The Science Behind Pixar
Summative Evaluation Report

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The Science Behind Pixar Summative Evaluation Executive Summary

Background and Methods

The Science Behind Pixar (SBP) exhibition was the product of a collaborative effort among the Museum of Science, Boston (MOS), Pixar Animation Studios, and the Science Museum Exhibit Collaborative (SMEC). The 13,000ft^2 exhibition presented the science, math, and computer science behind Pixar Animation Studios' animated films and innovation. Before entering *SBP*, visitors watched a five-minute film that oriented them to the exhibition and discussed its main messages. Visitors then interacted with screen-based and physical interactive exhibits, as well as the technical pipeline of the overall process, to increase their knowledge, skills, and interest in science, math, and computer science concepts and practices. Videos of Pixar Animation Studio employees detailed the range of technical jobs at Pixar Animation Studios, and their contributions to the technological advances that have revolutionized computer animation techniques.

This summative evaluation aimed to answer the following questions:

1. Who visited *SBP*, and why?`
2. What did audiences do during their visit?
3. What did audiences learn from attending *SBP*?
4. How did audiences feel about their experience at *SBP*?
5. How did different exhibit design features impact the social, physical, and cognitive experience for visitors, especially visitors with disabilities?
6. How do educators connect *SBP* to standards and classroom learning?
7. How, if at all, did educators connect the exhibition to standards and classroom learning, before, during, and after the Museum visit?

Data collection entailed a series of instruments and methods: tracking and timing observations, post-exhibition interviews, pre-exhibition surveys, post-exhibition and follow-up surveys, educator workshop surveys, and Visitor Experience Monitoring surveys (VXM).[1] At MOS, combinations of these data methods were used with: general public audiences, audiences with a range abilities, school field trip groups, and teachers attending educator workshops. Data from general public audiences were also collected at The Franklin Institute (FI).

Overall, visitors enjoyed their exhibit experience and many learned new information about Pixar Animation Studios' animation process. The following section provides main findings from the full report, as well as links to the report section(s) that discuss each finding in greater detail.

Findings: Public and School Audiences

Attracted the target audience: *SBP* drew public audiences in the target age of eight and older, and appealed to their interests in animation.

In particular, *SBP* appeared to attract more groups with 12-17 year olds or adults only, compared to the typical MOS audience. These groups came to the exhibition very interested in animation, with the expectation of learning more.

General public interest in learning animation, pre-exhibition surveys (N=155 public groups)

[1] Visitor Experience Monitoring (VXM) surveys are used at MOS for ongoing data collection about visitor loyalty, visitation experience, experience ratings, group demographics, and motivations for visitation.

Educators liked *SBP*: Middle and high school teachers brought school audiences to *SBP* because they valued its connections to STEM curricula, appreciated its interactive and cognitively engaging educational strategy, and saw animation as a relevant STEM application.

Educators brought their students to *SBP* for a variety of reasons, including the hands-on nature of the exhibition, its ability to engage student interest, and its relevant applications of STEM content. In particular, attending educators viewed *SBP* as a useful tool to supplement curricula goals. This is encouraging because the exhibit's content was designed to align with national standards, such as the Next Generation Science Standards.

"[SBP was] very interesting, interactive and relevant. It made so many real connections to art, math, and science."

- Educator, 7th grade

No single, iconic exhibit defined *SBP*: The exhibition's design and array of experience types supported self-led, educational, and entertaining experiences for a variety of audiences.

Using criteria defined by Beverly Serrell (2010), *SBP* was "exceptionally-thoroughly-used" and nearly every interactive exhibit was mentioned as a favorite by at least one visitor.[2] Most observed groups watched videos that featured interviews with Pixar filmmakers and explained aspects of Pixar's work. Both public and school audiences felt that their favorite exhibits, the interactive nature of the exhibition, and learning about the animation process at Pixar Animation Studios were the most memorable components of their *SBP* experiences. The public also valued the exhibition's design and array of experience types. Varied types of experiences throughout the exhibition supported engagement, entertainment, and learning for a range of audience types and preferences. Below are example quotes as to how visitors described the value of exhibition components in *SBP*.

"[The intro film is] very important. Guideline on what to expect [in the exhibition]."

-Female, adult

"[The interactives were] most meaningful to me…I'm a hands-on learner."

-Male, child

"[The immersives were] cute photo ops… fun visual interest."

-Female, adult

"Refreshing to see the real people who actually do it explaining it [in the videos]."

-Male, adult

"[The educator-led activity] was good for human interaction."

-Male, adult

[2] Beverly Serrell (2010) has established benchmarks for "exceptionally-thoroughly-used" exhibits, which include the following two independent indicators: The square footage of exhibition area visited per minute of average stay time, a quantity known as the "Sweep Rate Index," and the percent of "diligent visitors," defined as visitors who engage with more than half of the available exhibit experiences. An "exceptionally-thoroughly-used" exhibition includes a Sweep Rate Index lower than 300 and a percent of diligent visitors of 51% or higher.

Awareness and Knowledge: After visiting the exhibition, students and public visitors shared awareness and knowledge that aligned with the *SBP's* learning goals, particularly of STEM in animation.

Virtually all interviewed groups within the target age range demonstrated some awareness or understanding related to exhibition learning goals. Some visitors listed or explained the technical elements of the animation process. Others described more specific STEM (science, technology, engineering, and math) principles or techniques used in the animation process. Students also exhibited increased awareness of STEM's role and the steps involved in computer animation. For students, the most memorable and interesting information from *SBP* included increasing their knowledge about animation and Pixar Animation Studios. Below are two quotes that illustrate how visitors discussed STEM connections in the exhibition.

"[The Museum wants to] teach kids that computers have a bigger function than games."

-Female, adult

"Didn't know so much math and science was involved and [that] you could put that with art to make an animation."

-Female, student

Skills: Many visitors engaged in design process skills and recognized the resilience, work ethic, and other characteristics of Pixar employees.

Students and public visitors recognized and engaged in different STEM and computer science practices during their *SBP* experience. Most frequently, visitors mentioned that it takes a lot of time, effort, and complexity to make a Pixar Animation Studios film. Students also discussed understanding iterative design processes and the effort of Pixar employees. Groups that attended *SBP* had a better sense of some elements of programming practice. In particular, visitors had a better sense of how problem decomposition – breaking down problems into smaller parts – is used in programming, and a stronger awareness of the ability that programmers have to create new things. This evaluation found that students and public visitors not only engaged in problem decomposition, but also recognized that they were engaging in this practice.[3]

How students recognize and demonstrate engagement in STEM and computer science skills, follow-up interviews and surveys (N=82) [4]

Evidence of learning goal	Number of students	Percent of students	Example quotes
Students use design process skills.	23	28%	*"Brainstorm, build, fix, finish."* (female, 10)
Students acknowledge the resilience, work ethic, and other characteristics of Pixar employees.	21	26%	*"[I] didn't realize [making films] took so long and so much effort."* (female, 14)
Students use problem decomposition skills.	14	17%	*"When you're making a movie you have to do it in many steps."* (female, 14)

[3] When developing this exhibition, MOS conducted a research study about computational thinking strategies, specifically problem decomposition skills. Those findings were incorporated into the design of several *SBP* exhibition components (NSF, CNS-1339244).

[4] Learning goals coding scheme was applied across the following questions: 2) What did you: learn at this exhibition that you found most interesting or engaging, and why? 2) What would you say is the most memorable part of the exhibition, and why? 3) How would you explain the steps involved in making a Pixar film to your favorite teacher? 4) Explain how *SBP* relates to things you have learned or done in school.

Computer programming: Though patterns of change in self-efficacy for computer programming differed for school and public visitor groups, public visitor groups left with better understanding and interest in the subject.

High school groups demonstrated an increase in their self-efficacy in computer programming, while elementary/middle school groups demonstrated no change and public visitor groups indicated a decrease. Despite the decrease in self-efficacy for public visitor groups, they still left *SBP* with increased interest in and understanding of computer programming. Increased awareness of the complexity of computer animation may have contributed to the lower self-efficacy, but it did not seem to discourage their interest in learning more.

"[The Museum wants people to learn about] computer programming, and math, how it relates to something creative."

–Female, adult

Findings: Accessibility

Engagement and social inclusion: *SBP*'s design and content supported engagement and social inclusion.

SBP provided visitors with a range of disabilities many opportunities to successfully engage and learn socially. The exhibition layout, varied experience types, and multimodal representations supported accessible learning experiences.

"[SBP had] opportunities in every area to do, for example, rendering and adjust[ing] things in a hands-on way. [You could use] both 3D models and digital models. Combine that with videos [and] it really gives you lots of ways to learn."

-Female, caregiver

Touchscreens and hearphones: Multimodal representations (touchscreens and hearphones) both facilitated and hindered engagement for certain visitors.

Touchscreens and hearphones were beneficial for many visitors. Activities with touchscreens were engaging and the format of situating the control panel along the bottom half of the screen allowed for more visitors to physically access and easily manipulate exhibit controls. Hearphones were easy for most visitors to operate and they also facilitated independent experiences for different types of visitors, especially visitors with cognitive disabilities or ASD. On the other hand, hearphones and touchscreens hindered others' comfort and ability to engage with the exhibit controls and content. Touchscreens were not intuitive for all audiences. Hearphone audio was sometimes too loud, soft, or fast. These features did not encourage social inclusion, as the hearphones accommodated one listener at a time and touchscreens did not have multi-touch capabilities. In particular, visitors who were blind or had low vision experienced difficulty using both features.

"[Audio] explained stuff to you in order…play with button to see what they did, direct and immediate connection to what you see."

-Female, caregiver

"Some of the touchscreen ones [were difficult to use. I] wasn't sure if I was touching it in the right place."

-Female, blind

Implications

The *SBP* summative evaluation provides insight into the impacts of the exhibition on its public visitors and school audiences. The following bullets summarize primary findings from this study and reflections from the exhibition development team:

- *SBP* was successful in attracting the target age group of age eight and older, conveying intended learning goals, and supporting a broad range of visitor interactions. Evaluators also studied *SBP* at the Franklin Institute in Philadelphia, where the findings yielded few significant differences. This is encouraging evidence that *SBP* will function similarly at exhibition host sites outside the Greater Boston Area.
- New strategies for accessibility pertaining to audio labels and touchscreen interface design could inform future exhibit design at MOS and other museums.
- Partnerships, such as the one with Pixar Animation Studios, supported the Museum to look outside its own institutional knowledge and leverage the expertise of others. As a result, working together helps to produce exciting and innovative exhibitions.

HOW TO READ THIS REPORT

To navigate this document smoothly, the authors recommend the following strategies:

- **Know the structure**: There are six main parts of this document:
  Introduction: This section describes the *Science Behind Pixar* (*SBP*) exhibition and the evaluation questions that guided the summative evaluation study.
  Methods: This section details the ways the evaluators collected and analyzed data to investigate the evaluation questions.
  Findings: The findings present data and provide responses to the evaluation questions. There are three main findings sections:
    - Public audience impact: This section runs through each evaluation question, specifically sharing data about the general public visitors. Most of the data was collected at the Museum of Science, Boston (MOS). The section is supplemented with data from the Franklin Institute.
    - School group audience impact: This section also runs through each evaluation question, but includes only data about school groups of students in elementary, middle, and high school, who visited *SBP* at MOS.
    - Accessibility: Impact on visitors with social, physical, and cognitive disabilities: Moving away from the evaluation questions, this section focuses on the MOS priority to make exhibitions that are accessible to diverse audiences. The data included in this section are from groups with a range of disabilities. Findings highlight factors that facilitate and hinder these visitors' experiences at the exhibition.

  Overview of findings: A series of tables in this section lay out the finding statements from the previous sections.
  Conclusion: This section reflects on the overall evaluation findings, as well as lessons learned from exhibition development process.

- **Use hyperlinks**: Throughout the text, you will see blue and underlined text (example). Clicking on these links will take you to the point in the document that is being described. This means that, when content is relevant in multiple places, the authors have opted not to repeat that text but to refer readers to appropriate sections if they wish to review it later.

- **Reference key terms:** A list of key terms has been included in Appendix M (page 184) of this report. The first use of a key term in each section will be linked to its definition in the appendix.

- **Enjoy introductory finding sections**: The main finding sections and sub-sections begin with a section that lists the main finding statements for that theme and describes the organization of that section. The authors hope that these introductory pieces will help readers know what to expect in an upcoming section. For those who are short on time, these sections (and the table of contents) can provide a quick summary so readers can flip quickly to the findings that are most relevant to them, using hyperlinks as described above.

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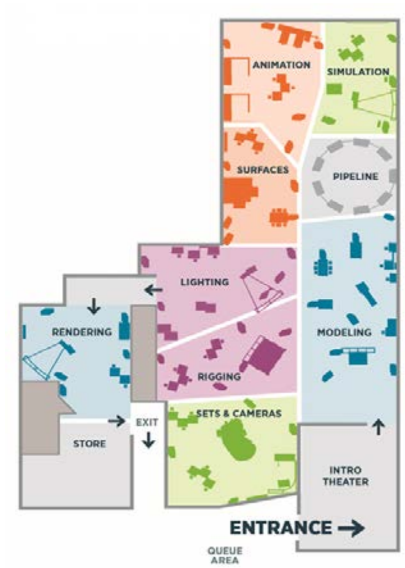
INTRODUCTION

The Science Behind Pixar (SBP) was a 13,000 square foot exhibition developed by the Museum of Science, Boston (MOS) in collaboration with Pixar Animation Studios and the Science Museum Exhibit Collaborative (SMEC). The exhibition featured the science, math, and computer science practices and concepts used to make Pixar's films. Detailed information about the exhibition—including further description about the messages, goals, activities, and specific exhibits—can be found in *The Science Behind Pixar: Exhibit Design & Development* (MOS, 2014).

Visitors entered *SBP* through an intro theater, where they watched a 5-minute film that prepared them for the exhibition. The film introduced visitors to the exhibition's main messages and provided the background content to orient visitors to the activities. Following the intro theater, the exhibition was set up according to the following eight steps of Pixar Animation Studios' animation process: Modeling, Simulation, Animation, Surfaces, Lighting, Rigging, Sets and Cameras, and Rendering. These steps were referred to as *the Pipeline*. For each of these steps in *the Pipeline*, there was a cluster of five kinds of experiences explaining the step:

- **Immersive experiences ("immersives")** used large-scale set pieces to attract visitors and immerse them in the settings of the Pixar films, as well as introduce the main idea of each section.
- **Interactive experiences ("interactives")** included screen-based and physical activities through which visitors learned about the animation process and other Science, Technology, Engineering, and Mathematics (STEM) content.
- ***Challenge* videos** focused on how employees at Pixar Animation Studios addressed challenges while making a particular movie.
- ***Behind the Scenes* videos** shared fun facts and details about film production.
- ***Working at Pixar* videos** gave visitors the opportunity to watch Pixar employees as they talked about their jobs and how they came to their careers in animation.

Finally, **educator-led experiences** were mobile exhibits that allowed visitors to interact with activities alongside educators and specially-trained staff. The diagram at the right illustrates the clusters and experiences in *SBP* as it was laid out at MOS.



As visitors explored the exhibition, they were exposed to the following main messages:

- Art, technology, science, and creativity are inseparable in animation.
- At Pixar Animation Studios, art drives digital technology and digital technology inspires the art.
- People at Pixar Animation Studios imagine and create compelling movies, using computers as a filmmaking tool.
- Understanding science, math, and computer science are necessary to create believable animated films.
- Filmmaking is a team sport.

This report focuses on the summative evaluation of *SBP*. The purposes of the evaluation were to:

- Determine how and to what extent the exhibition met the exhibition designers' goals.
- Gain a better understanding of audience behavior, interest, attitudes, and values associated with their decisions to attend the exhibition.
- Assess how and to what extent different features of the exhibits worked for different audience groups.
- Inform future exhibition development.

Audiences of particular interest in this evaluation included girls and women, families with children and/or youth, school groups, infrequent museum visitors, teachers, adults, and visitors with disabilities. The majority of this report focuses on data collected at MOS, where *SBP* premiered in June 2015 and ran until January 2016. Additional data was collected at the exhibition's second site, the Franklin Institute in Philadelphia. Where appropriate, comparisons are drawn between data at these two sites and can be found in callout boxes throught the section about the public's experiences with *SBP*. This can be found in the Public Audience Impact section, beginning on page 15.

The main questions that guided this evaluation included:

- **Who attended *SBP* and why?** Analyses compared data from *SBP* audiences and the Museum's typical audience in terms of attendance motivations, frequency of visitation, demographic characteristics, and (for school field trip groups) subjects and age ranges taught.
- **How did diverse groups and individuals interact with and respond to different types of exhibits?** Analyses identified and described patterns in how diverse audience groups used the exhibition and valued the different types of experiences.
- **What did visitors learn from attending *SBP*?** Analyses investigated how, and to what extent, the exhibition impacted visitors' attitudes, beliefs, conceptual understandings, and problem-solving capacities related to science, technology, engineering, math, and computer science.
- **How did different exhibition design features impact the social, physical, and cognitive experience for visitors, especially visitors with disabilities?** Data provided an understanding of how exhibition design elements, such as physical structures, screen design, graphic labels, audio labels, educator-led experiences, large-scale characters, set pieces, wayfinding, and seating, impacted visitors' learning, engagement, and inclusion.
- **How did visitors feel about their experience at *SBP*?** Analyses communicated visitor opinions regarding the overall experience, the educational quality, and the entertainment quality of *SBP*. They identified which exhibition aspects, if any, visitors considered memorable and/or planned to discuss with their friends and families after visiting.
- **How, if at all, did educators connect the exhibition to standards and classroom learning, before, during, and after the Museum visit?** Data analysis focused on what educators hoped students would gain from attending the exhibition on a class field trip, and how, if at all, the exhibition changed their perceptions of MOS or plans for future field trips.

METHODS

This summative evaluation investigated four audiences at MOS: general public visitors, visitors with disabilities, school groups on field trips, and educators. Additionally, a general public subsample was studied using the exhibition at the Franklin Institute in Philadelphia, PA. The overall evaluation strategy involved collecting data through several different methods (described below) that captured visitor understanding and attitudes before, during, and after visiting. At MOS, data for the summative evaluation were collected from August 2015-January 2016. At the Franklin Institute, data were collected in June 2016.

DATA COLLECTION INSTRUMENTS

Instruments used in this study included:

- Tracking and timing observations

POST-EXHIBITION AND FLASH INTERVIEWS

- Pre-exhibition and post-exhibition surveys and follow-up surveys
- Educator workshop survey for attendees post-workshop
- Visitor Experience Monitoring surveys (VXM)

A description of each type of instrument and the sampling approaches used for each can be found below. Additional details, including copies of the actual instruments, are provided in the Appendices on pages 132-185. Table 1 and Table 2 (on the following page) provide summary information about the samples for the instruments.

Table 1: Summary of data collection methods and sample sizes

	General public: MOS (Groups)	General public: Franklin Institute (Groups)	Visitors with disabilities (Individuals)	Students (Individuals)	Teachers (Individuals)	Total # collected
Timing and tracking observations	125	-	20	27	-	**172**
Exit interviews	125	76	20	136 short interviews	-	**375**
Pre-exhibition surveys	154	122	-	232	-	**508**
Post-exhibition surveys	155	120	-	184 one-month follow-up	-	**459**
Post-educator workshop surveys	-	-	-	-	45	**45**
VXM surveys[5]	798	-	-	-	199	**997**

Table 2: School group participation in each data collection method

	Elementary school	Middle school	High school	Overall
Students attending field trip	83	175	91	349
Completed pre-exhibition survey	67	125	40	232
Completed follow-up survey	65	83	36	184
Completed pre-exhibition and follow-up survey	59	77	34	170
# tracked and timed	10	12	5	25
# interviewed	52	66	18	136

[5] VXM surveys provide information about the Museum's general public audience and school groups who attend MOS on field trips. Not all VXM respondents attended *SBP* during their visit to MOS.

Tracking and timing observations

Overview

Timing and tracking observations focused on assessing how visitors—including visitors with disabilities, students on school field trips, and general audience groups—interacted within *SBP*. Beginning when a visitor left the intro theater and ending when that visitor exited the exhibition, data collectors unobtrusively watched the visitor, recording information about her or his visit using an observation instrument on a tablet device (iPad, smartphone, or iPod touch). Observers collected information related to use of exhibits and their elements, learning behaviors, social interactions, and usability concerns. The amount of time that visitors spent between exhibits, as well as how they spent that time (e.g. waiting in line, resting on a bench, etc.), was also collected and recorded.

Sampling

Evaluators used a random sampling strategy to recruit individuals for observation as they waited in line to enter the introductory theater. Data collectors approached every third visitor (ages five and older) as they queued for the exhibition. Children were only approached if a parent or guardian was present, as both adult consent and child assent were required for participation. A small incentive (a five dollar gift card) was offered to the tracked visitor. After agreeing to the study, the participant or parent (if the focus individual was a child) completed a demographic information form (See Appendix A: Visitor demographic survey, page 132) before the observation began. The total sample of observations consisted of a minimum of 30 cases of each of the following individual and group types: females (girls and women), groups with children 7 and younger, groups with youth 8 and older, and adult-only groups.

Individuals with disabilities were invited to the Museum to interact with *SBP* and provide feedback about their experiences. Visitors with disabilities who had previously expressed interest in participating in the Museum's evaluation efforts were invited to participate in the evaluation via direct email or phone. Evaluators also recruited subjects from a list of participants in a program with sighted guides that was taking place during the *SBP*'s run at the Museum of Science. Participants were strategically recruited to represent a range of ages; familiarity with the Museum; and different disabilities, including visitors who are blind or have low vision, visitors who are d/Deaf or hard of hearing, visitors with intellectual and learning disabilities, and visitors with limited mobility. Participants were offered free admission to the exhibition for themselves and one other group member. In total, 20 visitors with disabilities in 18 separate groups participated in the tracking and timing observations and interviews. Most sessions included the focus participant, multiple group members, and the researcher. However, two sessions exclusively consisted of the focus participant and the researcher, and two sessions consisted of the participant, a sighted guide, and the researcher.

Three school groups—one high school group with 92 students, one middle school group with 175 students, and one elementary school group with 83 students—were recruited to participate in the evaluation. Recruited groups had made reservations to see *SBP* and had applied for or requested funding support. School groups were chosen to reflect three different grade levels. Each of the invited school groups agreed to participate in the summative evaluation, and in return, received funding to attend *SBP*. Teachers asked all students to have a parent or guardian complete a parental consent form in order to participate. At the Museum, students with parental permission (identified through color-coded stickers) were randomly approached as they waited in line for the exhibition, and asked if they would be willing to be observed during their visit. A total of 25 students, across the three school groups, were observed for a full visit.

Post-exhibition interviews

Overview

Post-exhibition interviews were conducted with general audience groups, visitors with disabilities and their groups, and students on school field trips. The interview for general audience groups and groups with visitors with disabilities was semi-structured and assessed visitor learning, engagement, and perception of different aspects of the exhibition. Some questions investigated visitor reactions for different features of the exhibition, such as interactive components, large-scale dioramas, videos, and educator-led activities. For visitors with disabilities, the interview included questions specific to the exhibition's accessibility. Alternatively, students on school field trips were invited to participate in a two-question flash interview at the end of their visit. These post-exhibition interviews were short and open-ended, to allow students to express their thoughts about aspects of the exhibition quickly and openly. These interviews were designed to take a maximum of three minutes, so as not to interfere with the flow of their field trip.

Sampling

As interviews were a part of the timing and tracking protocol, separate sampling did not take place for those observed visitors. When the focus individual for the timing and tracking finished his or her time in the exhibition, researchers asked if s/he and her or his accompanying group would be interested in participating in the post-exhibition interview. Visitors in most groups (93%) agreed to be interviewed. Upon leaving the exhibition, an additional 15 groups were interviewed (but not tracked and timed) through a card sort protocol in order to reach a minimum sample size of 120 interview responses. A continuous random sampling approach was used for the card sorts, and the protocol was identical to that of the post-timing and tracking interviews, with the exception of the use of cards with images of all the exhibits to help facilitate the conversation between the evaluator and visitor. At the Franklin Institute, visitors were recruited for the post-exhibition survey as they exited the exhibition.

Visitors with disabilities were sampled as part of the timing and tracking recruitment protocol, described above. In general, the same visitors and their groups who participated in the timing and tracking were invited to participate in the interview. Of the 18 groups, one preferred to provide feedback to the data collector while using the exhibits, and one chose not to take part in an interview.

Students were sampled as part of the timing and tracking protocol for school groups. As students left the exhibition, those with parental permission were approached by data collectors and invited to answer two interview questions. Though an attempt was made to gather responses from all students with parental consent, evaluators' primary focus was on retrieving responses from their focus individuals.

Pre-exhibition and post-exhibition surveys and follow-up surveys

Overview

Surveys were used to understand some of *SBP*'s impacts on visitors' understandings, beliefs, capacities, and interests related to STEM and art (and particularly computer science). Pre-exhibition surveys also assessed visitor expectations of the exhibition, while post-exhibition surveys also assessed visitors' satisfaction with and perception of the quality of the exhibition. For students, the post-exhibition surveys were administered several weeks after their visit to the exhibition. These surveys used rating scales, multiple-choice selections, and Likert scales, along with a limited number of open-ended questions.

Sampling

Pre-exhibition and post-exhibition surveys were collected from separate general public audience groups. For both groups, a continuous random sampling approach was used, as follows: To recruit for pre-exhibition surveys, evaluators asked visitors in the first two or three eligible groups waiting in line to enter the intro theater to complete a survey. Only the first two or three groups for each time slot were asked, to be mindful that the visitors had timed tickets to enter the exhibition. For post-exhibition surveys, visitors in each eligible group were approached as they exited the exhibition. For both pre-exhibition and post-exhibition surveys, one adult (age 18 or older) in each eligible group was handed a clipboard with the survey to complete with their group members. Pre-exhibition and post-exhibition surveys were collected at similar times of day to improve comparability. Data collection was strategically planned to reflect Museum attendance at different times of day on weekdays, weekends, holidays, and Friday afternoons or evenings. Overall, 155 groups including 437 individuals participated in the pre-exhibition survey, and 154 groups comprised of 421 individuals participated in the post-exhibition survey at MOS. Group composition in terms of age, gender, membership, math and programming knowledge, and disability status were similar between the pre and post groups and between MOS and the Franklin Institute; there were no significant demographic differences between them.

Students were sampled as part of the timing and tracking protocol for school groups. All eligible students were asked to complete pre-exhibition surveys before visiting *SBP*. Additionally, this same sample of students was sent follow-up surveys approximately 3-6 weeks after their school's visit. The students did not complete the post-exhibition survey immediately following their visit, which differed from how the public responded to the post-exhibition survey.

Educator workshop surveys

Overview

To investigate the relevance and usefulness of the *SBP* for teachers and school field-trip audiences, educators who attended one of two educator workshops were invited to complete a brief follow-up survey. Post-educator workshop surveys focused on identifying what teachers hoped students would gain from the exhibition, what relevance, if any, *SBP* had to classroom content and curricula, and what strategies and resources teachers used for engaging students and connecting the classroom and museum experiences before, during, and after their visit. The purposes of the workshops themselves were to provide interested teachers with the goals and content of *SBP*, support and logistics for planning a field trip, an opportunity to preview the exhibition itself, and supplemental *SBP*-related educational resources. The agenda included presentations about the exhibition and educational resources, time for questions to MOS staff, and a segment in which the teachers explored the exhibition on their own.

Sampling

Teachers were asked to complete a post-exhibition survey at the conclusion of each workshop. The educator workshops attracted teachers who had strong previous visitation to MOS, with 82% of attendees having been on a previous field trip. A census sampling approach was used to recruit participants. Overall, 45 teachers attended the first educator workshop and 27 attended the second. A total of 45 educators completed the surveys, totaling a 63% response rate.

Visitor Experience Monitoring Surveys (VXM)

Overview

Visitor Experience Monitoring (VXM) surveys are used at MOS for ongoing data collection about visitor loyalty, visitation experience, experience ratings, group demographics, and motivations for visitation. These surveys provide information about the Museum's general public audience and school groups who attend MOS on field trips. Not all VXM respondents attended *SBP* during their visit to MOS. Data collected as part of VXM were used to understand how attending *SBP* related to audience demographics, motivations for visiting, and perceptions of different aspects of the institution. These surveys also provided information about the characteristics of the educators who brought classes to *SBP* (including demographics, motivations, and visitation behaviors).

Sampling

Data collectors for Public VXM compile email addresses from visitors throughout the year. The visitor is immediately emailed a link to a visitor experience survey, which can be completed at the visitor's convenience. Data collection is scheduled according to anticipated attendance at the Museum, such that the proportion of emails collected from visitors on weekdays, weekends, and holidays each month is proportional to anticipated attendance. During data collection, a random, continuous sampling strategy is used to solicit participation. One adult in each eligible group is approached and asked for an email address. While *SBP* was open at the Museum, 3,271 visitors were approached to participate in the Public VXM survey, and a total of 798 eligible surveys were completed from general public groups, with an overall response rate of 24.4%. Of the groups who completed a survey, 341 (43%) attended *SBP*.

For school groups, the Museum's School VXM uses a census sampling approach. The day after the field trip, one survey is emailed to each person who makes a school field trip reservation. The survey has a response rate of 20-30%. While *SBP* was open at the Museum, a total of 199 survey responses were received from educators who reserved field trips. Of these, 82 (41%) had attended *SBP*.

ANALYSIS

Open-ended survey and interview responses were open-coded or coded typologically. Open coding was used to identify themes that emerged inductively from the data with respect to specific evaluation questions (Patton, 2002). Typological coding was used to categorize visitors' comments with respect to pre-determined themes of interest, such as the learning goals. For example, responses to open-ended interview and survey questions were coded using a typological coding approach where themes related to each of the learning goals were identified through inductive analysis (Maxwell, 2004). The general audience post-exhibition interview and the student flash interviews, in combination with the follow-up surveys, were coded in this way. When coding the general audience interviews, three independent raters each coded two-thirds of the data so that each third of the data was coded by two coders. If discrepancies existed between the two raters' coding, those differences were discussed until 100% agreement was achieved. Two independent raters coded the open-ended student flash interview and survey data, and inter-rater reliability was assessed via Cohen's Kappa. For each coding category, a Cohen's Kappa of .7 or higher was achieved. For accessibility testing, data collectors reviewed the observations and interviews they conducted in order to clarify written notes and identify preliminary examples of physical, social, and cognitive inclusion for each group. Data collectors created mini-memos that organized these examples in a more useable format. These memos were then coded and analyzed using NVivo software.

Quantitative data were analyzed using descriptive statistics (means, counts, percentages, etc.) as well as inferential statistics (regression, chi-squared tests, Mann-Whitney U tests, t-tests, and Wilcoxon Signed-Ranks tests, etc.) as appropriate. Statistically significant results are marked throughout the text with an asterisk (*), and specific details of the analyses are included in footnotes. Further information about these methods and demographic information about each sample can be found in the Appendices, beginning on page 132.

PUBLIC AUDIENCE IMPACT

This section addresses the summative analysis for general public visitor data collected at *The Science Behind Pixar (SBP)* exhibition.

Based on this data, this section focuses on answering the following evaluation questions:

1) Who attended *SBP* and why?
2) What did the general public audiences do during their visit?
3) How did public groups and individuals interact with and respond to different exhibits and features?
4) What did public audiences learn from attending *SBP*?
5) How did public audiences feel about their experiences at *SBP?*

Data analysis for public audiences was derived from the following instruments and data collection methods, which are explained in the Methods section (page 8):

1. The Public Visitor Experience Monitoring Survey (Public VXM; N=798 groups)
2. Public pre-exhibition and post-exhibition surveys, completed either before entering or after exiting *SBP* (N=154 groups; N=155 groups)
3. Timing and tracking observations (N=125 visitors)
4. Post-exhibition interviews, given to visitors who were timed and tracked and visitors as they were leaving the exhibition (N=138 groups)

Public audiences at the Franklin Institute

The data in this section were primarily collected at the Museum of Science, Boston (MOS). Public audience data from the exhibition's time at the Franklin Institute was also collected in order to see if there would be differences as the exhibition traveled from site to site. In general, results from the Franklin Institute were consistent with those from the MOS. Due to this, Franklin data will only be mentioned when there are significant differences to the MOS and will be called out in orange boxes like this one.

Public audience data for the Franklin Institute was taken from instruments and methods similar to those mentioned above:

- Pre-exhibition and post-exhibition surveys completed in line for the exhibit or exiting *SBP* (N=122; N=120)
- Post-exhibition interviews (N=76)

WHO ATTENDED *SBP* AND WHY?

As mentioned in the Methods section (page 8)**,** Public VXM is used at MOS to assess general demographic information across museum visitors. The Public VXM survey is an ongoing data collection effort used at the MOS to better understand the visitor experience. Visitors are asked about what parts of the museum they visited, as well as basic demographic information, and their satisfaction with different aspects of the museum.

Public VXM data collected during the run of *SBP* was analyzed in order to see who visited the exhibition and what their motivations were for attending the museum. Over the course of the exhibition's run at the MOS, over 321,000 visitors saw the exhibition. During this time, 798 VXM surveys were completed by MOS public visitors, including both *SBP*-attendees and non-attendees.

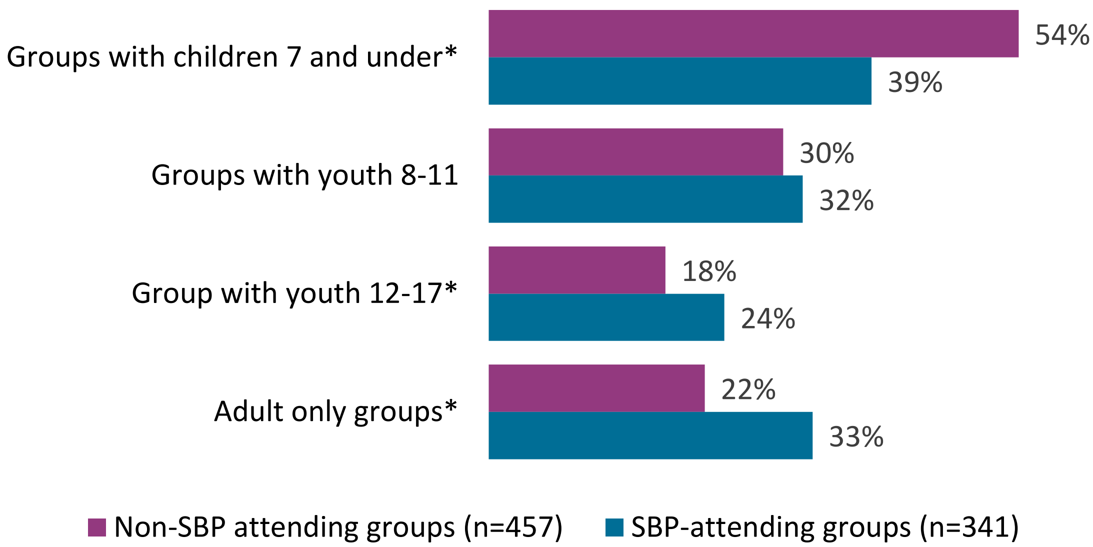
These audiences were compared to see how, if at all, *SBP*-attending groups differed from non-attending groups. Based on this data, findings in this section suggests the following:

- *SBP* attracted its target age range (8 and older) and drew in higher proportions of older children in comparison to non-*SBP* visitors.
- While demographics were similar between *SBP*-attending and non-attending groups, the exhibition drew in less frequent visitors to the Museum.
- *SBP*-attending groups came to the Museum primarily to spend time as a group or family and to see the exhibition. Many also expected to learn about Pixar Animation Studio's process for animation.

***SBP* attracted its target age range (8 and older) and drew in higher proportions of older children in comparison to non-*SBP* visitors.**

The majority of general public audience groups attending *SBP* (61%) included visitors ages 8 and older, which was the exhibition's target demographic. In particular, the exhibition attracted a relatively high proportion of groups with youth ages 8-17 (24%, compared with 18% of groups that did not attend *SBP*), and adult-only groups (33%, compared to 22% of groups that did not attend *SBP).* This suggests that the exhibition successfully attracted visitors in the target age range (See Figure 1 on the following page). This success is similar to results in the School Group Audience Impact section (page 63) where the majority of the *SBP*-attending school audience was within the middle and high school age ranges.

Figure 1: Group member ages for *SBP* attendees and non-attendees, Public VXM (N=798 groups)[6]



While demographics were similar between *SBP*-attending and non-attending groups, the exhibition drew in less frequent visitors to the Museum.

SBP-attending audiences were similar in demographic composition to the museum's general audience. Between *SBP*-attending and non-attending groups there were no differences in terms of museum membership status, race, ethnicity, income, education, and disability status (See Table 3 on the following page).

[6]Group includes children 7 and under: $\chi^2(1, N=798)=18.76, p < .05$
Group includes youth 12-17: $\chi^2(1, N=798)=4.80, p < .05$
Group includes only adults: $\chi^2(1, N=798)=10.93, p < .05$

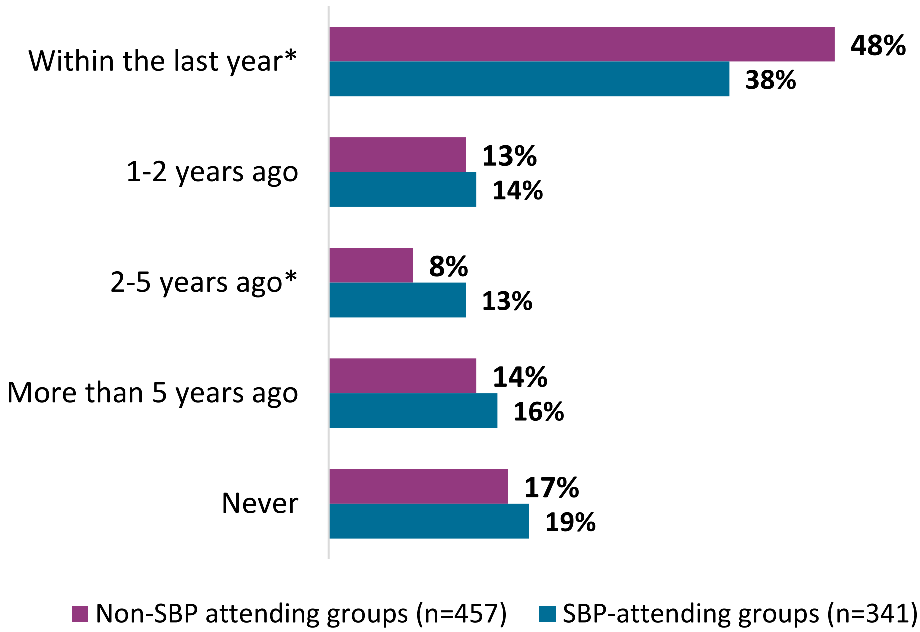
Table 3: Disability status, membership, race/ethnicity, and income status of general public audience attendees, VXM surveys (N=798 groups)

		Did not attend *SBP* (n=457 groups)	Attended *SBP* (n=341 groups)
Highest level of education	Some high school	<1%	<1%
	High school degree	3%	3%
	Some college	11%	12%
	College degree	36%	33%
	Some graduate work	7%	10%
	Graduate degree	41%	40%
	Other	1%	1%
Members		38%	36%
Group includes a visitor with a disability		8%	6%
Race/Ethnicity	White/Caucasian	69%	67%
	Asian/Asian American	7%	7%
	Hispanic or Latino	4%	6%
	Black or African American	3%	2%
	Other	2%	2%
	American Indian or Alaskan Native	1%	1%
	Did not respond	16%	19%
Income (n=595 of 798 respondents; 25% did not know or did not respond)	Under 25,000	3%	6%
	$25,000 - $49,999	10%	10%
	$50,000 - $74,999	12%	14%
	$75,000 - $99,999	17%	17%
	$100,000 - $149,999	30%	25%
	$150,000 - $200,000	15%	12%
	$200,000 - $250,000	4%	5%
	$250,000 - $300,000	4%	4%
	$300,000+	6%	7%

However, while *SBP* did not broaden the museum's audience, it did attract infrequent visitors to the museum. On the VXM survey, visitors were asked to indicate when they had last visited MOS. *SBP* attracted groups that had visited the museum before, but not within the last 2-5 years (13%, see Figure ***2*** on the following page).

Among visitors who had been to the museum in the past year, SBP attendees had come to the museum slightly less frequently than non-attendees, (four prior visits that year for *SBP* attendees, on average, compared to five prior visits in the past year for non-attendees).[7]

Figure 2: General public: Previous MOS visitation for *SBP* attendees and non-attendees,

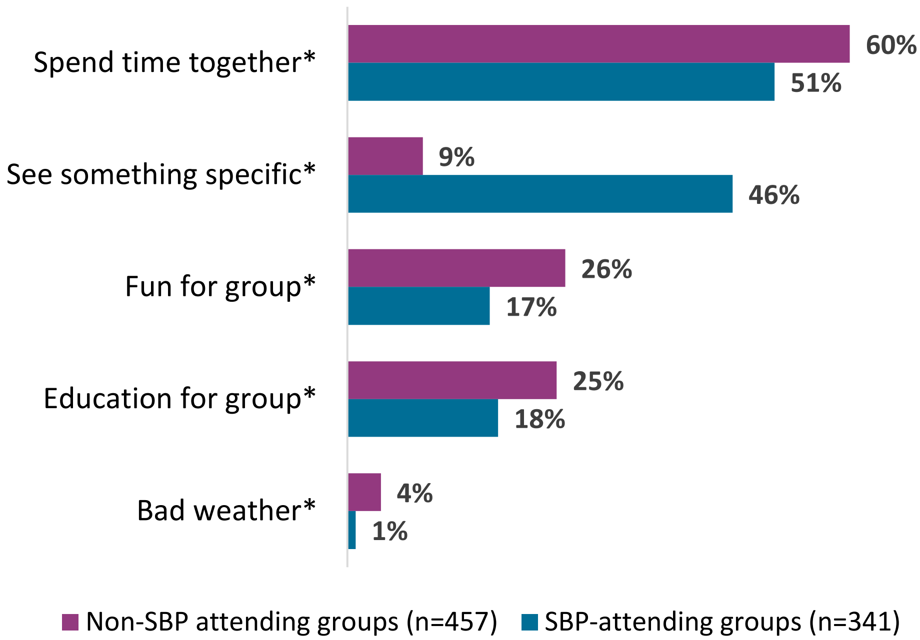


***SBP*-attending groups came to the museum primarily to spend time as a group or family and to see the exhibition. Many also expected to learn about Pixar Animation Studios' process for animation.**

The Public VXM survey includes a question asking visitors to select their top two motivations for visiting the museum from a list of possible responses. For both *SBP* attendees and non-attendees, the most frequent motivation for attending the museum was to spend time together as a family or group, although a higher proportion of non-attendees reported this motivation for attending (60% in comparison to 51%; see Figure 3, below). Many (46%) of the attendees to *SBP* also said they came "to see something specific." Of these groups, 73% indicated that they came specifically to see the exhibition. Major marketing efforts were made to promote the exhibition, and this evidence suggests that these efforts were successful in getting the word out to prospective audiences. Other motivations were also statistically significant and can be seen in Figure 3 on the following page. Additional motivations can be found in Appendix E on page 140.

[7] Mann-Whitney U=11,684; p<0.010; n=346)
[8] *SBP*-attending groups and non-attending groups within the last year: $\chi^2(4, N=798)=10.21, p < .05$

Figure 3: Public motivations for visiting MOS, Public VXM (N=798 groups)[9]



To further understand visitors' motivations and expectations of *SBP* prior to seeing the exhibition, attendees were asked to respond to the following open-ended question in the pre-exhibition survey: "What do you hope to see, do, or learn at this exhibition?" The majority (58%) of visitors indicated that they expected to learn about Pixar's process and/or the process of animation (58%; see Table 4 on the following page). Similar expectations were also found in school group audiences, with 73% also stating they hoped to learn about Pixar's animation process. More information on school audiences can be found in the Student Group Audience Impact section, on page 70.

[9] Spend time together: $\chi^2(1, N=798)=6.32, p < .05$; See something specific: $\chi^2(1, N=798)=141.3, p < .05$; Fun for group: $\chi^2(1, N=798)=9.46, p < .05$; Education for group: $\chi^2(1, N=798)=6.53, p < .05$; Something to do in bad weather: $\chi^2(1, N=798)=6.45, p < .05$.

