overview of engineering, roles of engineers, and the engineering design process
- Pre-recorded videos, which included an introductory video for NBM and three video interviews with engineers during which they spoke about their careers
- Open-ended questions to encourage student participation through the chat box feature
- A demonstration of a paper tower design challenge to complete after the program ended

Screenshot of program with paper tower, design process, and chat box



[5] In one observed session, none of the registered participants logged on during the program.

FACILITATOR STATION CONDITIONS

For the October programs, the facilitator station was set up in the Beverly Willis Library on the third floor of the NBM in front of a window with a view of the museum's Great Hall. For the November and December programs, the facilitator station was in a different room in the NBM with white walls and no windows. In both locations, the facilitator stood behind a table which held various props for the program, including 3-dimentional architectural shapes, a white board for displaying design process stickers, and materials for the hands-on paper tower building activity (as shown in the photos below), as well as a script for the program.[6] The facilitator held an iPad during the program to view participant responses in the chat box.

Views of Facilitator Station at NBM

The lighting in the Library was bright, and it was easy to see the facilitator and props; lighting in the second location used in the November and December sessions was dimmer, which made it hard to read the design process stickers in some cases. As noted in the formative evaluation, glare on the white board was a minor issue but did not significantly interfere with the program. The facilitator wore a microphone in most sessions, but a table microphone was added in one case in response to participants complaining through the chat box about audio issues.

[6] In one session, the facilitator did not have the prop example of a completed paper tower.

PROGRAM DELIVERY

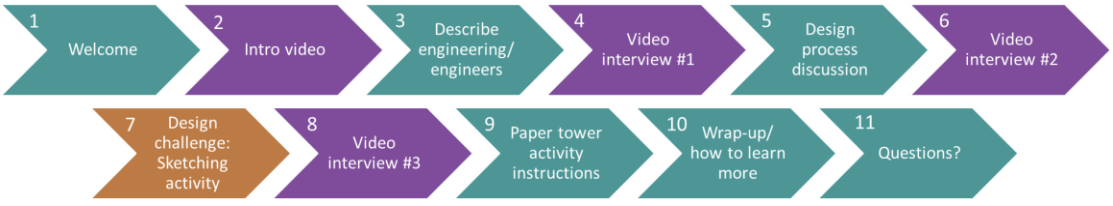
STRUCTURE OF THE PROGRAM

Observed sessions followed the same structure and almost exactly the same script. Similar to the programs observed during the formative evaluation, the program began with the facilitator introducing themselves and the topic of engineering.[7] The facilitator also introduced NBM with a two-minute video. Following the video, the facilitator explained the chat box function and had the participants practice using the chat box by introducing their school name and location.

During the sessions, the facilitator gave an introduction to the field of engineering and different types of engineers. Then, the facilitator described the design process and guided participants through a "design challenge" tower sketching activity where participants sketched a tall tower (two minutes) and then discussed with a partner how to make their tower stable and strong (two minutes).[8] This was a new activity added since the program was observed during the formative evaluation. Finally, the facilitator described and demonstrated an activity students could complete after the program—building a paper tower with newspaper and tape (formerly completed during the program during the formative evaluation).

Throughout the program, the facilitator also showed students three video interviews with real engineers working the field. Each video lasted a few minutes and featured between one and three engineers speaking about their training, inspiration, and day-to-day work. At the end of the sessions, the facilitator took questions from participants in the chat box, thanked participants for joining the session and encouraged them to visit the National Building Museum and continue learning about the field of engineering. The overall program structure is summarized below, with video components presented in purple, the design challenge in orange, and all other program components in teal.

Program milestones



[7] In two sessions, the facilitator did not introduce themselves, and started straight into the introduction of engineering.

[8] In two sessions, the facilitator only allowed about 30 or 45 seconds for the sketching activity and sharing with a partner. In the remaining sessions, the facilitator allowed close to two minutes for each part of the activity.

FACILITATION

There were several different facilitators who facilitated the observed program sessions. Observations showed a range of comfort levels with facilitation and being in front of a camera. For example, throughout the programs, most facilitators were clearly reading from a script on table—facilitators were observed frequently looking down at the paper and their speech indicated they were reading, rather than speaking with a conversational tone. In some cases, facilitators became more comfortable and conversations as they got further into the program. Facilitation seemed most natural and comfortable when the facilitator was interacting participants via the chat box, reading aloud their answers, and encouraging and building off the participants' responses.

USE OF QUESTIONS

Observations show that the facilitator asked roughly six open-ended questions throughout the program, both to encourage participants to think critically about engineering and the job of an engineer, and to engage with the facilitator through the chat box. Aside from introductions at the beginning, the facilitator asked students:

- What jobs do you think are involved in making buildings?
- What do we need a building to have in order to use it?
- What was something interesting or surprising you learned about engineers?
- What are some examples of when you have you used the engineering design process?
- What is one example of a time when an engineer needed to work with someone else?
- What will you do to learn more about engineering after today?

Based on observations, it appears teachers typed into the chat box for traditional classes. It is unclear whether students or teachers typed responses for homeschool students. Aside from the two programs in October, which had low attendance, chat responses were robust for the questions posed to students. Many classrooms offered multiple responses to the questions posed. The facilitator read responses aloud from an iPad in real time, often affirming and encouraging the responses with phrases like, "Absolutely, that's right!" Similar to the formative evaluation, observations suggest participants sometimes needed more time to type responses than was allowed for during the program. For example, some responses continued to appear in the chat box after the facilitator had moved on to the next part of the program and were not acknowledged by the facilitator.

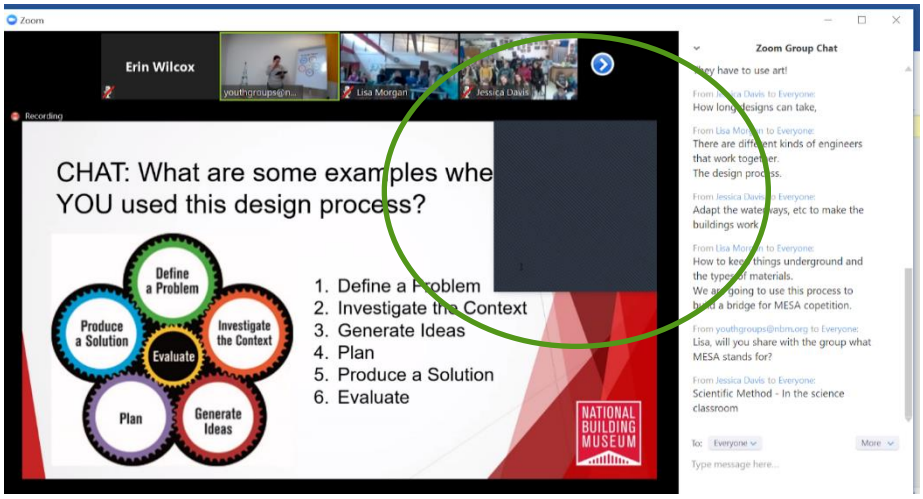
While the facilitator uses the iPad to view the chat box responses, observations showed facilitators often continue holding the iPad throughout the program. This appeared to create somewhat of a barrier between the facilitator and participants because they would look at the iPad rather than make eye contact with the camera when they were talking to participants, even during parts of the program that did not involve the chat feature.

TECHNOLOGY

Observations showed a few strengths of the technology used for the program. For example, when classrooms joined the program, they were automatically muted so that their audio did not compete with the facilitator's audio. Moreover, the chat box function appeared to be intuitive for participants to use, and generated much participation from classrooms in the November and December sessions with strong attendance.

However, in every observed program there were some significant audio and/or video playback issues that affected the program experience. The audio would stop, or videos would "skip" of "freeze" so that part or all of a sentence was inaudible. In some cases, it affected participants' ability to understand the information or instructions the facilitator was providing (e.g., instructions for the design challenge), or made the videos of the engineers very difficult to understand. During the December sessions, an off-screen facilitator responded to participants' complaints about audio issues through the chat box and troubleshooted during the program to improve audio quality by adding a microphone on the facilitator's table. This seemed to resolve the facilitator audio issues temporarily for participants, although issues remained with the engineering video sound quality and the facilitators' audio quality declined again at the end of the program. There was also one session where a gray box appeared for part of the program and blocked part of the PowerPoint slide (see gray box circled in picture below).