Table 4: General public expectations about what they would be able to see, do, or learn in SBP, Pre-exhibition surveys (N=98 groups)[10]

Category	Explanation	% of responses	Example responses
Pixar's process and/or the animation process	Visitor expects to learn about how Pixar movies are made, or learn more about aspects of the animation process.	58%	*"How the movies are made."* (group with youth)
Learning experience qualities	Visitor expects specific qualities about their visit to *SBP*.	26%	
Fun or interest	Visitor expects the exhibition to be fun or interesting	13%	*"To have fun."* (adult-only group)
Age appropriateness	Exhibition information/activities will be appropriate for children.	11%	*"Child-friendly info."* (group with children)
Interactivity	Visitor expects the exhibit to be hands on/interactive.	4%	*"Interactive exhibits."* (group with children)
Specific art, STEM and creativity content	Visitor expects to learn specific content relating to STEM, art, or creativity.	21%	*"How math is applied to movies and animation."* (group with youth)
Relevance of content to school, life or career	Gaining something to apply outside of the exhibit, such as learning about careers, or inspiring their children.	14%	*"Creating computer graphics is my career and I'm really interested in seeing how they present concepts that even I struggle with sometimes…"* (adult-only group)

In support of this data, when asked about their interest in learning about animation, math, and computer programming prior to entering the exhibit, visitors had significantly higher levels of interest in learning animation than the other two subjects (See Table 5 on the following page).

[10] Percentages do not add up to 100% as responses were often double-coded into multiple categories.

Table 5: General public interest in learning about animation, programming, and math prior to the exhibition, Pre-exhibition surveys (N=155 groups)[11]

	Not at all interested	A little interested	Somewhat interested	Very interested
Animation	1%	13%	33%	54%
Computer programming	10%	21%	40%	29%
Math	12%	30%	33%	25%

WHAT DID THE GENERAL PUBLIC AUDIENCES DO DURING THEIR VISIT?

This section focuses on how visitors from the general public experienced *SBP*. A total of 125 general public individuals were observed at *SBP*. To read more about observations for students on field trips, see the School Group Audience Impact section (page 63). To read about visitors with disabilities, see the Accessibility section (page 97). Additionally, descriptions of the exhibit and its types of experiences can be read in the Introduction (page 6).

For this report, general public visitors were categorized into three group "types," in accordance with the age ranges of interest to this summative evaluation. The three group types exhibited differences in visitation, use, and learning behaviors within the exhibition. The three group types are:

- **Groups with children**: Any group that contains at least one child age 7 and younger, and accompanying parents. Usually the group experience was focused on and led by the child (n=35 groups).
- **Groups with youth**: Groups that only consisted of children ages 8-17 and adults (n=38 groups).
- **Adult-only groups**: Groups with only visitors ages 18 and older (n=51 groups).

This section covers the following findings:

- Using criteria defined by Beverly Serrell, *SBP* was an "exceptionally-thoroughly-used" exhibition.
- Groups varied the extent in which they engaged in the different types of *SBP* experiences.

This section uses terms such as kinesthetic experiences, tactile models, and audio labels to describe aspects of the exhibition. Definitions can be found in the Key Terms section (page 184) of the report.

[11] Pre-exhibition interest in learning about animation compared to computer programming: Z=-5.7; p<0.001; Animation compared to math: Z=-5.8; $p < .001$

Using criteria defined by Beverly Serrell, *SBP* was an "exceptionally-thoroughly-used" exhibition.

Beverly Serrell (2010) has established benchmarks for "exceptionally-thoroughly-used" exhibits using the following two independent indicators:

- The square footage of exhibition area visited per minute of average stay time, a quantity known as the "Sweep Rate Index"
- Percent of "diligent visitors," defined as visitors who engage with more than half of the available exhibit experiences

Benchmarks for "exceptionally-thoroughly-used" exhibitions include a Sweep Rate Index lower than 300 and a percent of diligent visitors of 51% or higher. According to both benchmarks, *SBP* was an "exceptionally-thoroughly-used" exhibition. *SBP* had a Sweep Rate Index of 224 (based on an average stay time of 57.7 minutes and a square footage of 13,000ft^2), and a diligent visitor percentage of 63%.

Most visitors engaged with at least one experience in each thematic cluster.

Overall, 61% of observed visitors spent at least one minute engaging with immersives, interactive exhibits, or videos in each thematic cluster of *SBP*. Nearly all immersive experiences (*Dory*, *Buzz Lightyear*, *WALL-E*, *Mike and Sulley*, *A Bug's Life*, *Incredibles*), had visitation rates of 80% or higher. This suggests that these experiences may have been effective at drawing visitor attention to each cluster of the exhibition.

SBP's interactive and immersive exhibits were well-attended.

On average, visitors engaged with 30 (of 55) exhibits, including videos, immersive experiences, interactive exhibits, and educator-led experiences. All but one of the 55 interactive and immersive experience were used by more than 50% of public audience groups.[12] More detailed information about visitation rates for individual components, see Appendix E on page 140.

Nearly every group engaged with the videos during their visit, spending over a minute on average at each one they stopped to view.

Nearly every group engaged with at least one video during their visit, although individual videos had lower visitation rates than most individual interactive or immersive exhibits. The *Behind the Scenes / Challenges* videos in particular were visited by almost all observed groups (98%; N=124) and the median number of videos seen by each group was 5 (of 16) of these videos during their visit. The most popular videos, each seen by over half of observed visitors, were *Pixar's Modeling Challenge*, *Pixar's Simulation Challenge*, and *Behind the Scenes on "Cars 2."* Video runtime varied from 2-3 minutes, and visitors spent an average of 1 minute and 25 seconds at each Behind the Scenes/Challenges video they stopped to watch.

The median number of *Working at Pixar* videos seen by public audience groups was 1 (of 8). These videos may have attracted fewer visitors than the other types of videos because of their physical presentation. When visitors stopped at these videos, they frequently watched all – or

[12] Sculpt-by-Numbers was attended by 46% of general public audiences. *Sculpt by Numbers*' visitation rate may have been impacted by its placement in the exhibition behind the *Buzz Lightyear* immersive, which may have partially obscured the exhibit. Another possibility could be that there was only one available station (many other exhibits had copies of themselves), and visitors may not have wanted to wait if there was no space available

nearly all – of an interview, spending an average of 1 minute and 50 seconds at each video they stopped to see.

Average per-video dwell times were also lengthy, with the average dwell time being over a minute. This means that visitors were spending enough time to get a significant amount of content from the videos, which typically ran 2-3 minutes long. More detailed information about visitation rates for individual videos, see Appendix E on page 140.

Groups varied the extent in which they engaged in the different types of *SBP* experiences.

The average stay time within the exhibition was nearly 58 minutes (not including the 5-minute intro theater film). Dwell times of observed visitors ranged from about 11 minutes to 2 hours, 21 minutes. As seen below in Table 6, groups with children, on average, spent the least amount of time on average in the exhibit (just under 45 minutes on average), while youth and adult-only groups both spent roughly an hour on average within the exhibition.[13]

Table 6: Range in time spent in *SBP*, by general public audience visitor type, timing and tracking (N=124 groups)

	Mean time spent (hr:min:sec)	Minimum time spent (hr:min:sec)	Maximum time spent (hr:min:sec)
Groups with children(n=35)	44:37	11:19	1:27:35
Groups with youth (n=38)	1:01:25	27:49	2:04:49
Adult-only groups (n=51)	1:03:58	26:52	2:21:12
General public visitors, overall (n=124)	57:43	11:19	2:21:12

Differences between groups were also observed in how each group type allotted time in *SBP*. These differences can be seen in Figure 4 and , and additional detail is provided in the following sections. Visitation and dwell time patterns were also consistent with school group audiences, which are explained in more detail on page 71 in the School Group Audience Impact section. Additional information about time and exhibition use by group type can be seen in the Appendix E (page 140) and overall findings for each group type are in the sub-findings below.

[13] $F(2, 121)=7.76$, $p = .001$, comparing total time spent overall between the 3 visitor types. Post-hoc Bonferroni analysis suggests that young children and their adults spend significantly less time in the exhibition than older children and their adults (p=0.008; mean difference = 16:48) and adults in adult-only groups (p=0.001; mean difference=19:21). There was no significant difference in time spent between adults in adult-only groups and older children and their accompanying adults.

Figure 4: Average total time (in minutes) spent at different experience types in *SBP* by group type, timing and tracking (N=124 groups)

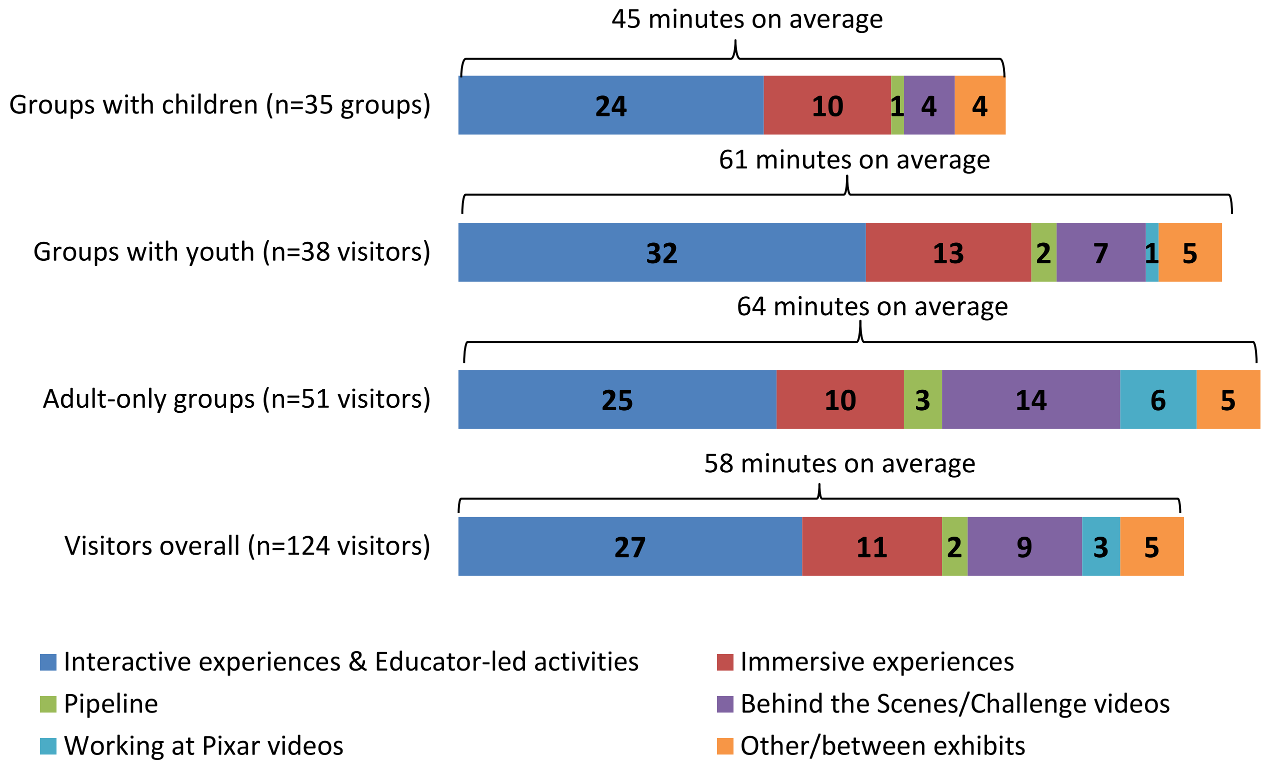
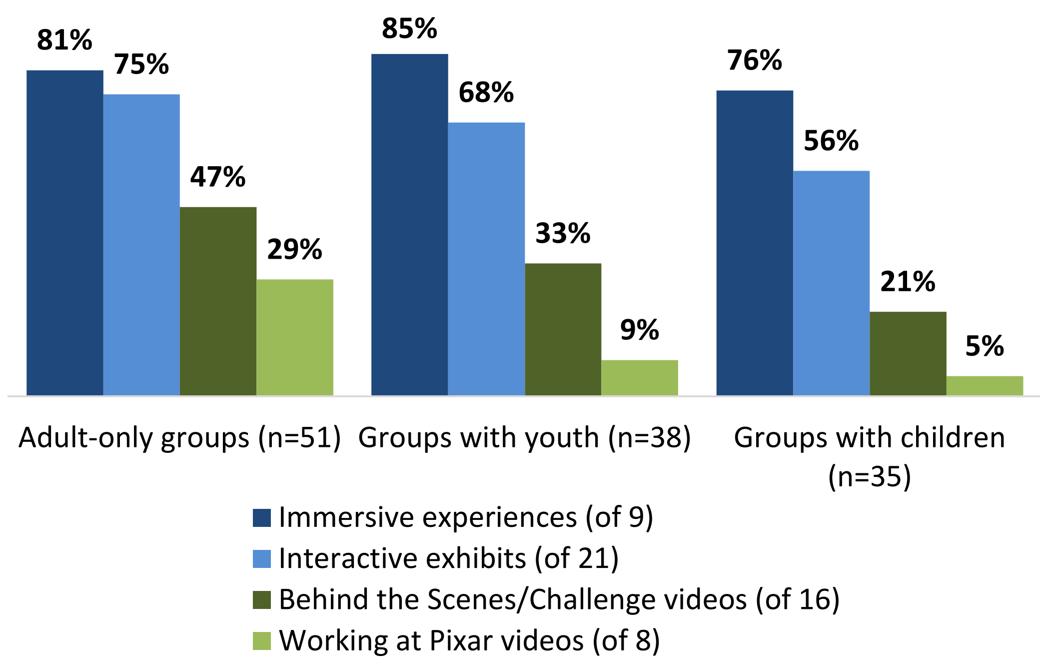


Figure 5: Average percent of interactive experiences, immersives, and videos experienced by general public visitor type, timing and tracking (N=124 groups)



Compared to other group types, groups with children (7 and younger) spent less time in SBP. They were drawn towards immersive experiences and interactive exhibits with kinesthetic experiences or tactile models.

As shown in Figure 5 on the preceding page, on average, groups with children:

- Spent less time in the exhibition than other types of visitors[14]
- Experienced fewer immersive experiences than groups with youth[15]
- Experienced fewer interactive exhibits than both other group types[16]
- Saw fewer videos than both other group types[17]

For this group type, the exhibits with the highest visitation rates included several immersive experiences. These exhibits featured large-scale character models that children and their groups could recognize, interact with, or take photos near:

- *Modeling (Buzz Lightyear)* (97%; n=35)
- *Sets and Cameras (A Bug's Life)* (89%; n=35)
- *Rigging (Mike and Sulley)* (89%; n=35)
- *Lighting (Dory)* (86%; n=35)

Other popular exhibits, attracting 70% or more child groups, featured mechanic controls or physical experiences:

- *Build a Robot* and *Character Maquettes* had tactile models or character pieces that visitors could feel or manipulate (picking up, building) to understand the exhibit material.
- *Lighting Design Workstation, Face Rigging Workstation, Crowd Simulation Workstation* all had physical sliders instead of touchscreen sliders, which visitors could use to manipulate the scene on-screen.
- *Lighting Effects Basics* had physical buttons that children could push to see different lights.
- *Extruded Shapes* demonstrated how a 2D shape can become a 3D shape. Children could grab a knob to lengthen a flat shape into a 3D version of itself.

[14] $F(2, 121)=7.76$, $p = .001$, comparing total time spent overall between the 3 visitor types. Post-hoc Bonferroni analysis suggests that young children and their adults spend significantly less time in the exhibition than older children and their adults (p=0.008; mean difference = 16:48) and adults in adult-only groups (p=0.001; mean difference=19:21). There was no significant difference in time spent between adults in adult-only groups and between older children and their accompanying adults.

[15] Oneway Anova: $F(2, 121)=3.7$, $p = 0.024$; Post-hoc Bonferroni test used to identify significant between-group differences ($p<0.05$).

[16] Oneway Anova: $F(2, 121)=16.22$, $p < 0.001$; Post-hoc Bonferroni test used to identify significant between-group differences ($p<0.05$).

[17] Oneway Anova: $F(2, 121)=25.48$, $p < 0.001$; Post-hoc Bonferroni test used to identify significant between-group differences ($p<0.05$).

Groups with youth had longer average dwell times at interactive activities, compared to other group types.

As shown in Figure 4 and Figure 5, on average, groups with youth:

- Spent a similar amount of time in *SBP* to adult-only groups
- Experienced more interactive exhibits[18] and immersive experiences[19] than child groups
- Saw more *Behind the Scenes/Challenges* videos than child groups, but fewer than adult-only groups[20]
- Saw fewer *Working at Pixar* videos than adult-only groups[21]

Groups with youth were drawn to immersive experiences, and most of the interactive exhibits were experienced by at least two-thirds of observed groups. One experience that seems to have been particularly compelling for these groups was Stop Motion Animation, which was used by 84% of these groups and had a median stay time of 3 minutes and 47 seconds (see Table E6 on page 146).

Adult-only groups were the most "diligent" group type, and spent the most time in SBP.

As seen in Figure 4 and and Figure 5, on average, adult-only groups:

- Had the most "diligent" visitor, which Beverly Serrell (2010) defines as visitors who engage with more than half of the available exhibit experiences.
- Experienced more interactive exhibits than child groups.[22]
- Spent approximately a third of their time watching videos (*Behind the Scenes / Challenges* videos[23] and *Working at Pixar* videos[24]), which is a larger proportion than youth or child groups.
- Watched videos for a longer periods of time in comparison to the other two group types.
- Watched, on average, two *Working at Pixar* videos.

Adult-only groups had high visitation rates at all of the immersive experiences and nearly all of the interactive exhibits. The only two exhibits that were not attended by at least two-thirds of this type of visitor were *Sculpt by Numbers* and *Build a Robot.* Hypotheses for the lower use of *Sculpt by Numbers* were mentioned earlier, including its location and visitors being deterred by a long line at the exhibit. *Build a Robot* appeared to be more attractive to younger visitors than adult audiences.

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[18] Oneway Anova: $F(2, 121)=16.22$, $p < 0.001$; Post-hoc Bonferroni test used to identify significant between-group differences ($p<0.05$).

[19] Oneway Anova: $F(2, 121)=3.7$, $p = 0.027$; Post-hoc Bonferroni test used to identify significant between-group differences ($p<0.05$).

[20] Oneway Anova: $F(2, 121)=22.77$, $p < 0.001$; Post-hoc Bonferroni test used to identify significant between-group differences ($p<0.05$).

[21] Oneway Anova: $F(2, 121)=16.86$, $p < 0.001$; Post-hoc Bonferroni test used to identify significant between-group differences ($p<0.05$).

[22] Oneway Anova: $F(2, 121)=16.22$, $p < 0.001$; Post-hoc Bonferroni test used to identify significant between-group differences ($p<0.05$).

[23] Oneway Anova: $F(2, 121)=22.77$, $p < 0.001$; Post-hoc Bonferroni test used to identify significant between-group differences ($p<0.05$).

[24] Oneway Anova: $F(2, 121)=16.86$, $p < 0.001$; Post-hoc Bonferroni test used to identify significant between-group differences ($p<0.05$).

Some visitors at the Franklin Institute spent a long time in the exhibition

Timing and tracking was not done at the Franklin Institute, so we do not have a clear picture of how Franklin Institute audiences spent their time within the exhibition.

Visitors in post-exhibition interviews and surveys were asked what time they entered and left the exhibition, giving us an idea of their general stay time. A table of this data is below. Generally, FI visitors spent roughly an hour within the exhibition, which is similar to MOS visitors.[25] Notably, the maximum amount of time spent in the exhibition was double that of MOS visitors (2 hours and 21 minutes at the MOS compared to 4 hours and 30 minutes at the FI). While these Franklin data are self-reported, it demonstrates the range of duration for which visitors engaged with the exhibition.

Table 7: Range in time spent in *SBP* at FI, by general public audience visitor type, post-exhibition interviews and surveys (N=186 visitors)

	Mean time spent (hr:min:sec)	Minimum time spent (hr:min:sec)	Maximum time spent (hr:min:sec)
Groups with children(n=48 visitors)	1:10:01	0:30:00	3:00:00
Groups with youth (n=63 visitors)	1:09:21	0:19:59	4:00:00
Adult-only groups (n=75 visitors)	1:17:16	0:22:00	4:30:00
General public visitors, overall (n=186 visitors)	1:12:43	0:19:59	4:30:00

HOW DO PUBLIC GROUPS AND INDIVIDUALS INTERACT WITH AND RESPOND TO DIFFERENT EXHIBITS AND FEATURES?

Observers during timing and tracking recorded how visitors used the exhibits physically, socially, and cognitively. This section talks about differences and similarities in how visitors engaged with *SBP*.

Data from this section is drawn from timing and tracking observations (N=124 visitors) and post interviews (N=128 groups). This section covers the following findings:

- *SBP* provided a social atmosphere that encouraged discussion.
- Usage patterns of different multimodal representations used throughout the exhibition varied by group type.
- Overall, visitors tended to value exhibition components for their enjoyment, engagement, and content.

[25] Includes watching the 5 minute intro video.

SBP provided a social atmosphere that encouraged discussion.

As defined in the Introduction (page 6), the exhibition offered different types of experiences, including immersive exhibits, interactive exhibits, videos, and educator-led activities. Public groups engaged in discussions with others at 61% of the exhibits they visited. School groups and people with disabilities showed similar patterns of social engagement, which are described in the School Group Audience Impact (page 63) and Accessibility sections (page 97) of the report.

For each group type, different trends were observed in the specific exhibits that catalyzed the most frequent discussion. For example:

- At least two-thirds of adult-only groups (n=51) that stopped at *Pipeline*, *Stop Motion Animation*, and *Camera Basics* engaged in discussions during their interactions with those exhibits.
- Groups with youth (n=38) seemed most likely to engage in discussions as they used interactive exhibits where there was room for creativity. Nearly 80% of groups with youth who used *Face Rigging Workstation*, *Programming Natural Variety*, and *Stop Motion Animation* engaged in discussions during their interactions at each exhibit. These exhibits allowed visitors to change parameters or a scene to reflect their own preferences and goals.
- Groups with young children (n=35) engaged in discussions most frequently at exhibits where they spent the most time. For these groups, discussions were most frequently observed during interactions at *Build a Robot*, *Virtual Modeling Workstation*, *Stop-motion Animation*, *Face Rigging Workstation*, which catalyzed conversations among over 80% of groups with young children who used them. The longer dwell times that these exhibits encouraged may have given adults time to talk to their children about the exhibit content.

These findings suggest that different types of experiences may encourage different group types to engage socially, and that offering a variety of experiences may support a wider range of visitors to discuss the exhibition. A table of the most popular exhibits for group discussion can be found in Appendix E (page 140).

Taking photos was a popular means of socialization at immersive experiences.

Observers also noted where visitors engaged in the social activity of taking photos. *Dory* from *Finding Nemo* was photographed by 46% of the visitors who engaged with it, and *Modeling – (Buzz Lightyear)*, was photographed by 41% of those who visited it. For example, one 39-year-old woman said, *"Loved that I could take a picture of my son. I think he'll remember that."*

Usage patterns of different multimodal representations used throughout the exhibition varied by group type.

The following multimodal representations were used across exhibits to provide differentiated ways for visitors to interact with the exhibition's content:

- Tactile models
- Audio labels
- Graphic labels
- "More Info" button

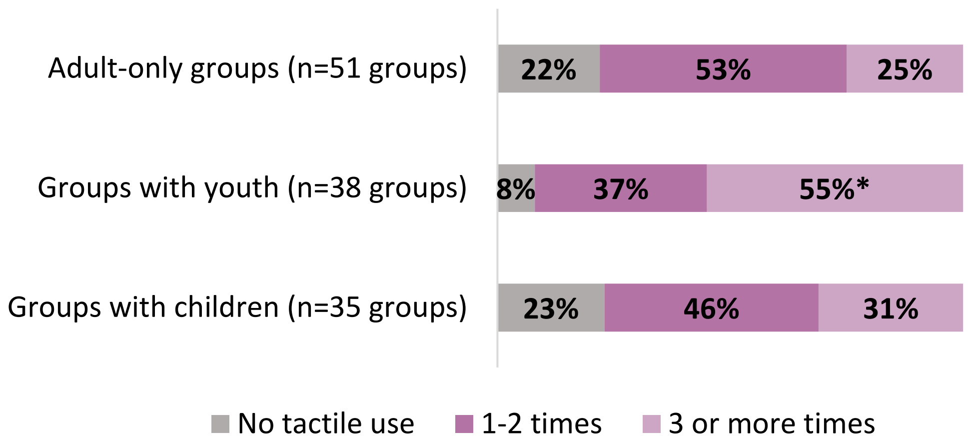
These exhibit elements had different usage patterns across the three group types. The summaries below describe how each group type utilized the different elements.

The usage of these multimodal representations was recorded on the timing and tracking instrument. Definitions for these methods can be read in the Key Terms section of the report on page 185 and additional information about their use for visitors with disabilities can be read in the Accessibility section on page 97.

Tactile elements were well-used by many groups, but groups with youth used them more frequently.

Visitors in all group types made use of *SBP's* tactile elements, with 82% of visitors engaging with tactile elements at least once. Groups with youth, however, used them more frequently than other groups, with over half (55%; see Figure 6 below) using these elements three or more times. This suggests that the tactile elements were an important way that youth engaged with the content of the exhibition. More details about the usage and importance of tactile models can be read about in the School Group Audience Impact (page 63) and Accessibility sections (page 97). Also, additional breakdowns of how different groups used tactiles can be found in Appendix E (page 140).

Figure 6: Visitors' frequency of use of tactile elements, timing and tracking (N=124 groups)[26]



Hearphones were used primarily by youth and child groups, and may have allowed them to access content that was challenging or difficult to read.

Use of the hearphone audio for 10 or more seconds was most common among child and groups with youth. These elements were used at three or more exhibit experiences by 20% of child and 24% of groups with youth compared to only 6% of adults. One possible explanation for this is that the audio provides a way for visitors – including young children – to access content that they find challenging or distracting to read. A graph of these results can be found in Appendix E (page 140).

[26] Groups with youth: $\chi^2(4, N=124)=12.010, p < .05$

The average visitor looked at graphics labels at nearly half of the exhibits they attended, but very few used exhibit instructions.

The typical visitor looked at graphic labels at nearly half (47%) of the exhibits that they attended. While there was wide variability in how often they were used amongst individuals (9% for one individual and 98% usage for another visitor), this suggests that the graphic labels were effective at attracting visitor attention.

Conversely, instructions were only used at an average of 13% of visited exhibits. Exhibits where instructions were most frequently used included: *Sculpt by Numbers* (35% of groups that used it), *Stop-Motion Animation* (34% of groups that used it), and *Virtual Modeling Workstation* (30% of groups that used it). Instructions for *Sculpt by Numbers* and *Virtual Modeler,* provided coordinates to input or challenges to try at the exhibit. Visitors at *Stop-Motion Animation* had a chance to read the instructions while waiting in line, and they aligned with the interaction of the exhibit. This suggests that the instructions at these activities were an integral part of using these exhibits.

The "More Info" buttons were used infrequently by general public audiences.

Overall, only 14% of general public audiences tapped the "More Info" button at any point during their visit. This infrequent use may have several explanations: visitors may not have noticed the button, may not have been interested in more information, or may not have understood what the purpose of the button was. Low usage rates were also seen in school group audiences (See School Group Audience Impact on page 75).

Overall, visitors tended to value exhibition components for their enjoyment, engagement, and content.

During the interview **(**See the Methods section on page 8), groups were asked to describe what they valued about five different exhibition components relative to their overall experience:

- Intro theater
- Videos
- Interactive exhibits
- Immersive experiences
- Educator-led activities

Visitors were prompted with, "I'd like to get your thoughts about the value of specific aspects of the exhibition, with respect to your overall experience today. What were your feelings about the value of…?" In sharing what they valued about *SBP*, visitors gave insight into what they felt was most important about the exhibition, the benefits, and challenges of types of experiences. Using an open-coding approach, visitors' responses were categorized based on the themes elaborated below and summarized on the following page in Table 8. Overall, visitors most often expressed value towards exhibition components in terms of fun and enjoyment, engagement, and informational content.

Table 8: Reasons visitors valued *SBP*'s types of experience, post-exhibition interviews (N=128 groups)

Theme		Explanation	Example quote
Fun and enjoyment		The visitor shared that the type of experience added or detracted from their entertainment.	*"Cute."* (female, 25) *"Awesome, I liked moving Jessie's eyes."* (male, 23)
Tone setting and orientation		Value with respect to the exhibition space or establishing the overall feel, tone, or atmosphere.	*"[It] got us excited to go in!"* (male, 42)
Informational content		Visitors valued what they learned about Pixar Animation Studios, STEM, art, animation, and the work involved in each.	*"The whole process from scratch from something on the computer, not just start with drawings, takes many, informational, even for those that did not know how cartoons were made."* (female, 35)
Engagement		Visitors mention ways in which they interacted or connected with the exhibition including physically, cognitively, or creatively.	*"I felt like I was a part of Pixar!"* (female, 24)
	Physical	Visitor addresses engagement in terms of hands-on, accessible, general physical activities.	*"[The interactive exhibits] added to the experience, you weren't just hitting play. You can change them and see how it works."* (male, 41)
	Cognitive	Visitor addresses engagement in terms of learning, thinking, keeping attention, content ownership.	*"I made a staircase on [virtual modelling workstation] and it was challenging but then I finally got it."* (female, 9)
	Creative	Visitor addresses engagement in terms of ownership over the possibilities of building or creating something "unique," using imagination.	*"Cool because you got to play around and do what you want."* (male, 12)
Social or memory-making value		Visitor talks about how they engaged socially or made memories at the exhibition.	*"Cute photo ops!"* (female, 44)
Age-appropriateness		Value or lack of value for different audiences, especially audiences in different age or social groups	*"For adults very fun, but younger kids won't get much out of it."* (female, 33)
Suggestions		Suggestions to improve the exhibition	*"It [the Intro film] was cute, but we only paid $12, (exhibit) is a lot of money, movie could be more, could be 3D maybe."* (female, 27)

Public audiences valued experiences that they felt were enjoyable and engaging.

The majority of groups (92%) described the value of at least one type of activity in terms of whether or not it was generally enjoyable or fun. Visitors in most groups (82%) also expressed value in terms of physical ("Hands on!"), cognitive ("Interesting"), or creative engagement ("You got to play around and do what you want").

Age-appropriateness was important.

Visitors in child groups, and to a lesser degree visitors in adult-only groups, frequently assessed value in terms of whether or not activities felt age-appropriate more often than groups with youth.[27] For groups with young children, participants appreciated activities that were accessible to children. For example, one participant appreciated the educator-led activities because it was "*good to have someone to keep the kids engaged…and to guide them*."

Youth and adult-only groups valued interesting content or information more than child groups.

Findings suggest that groups with youth and adult-only groups placed a higher value on learning new content and information than child groups. These groups mentioned valuing informational content more often when describing what they valued about different experiences.[28] Child groups, on the other hand, spoke more about engagement, entertainment, and age-appropriateness in comparison to other groups.

The intro theater provided orientation and tone setting that visitors valued during their experience.

Many groups (46%) noted that the intro theater was valuable for setting the tone of the exhibition and providing an orientation to the exhibition content. Table 9 below outlines how visitors mainly described their perceptions of the exhibit:

Table 9: How visitors described the value of the intro theater, post-exhibition interviews (N=128 groups)

Value	% of groups	Example quote
Tone setting and orientation	48%	*"It took us directly into the world of Pixar."* (male, 12)
Fun and enjoyment	54%	*"Loved it."* (female, 35)
Informational Content	24%	*"Shows Pixar as a cool place to work."* (male, 36)

Groups with youth ages 8-17 were more likely than other groups to comment that the intro theater was engaging[29], sometimes citing specific aspects of the film that appealed to them. For example, one 13-year-old boy noted, "*I liked how people kept changing their shirts*." These shirts were used in the intro film to outline stages in the animation "pipeline." For example, in the part about rigging, one of the animators would wear a shirt that read "Rigging" on it.

[27] Groups with children: $\chi^2(2, N=135)=15.3$, $p < .001$.
[28] Groups with youth and adult-only groups placed a higher value on learning new content and information than child groups: $\chi^2(2, N=135)=27.6$, $p < .001$.
[29] Engagement: $\chi^2(2, N=128)=6.1$, $p < .05$.

While no groups expressed strongly negative feelings about the intro theater, few groups (19%) had mixed feelings or were ambivalent about the film. One visitor commented that "*[It was] entertaining. I didn't find it as informing. It only gave an overview*" (16-year-old male). Others reflected that they expected a flashier or deeper introduction.

Interactive experiences were valued for providing creative, cognitive, and physical engagement.
Interactive experiences were seen as valuable because they were enjoyable, and because they provided opportunities for creative, cognitive, and physical engagement. Visitors in adult-only groups were more likely than others to talk about the interactive exhibits in terms of informational content (See Table 10 below).[30]

Table 10: How visitors described the value of the interactive experiences, post-exhibition interviews (N=128 groups)

Value	% of groups	Example quote
Fun and enjoyment	70%	*"Fun, liked them. Create things in the program."* (male, 15)
Engagement (creatively, cognitively, and physically)	44%	*"Helped you learn more because you were actually trying it. Cool because you could see how it changes, different versions of it. Shows how (they) create it. Goes from blank to creativity, (shows) finished product."* (female, 12)
Informational content	14%	*"Definitely shows you step-by-step on how to make a movie, like the schools of fish."* (female, 27)

Immersive experiences were valued for contributing opportunities to make memories and for setting the tone of the exhibition, but were seen by some as most appropriate for young visitors.

Immersive experiences were valued for contributing to visitors' sense of fun and enjoyment, offering opportunities to take photos, and for helping to set the tone of the exhibition (See Table 9 on the preceding page). As one 36-year-old noted, it was "Nice to give Wall-E a hug," while another stated that she "Loved that I could take a picture of my son. I think he'll remember that." Visitors felt that these characters contributed to the exhibition's tone and feel. As one 55-year-old woman noted, "You would need them in a thing like this. Without them, it loses its energy."

In fact, some groups suggested that the value of the immersives was solely based on their appeal for young children. For example, one 17-year-old noted that "[They were] childish…for kids to admire characters."

[30] Information and content: $\chi^2(2, N=128)=6.9, p < .05$.

Table 11: How visitors described the value of the immersive experiences, post-exhibition interviews (N=128 groups)

Value	% of groups	Example quote
Fun and enjoyment	66%	*"We loved that. Nice to give Wall-E a hug."* (female, 36)
Social or memory-making value: taking photos	23%	*"Didn't really find them too informative. Just kind of there to take pictures of."* (male, 15)
Age-appropriateness: young children	20%	*"Awesome! One of the very best parts of the exhibits…Especially for younger kids that want to see Pixar, maybe not for high school."* (female, 33)
Tone setting and orientation	16%	"*Brought it more to life….Characters were showing all of the different movies that had been made.*" (male, 13)

Franklin Institute groups valued the social aspects of the immersive characters, with adults talking about them the most.

FI visitors valued immersive experiences for the same reasons as MOS audiences and valued the social and memory-making aspects of these large-scale characters (40%; N=76 groups, see table below). For Franklin audiences it was adult-only groups who were more likely to talk about this value in comparison to youth and child groups, who were more likely to discuss social and memory-making aspects at MOS. [31] One 35-year-old woman at the Franklin remarked, *"We took pictures with all of them!"* and another said that she had sent pictures to her nephew. These data suggest that the characters were appealing to all ages.

Table 12: How visitors described the value of immersive experiences at FI, post-exhibition interviews (N=76 groups)

Value	% of groups	Example quote
Fun and enjoyment	43%	*"They were awesome."* (female, 11)
Social or memory-making value: taking photos	40%	*"We took pictures with all of them*!" (female, 35)
Age-appropriateness: young children	13%	*"Kids liked taking pictures with those."* (female, 52)
Tone setting and orientation	15%	*"Favorite, gives context to the whole thing Seen the movies."* (male, 42)

Videos supported cognitive engagement and provided STEM content in a way that was appealing for some visitors.

As noted in the Public Audience Impact section (page 27), adult-only groups used videos the most, but nearly all observed groups used them at least once. Visitors who enjoyed the videos often liked them because they made them think, or because they presented information in a straightforward way (See Table 13, on the following page). While the majority of groups found the videos enjoyable, a few indicated that they preferred more interactive activities or that they did not find the content interesting. These types of neutral or negative perspectives were expressed by approximately 21% of visitors. For example, one 10-year-old boy stated, *"I didn't like them; more interactive things are better because it gives more information when you are doing it yourself."* Like the Accessibility section (page 97), this finding underscores the importance of having multiple types of experience in order to support different types of learning.

[31] Social value: Adults more likely than other groups at FI: $\chi^2(2, N=76)=6.1, p < .05$)

Table 13: How visitors described the value of the videos, post-exhibition interviews (N=128 groups)

Value	% of groups	Example quote
Fun and enjoyment	52%	*"Excellent. We watched most of them. I liked the ones that showed how they ended up at Pixar, their likes and dislikes as children."* (male, 46)
Cognitive engagement	43%	*"Nice to see how they do it after doing the activity. I liked that there were actual Pixar animators talking, liked the fun touches in the videos."* (female, 9)
Informational content	28%	*"I liked the one about her hair [Merida's] and how they made the spring."* (male, 13)

For some, educator-led activities presented a unique opportunity to engage socially with an educator.

Educator-led activities were used by only 23% of groups who were interviewed. While some groups chose not to engage with these activities, others were not presented an opportunity to engage because educators were not in the exhibition from open to close each day. Among visitors who used these activities, they were seen as valuable because they engaged visitors cognitively or physically, particularly with concepts related to programming or computing (See Table 12 on the preceding page). A few groups particularly appreciated the opportunity to interact socially with an educator who could explain ideas interactively. However, some groups felt that these activities were primarily designed for older children and youth.

Table 14: How visitors described the value of the educator-led experiences, post-exhibition interviews (N=31 groups)

Value	% of groups	Example quote
Engagement: Cognitive and physical	48%	*"Nice to know that's how they do it in movies; [the educator] said a computer does it."* (male, 10)
Enjoyment and fun	45%	"*We, it was cool and fun, we played with the objects that kind of resembled computers and coding. Fun.*" (female, 13)
Social value: Educator guidance	19%	*"I liked having the live person; it adds another dimension to be guided through it. I think it still went over [my 5 and 7-year-old female children]'s heads, but I think they liked the idea of probability. It would be good to have more people to talk to and ask questions to too."* (female, 42)

Visitors mentioned enjoying the challenges posed by the activities, which were focused on concepts related to programming and computing. A 54-year-old male said "*At my age, you can see the parts, like the engine of a car, but now there is a removal of that component with computers; it was nice to interact with a person to bridge that gap and make the connection.*" A 9-year-old female remarked "*There was a formula for what we had to do; it was challenging*."

Some visitors who used the educator-led activities mentioned age-appropriateness. This was mentioned by 5 of the 35 groups who visited the educator-led activities. Groups with young children in particular felt that these activities were too complicated. For example, one visitor remarked that they were *"Definitely for older than a 4-year-old, such as kids in second grade or higher" (female, 46)*. Conversely, some adults seemed to feel the activities were more valuable for children and made comments such as *"I did [it], but I felt too old for it" (male, 30).* Overall, visitors felt that these activities were primarily designed for groups with youth.

Even when educator-led activities were present, some groups chose not to take part in them. During the exit interview, a total of 14 groups gave reasons as to why they did not participate in the experience. Reasons included that they felt that the activities were more appropriate for a different age group (n=7 groups), that the activities were too crowded (n=4 groups), or that they were fatigued or short on time (n=2 groups). One visitor mentioned that she may have done it if *"it was earlier, in the first room,"* and that by the time she had gotten to where the activity was that "*there was an attention span factor" (female, 53).*

WHAT DID PUBLIC AUDIENCES LEARN FROM ATTENDING *SBP*?

As explained in the Introduction (page 6), the main messages of *SBP* focus on how the interdisciplinary nature of science, technology, art, and creative innovation are essential to filmmaking. In addition to these messages, the learning goals of *SBP* focused on increasing visitors' knowledge, awareness, skills, attitudes, and perceptions in these topics. While the exhibition was designed for visitors of all ages, these learning goals primarily targeted visitors ages 8 and older. With respect to these learning goals, findings suggest:

- **Knowledge and awareness**
  - Virtually all interviewed groups within the target age range demonstrated awareness or understanding related to the exhibition's learning goals.
  - The majority of visitors who referred to STEM careers and jobs had watched a *Working at Pixar* video.
- **Skills**
  - While not an explicit goal during the exhibition's development, many public visitors engaged in aspects of the design process and recognized the resilience, work ethic, and other characteristics of Pixar Animation Studio employees.
  - Public audiences who saw *SBP* had a stronger understanding of how programmers approach problem solving than those who had not yet seen the exhibition.
- **Attitudes and beliefs**
  - Visitors surveyed after seeing *SBP* had higher levels of interest in math, computer programming, and animation, compared to equivalent groups surveyed just before they entered the exhibition.

- After attending *SBP*, visitors had a stronger appreciation of the importance of knowing how to do programming.
- After seeing *SBP*, visitors reported lower self-efficacy for computer programming than visitors who had not yet seen the exhibition.
- Groups' comments suggested that most adult-only groups, and some groups with children, felt the exhibition inspired interest in STEM and related careers.

For general public visitors, several sources of data, defined in the Methods section (page 8**)**, are referenced in this section:

- Post-exhibition interviews (N=135 groups)
- Pre-exhibition surveys (N=154 groups)
- Post-exhibition surveys (N=155 groups)

KNOWLEDGE AND AWARENESS

Evidence of knowledge and awareness was analyzed across the entirety of the visitor's post-exhibition interview. Visitor comments that suggested an understanding of the core STEM content that underlies computer animation fell into two categories:

- Listing or describing technical elements of the animation process
- Describing more specific STEM principles or techniques used in the animation process

Evidence that visitors had an awareness of the interdependence of art and STEM at Pixar Animation Studios included:

- Broadly mentioning the topics of science, math, or programming
- Discussing STEM-related work or jobs in animation

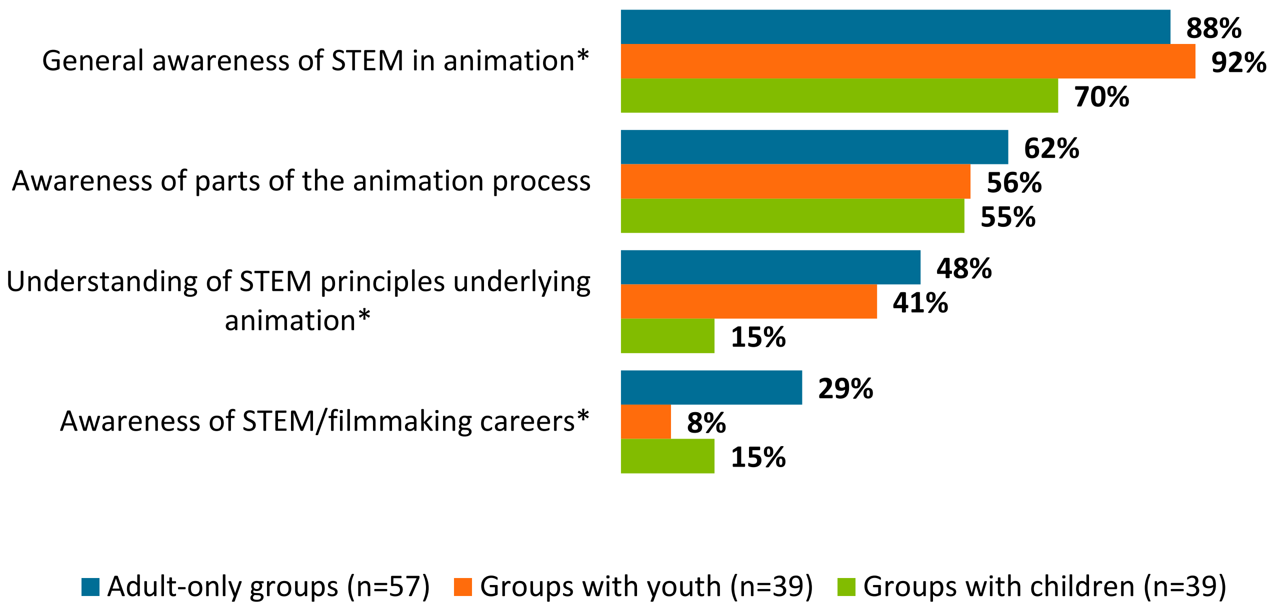
Virtually all interviewed groups within the target age range demonstrated awareness or understanding related to the exhibition's learning goals.

Overall, most groups left with an awareness and understanding of the connections between animation and STEM (See Table 15 on the following page). Awareness and understanding were especially strong for visitors in the target age group (8 and older). Virtually all interviewed groups within the target age range (100% of groups with youth and 96% of adult-only groups) demonstrated some awareness or understanding related to these learning goals, and most child groups (87%) did as well (See Figure 7). This demonstrates that audiences engaged with and showed awareness of these topics, although this may have been knowledge they had prior to entering the exhibition.

Table 15: How visitors demonstrate knowledge and awareness, post-exhibition interviews (N=135 groups)

Learning goals	Evidence	% of groups	Example comments
Understanding of the core STEM content that underlies computer animation.	Awareness of parts of the animation process: Listing or describing technical elements of animation	58%	*"[I was interested in the] technique of motion and how to make animation."* (male, 48)
	Understanding STEM principles underlying animation: Mentioning specific STEM and computer science used in Pixar animation	36%	*"Parabolas were on the first thing!"* (female, 42)
Awareness of the interdependence of art and STEM at Pixar Animation Studios.	General awareness of STEM in animation	84%	*"The blending of science and art."* (female, 44)
	Awareness of STEM / filmmaking careers	19%	*"They're actual scientists, not just artists sitting around drawing and then typing into computers…"* (female, 18)

Figure 7: Visitor knowledge, awareness, and understanding related to STEM learning goals, post-exhibition interviews (N=135 groups)[32]



The majority of visitors who referred to STEM careers and jobs had watched a *Working at Pixar* video.

At the *Working at Pixar* videos, visitors watched an interview with a Pixar employee speak about their profession. These videos typically touched upon STEM topics such as math, physics, and computer programming, highlighting the interdisciplinary nature of the animation process. Only a few groups' comments referred to STEM careers and jobs in filmmaking (29% of adult-only groups, 8% of groups with youth, and 15% of groups with children; see Figure 7 above). Nearly all (83%) of these comments were made by visitors who had seen at least part of one or more *Working at Pixar* video.[33] This may explain why these comments were most frequently from adult-only groups.[34] As explained in the Exhibit Use section (page 22), these groups were more likely to watch the exhibition videos. This implies that *Working at Pixar* videos were a main method for acquiring knowledge about STEM/filmmaking jobs within the exhibition.

[32] **General awareness of STEM in animation:** Less likely for children 7 or under and their group compared to overall ($\chi^2(2, N=135)=7.94, p = .02$). **Understanding of STEM principles underlying animation**: Less likely for children 7 or under and their group, and more likely for adult-only groups, compared to overall ($\chi^2(2, N=135)=11.68, p = .003$).

[33] Visitor groups who saw *Working at Pixar* videos were more likely to express awareness of STEM careers in filmmaking, compared to visitor groups who did not ($\chi^2(1, N=121)=11.73, p = .001$).

[34] In post-exhibit interviews, adult-only groups expressed awareness of the STEM-related jobs in filmmaking more frequently than groups overall ($\chi^2(2, N=135)=7.82, p = .02$).

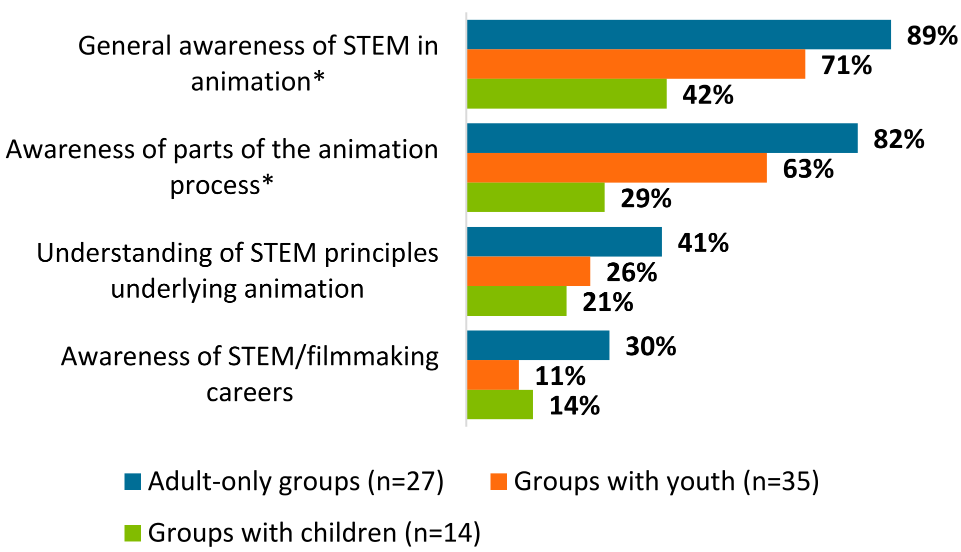
For the Franklin Institute, youth and adult-only groups were more likely to talk about parts of the animation process than groups with children

SBP had similar success at FI in regard to awareness in the general public audience. Similar patterns were observed, such as youth and adult-only groups being more likely to have a general awareness of STEM in animation (See Figure 8 below) For example, one visitor remarked that the exhibition, *"Takes art and adds in science, programming and math and mixes it together."*

Some minor differences were found for FI visitors. Youth and adult-only groups at FI were also more likely than child groups talk about the parts of the animation process.[35] Only 29% of groups with children mentioned this topic in comparison to 82% of adult-only groups and 63% of groups with youth. For the MOS, there was no statistically significant differences between groups, with similar percentages for all three age types mentioning this topic (adult-only groups: 62%; groups with youth: 56%; groups with children: 55%; see Table 15).

Additionally, while the MOS had statistically significant differences between groups for awareness of STEM careers in animation (See Table 15 above), this statistical significance was not seen in FI groups. However, percentages between groups were nearly the same as those at the MOS.

Figure 8: Visitor knowledge, awareness, and understanding related to STEM learning goals at FI, post-exhibition interviews (N=76 groups)[36]



[35] $\chi^2(2, N=76)=11.1, p < .05$

[36] Youth and adult-only groups more likely to talk about STEM connections at FI $\chi^2(2, N=76)=9.79, p < .05$
Youth and adult-only groups more likely to mention elements of the animation process at FI $\chi^2(2, N=76)=11.09, p < .05$)

SKILLS

While not an explicit goal during the exhibition's development, many public visitors engaged in aspects of the design process and recognized the resilience, work ethic, and other characteristics of Pixar Animation Studios employees.

As shown on the following page in Table 16, visitors' comments suggested that they engaged with STEM and computer science process skills in four main ways:

- **Character, resilience, and work ethic**: Recognizing the amount of complexity, time, and effort involved in making a Pixar Animation Studios film
- **Problem decomposition skills:** Engaging in aspects of problem decomposition such as making close observations and recognizing patterns, breaking things into steps, discussing making models or algorithms, discussing variables, and using formulas
- **Using design process skills:** Engaging in iteration, research, planning, testing, experimentation, and creativity
- **Use of creativity:** In conjunction with design skills, expression of ownership of a creative product or idea

Most frequently, visitors mentioned that it takes a lot of time, effort, and complexity to make a Pixar film (66%, see Table 16 on the following page). For example, one 24-year-old woman stated that the exhibition showed *"the amount of work it takes; attention to detail; when you watch a movie you think it's easy because it's on a computer; a lot more math, algorithms, formulas you don't think about."* The prevalence of these types of comments suggests that the exhibition helped visitors gain recognition for the challenge and effort that goes into filmmaking at Pixar Animation Studios. These findings are also supported by similar data from school audiences, which can be found in the Skills section on page 81.

Table 16: Awareness and recognition of skills in the STEM and computer science process skills used at Pixar Animation Studios

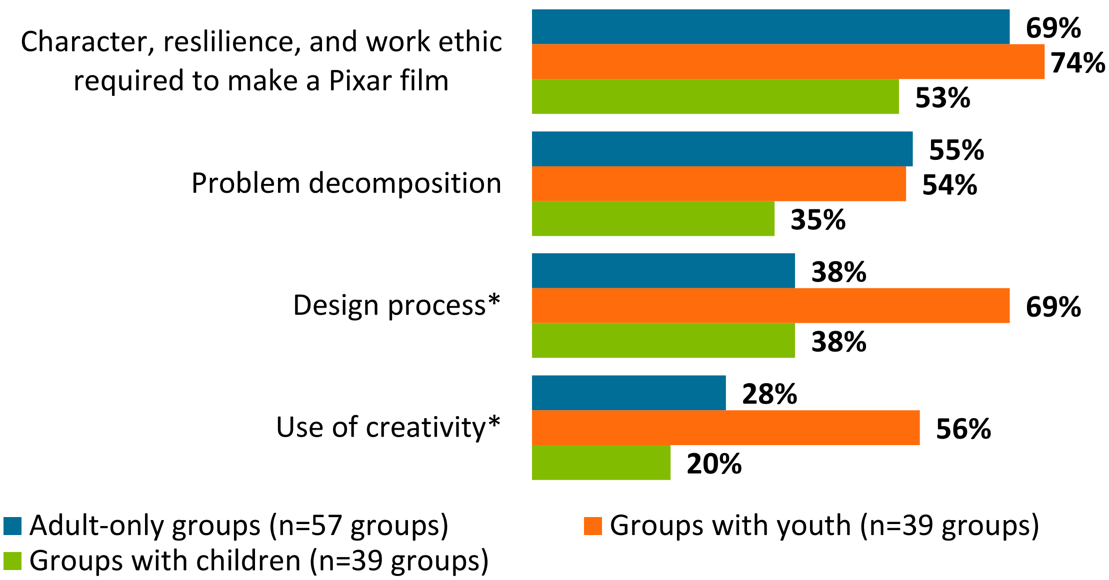
Skills Evidence	% of Groups	Example comments
Character, resilience, and work ethic: work, effort, determination, dedication, attention to detail	66%	*"That things like rigging take so much work, drawing, effort, trying over and over."* (female, 9)
Problem decomposition skills: including close observation and pattern recognition, breaking things into steps, creating models or algorithms, creating variables, using formulas	49%	*"Interactive- in one section you could can change the light, speed and brightness. It was cool. Easy to understand- understand what's behind the characters; it's math calculations."* (female, 12)
Using design process skills: including the process of iteration, research, planning, testing, experimentation, and using creativity to achieve goals	47%	*"Playing with Jessie's face. All the rigging. You're able to touch it and manipulate it like the animators."* (male, 31)
Use of creativity: in conjunction with design skills, expression of ownership of a creative product or idea	34%	*"Fun: You can make your own sets and play. Inspiring: take programming and see what you can do with it."* (male, 12)

Certain skills were mentioned more often when visitors had participated in educator-led activities or had spent more time using interactive exhibits.

Groups who described the design process skills they used in *SBP* spent more time using interactive exhibits,[37] while groups who participated in educator-led activities were more likely to describe the use of creativity.[38] Groups with youth were more likely than groups with children and adult-only groups to talk about the design process and using their creativity.[39] One explanation for these findings is that groups with youth spent more time engaged with interactive exhibits and educator-led activities, compared to other group types seen in the Public Audience Impact section on page 27, and in Figure 9 on the following page.

[37] Assessed via Regression: F=4.039; df=1; p=.047; n=123 groups; adjusted R^2= .027.
[38] $\chi^2(1, N=121)=6.07, p = .014$.
[39] Groups led by 8-17 year olds were significantly more likely to make comments that indicated that they were engaged in STEM skills and processes, compared to overall groups $\chi^2(2, N=135)=9.13, p = .01$.

Figure 9: Representation of STEM-related skills involved in animation in groups' post-exhibition interview comments (N=135 groups)[40 41]



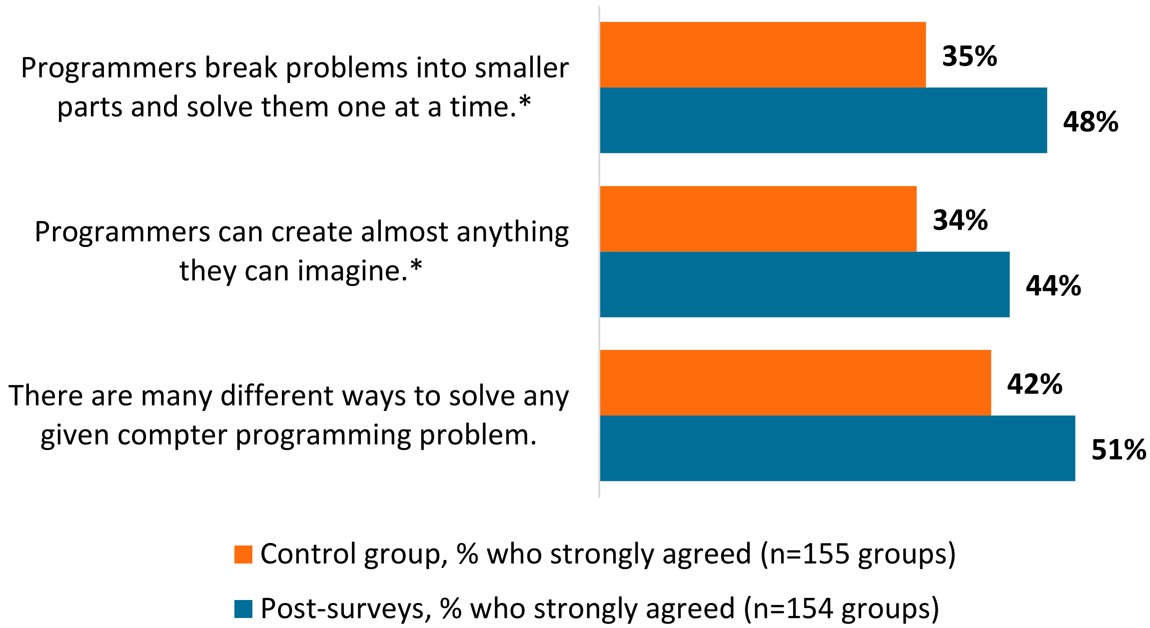
Public audiences who saw *SBP* had a stronger understanding of how programmers approach problem solving than those who had not yet seen the exhibition.

On the pre-exhibition and post-exhibition surveys, several items were designed to measure understanding of skills involved in computer animation. The pre-exhibition visit respondents were sampled from the same population of visitors as the post-exhibition visit respondents (See Methods on page 8), so their responses represent a control that enables the assessment of the impact of visiting *SBP* on public visitors' beliefs and attitudes.

Groups that had attended *SBP* had a better sense of some elements of programming practice, when compared to the control group surveyed pre-exhibition (See Figure 10 on the following page). In particular, visitors had a better sense of how problem decomposition – breaking down problems into smaller parts – is used in programming, and a stronger awareness of the agency programmers have to create new things. Additionally, over half of the respondents within the exhibitions' target age range (8 and older; see Figure 9) made comments during the interview which suggested that they engaged in or recognized aspects of the problem decomposition process (See Figure 11). This implies that the exhibition supports public audiences to develop problem-solving skills, particularly problem decomposition. Related impacts for school audiences can be found in the Skills section on page 81.

[40] Design process skills: More likely for 8-17 year-olds and their groups, compared to overall ($\chi^2(2, N=135)=11.48$, $p = .005$); Creative process: More likely for 8-17 year-olds and their groups, compared to overall ($\chi^2(2, N=135)=12.77$, $p = .002$).
[41] Compared to the comparable control group surveyed before their Pixar visit; $U=9045$, $Z=-2.76$, $p = .006$.* = statistically-significant difference between groups; $p<0.05$.

Figure 10: Visitors' understandings of the skills involved in programming, pre-exhibition control group and post-exhibition surveys (N=309 groups) [42] [43]



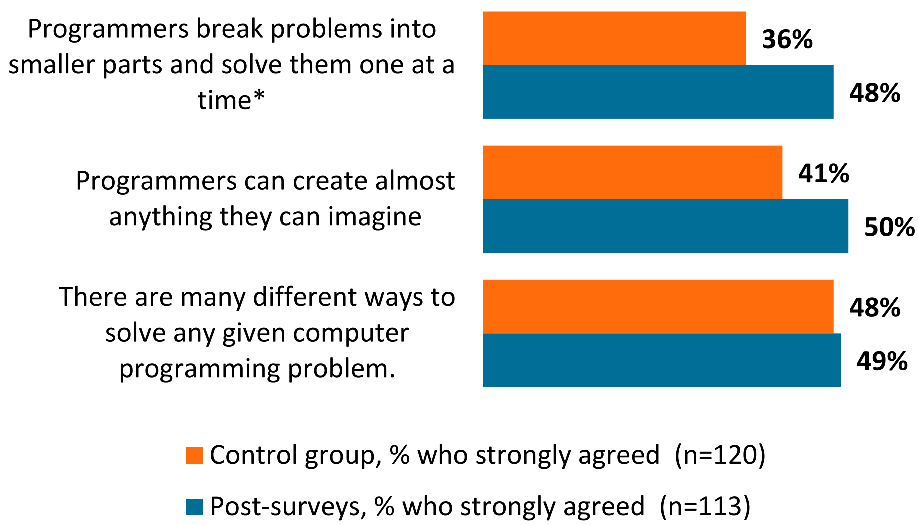
[42] Understanding of problem decomposition: *U*=9045, *Z*=-2.75, p = .005.
[43] Visitors had a stronger awareness that programmers had the ability to create new things: *U*=9130, *Z*=-2.81, p = .005.

Franklin Institute visitors had no differences between understanding the creativity in programming or understanding there are multiple ways to solve a problem.

Like visitors to the MOS, visitors who had seen *SBP* at FI had greater understanding of how programmers engage in problem decomposition than visitors who had not seen the exhibition.[44] Evidence of visitors' understandings of the problem solving approaches used in programming were also observed in visitors' interview responses. For example, one 18-year-old female commented *"So much detail behind one scene, they create the entire animation first and choose the view to go into, and the angle of the created image."*

Unlike the MOS, however, there was no statistically significant difference between FI groups' understanding that programmers can create almost anything they can imagine. This may be because when comparing responses to MOS and FI visitors before entering the exhibition, FI visitors were more likely to agree with that statement than MOS visitors.[45]

Figure 11: Visitors' understandings of the skills involved in programming, pre-exhibition control group and post-exhibition surveys (N=232 groups)



[44] FI visitors who saw *SBP* had a greater understanding of problem decomposition than the control group: U=5644; Z= -2.29 p=.05, N=232 groups

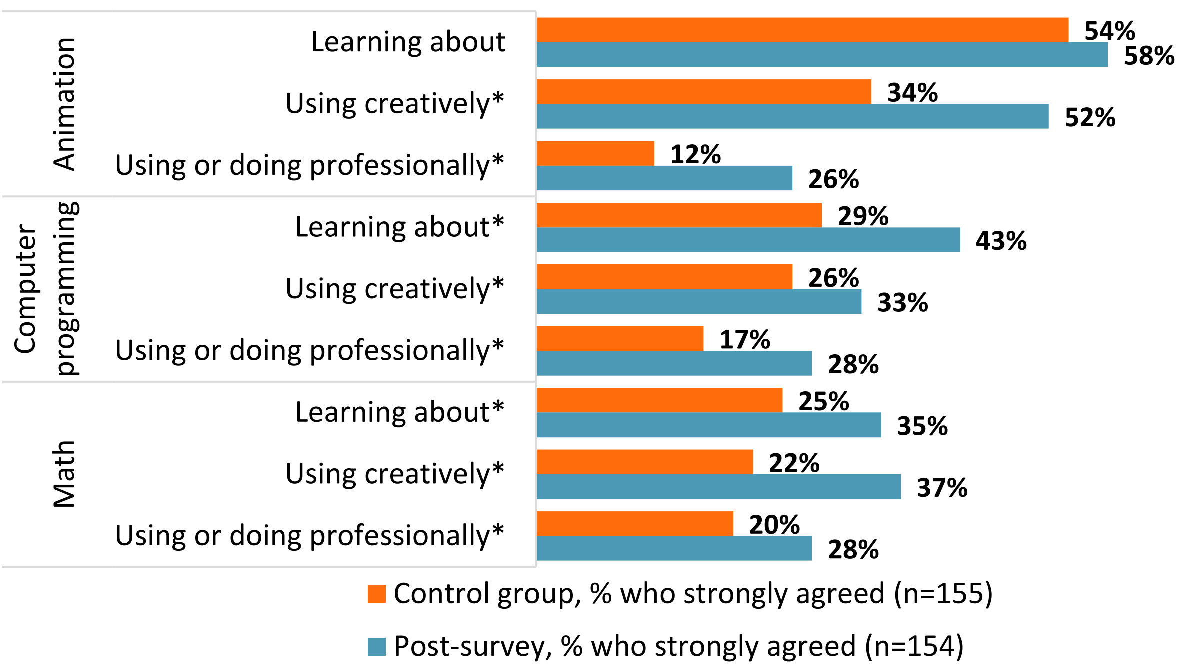
[45] W=19801.500; Z=-.345 p<.05, N=232 groups

ATTITUDES AND PERCEPTIONS

Visitors surveyed after seeing *SBP* had higher levels of interest in math, computer programming, and animation, compared to equivalent groups surveyed just before they entered the exhibition.

On pre- and post-exhibition surveys, visitors were asked about their interests in learning about and using three disciplines: animation, math, and computer programming. Over half of groups surveyed before entering the exhibition indicated they were interested in learning about animation, but only a quarter of them indicated high interest in learning about computer programming (29%) and math (25%) (See Figure 13 on the following page). Groups surveyed post-exhibition were significantly more interested in learning about math and programming, and in using math, programming, and animation creatively and in their careers than equivalent groups surveyed pre-exhibition.[46] This suggests that, while audiences may have come to *SBP* to learn more about animation, they left the exhibition with an enhanced interest in math and computer programming.

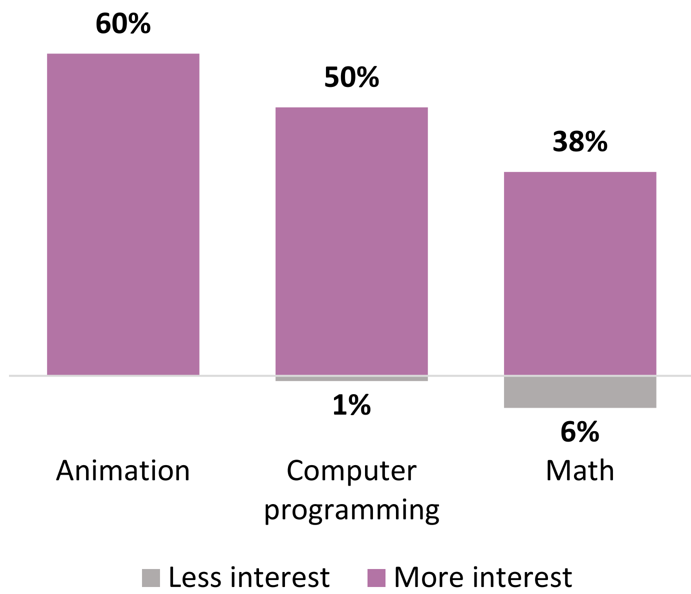
Figure 12: Groups with high levels of interest in math, computer programming and animation, pre-exhibition control group and post-exhibition surveys (N=309 groups)



[46] Post-visit were significantly more interested in learning about math: *U*=9826, *Z*=-2.25 *p* = .024.
Post-visit were significantly more interested in learning about programming: *U*=9420, *Z*=-3.12 *p* = .002.
Post-visit were significantly more interested in using math creatively: *U*=9755, *Z*=-2.34 *p* = .019.
Post-visit were significantly more interested in using programming creatively: *U*=9897, Z= -2.05, *p=.040*
Post-visit were significantly more interested in using animation creatively *U=9353*, Z= -3.21, *p=.001*.
Post-visit were significantly more interested in using math in their careers: *U=9596*, Z=-2.54, *p=.011*.
Post-visit were significantly more interested in using programming in their careers: *U=8748*, Z=-3.80 , *p=.000*
Post-visit were significantly more interested in using animation in their careers: *U=8344*, Z=-4.22 , *p=.000*

When asked whether and how attending *SBP* had changed their interest in learning about or doing animation, math, and computer programming, the majority of visitors said that the exhibition had increased their interest in animation (60%) and computer programming (50%). Over a third of visitors (38%) reported increased interest in math (See Figure 13 below).

Figure 13: Change in interest in learning or doing animation, programming, and math after seeing *SBP*, post-exhibition surveys and interviews (N=149 groups) [47]



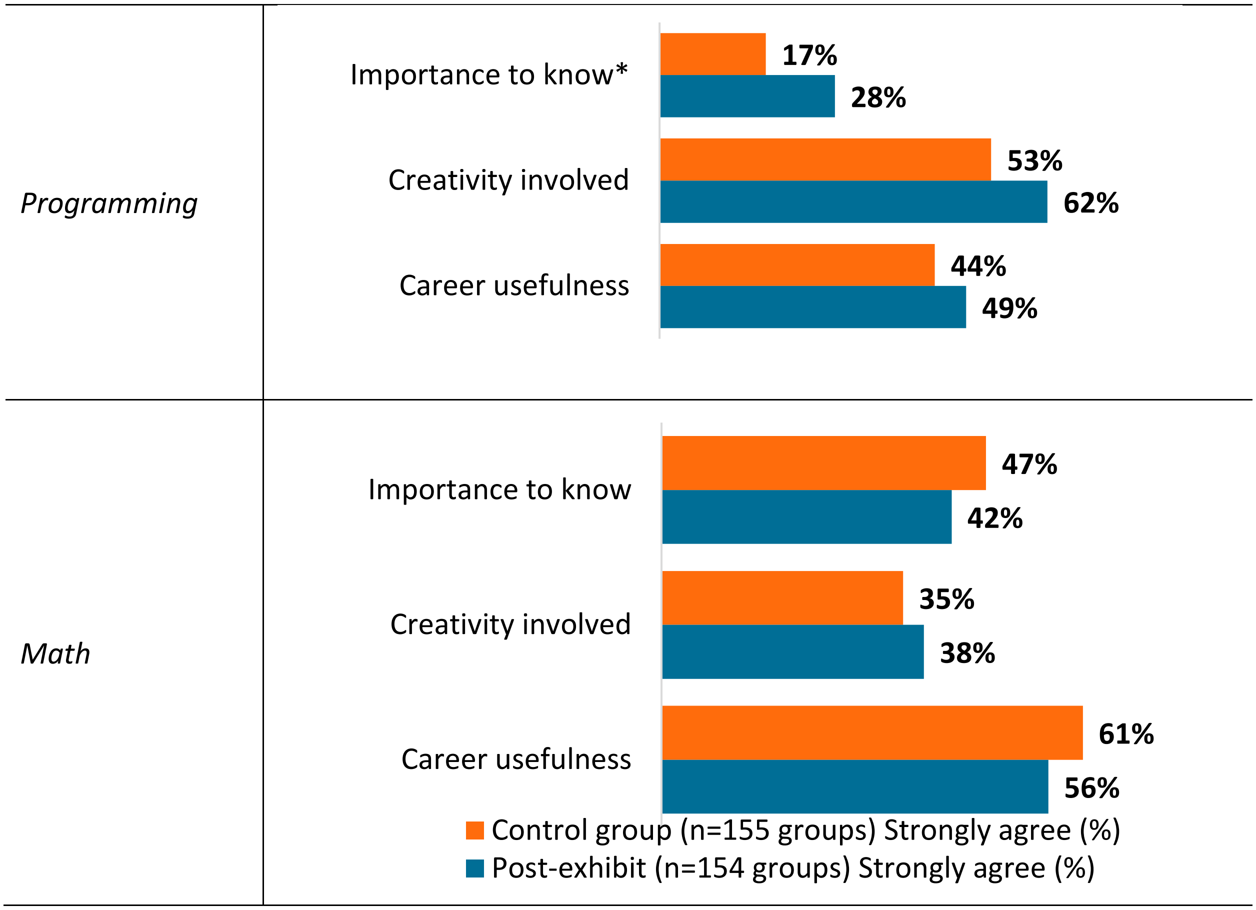
After attending *SBP*, visitors had a stronger appreciation of the importance of knowing how to do programming.

Visitors were asked to rate their perceptions of different aspects of math, computer programming, and animation. These aspects included their general importance, the amount of creativity involved in each subject, and their usefulness in a career. After attending *SBP*, groups had more positive perceptions of the importance of knowing programming, compared with equivalent groups surveyed before they entered the exhibition (See Figure 14 on the following page). [48]

[47] Respondents categorized their change in interest after attending *SBP* as "less interested," "the same as it was before," and "more interested". For clarity, respondents who indicated no change in interest are not represented on this visualization.

[48] Compared to the comparable control group surveyed before their Pixar visit; U=9136, Z=-2.75, p = .006.

Figure 14: Attitudes about math and programming, pre-exhibition control group and post-exhibition surveys (N=309 groups) [49]



Visitors came to the exhibit already believing in the creativity and career usefulness of computer programming and math.

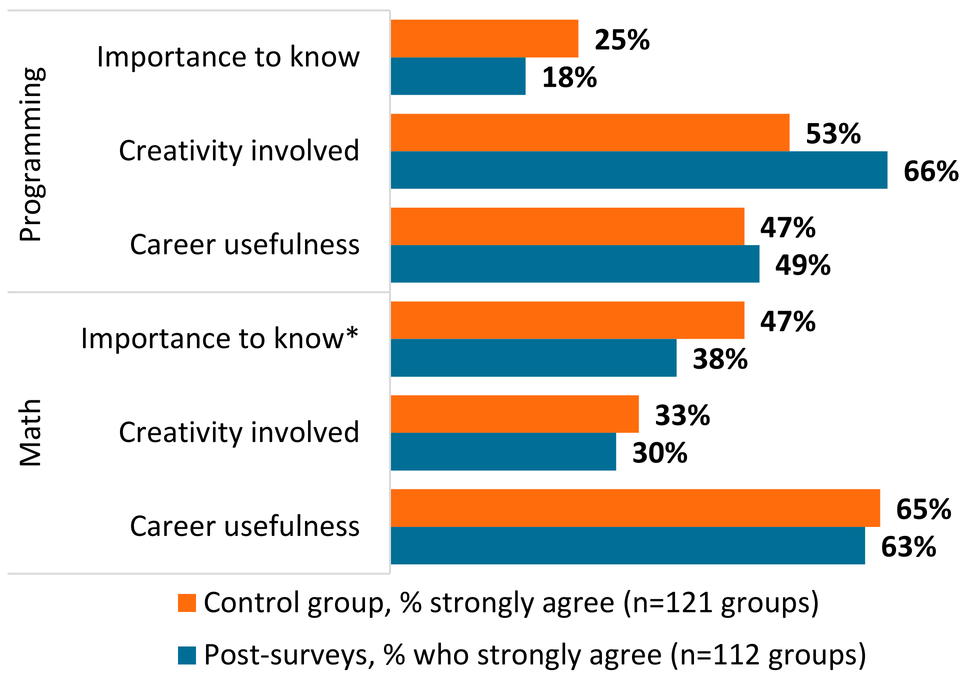
Most groups who choose to attend *SBP* agreed or strongly agreed that both programming (93%) and math (96%) are useful for careers, and that there is a lot of creativity involved in computer programming (97%). Most groups (88%) also agreed that math is one of the most important subjects to know, and many (71%) agreed that there is a lot of creativity involved in math. Groups surveyed before and after attending the exhibition reported similarly positive beliefs about math and programming.

[49] Compared to the comparable control group surveyed before their Pixar visit; *U*=9136, *Z*= -2.75 *p* = .006.

Franklin Institute pre-exhibition and post-exhibition surveys showed a decrease in agreement that it was important to know math.

At FI, attitudes about math and programming followed similar patterns to the MOS. However, at FI, visitors surveyed after the exhibit had lower levels of agreement that it is important to know math, when compared to equivalent groups surveyed before attending the exhibition there.[50]

Figure 15: Attitudes about math and programming, pre-exhibition control group and post-exhibition surveys, Franklin Institute (N=233 groups)



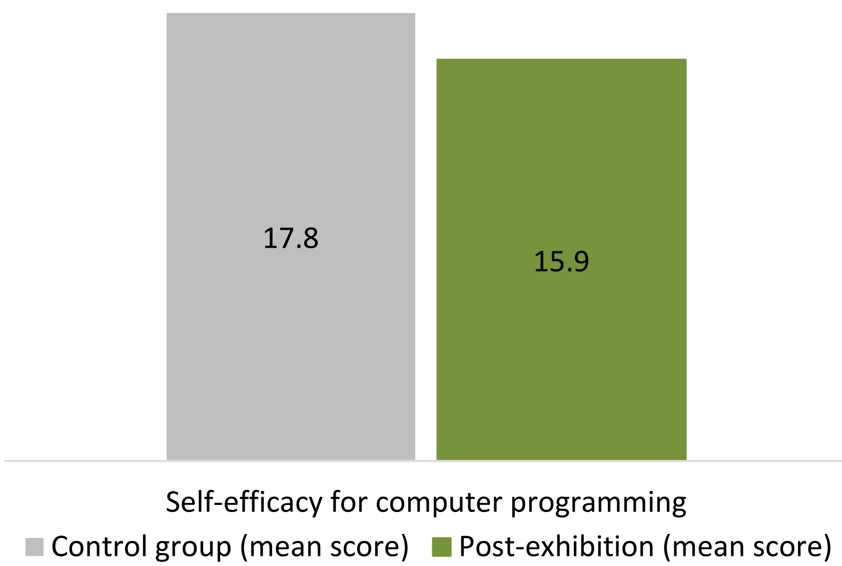
After seeing *SBP*, visitors had lower self-efficacy for computer programming than visitors who had not yet seen the exhibition.

Groups were asked to rate their confidence in their ability to write computer animation software in three scenarios: (1) after taking the right classes in school, (2) with the aid of a manual, or (3) on their own, without any help. These ratings were combined into a single self-efficacy for computer programming score. Groups surveyed after attending *SBP* had statistically significant lower self-efficacy for programming, compared with groups surveyed before entering the exhibition (See Figure 16 on the following page). The effect size was moderately low (Cohen's d=.24).[51] Promisingly, visitors with low self-efficacy for programming still showed stronger interest in programming after attending the exhibition, when compared with similar groups

[50] Comparison between FI control group and post-surveys: (U=5795, Z=-2.07 p=.05; N=76 groups)
[51] Independent samples $t(273)=2.15$, $p = 0.03$.

surveyed before attending *SBP*.[52] This suggests that even when visitors had relatively low confidence in their own programming capabilities, attending *SBP* may have stimulated interest in learning about it. One explanation for the lower self-efficacy expressed by visitors after attending the exhibition may have been that the exhibition helped them develop a better understanding of the complexity and amount of work involved in computer programming, as described in the Skills section (page 43).

Figure 16: Mean ratings: Self-efficacy for computer programming, pre-exhibition control group and post-exhibition surveys (N=309 groups)



Groups' comments suggested that most adult-only groups and some groups with children, felt the exhibition inspired interest in STEM and related careers.

As shown on the following page in Table 17, visitors' comments across the post-exhibition interview suggested that some visitors felt the exhibition changed their attitudes towards STEM and computer science in one of three ways: (1) inspiring interest and positive attitudes towards STEM and STEM careers; (2) giving them a sense of how much fun STEM and animation can be; (3) giving them a better appreciation of the creativity involved in STEM.

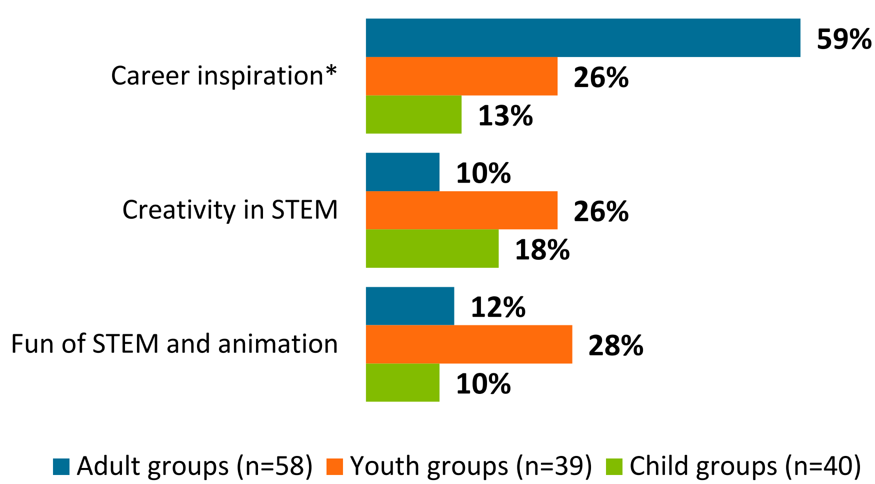
[52] Linear regression model (Adjusted R^2=.182; $p<0.001$; n=288). Attending *Pixar* predicted higher interest in computer programming (combined interest in learning about, using creatively, and using professionally) (β=.384; $p<0.001$) when controlling for self-efficacy for programming (β=.255; $p<0.001$).

Table 17: Types of visitor comments demonstrating attitudes and beliefs related to learning goals, post-exhibition interview (N=135 groups)

Learning goal	% of groups	Evidence	Example comments
Inspiration: Visitors have a positive attitude that they can learn about STEM and computer science	36%	Mentioning inspiration, confidence, or positive role models	*"Makes you want to pursue your dream job! I was inspired by how they do it and to see more movies."* (female, 25)
Positive attitude: Recognizing fun in STEM and computer science	18%	Connects fun with STEM and STEM careers	*"It is a lot of fun to work in those fields."* (male, 60)
Creativity: Recognizing the creativity in STEM and computer science careers	17%	Mentions creativity, innovation, art, or design	*"Inspiring; the new, creative opportunities. I can't wait for my grandkids to try it."* (female, 55)

Adult-only groups frequently commented on how the exhibition provided inspiration for potential work or creative opportunities in STEM.[53] These groups were the most likely to watch the *Working at Pixar* videos in the exhibition (See Figure 4), suggesting that they may have been seeking to learn more about careers at Pixar Animation Studios and that they, correspondingly, may have been more likely to be exposed to these types of jobs (See Figure 17 below).

Figure 17: Representation of visitors' attitudes and beliefs about creativity and STEM from groups' post-exhibition interview comments (N=137 groups) [54]

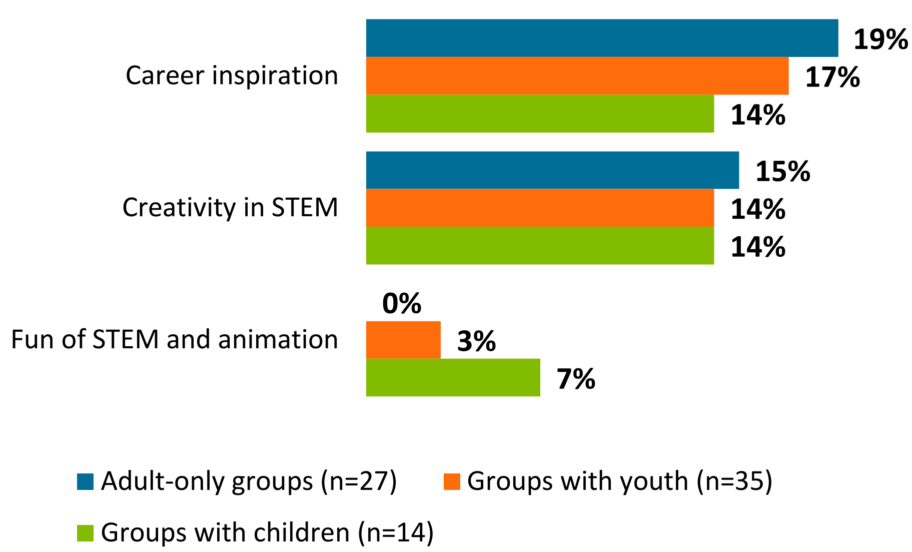


[53] $\chi^2(2, N=135)=24.66, p < .001$.
[54] $\chi^2(2, N=135)=24.65, p < .001$.

Perceptions at the Franklin Institute

There were no significant differences between groups at the Franklin. Very few visitors mentioned career inspiration, creativity, and fun during the post-exhibition interview (See Figure 18, below). Instead, visitors were more inclined to talk about knowledge/awareness ("[It's] *not all about drawing, math and science, [it's] important [to learn about] about math," female, 28)* or skills ("*How much work it takes. [How much] math and science and hours [it takes]," male, 46)* which was a pattern similar to the MOS.

Figure 18: Representation of visitors' attitudes and beliefs about creativity and STEM from groups' post-exhibition interview comments (N=76 groups)



HOW DID PUBLIC AUDIENCES FEEL ABOUT THEIR EXPERIENCE AT *SBP*?

Post-exhibition interviews and post-exhibition surveys gathered information about how visitors felt about their experience in *SBP*. The topics covered included how visitors felt about their overall experience, the educational and entertainment quality of their experience, as well as their most memorable and engaging experiences.

This section covers the following findings:

- Overall perceptions of *SBP* were high and were associated with visitors' positive, interactive, and educational experiences.
- Different visitor groups expressed their positive impressions of *SBP* in varying ways; children considered the exhibition "fun" while adults said it was "interactive."
- Specific exhibits and the exhibition's interactive opportunities resonated with visitors as the most memorable and interesting parts of *SBP*, though no single exhibit emerged as the most iconic.

Overall perceptions of *SBP* were high and were associated with visitors' positive, interactive, and educational experiences.

After indicating their favorite exhibit or activity in the exhibition during the post-exhibition interview, visitors were asked, "What did you find the most interesting or engaging? What did you get to do or learn?" Responses to this question support the success of the educational and interactive components. Visitors predominantly talked about the interactivity of the experiences (49%), learning about Pixar's filmmaking process (46%), and STEM and art content (14%). Additional top themes can be seen in Table 18 below, and a full list of codes can be found in the Appendix E (page 140).

Table 18: Top themes for why visitors found exhibits interesting, post-exhibition interviews (N=136 groups)

Top Themes	Explanation	% of groups	Example quotes
Interactivity of exhibits	Talking about the interactive or hand-on nature of the exhibit	49%	*"Part where you pop out of the bubbles and it shows the camera angles, it reminded me of the Discovery Center."* (male, 11)
Pixar's animation process	Visitor notes something about Pixar's Pipeline steps or discusses exhibit content. Noting that this is how Pixar makes movies.	46%	*"The Inside Out one that shows it from start to finish [Pipeline]."* (female, 33)
STEM and art content or skills	Connects exhibit to a STEM and art topic	14%	*"The grass generator. Seeing how they did it. Cool seeing the options and how they use the software."* (male, 30)
Affect (had fun)	Talks about how fun/cool the exhibit is, or if they appreciated something.	13%	*"Simulation was cool."* (female, 23)

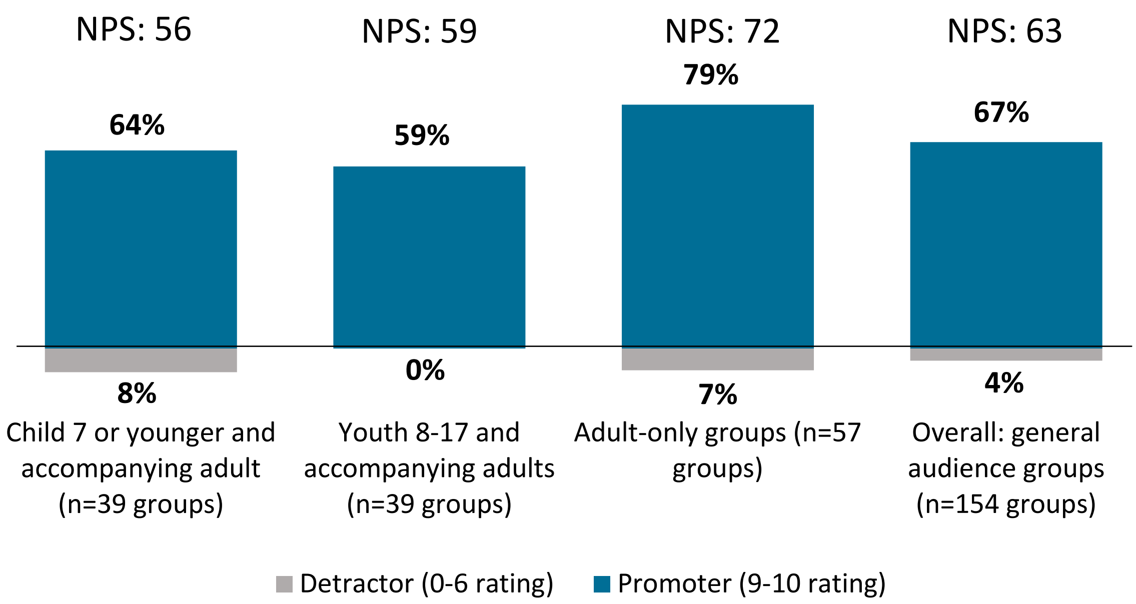
Post-exhibition survey and interview groups were asked to rate their likelihood to recommend the exhibition to friends or family on a scale from 0 - 10. Net Promoter Scores calculated from visitor ratings show that vistitors in all group types are likely to recommend *SBP* to friends and family. [55] As seen in Figure 19 on the following page, NPS for *SBP* were above 50 for all groups as well as overall. NPS were highest for adult-only groups (72) and lowest for child groups (56),

[55] As multiple visitors could respond to the question "How likely are you to recommend this exhibit to friends or family?" the average score across the whole group was used to calcluate their rating . NPS was then calculated using marketing standards, by subtracting "detractors" (those who rated 6 or below) from "promoters" (those who rated 9-10).

which is expected as *SBP's* target demographic was 8 and up. Overall the NPS was 63, which is close to the MOS' overall museum score of 70.