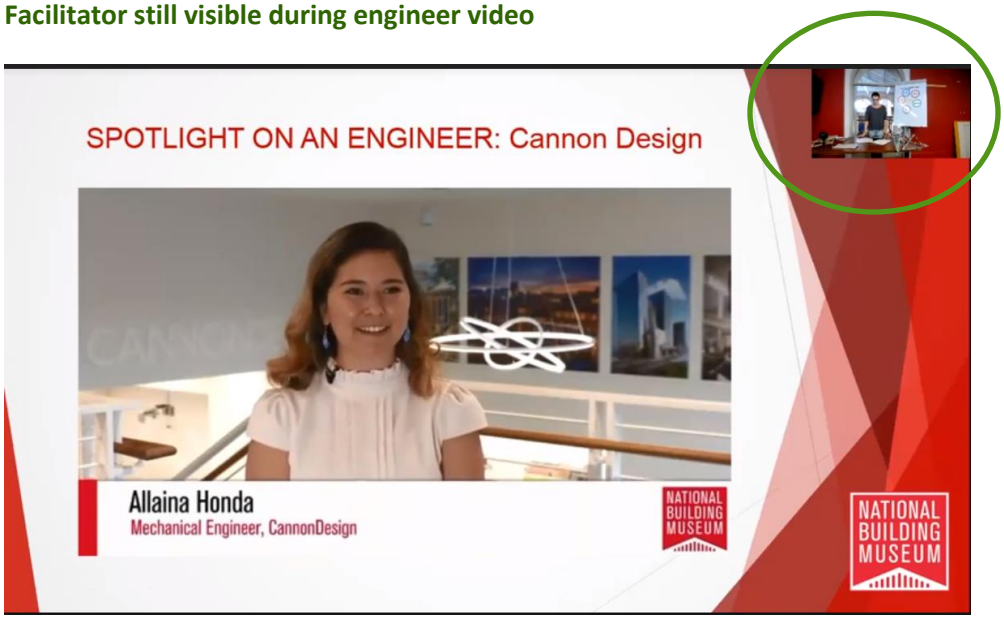
View of gray box covering slide



Observations also showed that about one-half of participants in each session activated their webcam; however, the participants' cameras were often not pointed at the students—rather they showed the teacher typing, or were pointed at a ceiling or wall so that no participants were visible. The facilitator cannot see or hear the participants, so there is not an advantage to participants using the webcam feature from a facilitation standpoint, although it does allow participants to see the other classrooms that are participating (if their cameras are pointed at students).

It should also be noted that in some sessions, the webcam showing the facilitator was visible throughout the program, even when it is minimized to show the PowerPoint slides or engineer videos. In at least one observed session, the facilitator appeared to be doing stretches (e.g., raising her arms over her head, bending over) while an engineer video was playing and may not have realized she was still visible on camera.

Facilitator still visible during engineer video



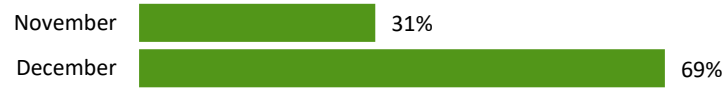
FINDINGS: STUDENT ASSESSMENTS

DATA COLLECTION CONTEXT

RK&A collected 137 assessments from students who participated in a *Why Engineering?* session. Two-thirds of students participated in the 10:30 a.m. or 1:30 p.m. sessions on December 20, and one-third participated in the 1:00 p.m. session on November 30. Most students attended a traditional elementary school and one attended homeschool.

DATA COLLECTION CONTEXT

Month of program (*n* = 137)



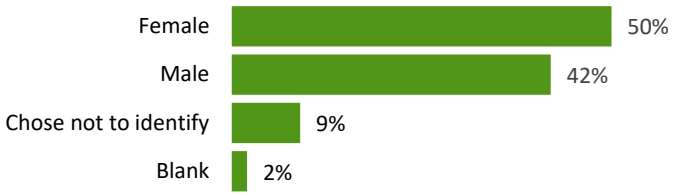
Type of school (n=137)

RESPONDENT CHARACTERISTICS

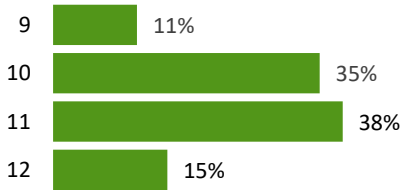
One-half (50 percent) are female and nearly one half are male (42 percent). A few chose not to identify their gender, and two skipped the gender question.[9] Many respondents were age 10 or 11 years, and the mean age was 11 years.

RESPONDENT CHARACTERISTICS

Gender (*n* = 137)



Age (*n* = 125)



Median age = 11 years; Mean age = 11 years

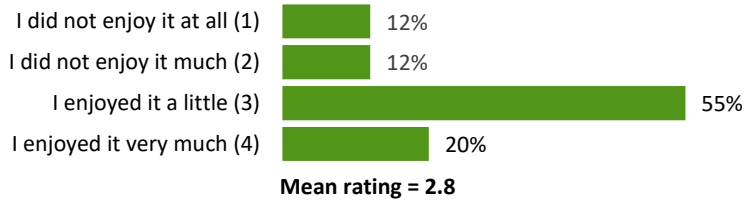
[9] Those who chose not to identify their gender wrote in responses like: "male or female," "N/A," "IDK," and "Nope."

PROGRAM ENJOYMENT

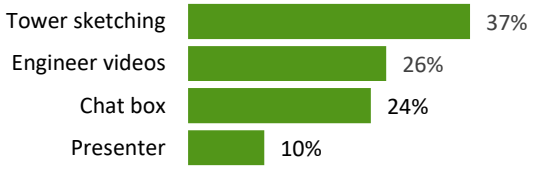
Students were asked to rate how much they enjoyed the *Why Engineering?* program on a scale from "I did not enjoy it at all" (1) to "I enjoyed it very much" (4). Majority of respondents rated the program "I enjoyed it a little" (3) and the mean rating was 2.8. When asked specifically which part of the program they enjoyed most, over one-third (37 percent) like the tower sketching partner exercise, one-quarter liked the videos of real engineers (26 percent) or chatting with the presenter and asking questions through the chat box (24 percent), and a few liked learning about engineering from the presenter (10 percent).

PROGRAM ENJOYMENT

How much did you enjoy the *Why Engineering?* program? (*n* = 136)



Which activity did you enjoy most? (*n* = 133)



STATISTICAL RELATIONSHIPS

Program enjoyment was tested against age and gender variables, and one significant difference emerged. Respondents who are 9 or 10 years old are more likely than those who are 11 or 12 years old to say the chat box was their favorite part of the program.

STATISTICAL DIFFERENCES FOR PROGRAM ENJOYMENT

DIFFERENCES BY AGE

Favorite activity	9-10 years old	11-12 years old	
Chat box	39%	17%	p = .006
Other activities	61%	83%	

ENGINEERING DESIGN PROCESS

Respondents were asked two true/false questions about the design process based on what they had learned about during the *Why Engineering?* program. Nearly all students correctly answered the two true/false questions about using the design process to plan a building and working in teams with other engineers to accomplish a project.

ENGINEERING DESIGN PROCESS

When Dave designs and plans a building, such as the African American Museum of History and Culture, he uses aspects of the Engineering Design Process, like following a logical thought process and asking a lot of questions. True or false? (*n* = 136)

Dave worked on his own and did not coordinate with other engineers to design and build the African American Museum of History and Culture. True or false? (*n* = 133)

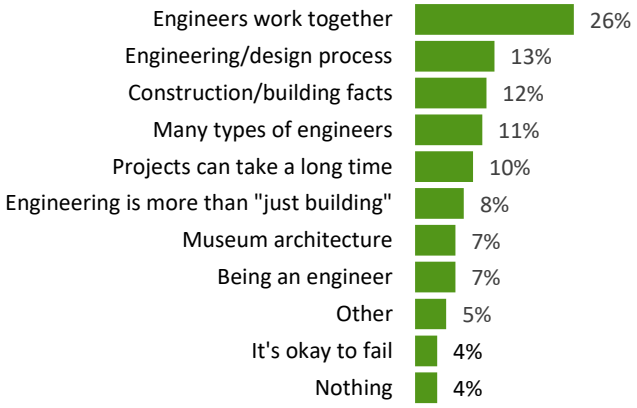
MAIN TAKEAWAY

Respondents were asked about something new they learned from the *Why Engineering?* program. The question was open-ended, and responses were later coded into groups by theme. Respondents listed a variety of items they learned, but the most common answer was that engineers work in teams and it takes many people to complete a project (26 percent). Several said they learned about the design process (13 percent).[10] Several named a specific construction or building fact they learned (12 percent)—for example, that "the strongest shape is a triangle." Several said they learned that there are many different types of engineers (11 percent) or realized that engineering projects take a long time to complete (10 percent each).