Visitors mainly came to *SBP* with the intent to learn about Pixar Animation Studios' animation process (See Who Attended SBP and Why? on page 16). The exhibition delivered this content, as well as interactive, educational experiences, both about animation and the underlying STEM components. Many visitors found the deilvery of the content interesting and digestible, and left the exhibition with positive affinities for the animation process, for its connection to STEM and art, and for the exhibition itself. These factors may have contributed to a high Net Promoter Score (NPS) and a positive influence on visitors in their understanding and appreciation of the STEM and art surrounding Pixar Animation Studios films.

Figure 19: Likelihood to recommend across groups and overall public, post-exhibition interview (N=135 groups)[56]



When asked in an open-ended question to explain their rating for likelihood to recommend, most visitors said they provided their rating because the exhibition was eductional (30%). These visitors wrote about the content they learned, including the components of the animation process, the amount of work involved, and the amount of detail required to make a film. Visitors also cited the exhibition's interactivity as a justification for their scores (26%; see Table 19 on the following page). Their comments mentioned how they enjoyed engaging with the hands-on exhibits, having multiple stations of many exhibits, and creating their own outputs at the activities.

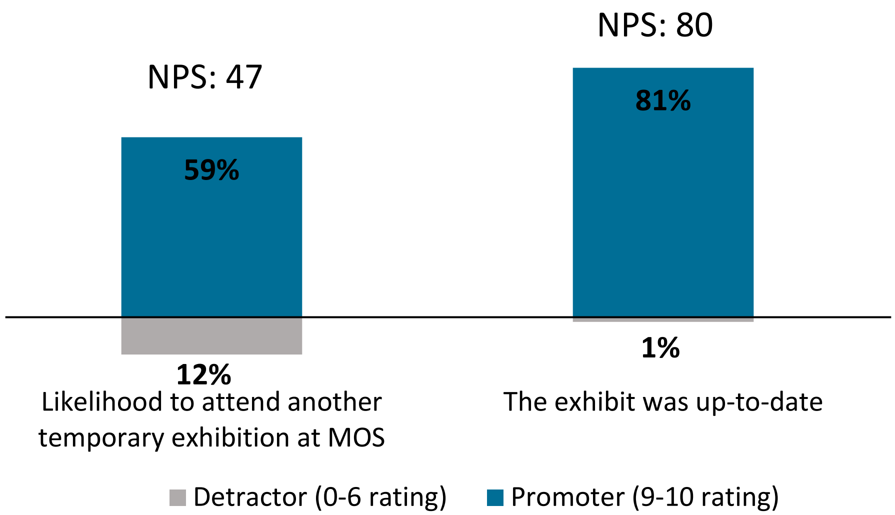
[56] Adult-only groups were more likely to promote the exhibit: $\chi^2(4, N=135)=11.004$, $p < .03$.

Table 19: Visitor's top explanations for likelihood to recommend scores, post-exhibition survey (N=101 groups)

Reasons for rating	Explanation	% of groups	Example quote:
Educational	Recommendation related to what the visitor learned	30%	*"Animation is awesome and the exhibit showed the steps accurately."* (adult-only group)
Interactive	Recommendation related to what the visitor got to do or experience	26%	*"This exhibit offers so much-visually, tactilly and emotionally. How can you not smile walking into the exhibit."* (group with youth)
Entertaining	Recommendation related to fun	17%	*"Oh my God, it was really too fun."* (adut-only group)
General response	General	16%	*"It was great."* (adult-only group)
Well-organized	Recommendation related to the blend of activities, content, variety of experiences	14%	*"Wonderful exhibit- nice blend of art, science and interactivity."* (group with youth)
Works well for certain age groups	Recommendation relates to how it works for the group or family as a whole	14%	*"Something for all types."* (adult-only group)
Recommend with stipulations	Recommended the exhibit, but had suggestions for changes/improvements	11%	*"Tough for 2-year-olds, but awesome for older kids!"* (group with children)
Pixar/Disney affinity	Recommendation related to feelings about Pixar's work	10%	*"My family and friends love Pixar."* (adult-only group)

Another factor that correlated with likelihood to recommend was visitors' likelihood to attend another exhibition and seeing *SBP* as up-to-date. As seen in Figure 20 on the following page, a little over half (59%) said they would attend another exhibition and a majority (81%) said *SBP* was up-to-date.

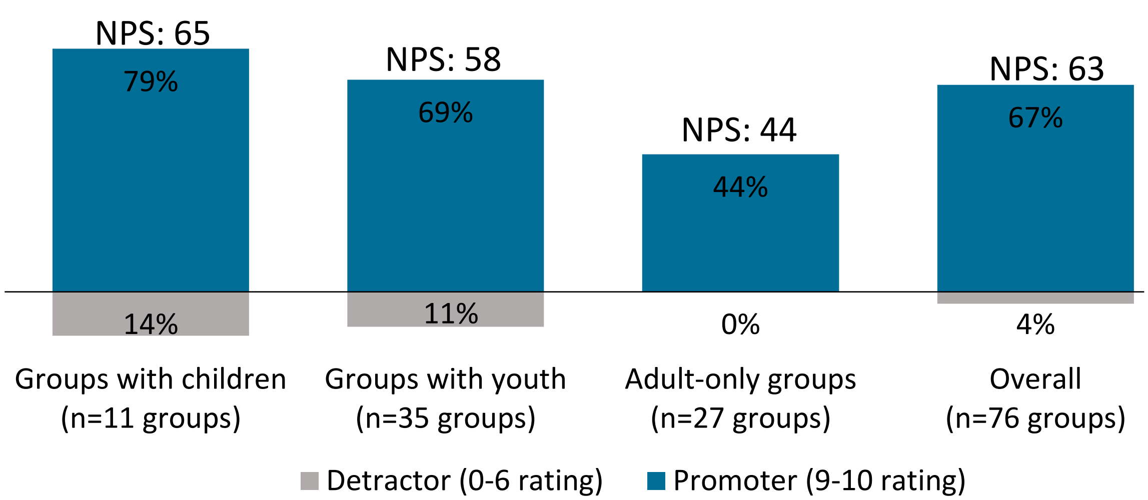
Figure 20: Likelihood to attend and up-to-date perceptions of *SBP*, post-exhibition surveys (N=154 groups)



At the Franklin Institute, groups with children were more likely to promote the exhibition

Like the MOS, *SBP* was well received and visitors at the Franklin Institute were also likely to recommend this exhibition to friends or family. However, groups with children were more likely to promote the exhibition ($\chi 2(4, N=76)=11.04$, $p < .05$). Adult-only groups had the lowest NPS score. This is different than MOS data, as seen in Figure 19 where adult-only groups were the most likely to recommend the exhibition. Despite these differences, this indicates that the exhibition appeals to all ages, including its target audience.

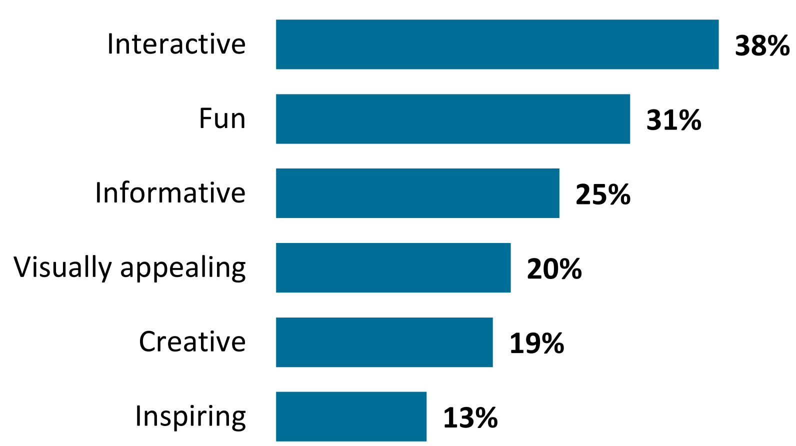
Figure 21: NPS Score for the Franklin Institute, post-exhibition interviews (N=76 groups)



Different visitor groups expressed their positive impressions of *SBP* in varying ways; children considered the exhibition "fun" while adults said it was "interactive."

Top reasons for recommending the exhibition mirrored the ways visitors describe the exhibition. During the post-exhibition interview, visitors were asked to pick two words that they thought best described *SBP*. As seen in Figure 22, the top words from all visitors were "interactive," "fun," and "informative." These words mirror visitor reasons for likelihood to recommend, with "educational," "interactive," and "entertaining" being the top three reasons for their score. Even though the word list was randomized after each interview to prevent selection bias, visitors were consistent in picking positive words. Negative words such as "over-simplified," "not interactive," or "confusing" were mentioned by less than 5% of respondents (N=270 visitors, see Appendix E, page 140).

Figure 22: Post-exhibition interview, most popular words from overall visitors, post-exhibition interviews (N=270 visitors)[57]



SBP made a positive impression on visitors across all audiences, but the three group types (child, youth, and adults) characterized their positive experiences differently, as described below.

Young children most often described SBP as "fun."

Groups with young children most frequently used the term "fun" to describe *SBP* (70%, see Figure 23). When asked to explain why *SBP* was fun, respondents shared broad reasoning, such as being able to control mechanical aspects of exhibits, having exposure to new information, and being able to create within the exhibition. Example quotes include:

- *"Playing with the buttons." (female, 5)*
- *"There's a lot of interesting things and things I've never known before." (female, 7)*
- *"We created a movie and got to make it." (male, 7)*
- *"Everything!" (female, 6)*

[57] Analysis for this question was done for all respondents within the group. For example, if three adult visitors answered "fun," "creative," and "inspiring" then all three were incorporated into the data set and tallied as adults. Due to this, Figure 23 below outlines number of individuals per age group as opposed to the entire group itself.

Youth characterized their experience in a variety of ways, including "fun."

Some groups with youth also characterized *SBP* as "fun" (34%; see Figure 23 on the following page), but they also called the exhibition "interactive" (52%), "creative" (24%), "informative" (21%), and "visually appealing" (24%). Example quotes are included below:

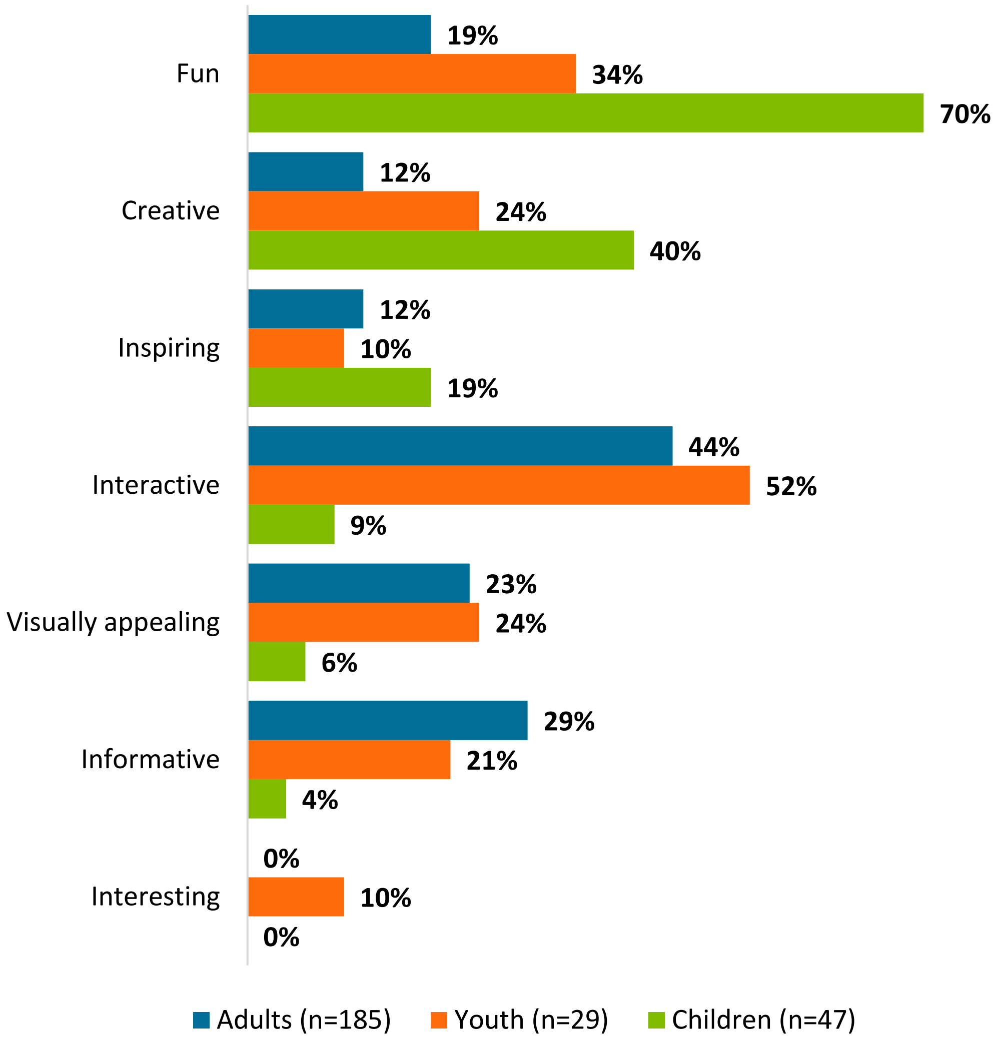
- *"I learned a lot and I'm very interested in this stuff." (female, 16, "informative")*
- *"Creative because you have to make up all the characters." (male, 8, "creative")*
- *"The drawings were nice and the rendering was, too." (male, 14, "visually appealing")*

Adults described the exhibition as "interactive" and "informative" more often than "fun" and "creative."

Youth and adult-only groups chose similar language to describe *SBP*. However, adults were less likely to use the terms "fun" and "creative" (19% and 12%, respectively, compared to 34% and 24% for youth) to categorize the exhibition (See Figure 23). Instead, "interactive" (44%) and "informative" (29%) were the main ways these groups described their experience. This supports the positive feelings visitors had about the exhibition, which the following quotes further demonstrate:

- *"Possibilities to check by yourself. What happens when this kind of light, moving, shapes. Helped to understand what's done." (male, 68, "informative")*
- *"Lots of things model…pick up and feel the difference between one stage and another stage of the process." (female, 22, "interactive")*

Figure 23: Breakdown of most frequently mentioned words by age group, post-exhibition interviews (N=270 visitors)



Specific exhibits and the exhibition's interactive opportunities resonated with visitors as the most memorable and interesting parts of *SBP*, though no single exhibit emerged as the most iconic.

In post-exhibition surveys, visitors shared what they felt was the most memorable part of *SBP*. The majority of visitors (64%) cited specific interactives, followed by the hands-on and creative opportunities (49%) and opportunities to learn about Pixar Animation Studios and the animation process (38%, see Table 20 on the following page). The latter two again emerge as key elements that visitors valued, and as important factors that visitors consider when reflecting on the exhibition. This data also echoes students' immediate takeaways, detailed in the School Group Audience Impact section (page 80).

Table 20: What did visitors find to be the most memorable part of *SBP*? Post-exhibition survey (N=154 groups)

Themes	% of groups	Example quote
Specific exhibit(s)	64%	*"The stop motion with lamp was fun."* (adult-only group)
Hands-on and creative opportunities	49%	*"Hands on experience with animation and math concepts."* (group with children)
Learning about the animation process and Pixar Animation Studios	38%	*"Seeing how everything comes together."* (group with children)
Exhibit videos	26%	*"The videos explaining the process."* (group with children)

During the post-exhibition interview, visitors were asked to name the exhibit or activity they found the most interesting or engaging. While some exhibits were brought up more frequently than others, all experience types, and most individual interactives, immersives, and thematic areas were mentioned. This demonstrates that there was no one iconic exhibit or experience type for *SBP*. Almost all respondents to this question (96%, N=118) were able to name a specific exhibit they found most interesting, although some visitors named whole thematic clusters. Exhibits in the lighting cluster were the most frequently named. The graph below shows all exhibits that were mentioned by 5% or more of interviewed groups, and a full breakdown of percentages can be found in Appendix E (page 140).

Table 21: Exhibits that 5% or more visitors found interesting, interviews (N=118 groups)

Exhibit	% of respondents
Stop-motion Animation	19%
Lighting Design Basics	16%
Simulation Immersive	13%
Pipeline	11%
Sets and Cameras Immersive	11%
Surface Appearance Workstation	11%
Lighting Immersive	10%
Set Layout Workstation	9%
Face Rigging Workstation	8%
Virtual Modeler Workstation	8%
Crowd Simulation Workstation	7%
Virtual Lighting Workstation	6%
Programming Natural Variety	5%

SCHOOL GROUP AUDIENCE IMPACT

This section compiles the data analysis for educators and school groups that visited *The Science Behind Pixar (SBP)* exhibition at the Museum of Science, Boston (MOS). The data analyses address the following evaluation questions:

- Who attended *SBP* and why?
- What did school group audiences do during their visit?
- What did school group audiences learn from attending *SBP*?
- How did school group audiences feel about their experience at *SBP*?
- How did educators connect *SBP* to standards and classroom learning?

Data analysis for school audiences was derived from the following instruments and data collection methods:

- The School Visitor Experience Monitoring survey (School VXM; N=199 respondents), an online survey sent to the main contact for each field trip.
- A survey distributed to teachers after they participated in *SBP* educator workshops (educator workshop surveys; N=45 educators).
- Student pre-exhibition surveys (pre-exhibition surveys, N=232 students) completed before attending *SBP* and follow-up surveys completed a month after (follow-up surveys, N=184 students); N=170 matched pre-exhibition/follow-up survey pairs.
- Flash interviews conducted as students left *SBP* (N=133 students).
- N=82 complete data sets composed of pre-exhibition surveys, follow-up surveys, and flash interviews.
- Tracking and timing observations (N=27 students).

Note that the sample sizes for total respondents per instrument, as they are stated above, will be included in all figure and table titles. However, as respondents may have skipped questions, the samples of respondents per question (n values) may not exactly match the N values above. Quantitative and qualitative data were analyzed using statistical analysis, descriptive analysis, inductive coding and deductive coding. See the Methods section (page 8) for more information about data collection, sampling, and analysis.

SCHOOL GROUP STUDY SUBJECTS

Educators' perspectives about *SBP* were collected in two ways: the School VXM survey (N=199 respondents) and a survey of educators who attended pre-educator workshops about *SBP* (N=45 educators).

- **School VXM:** The School VXM survey was analyzed to assess the demographics, motivations, and experience ratings of school groups who elected to integrate *SBP* into their field trips, and to compare these characteristics to school field trip groups that visited the museum, but opted not to visit *SBP*. School VXM is sent to all educators or school contacts who reserve a school field trip at the Museum of Science. The sample used for analyses in this report included responses from any school that visited the museum during *SBP*'s run (N=199 respondents, including 99 whose groups attended *SBP*).

- **Educator Workshop Survey:** The educator workshop survey was used to describe some of the perceptions, motivations, concerns, and goals that educators expressed for bringing students to visit *SBP* on a school field trip. The MOS hosted workshops for teachers interested in bringing their students to *SBP*, to help them plan their field trips. At the conclusion of each workshop, evaluators asked attendees to complete educator workshop surveys (N=45 educators). As the sample included only educators who chose to attend these planning workshops, they may not be fully representative of the broader range of teachers who brought students on school field trips to *SBP*.

To describe a range of students' experiences, perceptions, and outcomes on school field trips to *SBP*, evaluators tracked and timed, interviewed, and surveyed students from three different school groups. This sample included one high school (HS) class of which 45 students participated in data collection. It also included two fifth grade (elementary/middle school - E/MS) classes, one from an elementary school (73 students) and one from a middle school (132 students). These samples provided a descriptive examination of students' *SBP* experiences, perceptions, and outcomes. However, as only three schools are represented, they may not be representative of the full range of students' experiences and outcomes.

As mentioned above, a subsample of students from each of the three classes were tracked and timed during their visit to *SBP*. Descriptive case studies of three students – one from each class – were conducted to provide an in-depth illustration of how students on school field trips who experience positive changes in their attitudes, beliefs, or understandings may experience *SBP*. Male and female students were selected for the case study analysis on the basis of two criteria: (1) They fully completed each evaluation instrument (tracking and timing, pre-exhibition and post-exhibition surveys, and flash interviews) and, (2) they demonstrated some positive change in perspective, attitude, or learning, based on comparisons of pre-exhibition and post-exhibition survey responses. Pseudonyms and colored boxes, as assigned below, help identify these students throughout this section, while ensuring their privacy. Each student has a full vignette in Appendix G (page 165). To jump to a student's full vignette at any point, click on the student's name.

Joseph is a 14-year-old Lebanese male who attended *SBP* with his high school art class. He attended *SBP* with no expectations about his experience, but was very interested in computer programming and math, as well as creating his own animations. He spent most of his time in the exhibition with his friend, Marty, moving between exhibits or socializing with classmates. From his visit, he gained an understanding of the human input necessary to create animated films, and gained more interest across math, computer programming and animation, especially in creating his own computer programs and using math creatively (See Joseph, Vignette, page 167).

Alice is an 11-year old white female, who visited from a suburban middle school with her fifth grade class. She came to *SBP* with a strong interest in learning about and creating her own animations. She had little interest in math. During a 33-minute visit to the exhibition, she primarily focused on completing a worksheet. Often, Alice would observe her classmates as they used the interactives, orally providing her own opinions and guidance. Surveyed a few weeks after the field trip to *SBP*, her high interest in animation was accompanied by higher levels of interest in computer science and math (See Alice, Vignette, page 166).

Samuel is a Latino male who is about 10 or 11 years old. He came to *SBP* as a fifth grader from a public elementary school. Initially, he was "a little" interested in animations, math and computer science, but his interest in computer programming increased after visiting the exhibition, including his interest in doing computer programming in his future career. He spent most of his time in *SBP* moving quickly between exhibits with a group of classmates. This group used the exhibition collaboratively. The most memorable aspect of the exhibition for him was being able to "design...our own studio" at the *Set Layout Workstation*, suggesting that he found creative activities particularly engaging (See Samuel, Vignette, page 165).

WHO ATTENDED *SBP* AND WHY?

SBP drew school groups that were typical of MOS field trip demographics, as well as new audiences. Main findings suggest:

- The majority of *SBP* school audience consisted of middle or high school classes, as well as classes led by math or technology/engineering teachers.
- The opportunities to make content connections to classroom curricula and for students to learn about careers and the relevance of STEM motivated teachers to plan field trips to *SBP*.
- Students were expected to learn about the animation process, computer science, technology, and have a hands-on experience.

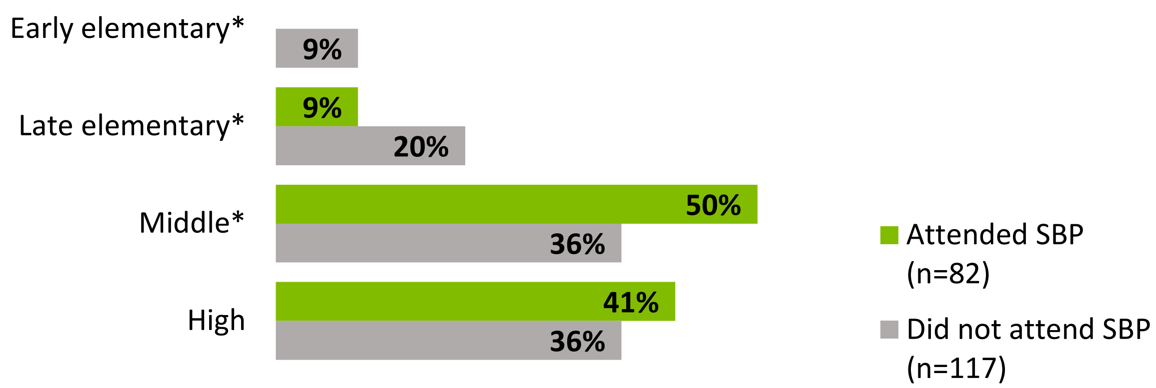
Analysis was drawn from educator workshop surveys, School VXM, and student pre-exhibition surveys.[58]

[58] Appendix K includes supplemental data pertaining to these sample groups.

The majority of *SBP* school audiences consisted of middle or high school classes, as well as classes led by math or technology/engineering teachers.

The school field trip audience for *SBP* primarily included middle or high school groups (91%) (See Figure 24 below). Compared to those school groups who visited the Museum without going to *SBP*, higher proportions of middle school groups and lower proportions of elementary school groups elected to attend the exhibition as part of their field trips.[59] This suggests that the exhibition and related marketing and communication strategies effectively targeted audiences within the exhibition's recommended age range (8 and older). The Public Audience Impact section (page 15) echoes this success, in that the majority of general public audience groups included visitors within this range of ages.

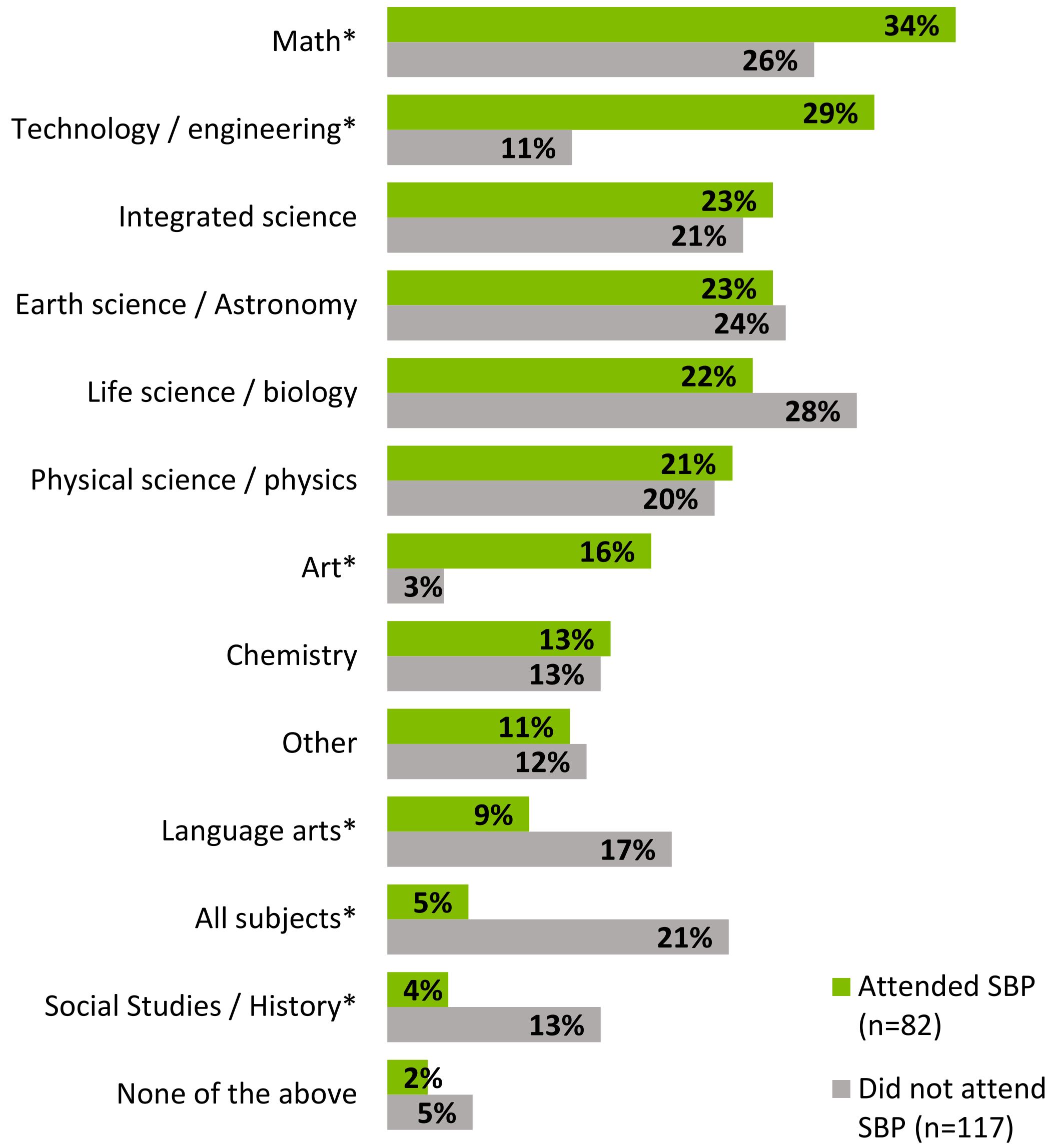
Figure 24: Grades taught by teachers, School VXM surveys (N=199)[60]



Over half of field trip planners who did visit *SBP* taught math and/or technology/ engineering (51%), and many taught a range of other science topics. In fact, *SBP* attracted significantly higher proportions of math, technology/engineering, and art teachers, when compared to field trip groups that opted not to see *SBP*, suggesting that the exhibition was attractive to teachers in these fields (See Figure 25 on the following page).

[59] X^2=13.654; df=3; p<0.05 (n=199)
[60] Some educators identified as teaching many grades across multiple categories. Therefore, the total will be over 100%. * = Statistically meaningful difference between attendees and non-attendees; Chi Square test used to assess significance; p<0.05 (n=199).

Figure 25: Subjects taught by teachers on field trips, both attending and not attending *SBP*, School VXM Surveys (N=199)[61]

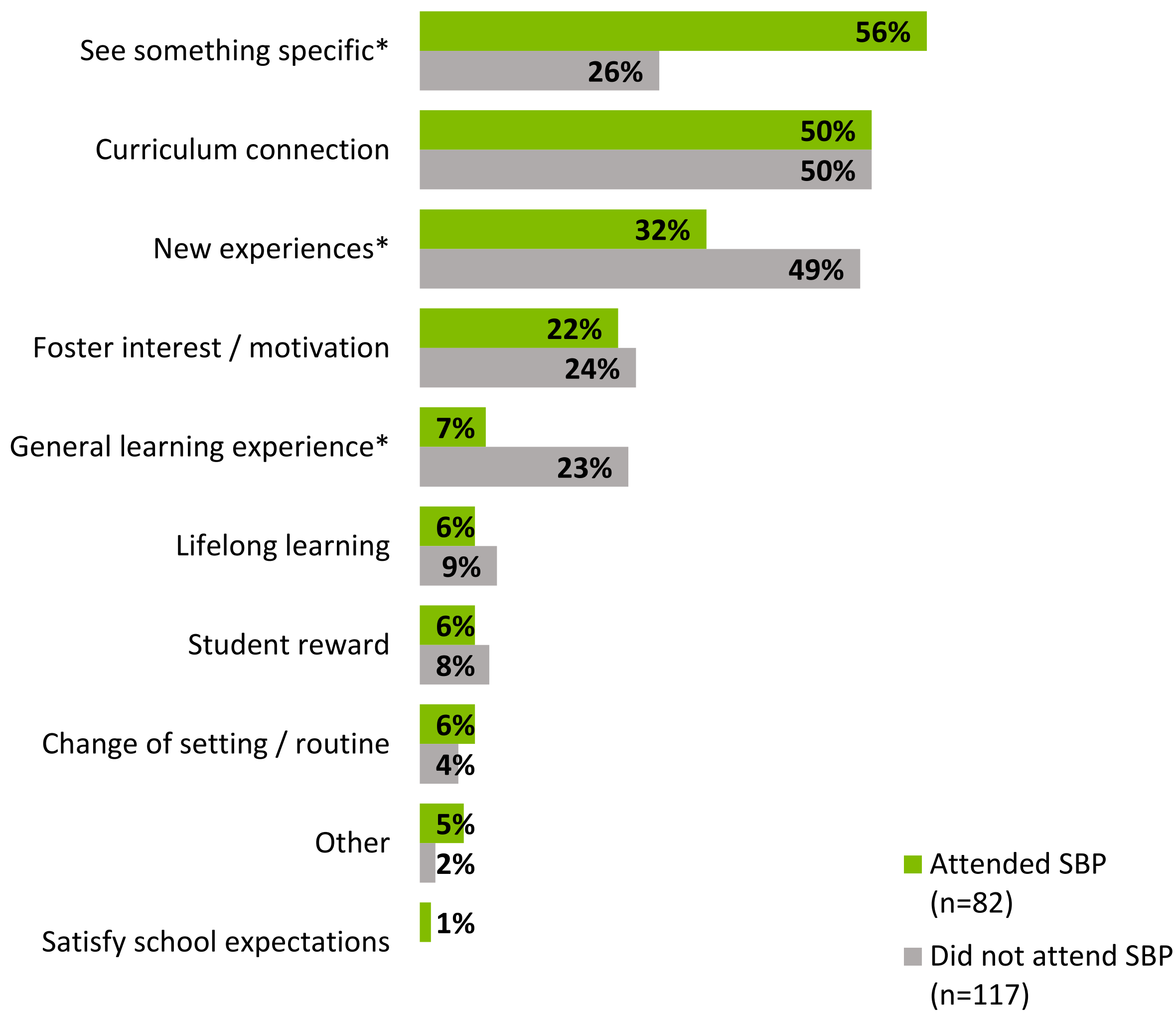


[61] $\chi^2(1, N=199)=5.78$, $p < .05$. * = Statistically meaningful difference between attendees and non-attendees; Chi Square test used to assess significance; p<0.05 (n=199). Appendix K shows the spread of subjects taught by teachers who attended *SBP*, those who did not, and those who attended educator workshops, separately.

The opportunities to make content connections to classroom curricula and for students to learn about careers and the relevance of STEM motivated teachers to plan field trips to *SBP*.

About half (52%, n=82) of School VXM respondents that went to *SBP* reported that they came to the museum to see a specific exhibit, and 96% (44 of 46) of these respondents identified *SBP* itself as the specific exhibition. Additionally, 50% of *SBP*-attending teachers came to MOS to draw connections to their classroom curricula (See Figure 26 below).

Figure 26: Motivations of educators for planning field trips to MOS, both attending and not attending *SBP*, School VXM surveys (N=199)[62]



[62] * = Statistically meaningful difference between attendees and non-attendees; Chi Square test used to assess significance; p<0.05 (n=798).

Responses from attendees to the educator workshop surveys elaborate on some of the expectations and goals that teachers had in bringing their students to *SBP*. When asked about their goals for student learning in *SBP*, 64% of the educator workshop participants mentioned a desire to expose students to STEM career opportunities and 64% described goals of helping students recognize the relevance of STEM and art outside of the classroom. Slightly fewer than half of these teachers (49%) hoped that their students would learn new content and skills, such as the process of computer animation or an understanding of "*the collaboration and the time and 'perseverance' required to get the final product*" (See Table 22 below). These data suggest that many teachers hoped that the exhibition would reinforce the relevance and importance of classroom content, while some also expected that students would learn new things from the experience.

Table 22: Educator goals and expectations for student learning and interest, educator workshop surveys (N=45) [63]

Theme	Percent of respondents	Example comments
Careers	64%	*"I also want them to walk away with an understanding of all the different career opportunities."*
Relevance of classroom content and STEM + art	64%	*"Hope they will take away that what they see and interact with whether movies (Pixar) or technology has a ton of engineering components to it. The different ways what they are learning about in schools can be applied to a wide variety of areas outside of school."*
Skills/content pertaining to the animation process and Pixar Animation Studios	47%	*"All the different steps (and the skills and training involved in each step) in making an animated film."*
Increased positive attitude towards STEM.	27%	*"I hope they will see that science and math can be fun even though you must work hard as well."*
Engagement with a specific exhibit at *SBP*	16%	*"The pipeline is so helpful and puts everything in perspective. I think the stop motion activity is super engaging, as well as the build-a-robot center."*
Interdisciplinary nature of STEM and art	11%	*"The science, math and art correlation."*

These expectations were analyzed alongside and compared to student feedback immediately following their *SBP* visit (See Figure 30).

[63] Coded responses to: 1) What do you hope your students will learn from their trip to *SBP*? 2) What, if anything, do you hope your students will find the most interesting or inspiring about *SBP*? **Note:** "Other" responses not included.

Students were expected to learn about the animation process, computer science, technology, and have a hands-on experience.

Pre-exhibition surveys collected information about students' initial interests and expectations for *SBP*. Students showed the highest levels of interest in animation, followed by computer programming, and then math. The variety in student interest is illustrated below in Table 23.

Table 23: Initial student interest, Pre-exhibition surveys (N=232)[64]

		Not at all	A little	Somewhat	Very
Animation	**Learning**	4%	17%	31%	49%
	Using creatively	5%	7%	21%	67%
	Using in my career	25%	24%	30%	21%
Math	**Learning**	34%	23%	18%	25%
	Using creatively	29%	28%	26%	17%
	Using in my career	42%	22%	23%	13%
Computer programming	**Learning**	8%	27%	30%	36%
	Using creatively	7%	15%	30%	47%
	Using in my career	29%	33%	18%	20%

A total of 220 students offered their expectations of the exhibition in the pre-exhibition survey. Like the general public audience, the majority (73%) of these students mentioned expecting to learn about the whole, or part, of Pixar's animation process, while 14% of students expected to learn about the technology and computer science involved in animation. Additionally, students had expectations about *how* the content of the exhibit would be presented: 14% of students expected a hands-on and interactive learning experience. See Appendix K (page 175) for a complete distribution of codes and example responses.

Example of student learning around Pixar's animation process

Alice (E/MS, 11) attended *SBP* with a very high interest in animation. She was very interested in learning about and creating her own animations and was even somewhat interested in doing animation as part of her career. As such, her expectations about the exhibition focused on animation, and she shared that she "*hope[d] to see and learn how they work the animations*." (See Alice, Vignette, page 166)

[64] Responses to "Please rate your interest in each of the following: Learning about animation, learning about computer programming, learning about math, creating my own animations, creating my own computer programs, using math in my own creative projects, doing animation as part of my career, doing computer programming as part of my career, and doing math as part of my career." Data split between HS and E/MS samples are in Appendix K.

WHAT DID SCHOOL GROUP AUDIENCES DO DURING THEIR VISITS?

Student experiences were recorded through a tracking and timing protocol. The HS class spent about 70 minutes in the exhibition, while the E/MS students were allotted 20-40 minute timeframes. This variation in time spent in the exhibition may have affected how they interacted with and used the exhibits. Main findings about exhibition use for school group audiences include:

- Patterns of exploration varied by student, suggesting that *SBP* created a self-directed learning experience for a range of learners.
- Students used interactive and immersive exhibits throughout the exhibition.
- Most students used tactile features and hearphone-based audio labels as part of their exhibition experience, suggesting the importance of multimodal representations for student engagement.
- Most students engaged socially with classmates during their visits to *SBP*, both during and in-between exhibits.

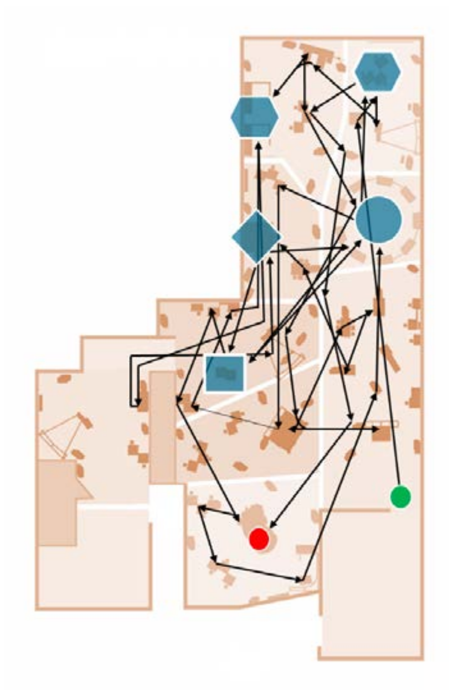
The findings above describe broader patterns emerging from aggregated student data. However, observational data collection revealed rich variety in how students explored and used the exhibition. This more in-depth, personalized data is integrated within the broader findings in boxed vignettes.

Patterns of exploration varied by student, suggesting that *SBP* created a self-directed learning experience for a range of learners.

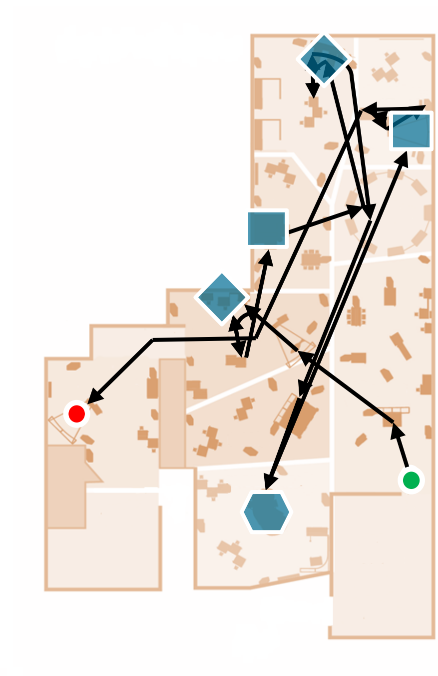
Tracking and timing observations mapped each student's route of exploration. These students did not take a uniform approach to navigating *SBP*, suggesting that the exhibition design enabled students to engage in a self-directed learning experience. The three case study students' paths are visualized in Figure 27 on the following page, and the variety within their experiences is clearly evident. For example, Joseph, who spent 78 minutes in the exhibition, experienced many more individual exhibits and a greater diversity of exhibit types than Alice or Samuel. Joseph also spent the largest portion of his time at *Pipeline*, which neither Alice nor Samuel visited for a notable amount of time. Alice and Samuel had much less time in the exhibition (33 and 39 minutes, respectively) and visited fewer exhibits, but even between themselves, they prioritized the areas they visited differently. While both students spent at least five minutes at the *Sets and Cameras* immersive, Alice spent larger amounts of time at the *Simulation, Animation,* and *Surfaces* immersives. On the other hand, Samuel prioritized the *Modeling* and *Animation* clusters, but spent longer amounts of time at the interactive exhibits instead of the immersives. This suggests that students did not take uniform approaches to exploring the exhibition, suggesting that *SBP* encouraged successful experiences for a range of learning styles and approaches.

Figure 27: Paths of exploration for students, Tracking and timing

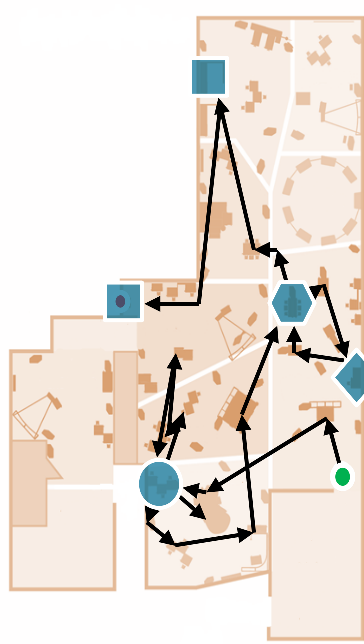
Duration at exhibits: 2-3 minutes 3-5 minutes 5-8 minutes 8+ minutes



Joseph's (HS, 14) path throughout *SBP*



Alice's (E/MS, 11) path throughout *SBP*



Samuel's (E/MS, ~10) path throughout *SBP*

Example of how a student navigated the exhibition

When Alice's (E/MS, 11) class came on the field trip, students were given a worksheet to guide their time. Alice, as her group's leader, was in charge of her group's worksheet and therefore guided her classmates' interactions. Alice wandered little, using the worksheet to guide herself. The group worked together through the assigned questions and the interactives. Alice was focused and as a result, she only spent a total of five minutes in between exhibits. (See Alice, Vignette, page 166)

Students used interactive and immersive exhibits throughout the exhibition.

Tracking and timing data collection illustrates the experiences of five HS students and 20 E/MS students from three different schools. Analysis of aggregated tracking and timing revealed several key trends in how the observed students tended to spend their time in *SBP*. The case study student data supplement this aggregated data to exemplify these findings, and to provide clear analyses of *SBP*.

Immersive and interactive exhibits were attractive to students in all grade levels, and most students saw at least one Behind the Scenes/Challenges video.

As depicted in Figure 27 from the preceding page, Joseph, Alice and Samuel chose to explore the exhibition differently. They also used the different exhibit types to various extents (See Figure 28 below). A more general illustration of how tracked and timed students spent their time in *SBP* is displayed on the following page in Table 24 and Figure 29. Patterns in how students were observed spending time with different experience types are described below.