A few said they learned engineering is more than "just building" (8 percent)—for example, it can incorporate art—or learned something about museum architecture (e.g., that the National Museum of African American History and Culture is partially built underground) (7 percent). A few learned something about being an engineer (7 percent) (e.g., engineering is a hard job). A few gave miscellaneous other responses (5 percent),[11] a few said they learned that it is okay to fail or make mistakes (4 percent), and a few said they did not learn anything new (4 percent).[12]

MAIN TAKEAWAY

What is something new you learned during the *Why Engineering?* program? (*n* = 136)



[10] Note that the top two ideas are related to the preceding two true/false question on the student assessment, which may have made these ideas top of mind for students.
[11] Other responses included: I learned that there is many famous engineers; Engineers; They talk to real engineers that worked on buildings; That there are engineers; To see the different rooms; That it's like Minecraft; I learned boing hypoptheific.
[12] Two who said they did not learn anything said the video was "glitchy" so they "couldn't hear any of the engineers."

FINDINGS: TEACHER INTERVIEWS

RK&A conducted nine interviews with teachers following their class's participation in the *Why Engineering?* program.[13] Of those who participated:

- **Grade level taught:** Three teach fifth grade, two teach fourth grade, and one teaches sixth grade. Three others teach multiple grades—two teach third through fifth grades, and one (homeschool teacher) teaches students in fifth grade, seventh grade, and high school.
- **Subject area taught:** Four teach multiple subjects, three teach STEM/STEAM classes, and two teach social studies.
- **Traditional vs. homeschool:** Seven teach in traditional school classrooms, and two teach homeschool.
- **Special notes about schools or classes:** Two schools have school-wide emphasis on specific topics—one has an engineering focus this year, and the other has a career focus. One homeschool teacher participates in co-op science and history classes and takes her students to classes at museums and libraries.

[13] RK&A invited 29 teachers to participate in an interview. Two responded that they were unable to participate in the program because of audio issues. Of the remaining 27 eligible teachers, nine agreed and completed an interview, for a participation rate of 33 percent.

USING MATERIALS PROVIDED BY NBM

PREPARING FOR THE PROGRAM

Teachers were asked how, if at all, the materials provided by the National Building Museum helped them to prepare to participate in the program. They discussed using the materials to inform their expectations for the program, and whether they used the materials with students.

- **Overview of program content:** Four said they reviewed the materials to gain familiarity with the program's content and/or as part of their lesson-planning process.
- **Pre-activity:** Four said they used the materials to do the pre-program activity with their students; however, one of these did not do the pre-activity until *after* the program because she did not have time to do it before. All said their class enjoyed the pre-activity. One said the content was grade-level appropriate, and another said the activity was helpful for making the students think carefully about how thinking about the user of a product might impact your design choices.
- **Did not use materials with students:** Three teachers said they did not use or only briefly reviewed the materials, for a couple reasons. Two teachers said their students were already familiar with the design/engineering process because of their schools' STEAM program or classroom units. One registered only the day before the program and did not notice the materials in time.

FACILITATING CLASSROOM DISCUSSIONS

Teachers were also asked how, if at all, the materials provided by the National Building Museum helped them to facilitate discussions with their class before or after the program.

- **Facilitated discussions without materials:** Four said they discussed the program's ideas with students, though they did not specifically use the museum's materials to do so. For example, two said they referred to the program's examples of different engineering careers to talk with students about what engineers do in the real world (rather than discussing the design process in abstract).
- **Did not facilitate discussions:** Three did not use the materials to facilitate discussion before or after the program. Two, however, said this is because they have already discussed the concepts in the classroom. The other did not have time to incorporate additional discussions.
- **Facilitated discussions with materials:** Two said the materials helped them lead classroom discussions. One used the questions from the post-program materials to lead a discussion about what engineers do and what is needed to build a building, and another used the pre-activity to start a discussion about how thinking about the user may impact your design.

WHAT WORKED BEST FOR THE TEACHER

Teachers were asked what about the *Why Engineering?* program worked best for them as the teacher. Their responses include:

- **Engineering and design content:** Four said the program's content was appealing to teachers. Three of these liked the video interviews with real engineers, because these segments exposed students to a variety of engineering careers, real engineering work environments, and pathways to becoming an engineer—topics they had not explored with their students in the classroom. One liked the program's emphasis on the design process because it reinforced the school's STEAM curriculum.
- **Interacting with other schools:** Two liked connecting with other schools through the program. One said the facilitator made them feel connected to other classrooms by reading students' real-time responses aloud. Another liked knowing that other schools in their district also participated, because this shared experience supports "continuity" in their curricula and the teachers could discuss the program with each other.
- **Participating via webinar:** Two, both homeschool teachers, said doing the program online via webinar made the program "easy" and "accessible" for their students because they did not have to travel to NBM.
- **Pre-program materials:** One said the materials provided by NBM supported her in structuring the classroom experience to prepare for the program.

Reinforcing the design process

"The part that worked best for me as the teacher was the reinforcement of the design process and the fact that projects take a LONG TIME and a LOT of work. So many students want instant gratification and want things to work right away, so it was helpful for them to see engineers talk about how long the design process can take."

Webinar accessibility

"The fact that it was online made it very easy. It was free too and that made it accessible for me to offer my student as a homeschool. The subject matter was pertinent to what kids need to learn today."

HOW THE PROGRAM ENHANCES TEACHING ENGINEERING

Teachers were asked about what ways, if any, the program enhanced their teaching of engineering. Some shared multiple ideas, so the totals below exceed the number of interviews. Most said the program enhanced their teaching of STEM/STEAM subjects or fit in with a broader school-wide STEM/STEAM- or career-focused initiative.

- **"Real-world" connections:** Six said the program made them think about ways to apply their lessons to "an occupation, or the real world." Four of these said the interviews with engineers exposed students to career pathways and applications for STEM subjects, and two noted that the videos of interviews with engineers are a valuable resource that teachers couldn't replicate on their own.
- **Connection to design thinking:** Two said the program "reinforced" the design process, which they use in STEAM lessons or in a makerspace. One said the program's focus on design thinking made her think about "keeping in mind the user," which she applies to both the makerspace and the classroom.
- **Connection to students' interests:** One (homeschool teacher) said the interview with an engineer who described taking things apart to see how they work connected to her student's interest in taking things apart. Thus, she hoped to the program would help him see how he might apply that interest to a career in the future.
- **Filled a knowledge gap:** One (homeschool teacher) appreciated the program as an opportunity to fill a gap in her own teaching knowledge beyond "basic" math and science.
- **Did not enhance teaching:** One said the program did not necessarily fit in with their teaching, but that it was an opportunity to gauge the program's usefulness in the future.

Valuable resource for teachers

"The program offered something I would not have been able to do. I would not have the ability to show interviews with engineers. The pre-activity was easy to do and follow, not something I would have found that on my own or would know how to do that. Being able to combine several hands-on activities along with learning about the engineering is quite a lot in a short amount of time. Almost like going on a field trip to a museum. But we got to do it all in the classroom. Never done anything like it."

Inspired to make real-world connections with other lessons

"I think now I will make sure with these lessons I make a connection to how whatever we've done in class can be applied to an occupation or the real-world situations where a lesson can connect to a specific type of engineering."

WHAT WORKED BEST FOR THE STUDENTS

Teachers were asked which aspects of the *Why Engineering?* program worked best for their students, and specifically which activity included in the program worked well for students. Most shared multiple ideas, so the totals reported below exceed the number of interviews.