Figure 28: Time spent at each type of exhibit by students, Timing and tracking

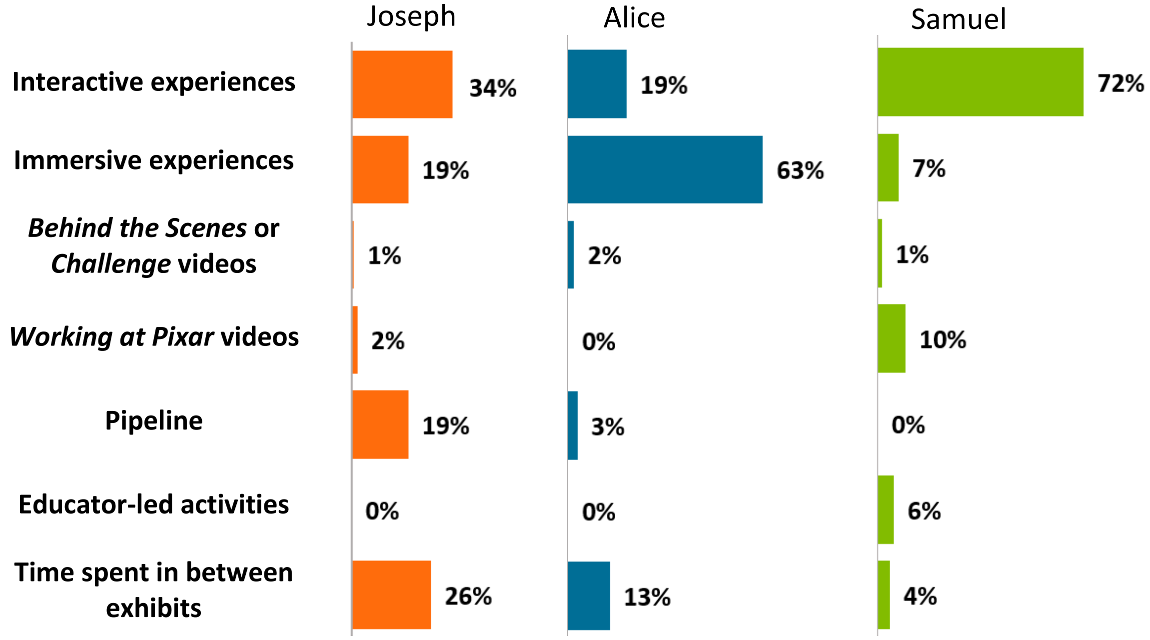
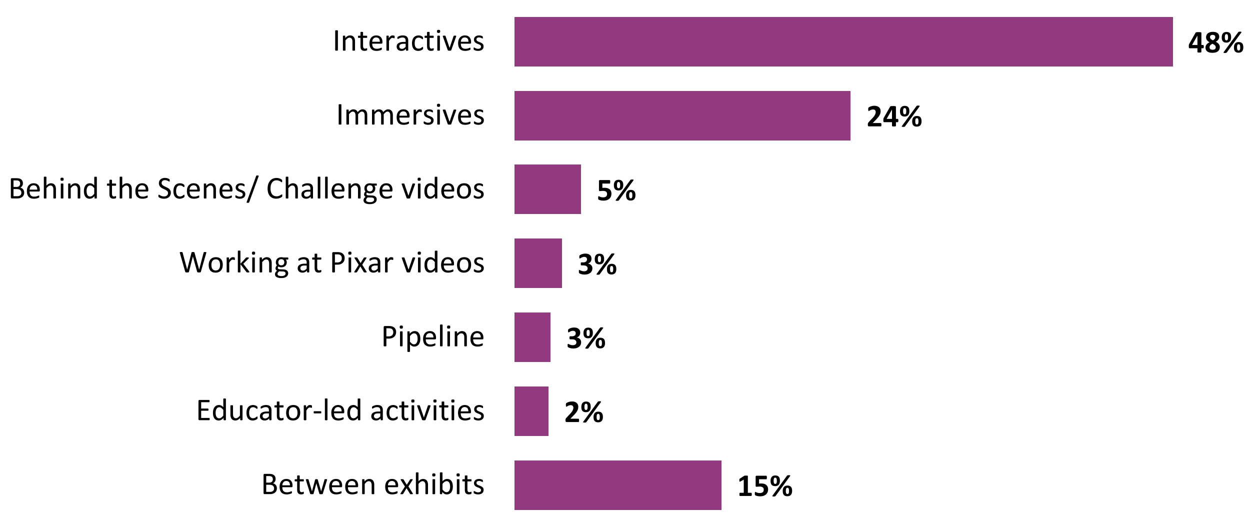


Table 24: Experiences visited and time spent by students, Tracking and timing (N=25 students)[65]

	Number of students that visited at least one activity	Average # of activities visited	Average total time spent (minutes:seconds) *(Range)*
Interactives	25	11 of 21	**20:36** *(6:15-48:27)*
Immersives	25	6 of 9	**10:31** *(2:23-20:57)*
***Working at Pixar* videos**	5	<1 of 8	**1:29** *(1:28-13:46)*
***Behind the Scenes / Challenge* videos**	22	2 of 16	**2:04** *(0:21-14:30)*
Pipeline	13	1 of 1	**1:07** *(0:21-14:43)*
Educator-led activities	9	<1 of 2	**1:03** *(0:43-9:14)*
Between exhibits	-----	N/A	**6:28** *(0:05-20:35)*

Figure 29: Average proportion of time spent at each experience type, Tracking and timing (N=25 students)[66]



[65] The calculations to determine the average activities visited and average time spent at these exhibits excluded students who did not visit any exhibits within that experience type.

[66] The calculations for the time spent at each experience type excluded those students who did not visit any of the exhibits within an experience type. The percentage of time spent only applies to those students who did visit the activities. See Table 22 for data about the number of students who visited activities in each experience type.

Immersives and interactives: Students on school field trips spent the majority of their time at the immersive and/or interactive exhibits.

Videos: Videos were visited less frequently than immersive and interactive exhibits for all timed and tracked students. However, use of the videos varied greatly among individual students. For example, one high school student spent over 28 minutes watching videos, including 14 minutes watching five different *Working at Pixar* videos and 14 minutes watching five different *Behind the Scenes/Challenge* videos. In contrast, another HS student in the same class spent just two minutes in total watching videos, watching only parts of a single *Working at Pixar* video and a *Behind the Scenes* video.

E/MS students had less time in the exhibition and spent less time watching the videos. Only one of the 20 observed E/MS students watched a *Working at Pixar* video, for a total of 4 minutes and 46 seconds. Three of the 20 E/MS did not watch any *Behind the Scenes/Challenge* videos, but those who did spent up to 3 minutes and 45 seconds doing so. This suggests that E/MS students were not particularly inclined to spend time using the videos in the context of their *SBP* field trip.

***Pipeline* and educator-led activities:** Each of the 5 HS students visited the *Pipeline* exhibit, with dwell times ranging from just under 3 minutes to more than 15 minutes. Some of the observed E/MS students (8 of 20) experienced the *Pipeline* exhibit during their visit, spending up to about 2 minutes there.

The amount of time spent at educator-led activities ranged substantially among those students who visited them. One E/MS student spent almost 10 minutes at an educator-led activity, while one HS student spent almost 4 minutes there. As they were not attended by all students, the average proportion of time spent at these activities was relatively small (See Figure 29 on the preceding page). Though these activities were less frequently visited, they provided an opportunity for a long, in-depth learning experience.

The variation in visitation and distribution of dwell time patterns were also evident in general public audiences. See Figure 6 for detailed analysis and interpretation of those public behaviors.

Most students used tactile features and hearphone-based audio labels as part of their exhibition experience, suggesting the importance of multimodal representations for student engagement.

Students utilized the multimodal representations in the exhibition to varying extents: 75% of all tracked students used the hearphones at least once, and 30% used them three or more times. The hearphones are a feature designed to broaden visitors' engagement with the exhibit and provide visitors with different options for accessing these aspects of the exhibition by including both a detailed audio description of the exhibit experience designed for visitors who are blind or have low vision. Additional findings related to the use and effectiveness of hearphones, specifically for visitors with disabilities, is evaluated in more depth in the Specific multimodal representations: Hearphones section on page 113.

Another exhibition design strategy used to provide multimodal access to exhibit content was the use of tactile models. These models were included as part of some, but not all, of the different exhibits and videos in *SBP*. Students on school field trips often used these models: 4 (of 5) HS students and 18 (of 20) E/MS students utilized them at least once. More details about the tactile models are also in the Accessibility section (page 97). For further details of student use of these exhibit elements, see Appendix K (page 175).

Another feature that was included in the exhibits was the “More Info” button, a small icon that could be selected on each of the touchscreen-based exhibits to access additional detailed information about the STEM content presented in the exhibit. Similar to the general public’s response (discussed on page 31 of the Public Audience Impact section), relatively few students (12%) were observed using this feature. This infrequent use may have several explanations: students may not have noticed the button, may not have been interested in more information, or may not have understood the button’s purpose.

Example of hearphone use

During his visit, Samuel (E/MS, ~10) used the hearphones and associated audio button. While at *Rotating Shapes*, he worked with his classmates and chaperone to understand the math concepts behind the exhibit. In the middle of this collaborative experience, one of his friends pulled him away and turned his attention to *Sets and Cameras*. The two of them ran over to stick their head in the tunnel and then came back to *Rotating Shapes* where they listened to the hearphone together while the rest of their group members and chaperone continued to talk through the math concepts. This allowed Samuel and his classmate to use the exhibit alongside their classmates, but in a different way. (See Samuel, Vignette page 165)

Most students engaged socially with classmates during their visits to *SBP*, both during and in-between exhibits.

Social engagement at exhibits: Social engagement and discussion were key components of some student experiences at *SBP*. On average, E/MS students (n=20) socially engaged in 72% of the exhibits they visited. On the other hand, observed HS students (n=5) displayed these behaviors at 47% of the exhibits they visited. This suggests that discussion and human interaction were critical for some students, while others preferred to explore exhibits independently. *SBP* offered similar opportunities of collaborative or independent engagement for other audiences, including general public audiences and people with disabilities, which are described in the Public and Accessibility sections (pages 29 and 107, respectively).

Example of engaging in social learning

Samuel (E/MS, ~10) took advantage of social learning and collaboration during his time at *SBP*. He stuck with a group of friends during his 39-minute visit, keeping up with their energetic pace as they weaved through the exhibition and bounced from one exhibit to the next. He spent the most time at *Set Layout Workstation* and *Build a Robot*, where multiple people could work at one time. At other exhibits, where the whole group worked together at one interface, Samuel was more of an observer. He often offered suggestions, opinions, and insight as others interacted with the touchscreen (See Samuel, Vignette, page 165).

Social behaviors between exhibits: On average, tracked students spent over 10% of their time between exhibits. Specifically, the observed HS students (n=5) averaged 12 minutes (17% of their time) and E/MS students (n=20) averaged 5 minutes (14% of their time) not directly interacting with *SBP* exhibits. It is important to note that time between exhibits was not necessarily time off-task, as coordinating with teachers, finding other group members, and figuring out where to go next in the exhibition helped facilitate their educational experience. However, notes from tracking and timing observations suggested that some students spent time between exhibits participating in other social behaviors, such as using their personal smartphones and talking with peers. These social behaviors are typical of field trip experiences, and so were expected in *SBP* as well.

Example of social behaviors between exhibits

On-task and off-task socialization was an important component of Joseph's (HS, 14) *SBP* field trip. Joseph and his classmate, Marty, spent most of their time together in the exhibition. They worked together at interactive stations and immersives, at which he and Marty took pictures of each other with the characters and scenes. Their experience had a strong social aspect, and often the pair were seen striking up conversations with their classmates instead of interacting with exhibits. When chaperones and teachers noticed this behavior, they would redirect Marty and Joseph to open exhibits or encourage them to explore the exhibition. Overall, Joseph spent 21 of his 78 minutes (26% of his visit) socializing, on his phone, and talking to teachers and chaperones (See Joseph, Vignette, page 167).

WHAT DID SCHOOL GROUP AUDIENCES LEARN FROM ATTENDING *SBP*?

The main messages of *SBP*, as explained in the Introduction (page 6), focus on how the interdisciplinary nature of science, art, and technology, along with the innovation of people, are critical to filmmaking. In addition, the exhibition's learning goals aim to increase and improve visitors' knowledge, awareness, skills, attitudes, and perceptions of computer science, math, and animation. These learning goals were used to guide analysis for student learning. Findings suggest the following:

- Knowledge and awareness:
  - Students exhibited increased awareness of STEM's role and the steps involved in computer animation.
  - Gaining knowledge about animation and Pixar Animation Studios was an interesting and memorable part of the student experience.
- Skills:
  - High school students' beliefs about the creative agency of programmers were more strongly positive after their field trip. Otherwise, student understanding of the skills involved in programming were generally similar before and after attending *SBP*. After their visit, high school students agreed more strongly that programmers can create almost anything they imagine.
  - Some students offered comments that suggested they had engaged in STEM and computer science practices during their visit.
- Attitudes and perceptions:
  - After attending *SBP*, the majority of students reported some positive changes in their perceptions of and interest in animation, math, or computer programming.
  - Compared to their views before attending the exhibition, elementary and middle school students agreed more strongly after attending *SBP* that programming is useful for many careers. However, no significant changes in attitudes and beliefs about math were observed.
  - After attending *SBP*, elementary/middle school students agreed more strongly that programming is useful for many careers. Students in all grades exhibited some increased interest and inspiration in pursing these careers.
  - High school students demonstrated positive changes in self-efficacy for computer programming after attending *SBP*.

The sources of data used to gather data regarding student learning are detailed in Methods (page 8), and include:

- Flash interviews conducted as students left the exhibition
- Pre-exhibition surveys and follow-up surveys completed by students

Researchers looked across all of a student's responses to open-ended questions on the follow-up survey and the two flash interview questions for evidence of learning goals, using the coding schemes in Table 15, Table 16, and Table 17. Only students who participated in the pre-exhibition survey, follow-up survey and in the flash interviews were included in this analysis (n=82).

KNOWLEDGE AND AWARENESS

Students demonstrated an awareness of STEM's role and the steps involved in computer animation.

Student responses were coded using the "knowledge and awareness" coding scheme located in Table 15. Student responses suggested that they left the exhibition able to articulate STEM's role in animation, as well as the steps of the animation process (See Table 25 below). For example, one HS student[67] said, "*There is a lot of overlap over math, science and art.*" A 14-year-old male shared, "*[What I learned that was most interesting was] probably the rendering because [I] got to see different stages in how it was made from beginning to end.*"

Table 25: How students demonstrate knowledge and awareness of STEM and animation content, interdependence, and careers, matching follow-up surveys and flash interviews (N=82)[68]

Evidence of learning goal	Number of respondents	Percent of respondents	Example quote
Students list or describe technical elements of the animation process	45	55%	*"There's lighting, surfacing, designing, etc."* (male, 14)
General awareness of the connection between animation and STEM	49	60%	*"All the math that goes into animation."* (female, 10)
Students mention specific STEM and computer science principles in animation	4	5%	*"In school we learned about reflections of light and in Pixar, animators add value to an object based on how light would hit in the real world."* (female, 15)
Students acknowledge awareness of STEM in animation-related careers	1	1%	*"How [the animations] transfer from job to job and how each job helps."* (female, 10)

[67] Student did not provide gender or age on survey.
[68] Learning goals coding scheme was applied across the following questions: 1) What did you learn at this exhibition that you found most interesting or engaging, and why? 2) What would you say is the most memorable part of the exhibition, and why? 3) How would you explain the steps involved in making a Pixar film to your favorite teacher? 4) Explain how *SBP* relates to things you have learned or done in school.

Example of increased awareness of the role of STEM in animation

As Samuel's (E/MS, ~10) class departed the exhibition, he explained that the most interesting and memorable parts of his experience were that *"[I] learned that animation is pictures, in 3D, but it's more complex than in 2D."* This comment suggests that he gained an enhanced understanding of the nature of 3D animation and how it differs from 2D animation (See Samuel, Vignette page 165).

Gaining knowledge about animation and Pixar Animation Studios was an interesting and memorable part of the student experience.

Immediately upon leaving the exhibition, students in each school group shared the most interesting things they learned and the most memorable parts of *SBP* through an open-ended flash interview. Their responses provided evidence for what content or experiences in the exhibition were most impactful. Most frequently, students indicated some the most memorable and interesting parts of their visit were learning about the animation process and learning about the Pixar Animation Studios (See Table 26 on the following page). Their responses suggest that students found the exhibition content to be interesting, and that they learned and gained awareness about the process of animation, including associated STEM content, the technical steps of the process, the time it takes, and the contributions of Pixar employees. Analysis about the general public suggests that content related to animation and Pixar Animation Studios were among the top takeaways that resonated with these audiences as well. See page 61 in the Public Audience Impact section for full interpretation and analysis.

Table 26: Most memorable and interesting parts of *SBP*, student flash interviews (N=133) [69]

Theme	Number of respondents	Percent of respondents	Example quotes
Learning about animation and Pixar Animation Studios	107	79%	*"They have to do brightness, the lighting, movement, the setting, so much beyond the cartoons."* (male, 10)
Using a specific exhibit	104	76%	*"Stop-motion animation with lamp; I got to see the movie at the end."* (male, 17)
Positive outlook towards STEM, art and/or animation	40	29%	*"When you see the final creation it's so cool that anyone can do it."* (male, 10)
Real world STEM and art applications	16	12%	*"[Animation] uses math and science."* (female, 10)
Careers	3	2%	*"How [the animation] transfers from job to job and each job helps [make the final film]."* (female, 10)
Interdisciplinary understanding of STEM and art	2	1%	*"Didn't know so much math and science was involved and you could put that with art to make an animation."* (HS student)

SKILLS

High school students' beliefs about the creative agency of programmers were more strongly positive after their field trip. Otherwise, student understanding of the skills involved in programming were generally similar before and after attending *SBP*.

Students on field trips expressed their understanding of programming skills via Likert-scale questions on the pre-exhibition and follow-up surveys. Overall, after attending the exhibition, most surveyed students agreed or strongly agreed that "programmers can create almost anything they can imagine." The majority of students also agreed or strongly agreed that "there are many different ways to solve computer programming problems" and that "programmers break big problems into smaller parts and solve them one at a time" (See Table 27 on the following page).

To assess whether the exhibition had an impact on student perceptions of these aspects of programming, student ratings on the follow-up survey were compared to their ratings on the pre-exhibition survey. While E/MS students did not express significant changes in their beliefs related to the creativity and problem solving strategies used by programmers, HS students did

[69] A single student may have reference more than one code in his or her response, and so may have been counted multiple times. Therefore, the table percentages will sum to more than 100%. These are responses to the questions, "What did you learn at the exhibition that you found the most interesting or engaging, and why?" and, "What would you say is the most memorable part of this exhibition, and why?"

express more positive perceptions about the ability of programmers to create anything they imagine after their field trip (see Table 27 on the following page).

Table 27: Changes in students' understanding of how programmers approach problem-solving, matched pre-exhibition surveys and follow-up surveys (N=170) [70]

	HS (n=33)	E/MS (n=131)
Programmers have the ability to create anything they imagine	Positive change*	No change
There are many different ways to solve computer programming problems	No change	No change
Programmers break big problems into smaller parts	No change	No change

Table 28: Student understanding of how programmers approach problem-solving, follow-up surveys (N=186)[71]

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
There are many different ways to solve any given computer programming problem.	1%	6%	31%	39%	22%
Computer programmers can create almost anything they imagine.	2%	4%	16%	35%	41%
When solving a problem, computer programmers break it into smaller parts and solve them one at a time.	2%	3%	30%	43%	22%

Some students offered comments that suggested that they engaged in STEM and computer science practices during their visit.

The "skill" coding scheme located in Table 16 was applied to student responses in order to identify instances of students utilizing defined skillsets while in the exhibition. In particular, the coding scheme identified four primary ways that visitors expressed their use of STEM skills during their visit: recognition of the character and work ethic required to produce Pixar Animation Studios designs, engagement in design process skills, use of creativity, and use of problem decomposition skills (all defined in Key Terms on page 184). The data suggested that students did engage in STEM and computer science practices in *SBP* (See Table 29 on the following page).

[70] *=$p<0.05$ using Wilcoxon Signed-Ranks test

[71] Responses to, "Please rate the following statements again based on your beliefs about math and computer programming." Appendix K includes data for HS and E/MS samples separately.

Similar to the findings from the General Public Audiences (further explained on page 38), many students made comments that expressed a strong recognition of the characteristics and work ethic required for animation work. For example, one student learned "*How it is a lot of work…because when you're watching the movies you think they paste it into the computer but actually it' a long process, like 24 frames per second*." In their comments, over a third of E/MS students and over half of HS students made comments that suggested that they were engaged in STEM and computer science practices, such as problem decomposition and the engineering design process. For example, one student talked about how the process is broken down, stating "*Amazing. They have to do brightness, the lighting, movement, the setting, so much beyond the cartoons…*", while another student described experimenting with lighting, stating "*I liked the lighting. It was fun to mess around. What little input can do to affect a whole scene.*"

Table 29: How students demonstrate engagement in STEM and computer science skills, flash interviews and follow-up surveys (N=82) [72]

Evidence of learning goal	Number of students	Percent of students	Example quotes
Students use design process skills.	23	28%	*"Brainstorm, build, fix, finish."* (female, 10)
Students acknowledge the resilience, work ethic, and other characteristics of Pixar employees.	21	26%	*"[I] didn't realize [making films] took so long and so much effort."* (female, 14)
Students express ownership over their own creativity and creations.	17	21%	*"[I liked] the computer where you build your own room. It's creative."* (male, 10)
Students use problem decomposition skills.	14	17%	*"When you're making a movie you have to do it in many steps."* (female, 14)

Example of students using creative skills in *SBP*

When reflecting on his visit to *SBP*, Samuel (E/MS, ~10) shared that he would explain the steps in Pixar Animation by emphasizing "*creativity; it is harder than you think*." This consideration supplemented his observed experience and his responses to the flash interview immediately following his visit to *SBP*. He spent the most time at *Build a Robot* and *Set Layout Workstation*. At *Build a Robot,* he exercised creativity skills in discussing his various robot designs with his classmate and at *Set Layout Workstation*, he tried to make the room look futuristic, saying, "*everything floats in the future*." Samuel took ownership over this creativity in the flash interview, responding, "*I liked when we designed our own studio. We got to animate our own room.*" (See Samuel, Vignette, page 165)

[72] Learning goals coding scheme was applied across the following questions: 1) What did you learn at this exhibition that you found most interesting or engaging, and why? 2) What would you say is the most memorable part of the exhibition, and why? 3) How would you explain the steps involved in making a Pixar film to your favorite teacher? 4) Explain how *SBP* relates to things you have learned or done in school.

ATTITUDES AND PERCEPTIONS

After attending *SBP*, the majority of students reported some positive changes in their perceptions of and interest in animation, math, or computer programming.

The follow-up survey asked how, if at all, students' experiences at *SBP* affected their interest in math, computer programming, and animation. Most students (87%) reported that attending *SBP* had positively changed their level of interest in learning about animation and/or using it creatively. More than two-thirds of students (71%; n=184) reported that the exhibition had positively changed their interest in learning about computer programming or using it creatively, and just over half of students reported some increase in interest in learning about math or using it creatively (51%; see Table 30 below).

Table 30: Students' self-reported change in interest, follow-up surveys (N=184)[73]

		Much LESS interested	A little LESS interested	No change	A little MORE interested	Much MORE interested
Math	**Learning**	11%	9%	49%	17%	13%
	Using creatively	9%	13%	39%	24%	16%
Computer programming	**Learning**	3%	8%	32%	30%	27%
	Using creatively	4%	9%	27%	29%	32%
Animation	**Learning**	3%	7%	17%	37%	37%
	Using creatively	3%	7%	11%	25%	53%

Students also rated their perceptions about the importance, usefulness, and creativity of math, animation, and computer programming on both pre-exhibition and follow-up surveys. Analysis comparing student responses suggests that the exhibition resulted in no statistically meaningful changes in student attitudes towards computer programming and math with regard to how important they are to know, the amount of creativity they require, and their usefulness in careers. However, most students entered the exhibition with strong positive ideas about these factors. This suggests that *SBP* may have affirmed these perceptions. See Appendix K (page 175) for a full distribution of student responses.

[73] Responses to, "Please rate how, if at all, *SBP* changed you interest level in [learning about math, programming, and animation and creating your own or using in your own creative projects]." Appendix K includes data for HS and E/MS samples separately.

Example of increased interest in computer programming

Samuel (E/MS, ~10) exhibited positive changes in interest across math, computer science and animation. He came to *SBP* somewhat interested in learning about all of them, using them creatively, and applying them to a career. After his visit, he declared himself much more interested in learning about computer programming, creating his own computer programs, using math creatively, and applying computer programming to a career. In fact, he suggested that the exhibition did not provide enough of the computer programming component, suggesting that "*maybe you should teach us how to code animations.*" The interest in computer science and programming that he gained through his visit to *SBP* fueled a curiosity about the computer coding involved in constructing animations. (See Samuel, Vignette, page 165)

Compared to their views before attending the exhibition, elementary and middle school students agreed more strongly after attending *SBP* that programming is useful for many careers. However, no significant changes in attitudes and beliefs about math were observed.

For students on school field trips, the exhibition seemed to have few statistically meaningful impacts on attitudes towards programming and math when comparing pre-exhibition attitudes to attitudes 3-6 weeks after attending *SBP*. In particular, most students had positive beliefs about the importance and creativity of programming, and about the usefulness and importance of math before and after attending the exhibition (See Table 27).

Table 31: Changes in students' attitudes and beliefs about programming and math, before and after attending *SBP*, pre- and post-exhibition surveys (N=170) [74]

		HS (n=33)	E/MS (n=131)
Math is…	**Important to know**	No change	No change
	Full of creativity	No change	No change
	Useful in careers	No change	No change
Computer programming is…	**Important to know**	No change	No change
	Full of creativity	No change	No change
	Useful in careers	No change	Positive change*[75]

After attending the exhibition, 77% of E/MS students and 80% of HS students agreed or strongly agreed that programming is useful for many careers (See Table 32 on the following page). For E/MS students, levels of agreement with this belief were significantly higher after attending the

[74] Wilcoxon Signed-Ranks test was used to assess differences in student beliefs; Z=-2.121; p<034; n=135.

exhibition. This suggests that, while HS students may have already felt that programming can be useful, the exhibition may have helped E/MS students recognize the application of programming across diverse fields. There were no statistically meaningful differences in HS students' beliefs before and after attending the exhibition.

Table 32: Student attitudes and beliefs about programming and math, *SBP* 3-6 week follow-up (n=183 students)

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Math is…	**Important to know**	4%	5%	15%	31%	45%
	Full of creativity	11%	18%	32%	21%	17%
	Useful in careers	2%	4%	8%	34%	52%
Computer programming is…	**Important to know**	9%	28%	39%	14%	10%
	Full of creativity	2%	2%	9%	44%	43%
	Useful in careers	2%	3%	18%	51%	26%

Controlling for these pre-exhibition levels of interest, gender was not a statistically meaningful predictor of change in interest in animation, computer programming, or mathematics. However, female students had lower levels of initial interest in both computer programming and mathematics than male students did, although females and males had similar levels of interest in animation. Specifically, controlling for age, pre-exhibition interests in computer programming and math were lower for girls compared to boys. This difference was significant, but small: gender predicted approximately 6% of the variance in pre-exhibition interest in computer programming, and approximately 4% of the variance in pre-exhibition interest in math (See Appendix K on page 175). These pre-exhibition levels of interest were positive predictors of change in students' interest in each discipline after attending *SBP*. That is, students who had stronger initial interests in math and programming were more likely to report increased levels of interest after the field trip to *SBP*.

After attending *SBP*, elementary/middle school students more strongly agreed that programming is useful for many careers. Students in all grades exhibited some increased interest and inspiration in pursuing these careers.

After attending *SBP*, E/MS students had more positive perceptions about the usefulness of programming for many careers, when compared to their views before attending the exhibition.[76] This suggests that the exhibition may have expanded E/MS students' understandings of applications of programming. No statistically meaningful positive or negative changes in E/MS or HS students' perceptions of the creativity or importance of knowing math or computer science resulted from attending the exhibition.

[76]Wilcoxon Signed-Ranks test was used to assess differences in student beliefs; W(DF)=WVALUE, $Z=-2.12$, $p < .034$.

Example of improved opinion towards usefulness of computer programming

Between her *SBP* visit and a month after, Alice's (E/MS, 11) understanding of the usefulness of computer programming improved. Based on her responses to the pre-exhibition and post-exhibition survey questions, Alice's perspective was positively affected with regard to the usefulness of computer programming in careers and to the importance of math as a subject to understand. Her improved attitude towards programming's usefulness mirrors the emergent pattern in her age group, suggesting that *SBP* contributed to this change (See Alice, Vignette, page 166).

The "attitudes and perceptions" coding scheme (See Table 17), which applied across flash interview and follow-up survey questions, yielded few connections to STEM or CS careers (See Table 33 below). When asked about the most memorable part of the exhibition, one inspired student said, "*Learning about animation. I want to do that when I grow up. It was cool how much detail they use, and how it's more than just one person involved in doing the work*" (female, 15). In closed-ended questions directly asking about changes in interest in STEM careers, about a third of students expressed that they were a little or much more interested in pursuing animation, computer science, or math careers after visiting *SBP* (See Table 34 on the following page). This suggests that *SBP* had some impact on student perception of careers.

Table 33: How students acknowledge positive attitudes towards STEM and computer science, flash interviews and follow-up surveys (N=82 students) [77]

Evidence of learning goal	Number of students	Percent of students	Example quotes
Students recognize the creativity and art in Pixar, STEM and computer science	7	9%	*"There's art involved."* (female, 11)
Students are inspired, more confident or see positive role models in Pixar employees	2	2%	*"I want to do that when I grow up."* (female, 15)
Students connect fun with STEM and STEM careers	1	1%	*"[Making a Pixar film] is really hard but fun."* (female, 10)

[77] Learning goals coding scheme was applied across the following questions: 1) What did you learn at this exhibition that you found most interesting or engaging, and why? 2) What would you say is the most memorable part of the exhibition, and why? 3) How would you explain the steps involved in making a Pixar film to your favorite teacher?

Table 34: Change in interest in using animation, math and computer sciences in careers, follow-up surveys (N=184 students)[78]

	Much LESS interested	A little LESS interested	No change	A little MORE interested	Much MORE interested
Using math in my career	19%	12%	38%	14%	17%
Using computer programming in my career	15%	16%	31%	21%	17%
Using animation in my career	12%	15%	28%	24%	22%

Example of increased interest in STEM careers

SBP influenced Joseph's (HS, 14) interest in applying math, computer science, and animation to future careers. Joseph came into *SBP* with a high interest in computer programming and math careers and a little bit of an interest in animation careers. For all three subjects, he reported in the follow-up survey that he was a little more interested in pursuing these careers than before visiting *SBP.* This suggests that the exposure that he received from the exhibition positively inspired him to consider these fields in his future (See Joseph, Vignette, page 167).

High school students demonstrated positive changes in self-efficacy for computer programming after attending *SBP*.

Student self-efficacy for programming was assessed using a brief, three-item assessment, administered in both the pre-exhibition and follow-up surveys. Students rated their confidence in their ability to write computer animation software in three scenarios: (1) after taking the right classes in school, (2) with the aid of a manual, or (3) on their own, without any help. The ratings were then combined into a self-efficacy score. HS students had higher self-efficacy scores for programming after attending the exhibition, with an effect size (Cohen's d) of .33 (See Table 35 on the following page). The HS students were the only audience to leave the exhibition with higher confidence in their abilities, as E/MS students had no change and public audiences left with lower self-efficacy (see further explanation in the Public Audience Impact section on page 51).

[78] Responses to "Please rate how, if at all, *SBP* changed your interest level in each of the following: Doing animation as part of my career, doing computer programming as part of my career, and doing math as part of my career." Appendix K includes data for HS and E/MS samples separately.

Table 35: Student self-efficacy for computer programming, matched pre-exhibition/follow-up surveys (N=170) [79]

	Pre-exhibition survey mean (SD)	Follow-up survey mean (SD)	Effect size (Cohen's d)
E/MS (n=124 students)	16.4 (5.1)	16.7 (5.9)	---
HS (n=32 students)	15.0 (6.0)	17.0 (6.0)	.33*[80]

Among all students and controlling for initial self-efficacy, positive changes in self-efficacy were predicted by the degree to which students reported thinking about or talking about the exhibition after attending (See Appendix K on page 175). This suggests that follow-up activities and behaviors supported stronger self-efficacy for computer programming.

Example of HS students' increased self-efficacy after attending *SBP*

Although Joseph (HS, 14) spent a large portion of his time in between exhibits and socializing in *SBP*, he nonetheless developed stronger self-efficacy in computer programming. Like many other students, this change in confidence was accompanied with evidence of thinking about the exhibition material in other contexts. In his follow-up survey, he reported seeking out further information and ways to learn more about computer programming. Like many of his classmates, his increased self-efficacy and self-reported initiative in following up on the content suggest a correlation in which students leave the exhibit with higher confidence both in computer programming content and their ability to explore it further (See Joseph, Vignette, page 167).

HOW DID SCHOOL GROUP AUDIENCES FEEL ABOUT THEIR EXPERIENCES AT *SBP*?

Educators and students had overall positive feelings about *SBP* after attending. Findings suggest:

- Educators recommended *SBP* and valued its clear classroom connections and hands-on, cognitively engaging exhibits.
- Students' immediate reactions to *SBP* focused on learning about animation and Pixar Animation Studios or enjoying specific exhibits.
- Students remembered the interactivity, ability to create and build, topic of animation, and specific exhibits as the best parts of their *SBP* experiences.

These findings come from analysis of educator workshop surveys and student follow-up surveys. Educators provided numerical ratings as well as qualitative explanations, while students provided written responses to follow-up survey questions. Examples from the case study analyses are provided within this section in order to more fully describe these trends.

[79] *=p<0.05

[80] Paired Samples T-Test used to assess differences in self-efficacy; t=-2.154; df=31; n=32, p=.039.

Educators recommended *SBP* and valued its clear classroom connections and hands-on, cognitively engaging exhibits.

Educator workshop attendees provided ratings pertaining to their likelihood to recommend the exhibition, and then were invited to explain qualitatively why they chose that rating. Of the 44 respondents who obliged, 23 rated the exhibition a 9 or 10 (out of 10), while the remaining 21 had scattered ratings between 5 and 8.5 (out of 10).

The explanations for recommendation ratings, displayed on the following page in Table 36, suggest that teachers value exhibitions that encourage students to enhance their understandings of STEM disciplines, and that they value *SBP*'s hands-on, entertaining and cognitively engaging educational strategy. These are the same top reasons that promoters in the general public audience provided when explaining their ratings, as interpreted in the Public Audience Impact section on page 55.

Stipulations in recommendation ratings manifested into two main themes. First, educators claimed that the exhibit lacked certain content, such as direct applications of the science and math or complete explanations about how STEM applies to animation.

Secondly, educators were concerned that the educational quality may not be accessible to all groups. Three (of 45) teachers doubted that their elementary-aged students were capable of comprehending the presented STEM content. They felt that the exhibition was more valuable for middle and high school students. Other educators were concerned about the value of the exhibition without structured guidance: one expected students to press exhibit buttons without cognitively engaging with the content, while another said that *SBP*'s educational value can vary depending on student investment and educator guidance.

Table 36: Explanations for recommendation ratings, educator workshops surveys (N=45) [81]

Theme	Number of respondents	Percent of respondents	Example quotes
Exhibit content connects to STEM concepts	14	33%	*"There is so much that connects the math, science and computer."*
***SBP* is mentally engaging**	13	30%	*"As an educator I was engaged and learned a lot."*
***SBP* is physically engaging/ interactive**	13	30%	*"I loved how everything was hands-on and interactive."*
***SBP* has high entertainment quality**	10	23%	*"It's not my kind of thing but I think the kids would love it."*
I would recommend *SBP*, with stipulations	7	17%	*"I think depending on how it is handled by the teacher and explored by the students the educational value can vary."*
The content at *SBP* was insufficient	4	9%	*"The only reason my answer to 1 is not a 10 is because I foresee students actively engaging in the material but not necessarily understanding the science/math behind it."*
***SBP* is inspirational**	3	7%	*"Athletes and pop stars often celebrated or termed 'idols' and role models due to so much on screen coverage. It was great seeing all these Pixar staff 'on screen' so hopefully kids have newer 'idols' to look up to."*
***SBP* exposes students to career opportunities**	3	7%	*"The careers and technology skills that go into it."*
I would not recommend *SBP* for my students	1	2%	*"This was not something I would use for lower elementary."*
Other/ No feedback due to time constraint	5	12%	*"I need to spend a bit more time looking at how different aspects of the exhibit connect to the standards."*

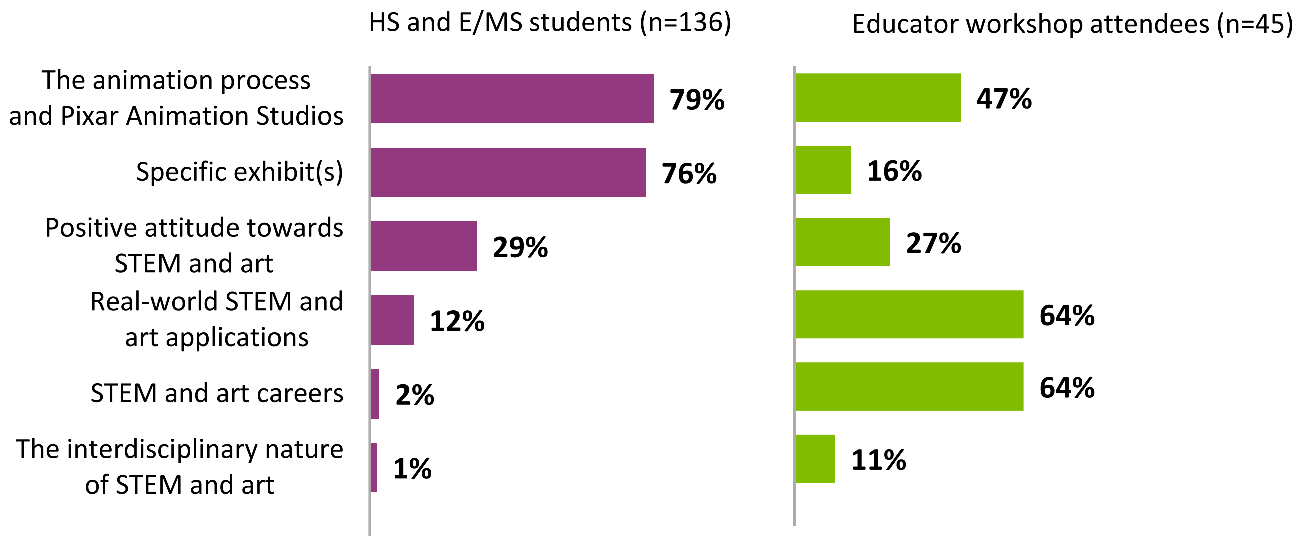
[81] Responses to, "How likely are you to recommend *SBP* as a field trip to colleagues or other teachers? Please explain your rating."

Students' immediate reactions to *SBP* focused on learning about animation and Pixar Animation Studios or enjoying specific exhibits.

In a flash interview conducted as they were leaving the exhibition, students (n=136) answered the following questions: "What did you learn at this exhibit that you found the most interesting or engaging?" and, "What would you say is the most memorable part of the exhibition?" Their responses were coded together and analyzed for patterns. In this context, students valued learning the content and engaging with specific exhibits (See Figure 30 below). This suggests that *SBP* had an immediate, positive educational impact on students.

Educator workshop attendees answered similar questions about their expectations for students (n=45). The survey questions asked, "What do you hope your students will learn from their trip to *SBP*?" and, "What, if anything, do you hope your students will find the most interesting or inspiring about *SBP*?" Their responses were coded by the same scheme as the student flash interviews. Analysis found that student's immediate reactions did not parallel educator expectations (See Figure 30). Teacher responses indicated wanting students to learn about and be inspired by the careers (64%) and real world applications of STEM (64%), while students' comments more often cited the animation process (79%) and specific exhibits (76%) as the most interesting and memorable parts. The exhibition's design or differences in how the groups approached the exhibition may have influenced their responses. The discrepancy suggests that the exhibition had a positive impact on students, but not in the ways that educators most often hoped for or expected. This presents an opportunity to bridge this potential gap between educators and students by encouraging teachers to be more upfront with students about their goals, sharing expected student outcomes with teachers before they visit *SBP*, or focusing even more on educator goals in future exhibition design.

Figure 30: Student reactions to and educator expectations for *SBP*, Flash interviews and educator workshop surveys[82]



[82] Student responses to the questions, "What did you learn at this exhibition that you found most interesting or engaging, and why?" and, "What would you say is the most memorable part of the exhibition, and why?" Educator responses to, "3. What do you hope your students will learn from their field trip to *SBP*?" and, "4. What, if anything, do you hope your students will find most interesting or inspiring about *SBP*?"

Students remembered the interactivity, ability to create and build, topic of animation, and specific exhibits as the best parts of their *SBP* experiences.

Follow-up surveys asked students, in an open-ended question, to share what they felt was the best part of their *SBP* experience. Their top responses are as follows:

Table 37: Students' favorite parts of the *SBP* exhibit, Follow-up surveys (N=184 students)

Theme	Number of students	Percent of students	Example quotes
Specific exhibits or sections of the exhibition	84	48%	*"I like when you take a photo of the Pixar lamp in different positions."* (female, 11) Responses also included: - *Stop Motion Animation* - *Sets and Cameras* - *Pipeline* - Intro Theater film - Lighting and surfaces clusters
The interactivity of the exhibits and experiences	72	41%	*"The best part was the interactive activities."* (female, 14)
Opportunities for creative ownership	52	30%	*"I liked when you could design your own field of grass."* (female, 11)
Learning about Pixar Animation Studios animation process	38	22%	*"How it goes from a sketch to an animation."* (female, 14)

[83]

Creative ownership includes times when students create, make, build or animate. These findings suggest that students liked the exhibition and enjoyed their visits because the exhibits were hands-on and allowed them to engage in the content as if they were animators themselves.

Example of students valuing a specific exhibit

While exploring the animation cluster, Alice's (E/MS, 11) friend excitedly pulled her away to show her a new exhibit. The friends approached *Computer Animation Workstation*, to which Alice reacted with an enthusiastic *"so cool!"* The two began working together to make Mike's arm move, collaborating happily and taking pictures of each other and the graphics of the iconic character. On her way out of the exhibition, Alice remembered this experience and shared, *"I liked Sully and Mike and how [Computer Animation Workstation] showed [how you] can move an arm for Mike. That was cool"* (See Alice, Vignette, page 166).

[83] Responses to, "What would you say was the best part of *SBP*?"

Example of students valuing the opportunity to learn about animation

Joseph (HS, 14) spent 74% of his time directly interacting with the exhibits, and he did express interest in the content. In particular, he responded positively to *Crowd Simulation Workstation*, and often conversed with Marty while using interactives. At the culmination of his visit, he reflected on his interest in how people make animated movies, and the work that goes into animating reflections and color. A few weeks later, these points still resonated with him, as he expressed his opinion that the best part of *SBP* is "*how they make animations*" (See Joseph, Vignette, page 167).

Example of students valuing the interactive learning opportunities

During her visit, Alice (E/MS, 11) was highly invested in completing her worksheet. As a result, she not only visited many of the exhibits, but also engaged with the content. Her exhibits of choice were the large immersives, where she spent 63% of her time. In particular, she spent a substantial portion of her time at *Sets and Cameras* with a large group of students. At each exhibit, Alice often observed instead of directly working with the interactives. However, she always interacted with her classmates while recording her group's answers to the worksheet questions. When recalling her favorite part of *SBP* a few weeks later, she said, "*I think the best part was the activities*" (See Alice, Vignette, page 166).

HOW DID EDUCATORS CONNECT *SBP* TO STANDARDS AND CLASSROOM LEARNING?

This section details the expectations teachers had for making connections between their classrooms and *SBP*. Findings suggest:

- Educators planned to connect *SBP* to STEM and art curricula.
- Students were able to make connections between the exhibition and their STEM classwork.

These findings come from analysis of open-ended responses from the educator workshop and student follow-up surveys. Data from the case study students give a detailed example of the broader student trends.

Educators planned to connect *SBP* to STEM and art curricula.

When asked how they planned to connect *SBP* to their classrooms, educator workshop attendees showed interest in connecting it to their math and general science curricula, followed by computer science (See Table 38 on the following page). These findings mirror both their expectations for students to see how the STEM they learn in school has real world applications and is clearly related to STEM classroom content (See Table 22). School VXM audience reported that the classroom connections were also a motivation to come to *SBP* for them (See Figure 26). Therefore, a common understanding across educator audiences is that they expect *SBP* to be a useful supplemental tool for STEM classrooms.

Table 38: Intentions for classroom connection, educator workshops surveys (N=45) [84]

Theme	Percent of Respondents	Example quotes
STEM and art concepts/skills: Math	45%	*"Math: geometry, 3D shapes, scale, measurement, spatial relationships."*
STEM and art concepts/skills: Science	43%	*"Relate the physics of design to the physics of earth science."*
STEM and art concepts/skills: Computer Science	17%	*"Computer science: dividing a task, looping, arrays, algorithms."*
Collaboration	10%	*"I will definitely speak to them about how they all work together for these animated movies."*
Careers	10%	*"I would love to show some videos of the jobs at Pixar to the STEM classes."*
STEM and art concepts/skills: Art	7%	*"With art: visual rendering shape - form, drawing, light/value, 3D vs 2D."*
Khan Academy/MOS-developed activities	7%	*"We are completing the Pixar in a box curriculum through Khan Academy so the kids can practice using math in graphic animation."*
STEM and art concepts/skills: Engineering	5%	*"Engineering processes in movie making."*
Inspiration/Motivation	5%	*"Use it as inspiration and reference to help motivate my students."*

Students were able to make connections between the exhibition and their STEM classwork.

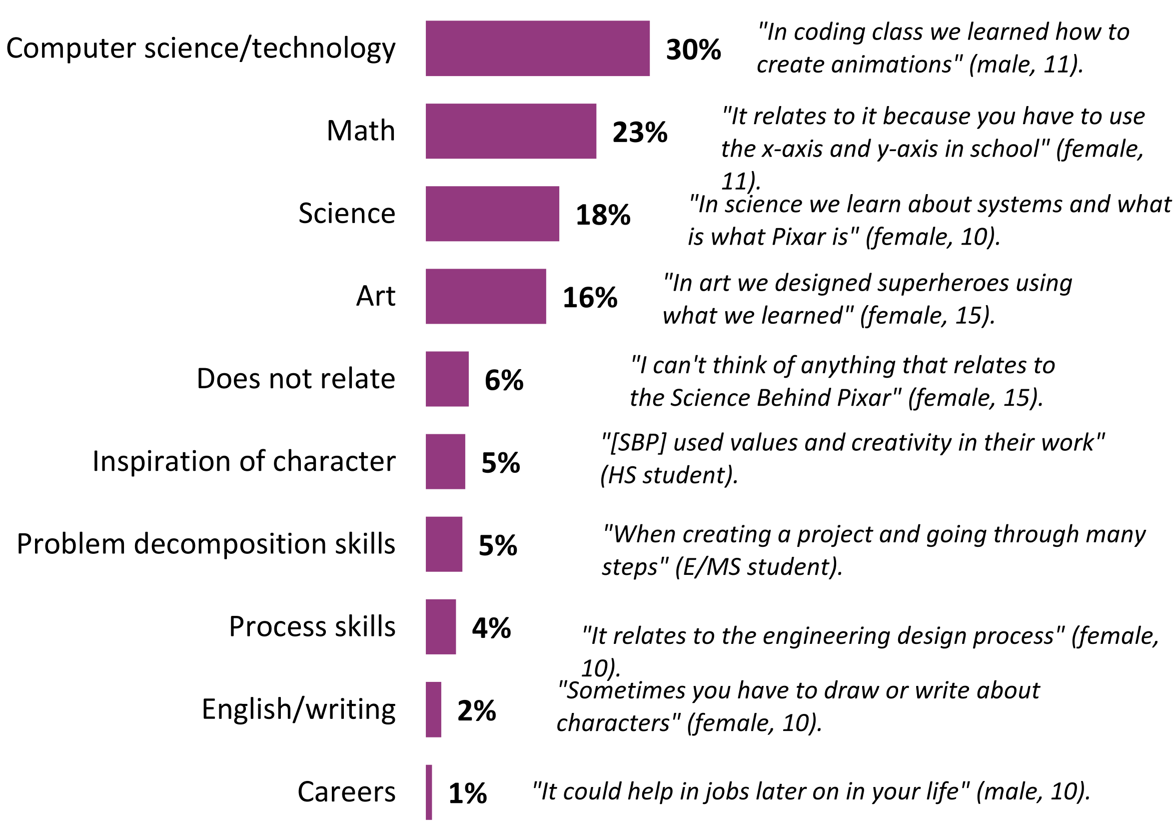
Follow-up surveys asked students to reflect retrospectively on their experience in *SBP* and how the exhibition related to what they learn in school. The school groups were not matched to the educator sample, but they made similar connections to their classrooms. Because three school groups participated in data collection, the demographics of surveyed students were limited to a few types of classes, which may have affected their experiences, expectations and retrospective content connections. For example, the HS students came to *SBP* as an art class, so their

[84] Responses to, "How, if at all, do you plan to connect *SBP* to your classroom curriculum?" "Other" responses not included in table.

experience was strongly guided by an art-focused mentality. As a result, 54% (n=28) of them connected *SBP* to their art class curriculum. The E/MS sample consisted of two classes: 68% (175 of 258) of the students came to *SBP* as a math class with a focus on computer science, and 32% (82 of 258) came as a science class. Out of all the E/MS students, the most frequently cited connections between school and the exhibition were to computer science (32%), math (22%) and science (19%).

Some responses indicated that students also recognized some of the STEM skills highlighted in *SBP* in their classrooms. For example, some students showed evidence of using problem decomposition skills in the classroom, one saying, "*When you work on a project of something like that, you have to do it in…many steps and it takes a very long time*" (male, 14). Other students made references to using components of design process skills in their classrooms. For example, one student referenced the importance of iteration, saying, "*[SBP] relates to science because we need to adjust things to make things work*" (male, 11). These varied responses suggest that *SBP* has potential as a successful educational tool both in helping students understand STEM content and providing opportunities to learn about and practice useful skillsets. Only 6% of all students did not think that the content in *SBP* related to their classwork. The full spread of responses from students is illustrated in Figure 31 below.

Figure 31: Connections between *SBP* and school curriculum, Post-exhibition surveys (N=184 students)[85]



[85] Responses to, "Please explain how *SBP* relates to things you have learned about or done in school."

Example of using problem decomposition

"Problem decomposition" refers to the skills required to solve complex or multi-part problems, including making close observations and breaking things into parts or steps. Joseph (HS, 14), when thinking about how he would explain the process of animation to a teacher, said, "*by showing my work and every step.*" His answer focused on the importance of doing animation in steps, a critical part of understanding and applying problem decomposition. His response indicates that problem decomposition was part of this thought process, suggesting that as he learned about animation in *SBP,* he started internalizing and understanding the value of these skills (See Joseph, Vignette, page 167).

ACCESSIBILITY: IMPACT ON VISITORS WITH SOCIAL, PHYSICAL, AND COGNITIVE DISABILITIES

This section addresses the summative analysis of the accessibility testing that happened in *The Science Behind Pixar (SBP)* exhibition. This section looks at how accessible *SBP* was for visitors with disabilities (as defined in Appendix M on page 184) and their visiting groups, taking into consideration the physical, cognitive, and social needs and preferences for this audience. Analysis looked at the experiences of 20 focus subjects, comprised of the 18 participating groups. A total of 20 tracking and timing observations and 19 post-exhibition interviews were conducted and reviewed for evidence of how exhibition design impacted inclusion and accessibility of the *SBP* experience. Cross-case analyses were used to identify and assess patterns and emergent themes related to each aspect of inclusion. See the Methods section (page 8) for more details about recruitment, data collection, and analysis.

This section exploring the experiences of visitors with disabilities in *SBP* will detail factors that facilitate and hinder multiple aspects of inclusion (Reich, Price, Rubin, & Steiner, 2010):

- Content and relevance (page 98)
- Physical access and reach (page 102)
- Comfort (page 105)
- Social inclusion and independence (page 107)
- Wayfinding (page 111)

Due to interests of the *SBP* development team, the final part of this section will specifically discuss affordances and challenges to two specific multimodal representations in the exhibition: hearphones (page 113) and touchscreen-based activities (page 115). These features are also described throughout the findings sections mentioned in the bulleted list above.

STUDY PARTICIPANTS

Study participants were strategically recruited to participate in the evaluation of the accessibility of the *SBP* exhibition. This sample was not intended to provide a comprehensive view of the experience of all visitors with disabilities, but rather a representative view. Recruitment drew visitors with a range of abilities, ages, and familiarity with MOS. The range of abilities represented in this sample are included in the table below (See Table 39). For detailed descriptions of the 20 focus participants and their groups, see Appendix L: Accessibility (page 181). Participants in this round of testing identified areas where the *SBP* exhibition supported or hindered their experience. All participating groups were tracked and timed in the gallery, although one group did not take part in an interview following their visit. Participants are grouped by study session and each participant has been assigned a pseudonym.

Table 39: Range of visitor abilities (N=20 visitors)

Abilities and/or disabilities represented	Number of visitors
Autism-spectrum disorders (ASD) or Asperger's	7
Communication, cognitive, sensory processing, or emotional disabilities that are not attributed to ASD	7
Blind or have low vision	5
Limited mobility or dexterity	5
d/Deaf or hard of hearing	3

Note: Individuals may have fallen into multiple categories.

CONTENT AND RELEVANCE

This section details successes and challenges of *SBP* with respect to content and relevance among visitors with disabilities. Content refers to visitor interest and learning related to the exhibition's content, as well as how the design of *SBP* facilitated or hindered visitor engagement with the content. Relevance refers to moments when visitors made personal or educational connections to the *SBP* exhibition.

SBP's design and content supported content engagement in the following ways:

- Familiar content and imagery fostered engagement and relevance.
- The variety of experience types used in the exhibition provided a range of ways for visitors to engage with content.
- Multiple multimodal representations at each exhibit supported visitor engagement with the content.
- Most visitors with disabilities who participated in the summative evaluation gave high ratings for their likelihood to recommend the exhibition to friends or colleagues.

Barriers to content and relevance included:

- Exhibition content may not have appealed to all visitors.

Aspects of *SBP*'s design and content that supported content and relevance

Familiar content and imagery fostered engagement and relevance.

Exhibits that featured beloved Pixar Animation Studios characters helped to foster emotional and educational engagement for visitors. Particularly effective were experiences that used the familiar characters from Pixar Animation Studio films to illustrate the use of relatable expressions, life-like behavior, and emotion – including experiences such as *Character Maquettes, Face Rigging Workstation*, and several experiences in the Animation cluster. For instance, *Pipeline* illustrated each of the main parts of the technical animation process using a short clip that featured the character Joy from the film *Inside Out*. At this exhibit component, Walter imitated Joy's movements in each of the different clips. Walter, a child with fine motor difficulties and cognitive disabilities, was particularly compelled by the characters. He noted that he also enjoyed the character voices on the hearphones, explaining that they *"told [him] how they made things and what they did."* This suggests that the characters gave him a way to relate to the content and make sense of the ideas presented throughout the exhibition.
Additionally, several visitors discussed how *SBP* was relevant to them by relating the exhibition's content to prior experiences, knowledge, or interests. For example, Cedric, a 13-year-old boy with ASD, mentioned that he favored the exhibit *Limit Complexity*, which addressed one way that Pixar filmmakers balance the level of detail with the cost of rendering. He explained that he liked *"…how it has the background. My middle school has a visual arts class and it reminds me of perspective."* Cody and Milton, who had cognitive disabilities, expressed an appreciation for *Cars* where it was represented in the exhibition. These two examples illustrate how prior knowledge and/or interests contributed to the relevancy of *SBP* for visitors.

For more examples of how visitors related prior experiences, knowledge, or interests to their *SBP* experiences, see Appendix L: Accessibility (page 181).

The variety of types of experiences used in the exhibition provided a range of ways for visitors to engage with content.

Visitors with disabilities engaged in different types of experiences that were a part of *SBP*. Visitors in all groups experienced at least one immersive exhibit and at least six interactive exhibits. Most visitors (17 of 19) saw at least one *Behind the Scenes / Challenge* video, and many (11 of 19) saw at least one *Working at Pixar* video. Some (6 of 19) also experienced educator-led activities. Similar to the general audience and school group audiences, when asked about which exhibit in the exhibition was their favorite, visitors with disabilities expressed a range of preferences, indicating that no single exhibit was their favorite. The various exhibit types discussed by these visitors exemplified different types of experiences. These approaches were important for supporting inclusion, as they encouraged visitors to be creative, challenge themselves, and learn new information. Below are some examples of the strategies used at different types of exhibit experiences and how they supported visitor engagement and learning.

Immersive experiences: Immersive experiences often featured large-scale characters and offered tactile or kinesthetic experiences. For example, Cody and Milton, who have cognitive disabilities, enjoyed crawling through *Sets and Cameras* together to get a different perspective of the scene, while also using the camera controls to manipulate the camera view. The design of the *Sets and Cameras* immersive allowed the boys to experience the exhibit's content in different ways. In another example, Theresa, a visitor with low vision, was able to engage with the tactile leg pieces while listening to the audio at the text panel about the *Rigging (Mike and Sulley)* immersive.

Interactive exhibits: Several visitors appreciated being able to physically engage with the content through interactive opportunities. For example, Eugene, who was blind, expressed an appreciation for *Build a Robot*. Eugene, age 68, noted that it was *"more than just a tactile model – it was tactile and mobile [flexible]."* This comment refers to the exhibit as both a touchable model and an activity that is open-ended in what visitors could create. Judith, a 39-year-old visitor who is deaf noted that she liked how in *Lighting Design Basics* you could *"change light to create different moods…see how sunlight enters the room."* She thought it was *"neat to see illustration of how light changes mood, from happy to sad, depends on when light is hitting."* This interactive experience suggests that that *SBP* supported her creativity and exploration with the exhibition's content.

Videos: Filmmakers featured in the videos about Pixar Animation Studios fostered engagement and positive emotional reactions from participants. For example, June, a visitor who was blind, noted that she appreciated the videos because it was *"really good to have a narrative, the personal story is relatable and real science and real artists and how they're using their creativity and how it's become their career is really good to hear."* The videos also seemed to work well for Cody, a visitor with cognitive disabilities, who watched *Behind the Scenes on The Incredibles* in its entirety. While watching, he started acting out parts of the film and laughing at funny moments. For Judith, the captioning on the videos worked particularly well for her as well, as the captions allowed her, as a visitor who was deaf, to easily know the topic of a video and watch or walk away if it was not of interest to her.

Educator-led experiences: Several visitors noted that they appreciated the experience of Educator-led activities. Marcia, a visitor with ASD and sensory processing issues, was particularly engaged in the *Set-It Up* activity. She participated in the activity and then conversed about coding with the educator. Marcia noted in her interview that she thought *Set-It Up* was one of the best exhibits in *SBP*. For Eugene, a 68-year-old visitor who was blind, the educator-led activities were his favorite. He shared, *"[I] liked these the best - rather listen to a human than recording any day of the week."* Educator-led experiences provided an alternative to listening to audio, and it also allowed visitors to ask questions.

For more examples of how visitors engaged with different types of experiences see the Appendix L: Accessibility (page 181).

Multiple multimodal representations at each exhibit supported visitor engagement with the content.

SBP exhibits delivered content in a variety of ways: text-based information (instructions and content), graphics (diagrams or images), audio labels through hearphones, broadcast audio, kinesthetic experiences (full-body movement), and tactile experiences. Many visitors with disabilities took advantage of these multimodal representations during their interactions and these supports helped them engage with the exhibition content successfully. Below is one example of how different multimodal representations were integrated into an exhibit component, as well as how they supported visitor learning.

Rotated Shapes was designed to demonstrate how a 2D shape can be rotated around an axis in order to describe a 3D form. In order to demonstrate this content, this exhibit provided:

- An interactive **tactile model** that depicted how rotating a 2D shape can describe a 3D form.
- A **kinesthetic experience** where the visitor physically rotated the control of a 2D shape to operate the exhibit.
- **Graphics** that showed the emergence of a 3D form onscreen as the visitor rotated each 2D shape. The graphics also showed how this rotation process could be used to create shapes in a scene from the movie *Toy Story*.
- **Text-based** instructions and explanations that were provided on the label and screen.
- **Audio labels**, that repeated the text-based instructions, provided an audio description of the exhibit.

Mitchell's experience at *Rotated Shapes* showcases how engagement with these multimodal representations led to a prolonged, interactive experience. Mitchell is an 8-year-old boy with William's syndrome. He and his mother used graphic, tactile, and kinesthetic representations at *Rotated Shapes* to engage in learning. He first used the tactile sphere at the exhibit. He then played with the exhibit controls, turning one of the exhibit controls all the way around. When he saw a battery image emerge on screen, he exclaimed to his mother, *"I made a battery!"* Mitchell's mom encouraged him to apply what he had learned to predict other shapes, asking *"What do you think this shape is going to be?"* as Mitchell started to use other controls. At this exhibit, Mitchell used his whole body to turn shapes, seemingly intent and focused. Mitchell and his mother spent 3 minutes, 37 seconds engaging with this exhibit.

For more examples of how multiple multimodal representations enhanced visitor experiences, see Appendix L: Accessibility (page 181).

Most visitors with disabilities who participated in the summative evaluation gave high ratings for their likelihood to recommend the exhibition to friends or colleagues.

Similar to findings from in the general public audience surveys and interviews (as detailed in the Public Audience Impact section on page 54), nearly all visitors with disabilities who participated in the summative evaluation (17 of 20) gave high ratings for their likelihood to recommend the exhibition, ranking it at a 9 or 10 on the scale from 0-10. For example, Judith, a 39-year-old visitor who was deaf, gave the exhibition a rating of 8.5. She noted that *"this is super, super engaging and fun. I would recommend it for adults to do, not just for kids."* She explained that *"a lot of deaf people are especially more visually oriented,"* and that it *"met [my] criteria of being accessible, [you could] almost market it to deaf people."*

Barriers to content and relevance

Exhibition content may not have appealed to all visitors.
Two of the visitors who gave the exhibition lower ratings explained that they did so because they felt that the exhibition content would not appeal to all visitors. For example, Eugene, a 68-year-old man who is blind and visited with friends, gave the exhibition a 7 (out of 10). He noted that if he was not participating in the evaluation,

> *I wouldn't go to the Pixar [exhibition] as a choice because it is a video-focused company. [It] has the least appeal to a blind person. [I] can't appreciate the work...so I don't have a rational reason to care. A blind person can't work at Pixar. At best, it would be of marginal interest.*

Another visitor, Marcia, a 26-year-old impacted by ASD and sensory processing disorders, rated her likelihood to recommend the exhibition at 4 (out of 10). She explained that she thought that her friends might not be interested. Nevertheless, Marcia spent 2 hours and 21 minutes in *SBP*, suggesting that she herself found the exhibition engaging.

PHYSICAL ACCESS AND REACH

This section details affordances and challenges of the exhibition with respect to physical access and reach. As described in the upcoming pages, the following findings indicate how *SBP* supported physical access and reach:

- Tactile features were accessed by nearly all groups of visitors with disabilities who participated in the summative evaluation.
- In most cases, the location and function of exhibit controls were within reach and most physical controls seemed easy to manipulate.

The exhibition presented some barriers to physical access, including:

- The bases of some immersives and *Pipeline* created barriers to access and reach for some visitors.
- In some cases, exhibit controls were not within reach or easy to manipulate.
- In a few instances, limited contrast on images and small images or font sizes restricted access for a visitor with low vision.
- Touchscreen-based activities were not physically accessible for visitors who were blind.
- The use of the hearphones introduced physical barriers to access, and for visitors who were blind, the hearphones and their buttons were sometimes difficult to find.

Aspects of the exhibition that supported physical access and reach

Tactile features were accessed by nearly all groups of visitors with disabilities who participated in the summative evaluation.
Visitors in all groups that participated in the summative evaluation experienced aspects of the exhibition in tactile ways. Many visitors touched the large-scale characters in the immersive exhibits or used tactile controls/parts in interactive exhibits. In addition, 17 of the 18 groups who

participated in the accessibility testing used tactile models provided throughout the exhibition. Tactile models were exhibit features designed to convey visual content in a tactile manner. Several of these included the touchable grass model at *Programming Natural Variety*, the character models at *Character Maquettes*, or the leg rig models at the *Rigging* immersive experience.

The tactile features of *SBP* seemed particularly important for visitors who were blind or had low vision, as well as visitors with sensory processing disorders.

- For Maggie, *Buzz Lightyear* (from the *Modeling* immersive) was a large-scale structure she could touch while her sighted guide summarized the text panel accompanying the character.
- In the case of *Extruded Shapes*, Mitchell, an 8-year-old child with William's Syndrome, liked touching the 3D parts and seeing how their motions affected the on-screen image. The physicality and immediate on-screen response worked well for him.
- Another example of the affordances of tactile models in *SBP* is exemplified through touchable models of *Character Maquettes.* These tactile models provided access to the appearance of characters and to content for visitors who are blind or have low vision. As June noted *"it was interesting to feel the different ways tactilely of how they made Joy and Anger."* She enjoyed feeling the differences between the two characters and wished more tactile information was included throughout the exhibition.

In most cases, the location and function of exhibit controls were within reach and most physical controls seemed easy to manipulate.

The exhibition team tested several strategies for maximizing the physical accessibility of exhibit controls and parts in terms of reach. Overall, the team's strategy of locating controls within a horizontal band on the lower section of exhibit physical structure and touchscreens worked effectively: most visitors could reach exhibit controls and parts. Physical sliders worked well for some groups, particularly visitors with cognitive disabilities. For instance, Mitchell's mother noted Mitchell found the sliders easy to manipulate and more intuitive than the touchscreens. He liked the immediate response time when using the sliders as part of *Face Rigging Workstation*. Cody and Milton's mothers also noted that the hands-on, physical nature of many exhibits worked well for their boys.

Barriers to physical access and reach

The bases of some immersives and Pipeline created barriers to access and reach for some visitors.

The bases of some immersive exhibits and *Pipeline* created barriers to physical access. In particular, the bases used for immersives, such as *Lighting (Dory)* and *Modeling (Buzz Lightyear)*, as well *Pipeline* created challenges for some visitors. For example, Tom, a 25-year-old man with spina bifida, encountered barriers to engaging with several immersives. Upon entering the exhibition, his knee brace made it difficult for him to step onto *Buzz Lightyear*'s platform to take a photo. Ronald, who also has limited mobility, was unable to get his wheelchair close enough to comfortably touch the character *Dory* (as part of the *Lighting* immersive). The base of the exhibit made it difficult to get within an easy-to-reach distance.

Visitors who were blind or had low vision sometimes had trouble negotiating the exhibit bases and noted that the bases could also present tripping hazards. In particular, Maggie, a visitor with low vision, noted that the lack of contrast between the black base of *Pipeline* and black floor made it difficult for her to see where she was stepping. She suggested adding some color to the bases for added contrast. Eugene also noted difficulty maneuvering around the foot stools that surrounded the bases of some exhibits, such as *Extruded Shapes.*

For visitors who were blind, the function of the bases was hard to discern. June, when interacting with the *Rigging (Mike and Sulley)* immersive, walked into the barrier around *Mike* and *Sulley* and reached forward, touching *Mike's* head and legs. This part of the exhibition was one of the only experiences not touchable. This was problematic for June because she did not have other group members to help her navigate the space and there were no cues informing her that *Mike* and *Sulley* were not touchable.

In some cases, exhibit controls were not within reach or easy to manipulate.

Although most exhibit controls were within reach and easy for visitors to manipulate, a couple of visitors did experience some difficulty. Theresa, a visitor with low vision, had trouble pulling the shapes in *Extruded Shapes*. Marcia, a visitor with ASD and sensory sensitivities, had difficulty moving the bulky lamp in *Stop-motion Animation*. Additionally, Kenneth, a visitor with cerebral palsy, could not reach any controls during his visit because his wheelchair would not allow him to pull close or under the exhibits. His family, in most cases, asked him questions about the content and navigated the controls for him.

In a few instances, limited contrast on images and small images or font sizes restricted access for a visitor with low vision.

Maggie, one visitor in the accessibility testing sample who had low vision, noted a few instances where font or image size or low contrast ratios made it difficult for her to access exhibition content. Particular examples of low contrast resolutions that were challenging for her included:

- The blue particles against a blue background in *Simulating Water*
- The subtle lighting differences represented in *Lighting Effects Basics*
- The tennis ball in the *Pixar's Surface Challenge* video

Exhibits in which image or small font size limited her physical access included:

- Small onscreen text in *Set Layout Workstation*
- Small screen size and limited ability to see car details at any level at the *Limit Complexity* exhibit
- Small text under the tactile model in *Rotated Shapes*

Touchscreen-based activities were not physically accessible for visitors who were blind.

Visitors who were blind were not able to access touchscreen controls because they did not know what was selected when touching the screen. For example, June shared *"for some of the touchscreen ones, [I] wasn't sure if I was touching it in the right place."* She and other visitors who were blind or had low vision suggested that accessible touchscreen technology, such as audible feedback in response to touch, would have improved the accessibility of these experiences for them. More information about affordances and challenges of touchscreen use can be found in Specific multimodal representations: Touchscreens (page 115).

The use of the hearphones introduced physical barriers to access, and for visitors who were blind, the hearphones and their buttons were sometimes difficult to find.
When visitors' hands were occupied by using the hearphones, their ability to physically interact with the exhibit was limited, as one of their hands needed to be occupied by the hearphone. Visitors from 3 of 18 groups expressed a preference for broadcast audio, which would enable both hands to be free for exhibit interactions. For example, Cody's mother noted that she *"[Would have wanted] more audio to be able to hear aloud, have your hands free; [One is] not able to operate [the exhibit otherwise]."*

The audio labels were designed to provide audio description to visitors who are blind or have low vision so that they could experience exhibition content independently. However, without orientation from a sighted guide or group member, some of these visitors may not have known that the audio labels and audio description existed, or how to use them. Some visitors who were blind experienced difficulty locating the hearphones and their buttons. For example, June was unable to find hearphones at several exhibits, including the *Rigging (Mike and Sulley)* immersive and *Lighting Design Basics*. Maggie, who had low vision, noted that *"If I were totally blind, I wouldn't know what either button was for [on the hearphones]."* More information about affordances and challenges of hearphone use can be found in Specific multimodal representations: Hearphones (page 113).

COMFORT

This section details affordances and challenges of the exhibition with respect to visitor comfort. As seen on the upcoming pages, aspects of the exhibition that particularly facilitated visitors' comfort included:

- The volume, clarity, height, and placement of videos in the exhibition were comfortable for visitors.
- The availability of stools, footstools, and places to lean helped some visitors and their groups feel comfortable.

A few aspects of the exhibition were challenging to the comfort of visitors. Particular challenges included:

- Some visitors experienced barriers related to hearphone volume and narration speed in *SBP*.
- Certain exhibit effects and an absence of quiet spaces made *SBP* uncomfortable for some visitors, particularly those sensitive to overstimulation, emotion, and light.
- The absence of bathrooms in the exhibition made some visitors uncomfortable.

Aspects of the exhibition that facilitated visitor comfort

The volume, clarity, height, and placement of videos in the exhibition were comfortable for visitors.
Videos were a valuable way for some visitors to access information in the exhibition, providing a comfortable experience in terms of audio volume, clarity, placement, and familiarity. For example, for Kenneth, a 26-year-old with cerebral palsy who used a motorized wheelchair, the videos provided a comfortable experience because they were at eye-level for him in his wheelchair.

The broadcast audio volume on the videos was at a comfortable level as well. For example, for Bobby, a 10-year-old who is impacted by ASD, was highly concerned about the noise levels throughout the exhibition when he arrived, as he experiences high sensitivities to noise. Upon entering the intro theater and listening to his first video, he covered his ears before the audio started. However, after listening to the first video, he realized the sound was not going to be a problem. Bobby's Big Brother from the Big Brothers Big Sisters of America program noted that the audio worked well for Bobby: "*The videos had good sound for Bobby in that it was loud enough to be heard, but not loud enough to make Bobby physically uncomfortable.*"

The availability of stools, footstools, and places to lean helped some visitors and their groups feel comfortable.

Several groups used the stools throughout the exhibition. For some, the stools were a way for visitors to rest as they used exhibits and the footstools provided extra height for exhibit access. Visitors, such as Marcia, a visitor with ASD, preferred to use stools at most exhibits she visited. Mitchell, an 8-year-old child with William's syndrome, used the footstool at *Rotated Shapes* so he could better view the screen. Stools were also portable from one exhibit to another, and easily movable if blocking an intended path. For example, Hazel, a visitor with scoliosis and a two-inch leg difference, had no trouble moving the stools when she wanted to join her daughter at different exhibits. Alternatively, Ronald, a visitor who was blind and used a wheelchair, was able to easily move a stool out of the way so he could pull his wheelchair under the table at *Character Maquettes*.

A couple of visitors with mobility issues used other elements of the exhibit for stability, such as columns or an exhibit's physical structure. Hazel, a visitor with limited mobility, did not always use stools in the exhibit. She often braced herself on columns or against tabletop exhibits. This may have been social decision, as we spent the majority of her time talking with another adult in the group who preferred to stand. Tom, a visitor with mobility limitations from spina bifida, also used the exhibits' physical structure and slants to support his body and rest at points throughout his visit. He noted during the visit that the brace he was wearing during the visit made it more comfortable for him to stand. These experiences suggested that the physical structure of exhibits were designed in a way that supported visitors with limited mobility to rest against them effectively.

Aspects of the exhibition that hindered visitor comfort

Some visitors experienced barriers related to hearphone volume and narration speed in SBP.

Five (of 18) groups found the hearphone audio to be inconsistent (i.e. louder or softer) across exhibits. For example, Mitchell, a child with William's Syndrome, found the audio too loud at *Virtual Lighting Workstation*, while Ronald, a visitor who was blind, struggled to hear the audio at the *Modeling (Buzz Lightyear)* immersive. Ronald felt that sometimes the audio volume was overall too quiet, while other times group members talking around him made it harder for him to hear. Marcia, a visitor with sensory processing disorders, often listened to broadcast audio at the videos during her visit. She was not able to hear the video audio in the Rendering cluster due to another group's loud, social interaction at *Rendering Workstation*. Additionally, Tom's father felt the hearphone directions were spoken too quickly. He had to listen to the hearphone audio twice in order to understand the options. More information about affordances and challenges of hearphone use can be found in Specific multimodal representations: Hearphones (page 113).

Certain exhibit effects and an absence of quiet spaces made SBP uncomfortable for some visitors, particularly those sensitive to overstimulation, emotion, and light.

Visitors with particular sensitivities – to light, emotion, and overstimulation – experienced some discomfort when the exhibition impacted these sensitivities.

- For example, Joseph, a child impacted by ASD, felt overstimulated in *SBP* and needed to take short breaks. His family looked for a quiet space to eat a snack and have a drink, but one was not available in this gallery. Given the limited options available in the exhibition space, they found the bench in the Rendering cluster to work the best for their group.
- Marcia, who is impacted sensory processing disorders, experienced some sensitivities to light in the exhibition. She noted that the flickering lights at the *Lighting (Dory)* immersive bothered her eyes. She also suggested that the staff members tell visitors that flash photos are allowed in the exhibition so visitors can be prepared to sudden flashing lights.
- The manipulations of Jessie's face in *Face Rigging Workstation* also caused some discomfort for Cedric, a child impacted by ASD. He felt emotionally uncomfortable as he used the exhibit.

The absence of bathrooms in the exhibition made some visitors uncomfortable.

Visitors were told when they entered *SBP* at the Museum that there were no bathrooms available in the exhibition. Visitors who needed to use the restrooms during their visit had to find a staff member who could provide them with a pass to use the facilities, which were located on a different level than the exhibition itself, requiring visitors to take an elevator or use the stairs. This bathroom access policy made some visitors frustrated and uncomfortable. For example, Hazel, a visitor with limited mobility, and her daughter Roxanne, a visitor impacted by ASD and ADHD, expressed dissatisfaction with the exhibition's bathroom policy. They suggested that the process of finding a staff member and leaving the exhibition in order to use the restroom interrupted their group experience.

SOCIAL INCLUSION AND INDEPENDENCE

Most visitors who participated in accessibility testing chose to come to the exhibition with other group members (18 of 20 participants). The *SBP* exhibition provided visitors with the opportunity to choose to engage socially or choose to engage independently in a variety of ways. A range of social behaviors were observed at different types of exhibits within the exhibition, such as using an exhibit together, role playing, creating something collaboratively, exploring interactives, or using videos together. At times, visitors also shared exhibit content with other group members, interacted with an educator, took pictures, or modeled exhibit use for others.

Likewise, visitors were also supported by elements of *SBP* to engage independently. Behaviors that suggested independence included making independent choices about where to go or what to use, or using an exhibit or exhibit element on his/her own without needing facilitation, interpretation, or help from others. Visitors also demonstrated independence when expressing accomplishments or ownership over something they created within the exhibition. The section below will detail specific challenges and affordances of *SBP* with respect to both social inclusion and independence.

The exhibition particularly supported facets of social inclusion and independence in the following ways:

- The open layout provided opportunities for visitors to learn from one another.
- The open-sided exhibits provided opportunities for groups to interact.
- Side-by-side copies of the same exhibit supported both independence and social collaboration.
- Multiple approaches for delivering content provided a variety of ways for visitors to engage together.
- Content and picture-taking with familiar characters fostered social behaviors.
- Simple, intuitive, easy to use exhibit controls and instructions supported independent engagement.

A few aspects of the exhibition were challenging to the social inclusion and independence of visitors with disabilities. Particular challenges included:

- Hearphones only allowed one visitor to listen at a time, precluding the opportunity for shared engagement with these exhibit features.
- Touchscreens without multi-touch functionality did not work when multiple visitors tried to use them simultaneously.
- Visitors who were blind or had low vision were unable to use many aspects of the exhibition independently.

Aspects of the exhibition that fostered social inclusion and independence

The open layout provided opportunities for visitors to learn from one another.

The open layout of the exhibits provided opportunities for visitors to watch others interact before they engaged. Mitchell, a child with William's syndrome, watched another child use the *Animation (Incredibles)* immersive exhibit for over a minute before leaving to join family members who were engaged in nearby exhibits. Shortly thereafter, he returned to the exhibit and used it himself for nearly two minutes. The experience of watching another child use the exhibit may have provided Mitchell with a model for how to use it, allowing him to feel comfortable using it independently.

The open-sided exhibits provided opportunities for groups to interact.

Open-sided exhibits allowed for more than one visitor to engage with one activity at the same time. This allowed many groups to share experiences together. For example, *Build a Robot* included an open, multi-station design that facilitated group engagement. Jay was a visitor impacted by ASD. At this exhibit, Jay's Big Brother invited him over to the exhibit and they built a robot together. Another visitor with ASD, Joseph, and his father conversed with each other, while other children also created robots around them in the exhibit. The design of this exhibit encouraged visitors to socialize and work together.

Side-by-side copies of the same exhibit supported both independence and social collaboration.

The adjacent copies of interactive exhibits provided opportunities for visitors to engage socially and independently. For example, *Crowd Simulation Workstation* and *Surface Appearance Workstation* had adjacent copies. Visitors could sit next to each other and watch each other's interactions while working independently at the same time. Tom and his family took advantage of this feature at exhibits. They sat next to one another and discussed the exhibits together, while using their own workstation.

Multiple approaches for delivering content provided a variety of ways for visitors to engage together.

There were a variety of ways that the exhibition was designed to support visitors' abilities to use different exhibits together. For example, *Stop-motion Animation* was an activity that provided a collaborative, kinesthetic experience for groups. In this activity, Cody and Milton, two boys with cognitive disabilities, took turns being the participant who moved the lamp or the one who took the photos. Another example was at *Camera Basics*, where Jay was engaged for 3 minutes, 20 seconds. He used the Wall-E immersive and exhibit controls to pretend to be a director with his Big Brother. This was a longer-than-average dwell time for Jay, a child impacted by ASD. Both of these exhibits encouraged group members to interact and interpret the content together.

Content and picture-taking with familiar characters fostered social behaviors.

SBP was designed with many opportunities to take photos, which supported social engagement and spurred discussion. For example, the *Lighting* immersive featured a large-scale model of *Dory*, the beloved character from *Finding Nemo* and *Finding Dory*. At this exhibit, Hazel took photos of her daughter, Roxanne, and afterwards they talked about the photo and the exhibit's connections to animation in one of Roxanne's classes. In this way, the photo opportunities provided embedded opportunities for visitors to build shared relevance and integrate the *SBP* content and experiences into their existing knowledge and expertise.

Simple, intuitive, easy to use exhibit controls and instructions supported independent engagement.

The intuitive, easy-to-use exhibit controls at some components seemed to facilitate independence for some visitors. For example, Milton, a 19-year-old with cognitive disabilities, was happy that he could control the mechanical sliders on his own at the *Face Rigging Workstation*. In another example, Jermaine, a child with ASD, engaged with several of the screen-based activities independently and without help from group members. This observation suggested that he comprehended the instructions, challenges, and content of the exhibit. His autonomous engagement was observed at *Crowd Simulation Workstation*, *Surfaces (Car Hoods)* immersive, *Face Rigging Workstation*, *Surface Appearance Workstation*, and *Arm Rigging Workstation.*

Barriers to social inclusion and independence

Hearphones only allowed one visitor to listen at a time, precluding the opportunity for shared engagement with these exhibit features.

The individual hearphone only allowed one visitor in a group to listen to the audio at a time. Thus, listening to an audio label was an individual experience, causing challenges for groups who wanted to spend time together and share experiences in the exhibition. For example, Ronald noted that he sometimes missed out on conversations or on information because he was listening to the hearphone. If he wanted to hear his group's conversation, he would in turn miss instructions or content on the hearphone. More information about affordances and challenges of hearphone use can be found in Specific multimodal representations: Hearphones (page 113).

Touchscreens without multi-touch functionality did not work when multiple visitors tried to use them simultaneously.

One issue that caused some confusion at the touchscreen activities was that multi-touch was not supported. As such, when two users tried to use the touchscreen at the same time or when one visitor tried to do multiple actions at the same time, the touchscreens were unresponsive. Cody and Milton, two visitors with cognitive disabilities, experienced this issue when trying to use the exhibits together. Multi-touch issues affected how responsive the screen was for their group. At times, one of them would work individually, while the other watched. This was also an issue for Bobby, who was impacted by ASD, when he started using *Surface Appearance Workstation* and tried adjusting multiple controls at the same time. More information about affordances and challenges of touchscreen use can be found in Barriers to hearphone/audio label use (page 114).

Visitors who were blind or had low vision were unable to use many aspects of the exhibition independently.

In general, it was difficult for visitors who were blind or have low vision to be independent in this exhibition because they had difficulty locating and understanding exhibit content. Sighted guides or fellow group members were, at times, critical for visitors who were blind or have low vision to figure out where to go, what experiences might be accessible, and where to find tactile experiences and audio labels. Some of these visitors shared that more tactile experiences would allow them to better engage and understand.

June's experience showcases some of the difficulties she underwent and how these difficulties affected her time in the exhibition. June, who came with friends and family but did not have a sighted guide, had trouble interacting with exhibits on her own. First, she was confused by the two-button hearphone system. She did not realize that the triangle button would provide an audio description at each exhibit designed for visitors who are blind or have low vision. She noted that, when she pressed the square button - which did not provide an audio description, but just read all of the text on the exhibit out loud - *"It would say "Press to hear out loud" but I didn't know what it would read out loud and it didn't tell me what to do [at the exhibit]."* She was also frustrated by the lack of auditory feedback from the touchscreens or computer in the *Fire and Lights* educator-led activity. When asked about the value of the interactives (overall) in *SBP*, June shared in her interview that *"[I] couldn't utilize any of them. There was no feedback for those."* This comment suggests that because June was unable to successfully interact with touchscreen exhibits, she felt that most interactives in *SBP* were not accessible to her. More information about affordances and challenges of hearphone and touchscreen use can be found in their Specific Multimodal Representations sections (page 113 and page 115, respectively).

WAYFINDING

This next section details what helped or hindered wayfinding in *SBP*. Two effective strategies included:

- The intro theater film helped to orient visitors to *SBP*, while the Rendering cluster provided a helpful culmination to the experience.
- Repeated experience types used throughout the exhibition served as visual cues that supported wayfinding.

Some challenges included:

- Additional orientation at the start of the exhibition could have helped visitors who were blind understand and use *SBP* more effectively.
- The non-linear organization of *SBP* was appreciated by some visitors but posed navigational challenges for others.

Aspects of the exhibition that facilitated wayfinding

The intro theater film helped to orient visitors to SBP, while the rendering cluster provided a helpful culmination to the experience.

Several visitors indicated that the intro theater film provided a nice introduction to the exhibition. For example, Eugene, a visitor who was blind, remarked that the intro theater film was *"worth sitting through. Just a few minutes. It was a good breakdown of the process - told me whether there were five departments or twenty departments."* Cody and Milton's mothers also appreciated that the film was short and included both subtitles and the T-shirts that identified parts of the process. Meanwhile, the Rendering cluster, which was the last section of the exhibition, was appreciated by a few visitors for providing a strong summary and culmination of the content. Maggie, a visitor with low vision, noted that she liked this section because *"it's putting it all together. Seeing it come together and appreciating the prior detail. It gave me perspective."*

Repeated experience types used throughout the exhibition served as visual cues that supported wayfinding.

The repetition of experiences in each cluster created familiarity that supported orientation and wayfinding in the exhibition. Each cluster included an immersive experience that featured: a large-scale structure or interactive experience, three videos, including one *Behind the Scenes* video, one *Pixar's Challenge* video, and one *Working at Pixar* video, and a variable number of interactive exhibits.

- For some visitors, the large-scale immersives anchored the thematic clusters and provided guidance with wayfinding. For example, Judith, a 39-year-old visitor who is deaf, shared that she liked the *Modeling* immersive, which featured *Buzz Lightyear* from the *Toy Story* films, as well as the *Rigging* immersive, which featured *Mike* and *Sulley*, the central characters in *Monsters, Inc*. and *Monsters University*. She felt that these characters *"broke up monotony of exhibits [and] oriented me to where I was. Sometimes would look around and forget the direction I came from. [They were] visual landmarks [and] fun."*
- For Marcia, a 26-year-old with ASD, the consistent and familiar presence of videos throughout the exhibition seemed to provide a sense of predictability and navigation. As

she explored each area, she seemed to gravitate strongly towards the videos, to keep from getting overwhelmed by the exhibition's layout. The videos helped her move more comfortably through the exhibition space.

Aspects of the exhibition that hindered wayfinding

Additional orientation at the start of the exhibition could have helped visitors who were blind understand and use SBP more effectively.

Participants who were blind identified parts of the exhibition where additional information or description would have been helpful. For example, June and Eugene both suggested adding more verbal description in the intro theater film. Eugene noted that adding audible cues in the intro theater could have let visitors know that they were waiting for a film to begin. This would have helped him know what to expect in the intro theater. June commented on the film's content. She explained that *"there was a lot going on [in the video], but I didn't know what it was. Not a whole lot of description."* Additionally, the intro theater film provided background about the exhibition content, but it did not include wayfinding or accessibility information that would have been helpful as they entered *SBP*.

The non-linear organization of SBP was appreciated by some visitors but posed navigational challenges for others.

There were both affordances and challenges associated with the open layout and organization of *SBP*. The spacing of exhibits helped visitors who had limited mobility to move from one experience to the next. For example, Kenneth, a 26-year-old man with cerebral palsy, shared that it was easy for him to get around in his motorized wheelchair.

However, other visitors felt overwhelmed or uncomfortable with the lack of a clear path to guide them through the exhibition. They would have felt more comfortable if the exhibition had provided more guidance to help them navigate the experience. Visitors who were blind found the exhibition layout to be confusing. For example, June, who visited with her 6-year-old son and friends, shared that the layout could have been more intuitive:

> *It's very confusing to move from one exhibit to the next. I get the concept that you explore, but some of the exhibits could've been better laid out. Maybe a pattern. I moved from light to science, math, and art, and I couldn't find a correlation between them….it felt scattered.*

Similarly, this feeling of disorganization in the exhibition layout was an issue for some visitors impacted by ASD and sensory processing disorders. For example, Marcia found the lack of direction in the exhibition to be overwhelming, which led to difficulty navigating the space. She shared:

> *When I first came in, [it was] too open, no clue of how to orient myself, not just too open, too many places to go, no way to organize off of. [I] tried to follow the walls, [that was my] immediate response to that. Too overwhelming, too much without organization.*

Some groups suggested having additional prompts in the exhibition could improve wayfinding. This included suggestions such as character footprints or other pathway indicators that indicate an order for navigating *SBP*.

SPECIFIC MULTIMODAL REPRESENTATIONS: HEARPHONES

Due to interests of the *SBP* development team, findings related specifically to hearphones have been grouped into their own section. The following section highlights affordances and challenges that several visitors with disabilities experienced while using audio labels via hearphones as a multimodal representation. Some of the information included below is repeated from the main sections above.

Affordances of hearphone use included:

- Hearphones were easy to operate and used by a variety of visitors.
- Some visitors appreciated the type of information provided by the hearphones.
- Hearphones facilitated independence for some visitors.

Some challenges to hearphone use included:

- The purpose and function of hearphones were not always clear to visitors.
- At times, hearphones caused a barrier to social inclusion and physical access.
- Some visitors experienced barriers related to audio volume and speed in *SBP*.
- Hearphones were particularly challenging for visitors who were blind or had low vision.