- **Using the chat box:** Seven said their students liked the chat feature, which most describe as "interactive" or "engaging" for their students. Overall, students enjoyed the chat feature because they could see other students' responses, which made them feel like they were "part of a bigger class." Two said their students also felt excited or validated when the facilitator read students' responses aloud. While both teachers and students liked the chat feature, two others said that it was challenging to keep up with the chat discussion as teachers, as they typed all their students' responses during the program.
- **Video interviews with engineers:** Six said the video interviews with engineers was a highlight for their students. Two said hearing real engineers discuss their careers "made the subject come to life." Another valued the interviews because her students liked hearing the engineers' "different perspectives" and variety of roles. Similarly, one teacher praised NBM's inclusion of female engineers in this segment. One said the videos engaged her more advanced students, but the content was too complex for some of her other students.
- **Hands-on activities:** Six said the program's hands-on activities worked well for their students. Teachers discussed the following activities as most enjoyable for students.
    - **Tower-building:** Three said students enjoyed building towers or learning how to create successful structures. One, who did the activity with students before the program, said students enjoyed the activity because they could build and create. Two said students liked applying engineering concepts to tower-building. For instance, one, who did the tower-building activity with students after the program, used the activity as an opportunity discuss "supportive shapes" and applied what they learned during the program to the activity.
    - **Sketching:** Three said their students most enjoyed the sketching activity during the program. Two said that drawing building designs kept students' attention; as one put it, students didn't "tune out" because they were "actively doing something." Another said her students wished they could share their finished sketches with other classrooms during the program.

Chat box connects students

"They enjoyed doing the online chat and participating. They were excited when they wrote a response, and the facilitator read their response. They loved seeing themselves, in the little square, on the camera. They figured out they were part of a bigger class."

CHALLENGES TO THE EXPERIENCE

Teachers were asked what about the program could be improved. A few shared multiple ideas, so the totals reported below exceed the number of interviews. Their responses include:

- **Poor audio/video connection:** Five said they experienced technology issues, which affected their students' ability to hear the information being shared during the program.[14] Teachers said the video "cut in and out," and described the audio quality as "glitchy" or "like someone holding up a phone to the computer." A few said students lost interest because of the poor audio quality.
- **Facilitation style:** Four spoke about the facilitator's style, sharing a few ideas. Two described the facilitator as "dry" or "not very personal." One said students observed the facilitator's reliance on a script, which she said affected students' perception of her credibility, and thus their interest in the program. Another suggested the facilitator allow students more time to process her questions, as the she had moved on before acknowledging students' replies in the chat box.
- **Desire for more interaction:** A few wanted a more interactive experience from the program. For example, two said they wished the students could have interacted more with the other classrooms participating in the program. Another one expected that students would be able to ask the engineers questions directly and requested opportunities for students to interact with engineers through live discussions.
- **Grade-appropriate language:** One fourth-grade teacher said the facilitator's vocabulary and ideas were above her students' grade level. The teacher talking in terms that elementary students could relate to rather than focusing on engineers' specific titles.
- **Program registration and Zoom:** One said the process of registering for the program and Zoom was "clunky," and they needed assistance from the school's IT department to set up their computer for the program.

Audio/video quality and facilitator feedback

"The sound quality of the video was not great. And the preparedness of the person doing the webinar, the kids picked up on the fact that she was reading a script and the kids took that as seeing her as someone not credible to host the webinar. The program didn't flow well enough with the facilitator to keep their interest."

[14] A sixth teacher, who declined to interview but emailed brief comments to the researcher, shared similar feedback about the audio/video quality.

TEACHER RELATIONSHIP WITH THE NATIONAL BUILDING MUSEUM

Teachers were asked about their relationship to NBM prior to participating in the program, and how that relationship changed after the program.

- **Existing relationship with NBM:** Three described positive experiences with NBM prior to participating in the *Why Engineering?* program. Two have visited NBM before, and two have attended programs or used NBM materials with students, including the Green Community and Designing for Disaster kits.
    - **Interested in future opportunities:** When asked how their relationship to NBM had changed, all expressed interest in participating in more programs or visiting NBM.
- **No prior relationship with NBM:** Six said they had little or no experience with NBM prior to the program; that is, they had not visited the museum and/or did not know about NBM or its resources.
    - **Interested in future opportunities:** When asked how their relationship to NBM had changed, five said they would like to visit NBM or participate in similar programs given the opportunity.
    - **No change:** Of these, one said their relationship to NBM has "not yet" changed. This teacher did not indicate whether they intend to visit NBM or use other museum resources.