Affordances of hearphone/audio label use

Hearphones were easy to operate and used by a variety of visitors.

The controls for the hearphones were simple to operate, and as such, individuals from the sample of visitors with disabilities frequently used exhibit hearphones. Every hearphone consisted of a handset and two buttons. The square button read aloud the exhibit's printed text. The triangle button read aloud the printed text interspersed with audio description of the exhibit and images, as well as instructions on how to interact with the exhibit. A Pixar character voice read the information that oriented listeners to the hearphone, a female voice read the instructions and content that aligned with the text-based label, and a male voice added the audio description. Audio labels were particularly designed to support accessibility for visitors who were blind or have low vision. Hearphone-based audio labels were used at least once by most of the visitors with disabilities observed in this accessibility study (15 of 20 visitors), and half of the observed visitors (10 of 20) used the hearphones three or more times. Visitors who used the audio labels three or more times included: three of five visitors who were blind or had low vision, five of seven participants with cognitive, sensory processing, or emotional disabilities, and two of seven visitors with Asperger's or ASD.

Some visitors appreciated the type of information provided by the hearphones.

Visitors in several groups offered praise for the kinds of information offered on the hearphones. For example, Cody's mother explained that Cody and Milton liked the audio because it *"explained stuff to you in order…play with button to see what they did, direct and immediate* *connection to what you see."* Eugene, a visitor who was blind, praised how the information was organized, noting appreciation for the menus that announced what section of the audio label was being presented, and stating that it was *"as good as it could be. The scripting was good."* Additionally, some children who participated in the study noted that they liked hearing the character voices that were featured on the audio labels, and one child was observed pressing the audio label button repeatedly to hear the sound that was played at the start of the recording.

Hearphones facilitated independence for some visitors.

For some visitors, hearphones supported independence, as they provided a way to access exhibit content and instructions for visitors who had trouble reading or seeing the text or graphics. For example, hearphones allowed some visitors with cognitive disabilities or ASD, such as Mitchell, Kenneth, and Jermaine, to hear both directions and exhibit content. Some visitors listened to the audio while using controls or watching videos. This sentiment was also observed in some visitors who were blind or had low vision. For example, Theresa, a visitor with low vision, was able to engage with the tactile leg pieces while listening to the hearphone at the text panel about the *Rigging (Mike and Sulley)* immersive.

Barriers to hearphone/audio label use

The purpose and function of the hearphones were not always clear to visitors.

Some visitor behavior suggested they felt a disconnect between what visitors expected the hearphone buttons to do and how they actually functioned. For example, Tom's mother pressed hearphone buttons but did not pick up the hearphone to listen to the information, suggesting that she did not understand the purpose of those buttons. Jermaine, a visitor impacted by ASD, also showed some confusion about the purpose of the buttons that operated the hearphones. He thought that pressing the hearphone's square button would also start the *Behind the Scenes* video he was using. Cedric, a child impacted by ASD, also experienced challenges when he tried to listen to the hearphone while following along with the captioned text at a video exhibit. He noted that he could not find the right place in the text, as the audio label provided through the hearphone was not synced with the video. This kind of disconnect could lead to visitor frustration, if their expectations led to a perception that the exhibit was broken or malfunctioning.

At times, hearphones caused a barrier to social inclusion and physical access.

The hearphone's handset only allowed one visitor in a group to listen in to audio at a time. Thus, listening to an audio label was an individual experience, causing challenges for groups who wanted to spend time together and share experiences in the exhibition. For example, Ronald noted that he sometimes missed out on conversations or on information because he was listening to the hearphone, stating: *"Sometimes I was trying to listen to exhibit audio and [my wife] and the guide were talking; it was hard to hear. It would be good if you had a pause button."* His companion suggested that it would be good to have *"multiple feeds [of sound]. I liked the ones that played out loud…"* Based on the feedback and preferences of multiple visitors, it appeared that some would have wanted the ability to customize aspects of the audio labels.

When visitors' hands were occupied by using the hearphones, their ability to physically interact with the exhibit was limited, as one of their hands needed to be occupied by the hearphone. Visitors from a couple of groups expressed a preference for broadcast audio, which would enable both hands to be free for exhibit interactions. For example, Cody's mother noted that she *"[would have wanted] more audio to be able to hear aloud, have your hands free; [One is] not able to operate [the exhibit otherwise]."*

Some visitors experienced barriers related to audio volume and speed in SBP.

Five (of 18) groups found the hearphone audio to be inconsistent (i.e., louder or softer) across exhibits. For example, Mitchell, a child with William's Syndrome, found the audio too loud at *Virtual Lighting Workstation*, while Ronald struggled to hear the audio at the *Modeling (Buzz Lightyear)* immersive. Ronald, a visitor who was blind, felt that sometimes the audio volume was overall too quiet, while other times group members talking around him made it harder for him to hear. Marcia, a visitor with sensory processing disorders, often listened to broadcast audio at the videos during her visit. She was not able to hear the video's audio in the Rendering cluster due to another group's loud, social interaction at *Rendering Workstation*. Additionally, Tom's father felt the hearphone directions were spoken too quickly. He had to listen to the audio twice in order to understand the options.

Hearphones were particularly challenging for visitors who were blind or had low vision.

The audio labels provided audio description intended for visitors who are blind to support their experiences with the exhibition's content. However, hearphones and audio description presented some challenges for visitors who were blind. Some visitors who were blind experienced difficulty locating the hearphones and the buttons. For example, June was unable to find hearphones at several exhibits, including the *Rigging (Mike and Sulley)* immersive and *Lighting Design Basics*. Maggie, who had low vision, noted that *"if I were totally blind, I wouldn't know what either button was for [on the hearphones]."* Without orientation from a sighted guide or group member, some of these visitors may not have known that the audio labels and audio description existed, or how to use them. Another example is Eugene, who had multiple issues with the hearphones. He did not know the difference between the square and triangle buttons, and he wanted the hearphones to start playing automatically. While he liked the types of information that the audio labels provided, he did not favor the ordering of information, preferring to have the physical description first. Overall, he did not feel that the information he took away from the exhibition provided a cohesive picture about Pixar Animation Studios and their process.

SPECIFIC MULTIMODAL REPRESENTATIONS: TOUCHSCREENS

Due to interests of the *SBP* development team, findings related specifically to touchscreens have been grouped into their own section. The following section highlights affordances and challenges that several visitors with disabilities experienced using touchscreens as a multimodal representation. Some of the information included below is repeated from the main sections above.

Aspects that particularly supported touchscreen use and engagement included:

- Touchscreen-based activities were engaging for some visitors.
- Touchscreen-based exhibits facilitated social experiences for several visitors.
- Exhibit controls on touchscreens were physically accessible to most visitors.
- Touchscreens were not intuitive for all visitors, although many were eventually able to figure out how to interact with the interface.

Touchscreens caused some challenges in the following ways:

- Some visitors had difficulties using touchscreens and were not successful in figuring out how to use them.
- Touchscreen-based activities were not physically accessible for visitors who were blind.
- Touchscreens without multi-touch functionality did not work when multiple visitors tried to use them simultaneously.

Facilitators to touchscreen use

Touchscreen-based activities were engaging for some visitors.

Touchscreen activities worked well for some visitors. For example, Bobby, a 10-year-old impacted by ASD, engaged for extended periods of time with several touchscreen-based activities during his visit, spending more than eight minutes at *Set Layout Workstation* and more than five minutes at both *Programming Natural Variety* and *Surface Appearance Workstation*. These extended dwell times suggest that he was highly engaged by these experiences. Additionally, Cody and Milton, who had cognitive disabilities, were supported by their mothers to relate *Virtual Modeling Workstation* to Minecraft. Cody's mother noted that *"without Minecraft, [Cody and Milton] would have not known half of the stuff to do."* At this component, exhibit controls evoked familiar software or tools that supported these two visitors with disabilities to engage with exhibit content. These visitors were able to relate the touchscreen exhibit content to personal experiences and interests.

Touchscreen-based exhibits facilitated social experiences for several visitors.

Overall, most *SBP* exhibits provided for social experiences. These experiences were not exhibit-specific, but rather encouraged by most exhibits in *SBP*. *Programming Natural Variety* and *Surface Appearance Workstation* were two of the touchscreen exhibits where multiple visitors shared positive social experiences. For example, at *Surface Appearance Workstation,* Jermaine's mother explained animation concepts behind each part of screen. Then, Jermaine, his mother, and his cousin worked together using the controls of the exhibit. At *Programming Natural Variety*, Bobby, a child impacted by ASD, and his Big Brother collaborated to complete the exhibit challenge.

Exhibit controls on touchscreens were physically accessible to most visitors.

The exhibition team tested several strategies for maximizing the physical accessibility of exhibit controls and parts in terms of reach. Overall, the team's strategy of locating controls within a horizontal band on the lower section of the touchscreens worked effectively: most visitors could reach exhibit controls and parts. For example, Mitchell, a child with William's syndrome, had no problem independently using the controls at *Virtual Lighting Workstation*. Cody, who experienced cognitive disabilities, could easily select buttons and controls at *Arm Rigging Workstation*.

Touchscreens were not intuitive for all visitors, although many were eventually able to figure out how to interact with the interface.

Touchscreen-based exhibits often included a number of different steps for interacting and a number of different types of controls. The flexibility of touchscreens enables the design of interactives with a great range of flexibility and creativity, which many visitors appreciated and used effectively. Touchscreens were not intuitive for all visitors, but some visitors used different strategies to successfully engage with them.

At first, Walter, a 12-year-old with physical and cognitive disabilities, tried to control the upper part of the screen that did not have a touchable function on *Surface Appearance Workstation*. Despite this initial confusion, he was able to use the controls to match and create unique surfaces. Jay, a child impacted by ASD, initially had trouble understanding *Computer Animation Workstation*. Instead of hitting the play button, he was trying to move the line on the graph. After reading through the instructions and controls, he figured out where the play button was located and what the exhibit was trying to show.

Challenges of touchscreen use

Some visitors had difficulties using touchscreens and were not successful in figuring out how to use them.

As stated above, touchscreen exhibits offered visitors flexibility and creativity through their interface. Because of this complexity, some visitors were unable to successfully engage. To illustrate this point, this section will describe the expansive capabilities for two touchscreen exhibits and provide examples of how they were challenging to particular visitors. These examples show how the complexity of touchscreen use may have impeded visitors' use of the engaging or helpful parts of exhibit components.

Set Layout Workstation had layered menus of controls that enabled visitors to decorate a room from the movie *Monsters University*. Touchscreen controls enabled visitors to add, copy, or remove objects; adjust the scale of each object; adjust the position of each object in a 3D scene; and adjust the rotation of the object along a single axis. To review the room's décor and arrangement, the touchscreen had a set of controls to allow visitors to adjust their perspective. The "More Info" icon provided detailed information about the process of designing sets for visitors who were interested. When interacting with this exhibit, Milton had trouble understanding how to use the virtual sliders, icons, and control panel. He tried moving an object while the controls were in scale mode. Milton got frustrated and started banging his fist on the physical structure. He ended up leaving the exhibit to watch his friend.

Programming Natural Variety also offered a range of functionalities that gave visitors the opportunity to explore and adjust variables to create a field of grass. This touchscreen exhibit included onscreen "sliders" that could be adjusted left or right to control each different variable. Visitors could adjust these controls and test their program settings by tapping the "Generate" button, which would produce a field of grass matching their selections. Visitors could swipe their finger across the screen to examine their field of grass from different angles. This exhibit also included a “More Info” icon that shared more about the math and programming behind variables. Judith, a visitor who is deaf, had trouble using *Programming Natural Variety* because she did not discover the functionality of some of the features and therefore could not effectively understand how to use the exhibit. She adjusted the variables onscreen, but did not press the “Generate” button to see the results of her adjustment. She also did not figure out that the screen perspective could be changed. Even though she read the directions and looked at the screens of adjacent visitors, Judith was unable to grasp the point of the activity or figure out how to use the exhibit.

Touchscreen-based activities were not physically accessible for visitors who were blind.

Visitors who were blind were not able to access touchscreen controls because they did not know what was selected when touching the screen. For example, June shared *“for some of the touchscreen ones, [I] wasn't sure if I was touching it in the right place.”* She and other visitors who were blind or had low vision suggested that accessible touchscreen technology, such as audible feedback in response to touch, would have improved the accessibility of these experiences for them.

Touchscreens without multi-touch functionality did not work when multiple visitors tried to use them simultaneously.

One issue that caused some confusion at the touchscreen activities was that multi-touch was not supported. As such, when two users tried to use the touchscreen at the same time or when a visitor tried to do multiple actions at the same time, the touchscreens could seem unresponsive. For example, Cody and Milton had difficulty using the touchscreens together. Multi-touch issues affected how responsive the screen was for their group. At times, one of them would work individually, while the other watched. This was also an issue for Bobby, who was impacted by ASD, when he started using *Surface Appearance Workstation* and tried adjusting multiple controls at the same time.

OVERVIEW OF FINDINGS

The following tables list the main findings from the previous sections.

Who attended *SBP* and why?	
Public	• *SBP* attracted its target age range (8 and older) and drew in higher proportions of older children in comparison to non-*SBP* visitors.
	• While demographics were similar between *SBP*-attending and non-attending groups, the exhibition drew in less frequent visitors to the Museum.
	• *SBP*-attending groups came to the Museum primarily to spend time as a group or family and to see the exhibition. Many also expected to learn about Pixar Animation Studio's process for animation.
School	• The majority of *SBP*'s school audience consisted of middle or high school classes, as well as classes led by math or technology/engineering teachers.
	• The opportunities to make content connections to classroom curricula and for students to learn about careers and the relevance of STEM motivated teachers to plan field trips to *SBP*.
	• Students were expected to learn about the animation process, computer science, technology, and have a hands-on experience.

How do diverse groups and individuals interact with and respond to different types of exhibits and features?	
Public	• Using criteria defined by Beverly Serrell (2010), *SBP* was an "exceptionally-thoroughly-used" exhibition.
	• Groups varied the extent in which they engaged in different types of *SBP* experiences.
	• *SBP* provided a social atmosphere that encouraged discussion.
	• Usage patterns of different multimodal representations used throughout the exhibition varied by group type.
	• Overall, visitors tended to value exhibition components for their enjoyment, engagement, and content.
School	• Patterns of exploration varied by student, suggesting that *SBP* created a self-directed learning experience for a range of learners.
	• Students used interactive and immersive exhibits throughout the exhibition.
	• Most students used tactile features and hearphone-based audio labels as part of their exhibition experience, suggesting the importance of multimodal representations for student engagement.
	• Most students engaged socially with classmates during their visits to *SBP*, both during and in-between exhibits.

What did visitors learn from attending *SBP*?	
Knowledge and Awareness	Public • Virtually all interviewed groups within the target age range demonstrated awareness or understanding related to the exhibition's learning goals. • The majority of visitors who referred to STEM careers and jobs had watched a *Working at Pixar* video. School • Students exhibited increased awareness of STEM's role and the steps involved in computer animation. • Gaining knowledge about animation and Pixar Animation Studios was an interesting and memorable part of the student experience.
Skills	Public • While not an explicit goal during the exhibition's development, many public visitors engaged in aspects of the design process and recognized the resilience, work ethic, and other characteristics of Pixar Animation Studio employees. • Public audiences who saw *SBP* had a stronger understanding of how programmers approach problem solving than those who had not yet seen the exhibition. School • High school students' beliefs about the creative agency of programmers were more strongly positive after their field trip. Otherwise, student understanding of the skills involved in programming were generally similar before and after attending *SBP*. After their visit, high school students agreed more strongly that programmers can create almost anything they imagine. • Some students offered comments that suggested they had engaged in STEM and computer science practices during their visit.
Attitudes and Perceptions	Public • Visitors surveyed after seeing *SBP* had higher levels of interest in math, computer programming, and animation, compared to equivalent groups surveyed just before they entered the exhibition. • After attending *SBP*, visitors had a stronger appreciation of the importance of knowing how to do programming. • After seeing *SBP*, visitors had lower self-efficacy for computer programming than visitors who had not yet seen the exhibition. • Groups' comments suggested that most adult-only groups, and some groups with children, felt the exhibition inspired interest in STEM and related careers. School • After attending *SBP*, the majority of students reported some positive changes in their perceptions of and interest in animation, math, or computer programming. • Compared to their views before attending the exhibition, elementary and middle school students agreed more strongly after attending *SBP* that programming is useful for many careers. However, no significant changes in attitudes and beliefs about math were observed. • After attending *SBP*, elementary/middle school students agreed more strongly that programming is useful for many careers. Students in all grades exhibited some increased interest and inspiration in pursing these careers. • High school students demonstrated positive changes in self-efficacy for computer programming after attending *SBP*.

How did educators connect *SBP* to standards and classroom learning, before, during, and after the Museum visit?
• Educators planned to connect *SBP* to STEM and art curricula.
• Students were able to make connections between the exhibition and their STEM classwork.

How did visitors feel about their experience at *SBP*?	
Public	• Overall perceptions of *SBP* were high and were associated with visitors' positive, interactive, and educational experiences.
	• Different visitor groups expressed their positive impressions of *SBP* in varying ways; children considred the exhibition "fun" while adults said it was "interactive."
	• Specific exhibits and the exhibition's interactive opportunities resonated with visitors as the most memorable and interesting parts of *SBP*, though no single exhibit emerged as the most iconic.
School	• Educators recommended *SBP* and valued its clear classroom connections and hands-on, cognitively engaging exhibits.
	• Students' immediate reactions to *SBP* focused on learning about animation and Pixar Animation Studios or enjoying specific exhibits.
	• Students remembered the interactivity, ability to create and build, topic of animation, and specific exhibits as the best parts of their *SBP* experiences.

How did different exhibition design features impact the social, physical, and cognitive experience for visitors, especially visitors with disabilities?	
Content and relevance	• Familiar content and imagery fostered engagement and relevance. • The variety of experience types used in the exhibition provided a range of ways for visitors to engage with content. • Multiple multimodal representations at each exhibit supported visitor engagement with the content. • Most visitors with disabilities who participated in the summative evaluation gave high ratings for their likelihood to recommend the exhibition to friends or colleagues. • Exhibition content may not have appealed to all visitors.
Physical access and reach	• Tactile features were accessed by nearly all groups of visitors with disabilities who participated in the summative evaluation. • In most cases, the location and function of exhibit controls were within reach and most physical controls seemed easy to manipulate. • The bases of some immersives and Pipeline created barriers to access and reach for some visitors. • In some cases, exhibit controls were not within reach or easy to manipulate. • In a few instances, limited contrast on images and small images or font sizes restricted access for a visitor with low vision. • Touchscreen-based activities were not physically accessible for visitors who were blind.

	• The use of the hearphones introduced physical barriers to access, and for visitors who were blind, the hearphones and their buttons were sometimes difficult to find.
Comfort	• The volume, clarity, height, and placement of videos in the exhibition were comfortable for visitors. • The availability of stools, footstools, and places to lean helped some visitors and their groups feel comfortable. • Some visitors experienced barriers related to hearphone volume and narration speed in *SBP*. • Certain exhibit effects and an absence of quiet spaces made *SBP* uncomfortable for some visitors, particularly those sensitive to overstimulation, emotion, and light. • The absence of bathrooms in the exhibition made some visitors uncomfortable.
Social inclusion and independence	• The open layout provided opportunities for visitors to learn from one another. • The open-sided exhibits provided opportunities for groups to interact. • Side-by-side copies of the same exhibit supported both independence and social collaboration. • Multiple approaches for delivering content provided a variety of ways for visitors to engage together. • Content and picture-taking with familiar characters fostered social behaviors. • Simple, intuitive, easy-to-use exhibit controls and instructions supported independent engagement. • Hearphones only allowed one visitor to listen at a time, precluding the opportunity for shared engagement with these exhibit features. • Touchscreens without multi-touch functionality did not work when multiple visitors tried to use them simultaneously. • Visitors who were blind or had low vision were unable to use many aspects of the exhibition independently.
Wayfinding	• The intro theater film helped to orient visitors to *SBP*, while the Rendering cluster provided a helpful culmination to the experience. • Repeated experience types used throughout the exhibition served as visual cues that supported wayfinding. • Additional orientation at the start of the exhibition could have helped visitors who were blind understand and use *SBP* more effectively. • The non-linear organization of *SBP* was appreciated by some visitors but posed navigational challenges for others.
Specific multimodal	• Hearphones were easy to operate and used by a variety of visitors. • Some visitors appreciated the type of information provided by the hearphones.

representations: Hearphones	• Hearphones facilitated independence for some visitors. • The purpose and function of hearphones were not always clear to visitors. • At times, hearphones caused a barrier to social inclusion and physical access. • Some visitors experienced barriers related to audio volume and speed in *SBP*. • Hearphones were particularly challenging for visitors who were blind or had low vision.
Specific multimodal representations: Touchscreens	• Touchscreen-based activities were engaging for some visitors. • Touchscreen-based exhibits facilitated social experiences for several visitors. • Exhibit controls on touchscreens were physically accessible to most visitors. • Touchscreens were not intuitive for all visitors, although many were eventually able to figure out how to interact with the interface. • Some visitors had difficulties using touchscreens and were not successful in figuring out how to use them. • Touchscreen-based activities were not physically accessible for visitors who were blind. • Touchscreens without multi-touch functionality did not work when multiple visitors tried to use them simultaneously.

CONCLUSION

The Science Behind Pixar (*SBP*) summative evaluation aimed to do the following:

- Determine how and to what extent the exhibition met the exhibition designers' goals
- Gain a better understanding of audience behavior, interest, attitudes, and values associated with their decisions to attend the exhibition
- Assess how and to what extent different features of the exhibitions worked for different audience groups
- Inform future exhibit development

The following sections look across the exhibition team's goals and evaluation questions to summarize main themes. These themes are organized into exhibition strengths and areas for potential growth. This section ends with reflections on lessons learned for future exhibitions and evaluation studies.

STRENGTHS

Data gathered from the general public showed that *SBP* was successful in attracting the target age group of people who are 8 and older. These groups visited *SBP* due to an interest in iconic Pixar Animation Studio movies and computer animation. Groups with youth of ages 8 and older particularly valued exhibits that encouraged creativity. In addition to the target age group, *SBP* drew a range of families, students, and visitors with disabilities.

Findings from general public visitors and school groups suggested that no single, iconic exhibit defined *SBP*. As a 13,000 square foot exhibition with over 50 experiences, it is useful to know that all visitors' experiences did not depend on any single exhibit. Nearly every interactive exhibit was mentioned as a favorite by at least one visitor. Additionally, immersive characters located in each of the exhibition clusters seemed to encourage visitors to move around the full exhibition. Findings suggested that the exhibition's design and variety in types of experiences encouraged self-led exploration and social engagement for a range of audience types and preferences. As a result, visitors seemed to engage with all exhibit types, resulting in *SBP* meeting the standards of an "exceptionally-thoroughly-used" exhibition.[86]

Evaluation indicated that the exhibition effectively promoted learning about STEM's role in the animation process, particularly for general public groups and students. It suggested that the exhibition was successful in meeting its learning goals. Comments from visitors in the evaluation indicated that audiences learned how professionals create animated movies, as well as what characteristics and skills these professionals possess in order to be successful. Public audiences' interests in computer programming increased after visiting the exhibition, and these groups became more aware of how programmers break down problems using problem decomposition.

[86] Beverly Serrell (2010) has established benchmarks for "exceptionally-thoroughly-used" exhibits, which include the following two independent indicators: The square footage of exhibition area visited per minute of average stay time, a quantity known as the "Sweep Rate Index;" and the percent of "diligent visitors," defined as visitors who engage with more than half of the available exhibit experiences. An "exceptionally-thoroughly-used" exhibition includes a Sweep Rate Index lower than 300 and a percent of diligent visitors of 51% or higher.

This finding about problem decomposition is exciting because it suggests that visitors learned about a process that was potentially unfamiliar to them upon entering the exhibition. It also shows that visitors learned about the people behind the movies they know and love, as well as problem-solving skills that these professionals use. Ideally, visitors can apply these skills to other contexts. This finding also relates to STEM skills and the habits of mind that MOS is aiming to promote through future exhibits. It is the hope that MOS can draw from practices that worked well in *SBP* to support visitor behaviors associated with different habits of mind.

Educators' reactions and uses of *SBP* were important to understanding the exhibition's impact on school group audiences. The exhibition design team referred to the national Next Generation Science (NGS) standards to inform the exhibition's STEM content. Accordingly, this evaluation indicated that *SBP* attracted educators who taught science, math, computer science, and engineering. Additionally, *SBP* drew art teachers, suggesting that the exhibition opened an avenue for school group audiences not typical of the MOS demographic.

This summative evaluation maintained that effort put forth to connect *SBP* content to NGS standards mirrored educators' goals, values, and motivations. Educators shared that they wanted to use *SBP* in their classrooms to supplement STEM curricula, and student post-exhibition surveys provide evidence that students were successful in making those classroom connections. This suggests that educators recognized the parallels between national science standards and the exhibition, and that there is some alignment between educators' intentions and student takeaways related to STEM learning. Educators who visited *SBP* repeatedly identified *SBP*'s connections to their STEM curricula, examples of real-life relevance of STEM, interactive design, and cognitively engaging exhibits as reasons for visiting, recommending, and valuing the exhibition. Teachers who provided positive feedback and said they were likely to recommend the exhibition explained that *SBP* connected to STEM and art concepts generally, or within the contexts of the subject(s) they teach. They also recognized that Pixar animation is an application of STEM and art that was relevant to their students' lives and that the underlying STEM concepts were applicable to potential careers. Finally, this evaluation posited that educators valued that the exhibition was interactive, in that it was physically engaging for their students, and cognitively engaging, in that they were confident that students would learn a great deal about and be interested in the content.

The Museum of Science (MOS) has a strong commitment to accessibility, and exhibition designers continued to revise their past standards in *SBP.* This study highlighted that *SBP's* design and content supported visitor engagement through varied types of experiences, such as large-scale immersives, interactive exhibits, videos, and educator-led experiences. It was also found that multimodal representations at each exhibit, such as graphics, audio labels, tactile models, and kinesthetic experiences helped visitors' access similar content in different ways. Evaluation findings show that these supports enabled visitors with disabilities to learn and make personal connections to exhibition content. *SBP* design and content supported social inclusion across the exhibition through its open-layout, open-sided exhibits, and side-by-side copies of the same activity. These strategies encouraged parents and children to work together, discuss exhibit content, and take photos with familiar characters.

SBP is a traveling exhibition that is scheduled to tour for the next 10 years. As such, the *SBP* summative evaluation looked at visitor demographics, engagement, and learning at MOS and the Franklin Institute. Analysis indicated that in general the exhibition performed consistently at both sites. It is the hope that the exhibition's accessible design and pedagogical considerations will continue to support broader audiences with backgrounds potentially different from those in the Greater Boston Area.

AREAS FOR IMPROVEMENT

The *SBP* exhibition influenced visitor learning and perceptions in a variety of ways, but there were some areas where public audiences and students exhibited little change. Students showed little change in their perceptions of the usefulness of, importance of, or creativity in math and computer programming. Moreover, the exhibition was less successful in convincing students to use, appreciate, and pursue math as a career, in comparison to animation and computer programming. Overall, *SBP* was comparatively less impactful in increasing student excitement for math, as opposed to animation and computer programming. Future exhibition developers may consider revisiting math as a key STEM topic, and develop or build on the educational strategies used in *SBP* to better evoke positive perceptions of math in student audiences.

Feelings of self-efficacy for computer programming also differed across visitor groups. Analysis indicated that efficacy for general public audiences decreased and E/MS students' efficacy did not show any change. Alternatively, HS efficacy increased slightly. HS students also indicated a significantly positive change in their perception that programmers can create anything they imagine. These findings suggest that HS students made a creative connection about the agency of programmers, and this could have made them feel more confident in their own abilities. The public visitor audience's decrease in efficacy may have been influenced by their heightened awareness of the complexity of computer programming in animation, and this may have made them question the true capacity of their abilities. However, as with the E/MS students, their interest in computer programming increased. In future exhibition construction, developers may continue to explore the balance between feeding visitors' interest in learning in-depth, complex content, while encouraging them to realize that they have similar capabilities and agencies to those of STEM professionals.

In terms of accessibility, multimodal representations provided a variety of ways for visitors to engage with the exhibition. Two methods, hearphones and touchscreens, were given particular attention when developing *SBP*. Overall, hearphones were easy for most visitors to operate and they also facilitated independent experiences for different types of visitors, especially visitors with cognitive disabilities or ASD. However, the purpose of the hearphones and their controls were not always clear to visitors. At times, hearphones caused barriers to social inclusion in the exhibition because only one individual could listen at a time. Hearphones were particularly challenging for visitors who were blind or had low vision, who were considered a key audience for this multimodal representation. Visitors who were blind or had low vision shared that they needed greater orientation as to the existence of hearphones at exhibits and more information about the location and/or function of their controls.

Touchscreens were another complicated multimodal representation applied across several interactive exhibits. Many visitors found activities with touchscreens to be engaging and the format of situating the control panel along the bottom half of the screen allowed for more visitors to physically access and easily manipulate exhibit controls. Touchscreen functions were not intuitive to all groups, but many were able to engage with the activity after a brief exploration period. Despite these successes, touchscreens caused issues for visitors with cognitive disabilities, visitors who were blind or had low vision, and a visitor who was deaf. Some controls were complex to understand and the lack of multi-touch made it complicated for groups to work together. The touchscreens were also not accessible to visitors who were blind because they provided no audio or tactile feedback when these visitors interacted with the screen. It appears that when these two multimodal representations, hearphones and touchscreens, are used in future exhibitions, more thinking could go into how these strategies support and/or hinder visitor experiences.

LESSONS LEARNED FROM EXHIBITION DEVELOPMENT

When creating new exhibitions, the Museum recognizes that these large-scale projects advance staff knowledge, promote technology use, and inspire new design strategies. MOS is experienced in developing large-scale traveling exhibitions; for example, the *Star Wars: Where Science Meets Imagination* (*SW*) exhibition was another MOS-created exhibition that toured around the country for a decade. Developing *SW* helped exhibition designers consider new exhibit possibilities for *SBP*. *SBP* has already informed other recent exhibitions at the Museum, such as the *Yawkey Gallery on the Charles River*. As a traveling exhibition, the original copy is touring across the United Sates for the next five to ten years, and a second copy of the exhibition will start to tour Canada in summer of 2017. A main purpose of conducting the summative evaluation of *SBP* was to document lessons learned for future traveling exhibitions. The section below includes lessons learned from studying *SBP* through a summative lens, as well as the exhibition team's lessons learned from the exhibition development process. These reflections are important to record, as they speak to how the exhibition's design and pedagogical strategies impacted visitor experiences, in addition to how well the Museum integrated new or innovative practices into the process of developing *SBP*.

Lessons learned from summative evaluation findings:

- Exhibition pedagogy & design: The *SBP* structure organized the content by thematic clusters, which allowed visitors to dictate their own paths through the animation process. *SBP* incorporated large-scale immersives into each cluster that excited visitors and provided them with opportunities for social engagement. Evaluation indicated that these characters appealed to visitors of all ages, and drew most groups to all corners of the exhibition. Additionally, varied types of experiences within each cluster focused on the content for the corresponding theme. This design provided visitors with opportunities to access similar content through the types of experiences that worked best for them. Final design and pedagogy decisions in *SBP* were informed by visitor prototyping throughout the development process. The Museum's thoughtfulness toward pedagogy and design earned the exhibition a 2016 Leading Edge award for Visitor Experience from the Association of Science and Technology Centers.

- Accessibility: MOS used this exhibition to continue pushing their standards in accessibility and universal design. A new touchscreen design was created during *SBP*, which allowed visitors to easily reach the controls for each activity. The Museum also debuted a new audio label strategy that let visitors to skip to sections that interested them. For some visitors, this strategy allowed for more independent experiences, while visitors who were blind or had low vision would have benefited from greater orientation to the hearphones and their controls. These new strategies, although not perfect, showed promise with regards to inclusion of audiences with a range of abilities and disabilities and could be used as starting places for accessibility in future exhibit design at MOS or other museums.

- Reflecting on self-efficacy: Feelings of efficacy for computer programming differed across visitor groups, but two audiences showed a decrease or no change in this measure. Increased feelings of self-efficacy is one area where the *SBP* exhibition did not meet its intended goals. Self-efficacy is important to MOS and the organization looks forward to exploring what about the exhibition may have caused decreases or lack of change in self-efficacy, as well as what the Museum can learn from this experience so that new strategies can be applied to future exhibits.

The exhibition team's lessons learned from developing *SBP*:

- Partnerships: *SBP* was primarily created through a partnership between MOS and Pixar Animation Studios. Partnerships are valuable to the Museum's design process because they push our thinking around exhibit development. For *SBP*, the partnership between MOS and Pixar Animation Studios helped the Museum think deeper about STEM in animation, including computational thinking, and then how to present this type of content in a museum setting. Partnerships support the Museum to look outside its own expertise and leverage the expertise of others. As a result, they can work together to produce exciting and innovative exhibitions.

- Iterative development process: When developing this exhibition, MOS used an iterative design process that employed the repeating procedure of designing, building, testing, and redesigning exhibit ideas and components. As such, exhibits underwent this iterative design process and were tested with visitors representing a range of abilities and disabilities. This process, although time-intensive, was important to the development team because it ensured that the best versions of exhibits were produced for the *SBP*. As a traveling exhibition, this process is important for ensuring that exhibits will support a range of visitors in the Greater Boston Area, as well as in other communities across the world. In 2016, *SBP* won an Excellence in Exhibitions award for special achievement in the planning process from the American Alliance of Museums. The Excellent in Exhibition committee awarded this honor to the Museum for the level of evaluation, prototyping, universal design planning, and planned layering of content that produced an interesting and engaging exhibition.

- Research: Alongside *SBP's* development process, MOS received a grant from the National Science Foundation to study computational thinking strategies. Through this grant, the *SBP* team was able to design and study exhibits aimed to build computational thinking capacity in visitors. The grant specifically focused on ways in which learners break down complex problems. This research project helped the Museum learn more about design elements that scaffold novice learners to use more sophisticated strategies used more frequently by experienced programmers. As the Museum builds expertise in this area of study, findings from this research may inform the Museum's future thinking around computational thinking strategies in informal learning environments.

- Marketing: MOS developed marketing materials that thoughtfully reflected the intended messages of the exhibition. These materials have been shared with other sites hosting the exhibition, and those sites have found these materials to be of high quality and useful for promoting the exhibition in their own communities.

REFLECTIONS ON THE EVALUATION PROCESS

SBP was a complex exhibition with an elaborate evaluation plan. This study entailed a great deal of data collection, such as surveys, timing and tracking, and interviews, in addition to multi-site data collection. It also entailed data analysis that looked within and across different audience groups and experiences. Below are several reflections from the evaluation team about how the evaluation process worked for *SBP* and recommendations for using these methods in the future:

- Sampling: The summative evaluation aimed to gather data from a range of visitor demographics and group types. It was important to vary times of day for data collection, as well as collect on weekdays and weekends. This strategy was useful because it helped evaluators sample across a range of exhibition users so that exhibition feedback represented varied visitor perspectives.

- Defining exhibit elements and visitor behaviors: *SBP* included a range of experience types and exhibit features. It was important to define exhibit types, their different features, and associated visitor behaviors in order to streamline the tracking and timing process across four data collectors. To do this, data collectors conducted team practice sessions before data collection began in order to discuss instrument categories and potential areas of confusion.

- Flash interviews: One data collection method that worked well for school groups was the flash interviews that data collectors conducted at the end of each school group's visit. These flash interviews consisted of two quick questions, which helped the evaluation team learn initial student impressions from the exhibition, without holding up their field trip group. Due to its success in the *SPB*, this strategy has already been incorporated into data collection for other projects at MOS.

- Instrument length: The post-exhibition survey pushed the limit on how much time visitors were willing to spend on giving feedback after their experiences. This survey was 1.5 legal-sized, double-sided pages, and too long for visitors. Visitors often skipped the last page, limiting the robustness of the data set. Moving forward, it is important to make sure that all questions are relevant and have a clear purpose for the evaluation.

- Multi-site studies: Multi-site data collection was logistically complicated. Before data collection took place, coordinating collection strategies in a new location required months of additional planning. Data collection itself entailed traveling to the Franklin Institute twice for long weekend sessions. Analysis of a second data set was also time-consuming and, at times, difficult to incorporate into the final report. Overall, data collection at the Franklin Institute was useful in making rich comparisons across sites, but it was highly time-intensive for the evaluation team. For future evaluation projects, preliminary discussions about collecting multi-site data should include clearly articulated goals for data collection, as well as potential strategies for integrating the data once collected.

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APPENDIX A: VISITOR DEMOGRAPHIC SURVEY

Thank you for attending *The Science Behind Pixar*. Please complete this brief survey about your visiting group. Your response will be anonymous.

1. **Please list the genders and ages of your group members. <u>Please list yourself first.</u>**

Gender	Age	Gender	Age	Gender	Age	Gender	Age

2. **Why did you decide to visit the Museum today? [<u>select all that apply</u>]**

- ❒ To see *Science Behind Pixar*
- ❒ Something to do at the Museum
- ❒ Something to do in poor weather
- ❒ Had a coupon/free pass
- ❒ Something to do while visiting Boston
- ❒ To spend time together as a group/family
- ❒ For fun/entertainment for myself
- ❒ To see an exhibit, program, or show (other than *Pixar)*
- ❒ To bring out of town friends/family
- ❒ Educational experience for group members/children
- ❒ Educational experience for myself
- ❒ For fun/entertainment for group members/children
- ❒ Other: Please specify: ____

3. **Are you a Museum of Science member?**

❒ Yes ❒ No

3a. If yes, how long have you been a member?

- ❑ Just became a member today
- ❑ Less than 1 year
- ❑ 1-2 years
- ❑ 3-5 years
- ❑ 5 or more years
- ❑ Not sure

4. **Prior to this visit, when was the last time you visited the Museum of Science?**

- ❑ Within the past three months
- ❑ 3-6 months
- ❑ 6 months to within the last year
- ❑ 1-2 years ago
- ❑ 2-5 years ago
- ❑ 5-10 years ago
- ❑ More than 10 years ago
- ❑ Never
- ❑ Not sure

5. **Do you or anyone you are visiting with have a permanent or temporary disability?**

❒ Yes ❒ No

6. **What is your race or ethnicity? ____________________**

7. **What is your ZIP code? ___________**

APPENDIX B: PRE-EXHIBITION SURVEY, VISITOR

We hope you enjoy your visit to *The Science Behind Pixar!*
Please complete this brief survey to help us improve our future exhibits and programs.
Thank you for sharing your thoughts with us!

1. Please rate your interest in each of the following topics.

	Not at all interested	**A little** interested	**Somewhat** interested	**Very** interested
Learning about animation.	❐	❐	❐	❐
Learning about computer programming.	❐	❐	❐	❐
Learning about math.	❐	❐	❐	❐
Creating my own animations.	❐	❐	❐	❐
Creating my own computer programs.	❐	❐	❐	❐
Using math in my own creative projects.	❐	❐	❐	❐
Doing animation as part of my career.	❐	❐	❐	❐
Doing computer programming as part of my career.	❐	❐	❐	❐
Doing math as part of my career.	❐	❐	❐	❐

2. **Please rate the following statements based on your beliefs about math and computer programming.**

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
Knowing how to do computer programming is useful in many careers.	❐	❐	❐	❐	❐
There is a lot of creativity involved in computer programming.	❐	❐	❐	❐	❐
There are many different ways to solve any given computer programming problem.	❐	❐	❐	❐	❐
Computer programming is one of the most important subjects for people to know.	❐	❐	❐	❐	❐
Computer programmers can create almost anything they imagine.	❐	❐	❐	❐	❐
When solving a problem, computer programmers break it into smaller parts and solve them one at a time.	❐	❐	❐	❐	❐
Mathematics is one of the most important subjects for people to know.	❐	❐	❐	❐	❐
Knowing how to do math is useful in many careers.	❐	❐	❐	❐	❐
There is a lot of creativity involved in math.	❐	❐	❐	❐	❐

Use the scales from 0-10 to answer the following questions.

3. **Do you think you could write brand new programs or software (like apps for smartphones or tablets)**

3a. …if you took the right classes in school?
0 1 2 3 4 5 6 7 8 9 10
No way — Definitely

3b. …if you could ask an expert or use a manual for help?
0 1 2 3 4 5 6 7 8 9 10
No way — Definitely

3c. …with no manual or outside help?
0 1 2 3 4 5 6 7 8 9 10
No way — Definitely

4. **What do you hope to see, do, or learn in *The Science Behind Pixar***

OVER

Group Demographics

Please answer the following questions about your visiting group.

1. **List the genders and ages of your group members. <u>Please list yourself first.</u>**

Gender	Age	Gender	Age	Gender	Age	Gender	Age

2. **Why did you decide to visit the Museum today? [Please select two that best apply.]**

- ❒ To see *Science Behind Pixar*
- ❒ Something to do in poor weather
- ❒ Had a coupon/free pass
- ❒ Something to do while visiting Boston
- ❒ To spend time together as a group/family
- ❒ Fun/entertainment for myself
- ❒ To see a specific exhibit, program, or show (other than Pixar)
- ❒ To bring out of town friends/family
- ❒ Educational experience for group members/children
- ❒ Educational experience for myself
- ❒ Fun/entertainment for group members/children
- ❒ Other: Please specify: ______________________________________

3. **Are you a Museum of Science member?**

❒ Yes ❒ No

3a. If yes, how long have you been a member?

- ❑ Just became a member today
- ❑ Less than 1 year
- ❑ 1-2 years
- ❑ 3-5 years
- ❑ 5 or more years
- ❑ Not sure

4. **Prior to this visit, when was the last time you visited the Museum of Science?**

- ❑ Within the past three months
- ❑ 3-6 months
- ❑ 6 months to within the last year
- ❑ 1-2 years ago
- ❑ 2-5 years ago
- ❑ 5-10 years ago
- ❑ More than 10 years ago
- ❑ Never
- ❑ Not sure

1.

5. **Do you or anyone you are visiting with have a permanent or temporary disability?**

2. ❒ Yes ❒ No

6. **Please rate your own level of knowledge or experience in math and computer science / programming.**

	Not at all knowledgeable										Extremely knowledgeable
Math	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Computer science / programming	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

7. **What is your race or ethnicity? ____________________**

8. **What is your ZIP code or country (if out of US)? ___________**

Thank you - we hope you enjoy your visit!

APPENDIX C: POST-EXHIBITION SURVEY, VISITOR

We hope you enjoyed your visit to *The Science Behind Pixar!*
Please complete this brief survey to help us improve our future exhibits and programs.
Thank you for sharing your thoughts with us!

Use the scales from 0-10 to answer the following questions.

1. How likely are you to recommend *The Science Behind Pixar* to your friends or family?

0 1 2 3 4 5 6 7 8 9 10
Not at all likely — Very likely

Please explain your response:

2. How likely are you to attend another temporary exhibit at the Museum of Science, Boston?

0 1 2 3 4 5 6 7 8 9 10
Not at all likely — Very likely

3. How up-to-date was *The Science Behind Pixar* exhibition?

0 1 2 3 4 5 6 7 8 9 10
Not at all up-to-date — Very up-to-date

4. What would you say is the most memorable part of *The Science Behind Pixar* exhibition?

5. Please rate your interest in each of the following.

	Not at all interested	A little interested	Somewhat interested	Very interested
Learning about animation.	❒	❒	❒	❒
Learning about computer programming.	❒	❒	❒	❒
Learning about math.	❒	❒	❒	❒
Creating my own animations.	❒	❒	❒	❒
Creating my own computer programs.	❒	❒	❒	❒
Using math in my own creative projects.	❒	❒	❒	❒
Doing animation as part of my career.	❒	❒	❒	❒
Doing computer programming as part of my career.	❒	❒	❒	❒
Doing math as part of my career.	❒	❒	❒	❒

6. Please rate how, if at all, *The Science Behind Pixar* changed your interest level in each of the following.

After seeing *The Science Behind Pixar*, I feel:

	Less interested	The same as I did before	More interested
In learning about or doing animation.	❒	❒	❒
In learning about or doing computer programming.	❒	❒	❒
In learning about or doing math.	❒	❒	❒

7. How could we improve *The Science Behind Pixar* to make it a better experience for visitors like you?

OVER

Use the scales from 0-10 to answer the following questions.

8. Do you think you could <u>write brand new programs or software</u> (like apps for smartphones or tablets)

	0	1	2	3	4	5	6	7	8	9	10
8a. …if you took the right classes?	No way										Definitely
8b. …if you could ask an expert or use a manual for help?	No way										Definitely
8c. …with no manual or outside help?	No way										Definitely

9. Please rate the following statements based on your beliefs about math and computer programming.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
Knowing how to do computer programming is useful in many careers.	❒	❒	❒	❒	❒
There is a lot of creativity involved in computer programming.	❒	❒	❒	❒	❒
There are many different ways to solve any given computer programming problem.	❒	❒	❒	❒	❒
Computer programming is one of the most important subjects for people to know.	❒	❒	❒	❒	❒
Computer programmers can create almost anything they imagine.	❒	❒	❒	❒	❒
When solving a problem, computer programmers break it into smaller parts and solve them one at a time.	❒	❒	❒	❒	❒
Mathematics is one of the most important subjects for people to know.	❒	❒	❒	❒	❒
Knowing how to do math is useful in many careers.	❒	❒	❒	❒	❒
There is a lot of creativity involved in math.	❒	❒	❒	❒	❒

Turn to demographics

Group Demographics

Please answer the following questions about your visiting group.

1. **List the genders and ages of your group members. Please list yourself first.**

Gender	Age	Gender	Age	Gender	Age	Gender	Age

2. **What time did you ENTER *The Science Behind Pixar* exhibition? (time on ticket)** __________

3. **What time did you EXIT *The Science Behind Pixar* exhibition?** __________

4. **Why did you decide to visit the Museum today? [Please select two that best apply.]**

- ❒ To see *Science Behind Pixar*
- ❒ Something to do in poor weather
- ❒ Had a coupon/free pass
- ❒ Something to do while visiting Boston
- ❒ To spend time together as a group/family
- ❒ Fun/entertainment for myself
- ❒ To see a specific exhibit, program, or show (other than Pixar)
- ❒ To bring out of town friends/family
- ❒ Educational experience for group members/children
- ❒ Educational experience for myself
- ❒ Fun/entertainment for group members/children
- ❒ Other: Please specify: ____

5. **Are you a Museum of Science member?**

❒ Yes ❒ No

5a. If yes, how long have you been a member?

- ❑ Just became a member today
- ❑ Less than 1 year
- ❑ 1-2 years
- ❑ 3-5 years
- ❑ 5 or more years
- ❑ Not sure

6. **Prior to this visit, when was the last time you visited the Museum of Science?**

- ❑ Within the past three months
- ❑ 3-6 months
- ❑ 6 months to within the last year
- ❑ 1-2 years ago
- ❑ 2-5 years ago
- ❑ 5-10 years ago
- ❑ More than 10 years ago
- ❑ Never
- ❑ Not sure

7. **Do you or anyone you are visiting with have a permanent or temporary disability?**

❒ Yes ❒ No

8. **Please rate your own level of knowledge or experience in math and computer science / programming.**

	Not at all knowledgeable										Extremely knowledgeable
Math	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Computer science / programming	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

9. **What is your race or ethnicity?** ____________________

10. **What is your ZIP code or country (if out of US)?** ___________

Thank you for sharing your thoughts and ideas with us

APPENDIX D: VISITOR TIMING AND TRACKING POST INTERVIEW

11. Overall, how likely are you to **recommend** this exhibit to your friends or family? [Show scale on back of clipboard; ask for each individual, starting with focus individual].

12. [Show word list on back of clipboard; ask for each member of the group]. Please pick 2 words that you think **best** describe *The Science Behind Pixar* **as an exhibition**. You can use this list, or come up with your own words. [**Follow-up**: Please explain why you felt the exhibition was [Word 1, Word 2]:

13. [Ask for each member of the group] Which **one** exhibit or activity would you say you found most engaging or interesting? **[Follow-ups**: What did you find most interesting or engaging? What did you get to **do** or **learn?**]

14. Overall, what would you say the Museum wants people to learn from *The Science Behind Pixar?*

15. What kinds of things did you think about or talk about while you were using the exhibits?

[Follow-up on all areas not mentioned]: Anything related to Pixar's work? How about anything related to computer programming, math, or the connections between art, math, and science?

16. Now I'd like to get your thoughts about the value of specific aspects of the exhibition, with respect to your overall experience today. What were your feelings about the value of : [list experience; please vary the order in which you list the activities; probe for specifics]:

Introductory film

Educator-led activities

Large-scale characters and displays

Interactive exhibits

Videos

Is there anything else that you would like to add?

[To focus participant] Great – as a final thing, I'd like to get a little information about your group. How would you rate you level of knowledge in math. [Show scale on back of clipboard; circle response below].
How would you rate your level of knowledge in computer programming or computer science? [Show scale on back of clipboard; circle response below].

Math	0	1	2	3	4	5	6	7	8	9	10
Computer science / programming	0	1	2	3	4	5	6	7	8	9	10

Great! I have a quick survey here to get a few more details about your group, if you don't mind. [Flip over interview; hand survey to focus individual [if adult] or adult [if focus individual is under 18].

Overall, how likely are you to recommend this exhibit to your friends or family?

0	1	2	3	4	5	6	7	8	9	10
Not at all likely										Highly likely

Pick any 2 words that best describe *The Science Behind Pixar* as an exhibition.

Comprehensive	Over-simplified
Inspiring	Disappointing
Informative	Not educational
Visually-appealing	Drab
Fun	Boring
Innovative/cutting edge	Outdated
Creative	Typical or ordinary
Interactive	Not interactive
Easy to understand	Confusing

Please rate your level of knowledge using the following scale.

0	1	2	3	4	5	6	7	8	9	10
Not at all knowledgeable										Extremely knowledgeable

APPENDIX E: SUPPLEMENTAL PUBLIC DATA FOR THE MUSEUM OF SCIENCE, BOSTON

SUPPLEMENTAL DATA FROM THE VISITOR EXPERIENCE MONITORING (VXM) SURVEY

Table E1: Motivation for visiting the MOS, VXM surveys (N=798 groups)[87]

Reason	*SBP*-attending groups (n=341)	Non-*SBP* attending groups (n=457)
Spend time together*	51%	60%
See something specific*	46%	46%
Fun for group*	17%	26%
Education for group*	18%	25%
Something to do in Boston	12%	11%
Bring out-of-town guests	9%	8%
Fun for self	9%	8%
Had a coupon or free pass	6%	7%
Education for self	4%	6%
Other	2%	4%
Bad weather*	1%	4%

[87] Spend time together: $\chi^2(1, N=798)=6.32$, $p < .05$; See something specific: $\chi^2(1, N=798)=141.302$, $p < .05$; Fun for group: $\chi^2(1, N=798)=9.46$, $p < .05$; Education for group: $\chi^2(1, N=798)=6.53$, $p < .05$; Something to do in bad weather: $\chi^2(1, N=798)=6.45$, $p < .05$.

Table E2: Group demographics for *SBP* attendees, pre-exhibition and post-exhibition surveys, post-exhibition interviews (N=309 groups)

		Interviews and/or tracking and timing (n=136 groups)	Surveys		
			Pre-exhibition (Control sample) (n=155 groups)	Post-exhibition (n=154 groups)	Overall (n=309 groups)
Group composition	Adult-only groups (%)	42%	49%	47%	48%
	Groups with children ages 1 to 7 (%)	35%	28%	23%	26%
	Groups with children ages 8 to 11 (%)	26%	28%	29%	29%
	Groups with children ages 12 to 17 (%)	13%	16%	13%	14%
	Member group	32%	34%	33%	33%
	Group includes a person with a disability	2%	6%	2%	4%
Race (coded from open-ended responses)	Caucasian/White	72%	63%	62%	62%
	Asian/Asian-American/Pacific islander	10%	9%	8%	9%
	Hispanic/Latino/Latina/from South or Central American countries	6%	5%	2%	3%
	Multi-racial	2%	4%	2%	3%
	Black/African-American	1%	0%	2%	1%
	Indian/Indian-American/Middle Eastern	2%	1%	1%	1%
	Other	1%	1%	1%	1%
	No response	6%	19%	20%	20%
Knowledge (rating from 0-10)	Math	6.1	6.3	5.9	6.1
	Computer programming	4.4	4.4	4.7	4.5
Motivations for visitation	To see *SBP*	50%	65%	62%	64%
	Spend time together	33%	38%	36%	37%
	Fun for group or kids	18%	28%	18%	23%
	Something to do in Boston	25%	22%	21%	21%
	Fun for self	13%	20%	14%	17%
	Education for group or kids	13%	15%	17%	16%
	Education for self	10%	14%	11%	13%
	Bring guests from out of town	7%	8%	8%	8%
	To see a different exhibit	10%	6%	8%	7%
	Had a coupon of pass	3%	4%	5%	4%
	Other	4%	5%	3%	4%
	Because of bad weather	2%	3%	3%	3%

Table E3: Age and gender, *SBP* attendees pre-exhibition and post-exhibition surveys (N=288 groups)

		Groups surveyed pre-exhibition (Control) (n=142 groups)	Groups surveyed post-exhibition (n=146 groups)	Overall (n=288 groups)
# of adults		289	281	570
# of children		148	140	288
Adult gender	Female (%)	57%	54%	56%
	Male (%)	43%	46%	44%
Adult ages	18 to 24 (%)	15%	16%	16%
	24 to 29 (%)	20%	16%	18%
	30 to 34 (%)	12%	16%	14%
	35 to 44 (%)	22%	22%	22%
	45 to 54 (%)	18%	17%	18%
	55 to 64 (%)	6%	8%	7%
	65 and older (%)	6%	5%	5%
Child gender	Female (%)	48%	42%	45%
	Male (%)	52%	58%	55%
Child ages	4 and under	17%	12%	15%
	5 to 7	20%	24%	22%
	8 to 11	41%	42%	41%
	12 to 17	22%	21%	22%

Table E4: Average time spent at each attended experience type, in minutes: seconds, timing and tracking (N=124 visitors)

	Immersive experiences [88]	Interactive exhibits[89]	"BTS/ Challenge" videos[90]	"Working at Pixar" videos [91,92]	Educator-led activities [93,94]
Child 7 or under or accompanying adult (n=35)	1:28	1:44	1:08	1:09	4:01
Youth 8-17 or accompanying adult (n=38)	1:39	**2:04***	1:17	1:24	4:13
Adult in adult-only group (n=51)	1:25	1:28	**1:43***	**2:14***	2:48
General public visitors, overall (n=124)	1:30	1:43	1:25	1:50	3:46

- ** indicates that a group type had a significantly higher average dwell time when compared to other general public visitor types; p<0.05.*

[88] There was no significant difference in average time spent at immersive experiences, comparing the three visitor types. Significance was found for interactive exhibits, "BTS/Challenge" videos, and "Working at Pixar" videos. Significance was found in adult groups and youth with adult groups, but not for immersive experiences.
[89] One-way Anova: F=7.676; p=0.001, comparing average time spent at each interactive exhibit visited between the 3 visitor types. Post-hoc Bonferroni test used to identify significant between-group differences (p<0.05). Difference in time spent between children and their adults, and between youth and their accompanying adults is not significant.
[90] One-way Anova: F=12.740; p<0.001, comparing average time spent at each BTS/Challenge videos visited between the 3 visitor types. Post-hoc Bonferroni test used to identify significant between-group differences (p<0.05).
[91] *Working at Pixar* videos were attended by 29% of observed children ages 7 and younger and their accompanying adults, 45% of youth ages 8-17 and their adults, and 71% of adults in adult-only groups. Only visitors who attended these videos were included in the analyses for this chart.
[92] One-way Anova: F=4.429; p=0.016, comparing average time spent at each BTS/Challenge videos visited between the 3 visitor types. Post-hoc Bonferroni test used to identify significant between-group differences (p<0.05); difference in time spent between adults in adult-only groups and between youth and their accompanying adults is not significant.
[93] *Educator-led activities* were not always both available to visitors in the exhibition, as they required scheduled a staff or volunteer presence. They were attended by 31% of observed children ages 7 and younger and their accompanying adults, 39% of youth ages 8-17 and their adults, and 20% of adults in adult-only groups. Only visitors who attended these activities were included in the analyses for this chart.
[94] There was no significant difference in average time spent at educator-led activities, comparing the three visitor types.

Figure E1: Average percent of interactive experiences, immersives, and videos experienced by general public visitor type, Timing and tracking (N=124 visitors)

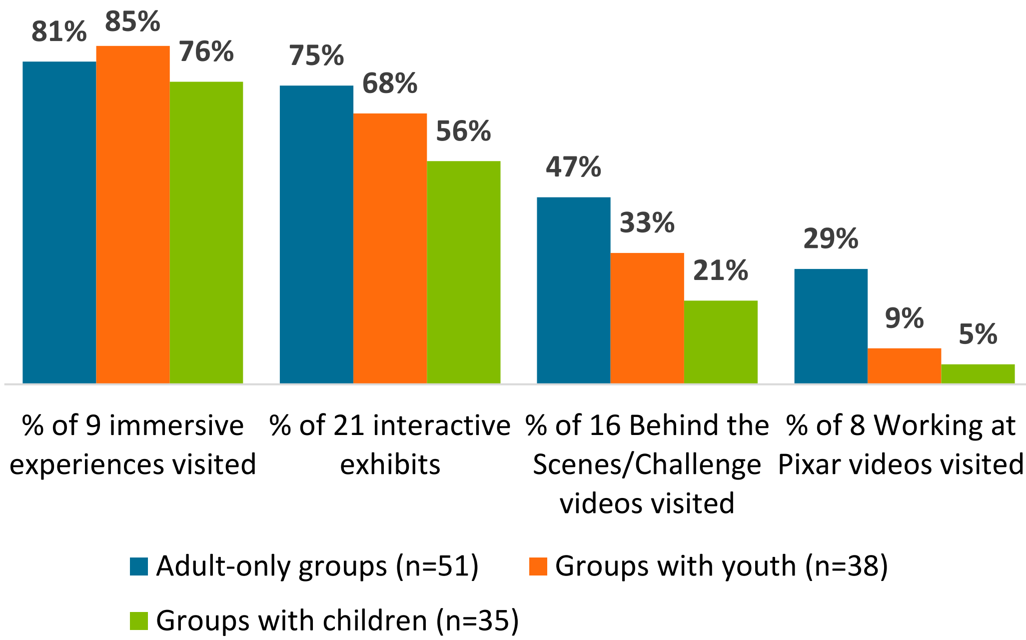


Table E5: General public visitation to exhibits and immersives, Timing and tracking (N=124 groups)[95]

	% of groups with children (n=35)	% of groups with youth (n=38)	% of Adult-only groups (n=51)	% seen – overall (N=124)
Sets and Cameras - "A Bug's Life"	89%	97%	90%	92%
Modeling - "Toy Story"	97%	84%	88%	90%
Animation - "Incredibles"	80%	89%	94%	89%
Pipeline*	77%	89%	96%	89%
Lighting - "Finding Nemo"	86%	89%	86%	87%
Rigging - "Monsters University"	89%	84%	78%	83%
Simulation - "Brave"	74%	87%	86%	83%
Camera Basics - "Wall-E"	69%	84%	90%	82%
Simulating water*	54%	92%	90%	81%
Crowd Simulation Workstation*	71%	71%	90%	79%
Lighting Effects Basics	71%	74%	84%	77%
Stop-motion Animation*	51%	84%	90%	77%
Limit Complexity	63%	84%	78%	76%
Lighting Design Basics*	60%	71%	88%	75%
Arm Rigging Workstation*	49%	79%	88%	74%
Character Maquettes	71%	63%	84%	74%
Computer Animation Workstation*	54%	74%	86%	73%
Extruded Shapes	74%	76%	71%	73%
Face Rigging Workstation*	71%	55%	88%	73%
Surfaces - "Cars"	63%	82%	75%	73%
Surface Appearance Workstation	66%	68%	80%	73%
Wrap It Up	66%	74%	75%	72%
Virtual Lighting Workstation*	43%	74%	86%	70%
Rendering - "Inside Out"*	46%	82%	76%	69%
Build a Robot*	86%	74%	53%	69%
Programming Natural Variety*	40%	76%	82%	69%
Rotated Shapes	60%	76%	69%	69%
Rendering Workstation*	43%	66%	71%	61%
Set Layout Workstation	49%	61%	71%	61%
Virtual Modeling Workstation	49%	58%	67%	59%
Sculpt by Numbers	37%	42%	55%	46%

[95] * = Visitation differed significantly by group; $p<0.05$. Significance testing was performed using a Chi Square analysis. Percentages in **red** indicate an experience that a group type was less likely to attend than the overall general public audience. Percentages in **green** indicate an experience that a group type was more likely to visit that experience, compared to overall general public audience.

Table E6: Visitation and stay time at interactive exhibits and immersives by visitor type, Timing and henry tracking (N=124 groups)

	Groups with children (n=35)		Groups with youth (n=38)		Adult-only groups (n=51)		Overall general public audience (N=124)	
	Median stay time (min)	% visitation	Median stay time (min)	% visitation	Median stay time (min)	% visitation	Median stay time (min)	% visitation
Sets and Cameras - "A Bug's Life"	1.6	89%	1.4	97%	1.3	90%	1.4	92%
Modeling - "Toy Story"	0.6	97%	0.7	84%	0.8	88%	0.8	90%
Animation - "Incredibles"	1.2	80%	3.0	89%	1.8	94%	1.9	89%
Pipeline	1.1	77%	1.5	89%	2.3	96%	1.6	89%
Lighting - "Finding Nemo"	1.3	86%	1.4	89%	1.2	86%	1.2	87%
Rigging - "Monsters University"	1.1	89%	1.0	84%	1.1	78%	1.1	83%
Simulation - "Brave"	1.4	74%	1.8	87%	1.4	86%	1.5	83%
Camera Basics - "Wall-E"	0.9	69%	1.1	84%	1.1	90%	1.1	82%
Simulating water	0.9	54%	0.9	92%	1.0	90%	0.9	81%
Crowd Simulation Workstation	1.3	71%	1.5	71%	1.3	90%	1.3	79%
Lighting Effects Basics	0.6	71%	1.0	74%	1.0	84%	0.9	77%
Stop-motion Animation	3.1	51%	3.8	84%	1.9	90%	2.7	77%
Limit Complexity	1.1	63%	1.1	84%	0.9	78%	1.0	76%
Lighting Design Basics	1.0	60%	1.1	71%	1.1	88%	1.1	75%
Arm Rigging Workstation	1.2	49%	1.5	79%	1.0	88%	1.2	74%
Character Maquettes	0.8	71%	0.8	63%	0.7	84%	0.8	74%
Computer Animation Workstation	1.0	54%	1.4	74%	1.1	86%	1.2	73%
Extruded Shapes	1.0	74%	0.9	76%	0.6	71%	0.9	73%
Face Rigging Workstation	2.1	71%	2.6	55%	1.7	88%	1.9	73%
Surfaces - "Cars"	1.2	63%	1.3	82%	0.7	75%	1.0	73%
Surface Appearance Workstation	1.5	66%	2.5	68%	1.7	80%	1.8	73%
Wrap It Up	1.1	66%	1.1	74%	0.8	75%	0.8	72%
Virtual Lighting Workstation	1.2	43%	1.3	74%	1.1	86%	1.2	70%
Rendering - "Inside Out"	0.8	46%	1.0	82%	0.8	76%	0.9	69%
Build a Robot	3.9	86%	2.2	74%	1.2	53%	2.1	69%
Programming Natural Variety	1.8	40%	1.9	76%	1.5	82%	1.7	69%
Rotated Shapes	1.5	60%	1.6	76%	1.1	69%	1.4	69%
Rendering Workstation	0.6	43%	1.3	66%	1.0	71%	1.0	61%
Set Layout Workstation	1.8	49%	3.0	61%	1.6	71%	1.9	61%
Virtual Modeling Workstation	2.1	49%	3.3	58%	2.2	67%	2.5	59%
Sculpt by Numbers	1.3	37%	1.3	42%	1.7	55%	1.3	46%

Table E7: General public visitation to videos and educator-led activities, Timing and tracking (N=124 groups)

	% of groups with children (n=35)	% of groups with youth (n=38)	% of adult-only groups (n=51)	Overall general public audience (N=124)
Pixar's Modeling Challenge	34%	50%	76%	56%
Pixar's Simulation Challenge	43%	58%	57%	53%
Behind the Scenes on "Cars 2"	49%	47%	55%	51%
Pixar's Sets Challenge	29%	34%	61%	44%
Behind the Scenes on "Toy Story 3"	26%	37%	51%	40%
Behind the Scenes on "A Bug's Life"	9%	34%	57%	36%
Behind The Scenes at Pixar	11%	29%	55%	35%
Pixar's Rigging Challenge	31%	34%	37%	35%
Pixar's Surfaces Challenge	31%	24%	43%	34%
Behind the Scenes in Simulation	14%	26%	45%	31%
Pixar's Animation Challenge	0%	37%	47%	31%
Behind the Scenes on "The Incredibles"	9%	29%	43%	29%
Pixar's Lighting Challenge	14%	24%	43%	29%
Pixar's Rendering Challenge	9%	29%	41%	28%
Set it up – Educator-led activity	29%	32%	14%	23%
Behind the Scenes in Lighting Design	6%	18%	35%	22%
Working at Pixar - Sets and Cameras*	6%	5%	39%	19%
Working at Pixar – Simulation	6%	16%	29%	19%
Working at Pixar – Rigging	9%	11%	29%	18%
Working at Pixar – Modeling	0%	11%	33%	17%
Working at Pixar*	6%	11%	27%	16%
Working at Pixar – Animation	3%	11%	25%	15%
Working at Pixar – Surfaces	6%	5%	27%	15%
Behind the Scenes on "Monsters University"	17%	16%	10%	14%
Working at Pixar – Lighting	3%	5%	22%	11%
Fire and Light – Educator-led activity	9%	8%	10%	9%

Table E8: Median stay times and visitation at videos by general public visitor type, Timing and tracking (N=124 groups)[96]

	Groups with children (n=35)		Groups with youth (n=38)		Adult-only groups (n=51)		Overall general public audience (n=124)	
	Median stay time (min)	% visitation	Median stay time (min)	% visitation	Median stay time (min)	% visitation	Median stay time (min)	% visitation
Pixar's Modeling Challenge	1.3	39%	1.6	50%	2.1	76%	1.9	56%
Pixar's Simulation Challenge	0.9	48%	1.5	58%	2.2	57%	1.9	53%
Behind the Scenes on "Cars 2"	0.4	55%	0.3	47%	0.6	55%	0.4	51%
Pixar's Sets Challenge	0.5	32%	2.1	34%	2.2	61%	2.0	44%
Behind the Scenes on "Toy Story 3"	0.6	29%	0.8	37%	2.5	51%	1.6	40%
Behind the Scenes on "A Bug's Life"	1.7	10%	0.6	34%	1.9	57%	1.7	36%
Behind The Scenes at Pixar	0.9	13%	1.9	29%	2.2	55%	2.1	35%
Pixar's Rigging Challenge	0.5	35%	1.0	34%	1.7	37%	1.4	35%
Pixar's Surfaces Challenge	1.3	35%	2.9	24%	2.8	43%	2.8	34%
Behind the Scenes in Simulation	0.8	16%	0.4	26%	0.9	45%	0.8	31%
Pixar's Animation Challenge	--	0%	2.5	37%	2.7	47%	2.7	31%
Behind the Scenes on "The Incredibles"	2.5	10%	2.5	29%	2.6	43%	2.6	29%
Pixar's Lighting Challenge	0.9	16%	1.0	24%	2.4	43%	2.2	29%
Pixar's Rendering Challenge	2.2	10%	1.5	29%	2.3	41%	2.2	28%
Behind the Scenes in Lighting Design	2.3	6%	2.3	18%	2.4	35%	2.4	22%

[96] Videos at which the median stay time was 2 minutes or longer (indicating that, when visitors stopped to see the exhibit, they stayed to watch all – or nearly all – of the video) are highlighted in **green.**

Working at Pixar - Sets and Cameras	0.7	6%	0.4	5%	2.1	39%	1.6	19%
Working at Pixar – Simulation	2.4	6%	0.5	16%	4.2	29%	2.7	19%
Working at Pixar – Rigging	0.7	10%	3.0	11%	2.6	29%	2.4	18%
Working at Pixar – Modeling	--	0%	1.1	11%	3.8	33%	3.8	17%
Working at Pixar	1.5	6%	2.1	11%	2.2	27%	2.2	16%
Working at Pixar – Animation	1.2	3%	1.8	11%	3.4	25%	3.1	15%
Working at Pixar – Surfaces	0.6	6%	1.1	5%	1.9	27%	1.7	15%
Behind the Scenes on "Monsters University"	0.5	19%	0.5	16%	0.5	10%	0.5	14%
Working at Pixar – Lighting	0.2	3%	1.4	5%	2.4	22%	2.4	11%
Fire & Light - Educator-led activity	2.4	10%	2.5	8%	2.3	10%	2.4	9%
Set it up - Educator-led activity	3.8	32%	3.1	32%	2.0	14%	2.8	23%

Table E9: Behaviors observed at each exhibit (% of attending groups), Timing and tracking (N=124 groups)

	# of visitors who used exhibit	Used graphics / displays	Used instructions	Took photo or video	Discussed exhibit	Had observable positive reaction
Sets and Cameras - "A Bug's Life"	114	61%	8%	7%	67%	53%
Modeling - "Toy Story"	111	78%	0%	41%	51%	49%
Animation - "Incredibles"	110	38%	20%	27%	58%	51%
Pipeline	110	93%	0%	4%	69%	41%
Lighting - "Finding Nemo"	108	74%	4%	46%	60%	56%
Rigging - "Monsters University"	103	78%	0%	37%	55%	46%
Simulating water	103	12%	4%	3%	65%	38%
Simulation - "Brave"	100	40%	25%	0%	51%	22%
Camera Basics - "Wall-E"	98	73%	22%	34%	59%	50%
Crowd Simulation Workstation	98	37%	17%	1%	62%	30%
Lighting Effects Basics	96	46%	13%	0%	54%	23%
Stop-motion Animation	96	58%	34%	11%	73%	55%
Limit Complexity	94	33%	13%	1%	67%	27%
Lighting Design Basics	93	53%	8%	3%	58%	27%
Arm Rigging Workstation	92	47%	14%	1%	58%	37%
Character Maquettes	92	82%	0%	5%	64%	27%
Computer Animation Workstation	91	29%	19%	2%	58%	30%
Extruded Shapes	91	36%	4%	0%	64%	40%
Face Rigging Workstation	91	47%	16%	5%	71%	69%
Surfaces - "Cars"	91	12%	7%	0%	53%	34%
Surface Appearance Workstation	90	38%	17%	1%	59%	38%
Wrap It Up	89	22%	24%	2%	51%	31%
Virtual Lighting Workstation	87	28%	11%	2%	60%	22%
Rendering - "Inside Out"	86	34%	8%	0%	58%	19%
Build a Robot	85	34%	18%	18%	66%	52%
Programming Natural Variety	85	47%	18%	1%	68%	42%
Rotated Shapes	85	31%	5%	1%	62%	38%
Rendering Workstation	76	34%	12%	0%	47%	21%
Set Layout Workstation	76	39%	13%	7%	64%	43%
Virtual Modeling Workstation	73	34%	30%	3%	62%	29%
Sculpt by Numbers	57	53%	35%	0%	60%	26%

Table E10: Exhibits that prompted the most discussion by group type, Timing and tracking (N=124 groups)

Groups with children (n=35 visitors)	Groups with youth (n=38 visitors)	Adult-only groups (n=51 visitors)
Extruded Shapes	Face Rigging Workstation	Pipeline
Virtual Lighting Workstation	Programming Natural Variety	Stop-motion Animation
Build a Robot	Simulation - "Brave"	Camera Basics - "Wall-E"
Stop-motion Animation	Character Maquettes	
Face Rigging Workstation	Computer Animation Workstation	
Surfaces – “Cars”	Stop-motion Animation	
Virtual Modeling Workstation	Virtual Lighting Workstation	
Rotated Shapes	Rendering - "Inside Out"	
	Lighting - "Finding Nemo"	
	Sets and Cameras - "A Bug's Life"	
	Surface Appearance Workstation	
	Limit Complexity	
	Virtual Modeling Workstation	
	Animation - "Incredibles"	
	Arm Rigging Workstation	

Table E11: Visitor discussion percentages by group type, Timing and tracking (N=124 groups)

	Groups with children		Group with youth		Adult in adult only group		Overall	
	%	n	%	n	%	n	%	n
Discusses_pipeline	70%	27	65%	34	71%	49	69%	110
Discusses_stop_motion	83%	18	72%	32	70%	46	73%	96
Discusses_cam_basics	50%	30	58%	31	68%	37	59%	98
Discusses_Limit_Complex	68%	22	69%	32	65%	40	67%	94
Discusses_programming_nat	57%	14	79%	29	64%	42	68%	85
Discusses_set_layout_w	65%	17	65%	23	64%	36	64%	76
Discusses_set_tree	71%	31	70%	37	61%	46	67%	114
Discusses_face_rig	80%	25	86%	21	60%	45	71%	91
Discusses_sim_bra	58%	26	79%	33	59%	44	65%	103
Discusses_char_maq	64%	25	75%	24	58%	43	64%	92
Discusses_rot_Shapes	76%	21	59%	29	57%	35	62%	85
Discusses_rendering_work	27%	15	48%	25	56%	36	47%	76
Discusses_crowd_sim	76%	25	63%	27	54%	46	62%	98
Discusses_sculpt_by_num	69%	13	63%	16	54%	28	60%	57
Discusses_lig_dory	60%	30	71%	34	52%	44	60%	108
Discusses_ani_inc	57%	28	68%	34	52%	48	58%	110
Discusses_build_robot	83%	30	61%	28	52%	27	66%	85
Discusses_rendering_insideout	50%	16	71%	31	51%	39	58%	86
Discusses_arm_rig	59%	17	67%	30	51%	45	58%	92
Discusses_rigging_mike_sulley	65%	31	53%	32	50%	40	55%	103
Discusses_virtual_mod	76%	17	68%	22	50%	34	62%	73
Discusses_Mod_buzz	50%	34	56%	32	49%	45	51%	111
Discusses_Light_design	71%	21	63%	27	49%	45	58%	93
Discusses_ext_shapes	88%	26	62%	29	47%	36	64%	91
Discusses_Lighting_eff	60%	25	61%	28	47%	43	54%	96
Discusses_sur_app	74%	23	69%	26	44%	41	59%	90
Discusses_comp_ani	68%	19	75%	28	43%	44	58%	91
Discusses_virtual_lig	87%	15	71%	28	43%	44	60%	87
Discusses_sim_water	63%	19	60%	35	39%	46	51%	100
Discusses_wrap_it	74%	23	54%	28	34%	38	51%	89
Discusses_sur_Car	77%	22	65%	31	29%	38	53%	91

Figure E2: Visitors' frequency of use of hearphones, Timing and tracking (N=124 groups)

	Did not use hearphones	1-2 times	3 or more times
Groups with children (n=35 groups)	34%	46%	20%
Groups with youth (n=38 groups)	44%	32%	24%
Adult-only groups (n=51 groups)	67%	27%	6%

Figure E3: Ways in which visitors described the value of different parts of the exhibition with respect to the overall experience, post-exhibition interviews (N=128 groups)

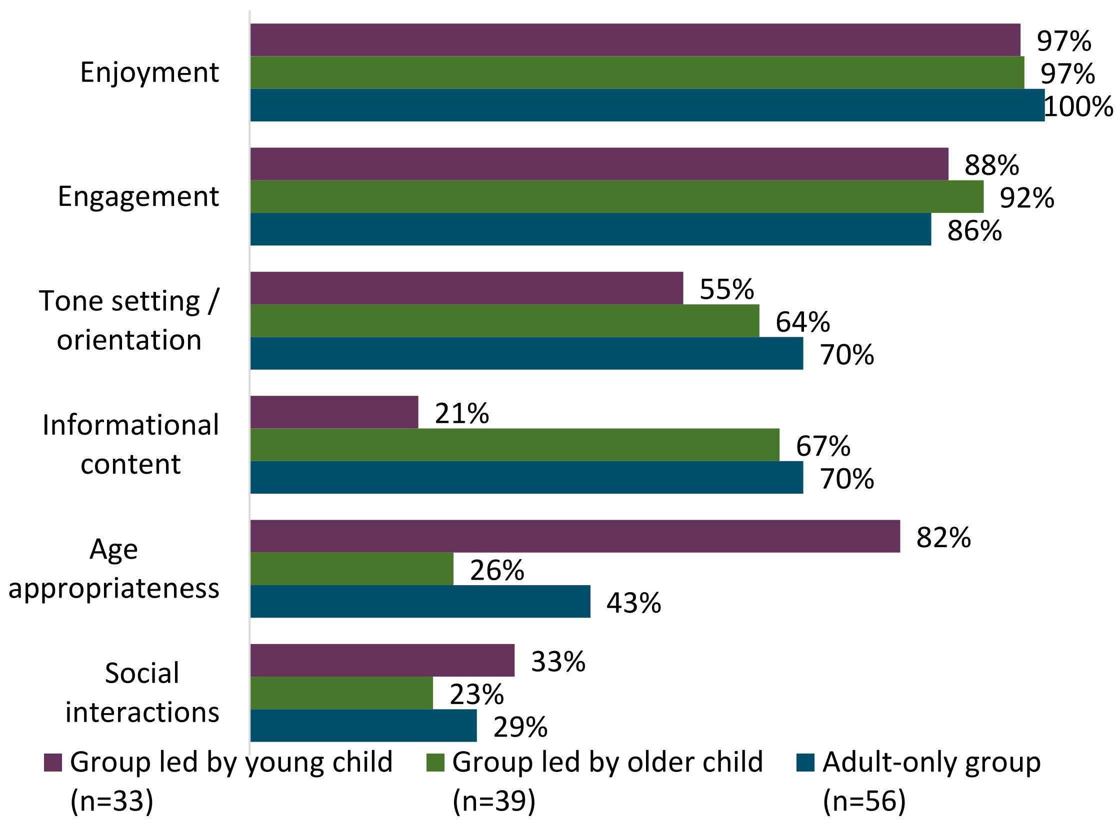


Table E12: How visitors would describe *SBP*, Post-exhibition interview, N=220 visitors

	Children (n=53)	Youth (n=29)	Adults (n=188)	Overall (N=270 visitors)
Interactive	9%	52%	44%	38%
Fun	70%	34%	20%	31%
Informative	6%	21%	30%	25%
Visually appealing	6%	24%	23%	20%
Creative	40%	24%	12%	19%
Inspiring	19%	10%	12%	13%
Easy to understand	6%	10%	7%	7%
Innovative	0%	0%	10%	7%
Comprehensive	0%	7%	8%	6%
Interesting/Exciting/Awesome	11%	10%	1%	4%
Confusing	2%	0%	3%	2%
Other	0%	0%	2%	1%
Oversimplified	0%	3%	0%	0%
Repetitive	0%	3%	0%	0%
Not interactive	0%	0%	1%	0%
Overpriced	0%	0%	1%	0%

Table E13: Reasons for likelihood to recommend, Post-exhibition surveys (N=101 groups)

Theme	% of groups
Educational	30%
Interactive	26%
Entertaining	17%
General response	16%
Well organized	14%
Works well for certain age groups	14%
Recommend with stipulations	11%
Pixar/Disney affinity	10%
Works well for families/groups	9%
STEM and art affinity	5%
Other	2%

Table E14: Visitors' responses for "Which exhibit did you find most interesting?" Post-exhibition interview (N=118 groups)

Exhibit	Count	% of groups
Stop-Motion Animation	23	19%
Lighting Design Basics	19	16%
Simulation Immersive	15	13%
Pipeline	13	11%
Sets and Cameras Immersive	13	11%
Surface Appearance Workstation	13	11%
Lighting Immersive	12	10%
Set Layout Workstation	11	9%
Face Rigging Workstation	10	8%
Virtual Modeler Workstation	9	8%
Crowd Simulation Workstation	8	7%
Virtual Lighting Workstation	7	6%
Programming Natural Variety	6	5%
Build a Robot	5	4%
Light Effects	5	4%
Simulating Water	5	4%
Animation Immersive	4	3%
Sculpt by Numbers	4	3%
Surfaces Immersive	4	3%
Rendering Immersive	3	3%
Camera Basics	2	2%
Computer Animation Workstation	2	2%
Modeling Immersive	2	2%
Rotating Shapes	2	2%
Wrap It Up	2	2%
Arm Rigging Workstation	1	1%
Extruder	1	1%
Limit Complexity	1	1%

APPENDIX F: SUPPLEMENTAL DATA FOR THE FRANKLIN INSTITUTE

Table F1: Age and gender demographics for *SBP* attendees, Franklin Institute pre-exhibition and post-exhibition surveys (N=288 groups)

		Groups surveyed pre-exhibition (n=122 groups)	Groups surveyed post-exhibition (n=120 groups)	Overall (n=242 groups)
# of adults		260	270	530
# of children		111	113	224
Adult gender	**Female (%)**	*54%*	63%	59%
	Male (%)	*46%*	37%	41%
Adult ages	**18 to 24 (%)**	22%	23%	23%
	25 to 29 (%)	16%	17%	17%
	30 to 34 (%)	12%	11%	12%
	35 to 44 (%)	22%	24%	23%
	45 to 54 (%)	13%	17%	15%
	55 to 64 (%)	8%	4%	6%
	65 and older (%)	6%	3%	5%
Child gender	**Female (%)**	49%	50%	50%
	Male (%)	51%	50%	50%
Child ages	**4 and under**	24%	19%	21%
	5 to 7	16%	19%	22%
	8 to 11	31%	28%	29%
	12 to 17	19%	35%	27%

Table F2: Franklin Institute group demographics for *SBP* attendees, Pre-exhibition and post-exhibition surveys, post-exhibition interviews (N=309 groups)

			Surveys		
		Interviews (n=76 groups)	Pre-exhibition (Control sample) (n=122 groups)	Post-exhibition (n=120 groups)	Overall (N=309 groups)
Group composition	Adult-only groups (%)	36%	36%	43%	39%
	Groups with children ages 1 to 7 (%)	18%	32%	30%	31%
	Groups with children ages 8 to 11 (%)	34%	22%	22%	22%
	Groups with children ages 12 to 17 (%)	29%	14%	25%	19%
	Member group	21%	22%	19%	21%
	Group includes a person with a disability	8%	5%	10%	7%
Knowledge (rating from 0-10)	Math	6.7	6.3	5.9	6.1
	Computer programming	4.7	4.7	4.6	4.7
Motivations for visitation	To see *SBP*	54%	66%	61%	64%
	Spend time together	34%	53%	34%	43%
	Fun for group or kids	28%	35%	29%	32%
	Something to do in Philadelphia	21%	21%	20%	21%
	Fun for self	15%	23%	15%	19%
	Education for group or kids	20%	14%	15%	14%
	Education for self	9%	13%	11%	12%
	Bring guests from out of town	7%	5%	5%	5%
	To see a different exhibit	10%	7%	12%	10%
	Had a coupon of pass	3%	3%	3%	3%
	Other	3%	2%	1%	1%
	Because of bad weather	1%	1%	1%	1%

Figure 32: General public interest in learning about animation, programming, and math prior to the exhibition, pre-exhibition surveys, Franklin Institute (N=120 groups)

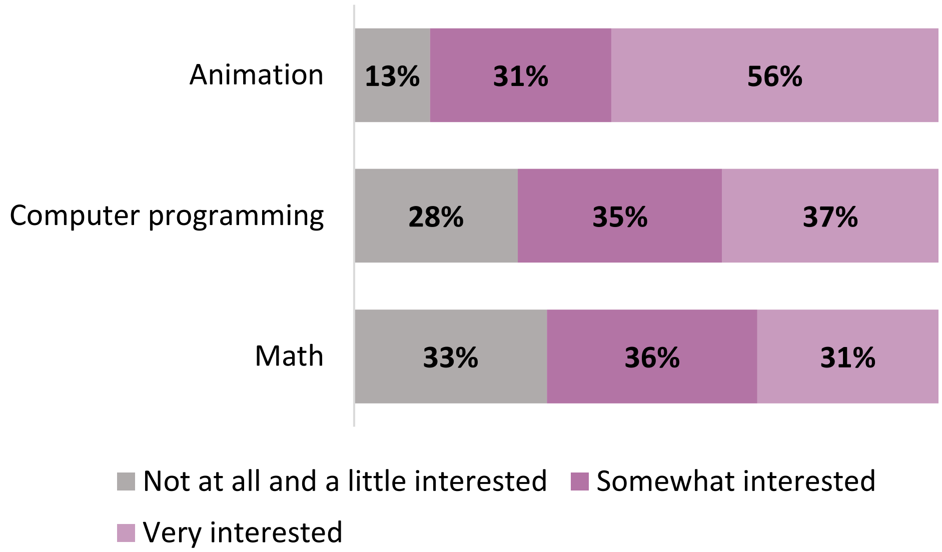
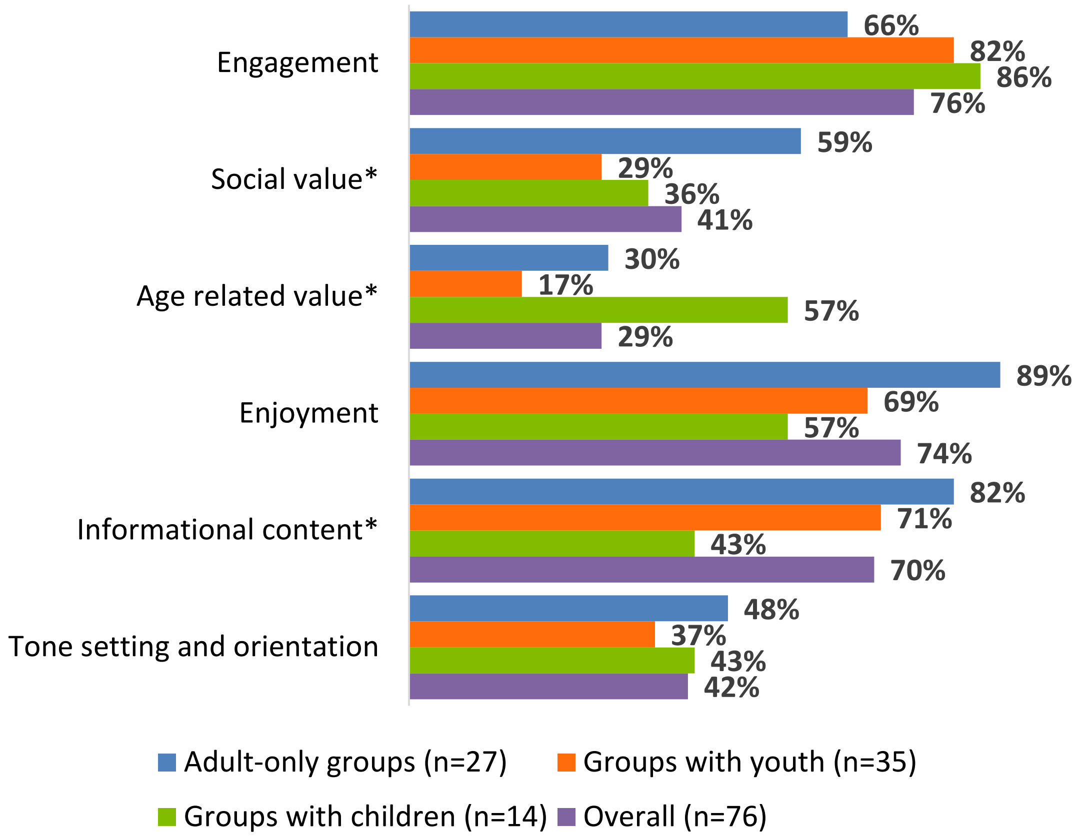


Table F3: General public expectations about what they would be able to see, do, or learn in *SBP*, Franklin Institute, post-exhibition interview (N=76 groups)

Category		% of FI responses
Pixar's process and/or the animation process		71%
Learning experience qualities		5%
	Fun or interest	5%
	Age appropriateness	0%
	Interactivity	3%
Specific art, STEM, and creativity content		21%
Relevance of content to school, life, or career		8%

Figure 33: How visitors describe the overall value of *SBP*, Post-exhibition interview, Franklin Institute (N=76 groups)[97]



[97] Social value: Adult-only groups were more likely to talk about the social value of exhibits. $\chi^2(2, N=76)=6.1, p < .05$; Age-related value: Groups with children and adult-only groups more likely $\chi^2(2, N=76)=7.7, p < .05$; Informational content: Adult-only and groups with youth more likely, $\chi^2(2, N=76)=6.6, p < .05$.

Table F4: How visitors described the value of the intro theater, Interviews, Franklin Institute (N=76 groups)

Value	% of visitors	Example quote
Tone Setting and Orientation	34%	*"Yeah. Good to get the mindset into it. The different aspects."* (female, 33)
Fun and Enjoyment	32%	*"Fun seeing how things got created."* (female, 10)
Informational Content	38%	*"I thought it was a great start to the different departments; I had no idea that there were so many."* (female, 39)
Engagement	16%	*"I thought it was interesting that there were different parts people took part in to make the movie together."* (male, 14)

Table F5: How visitors described the value of the interactive experiences, Interviews, Franklin Institute (N=76 groups)

Value	% of groups	Example quote
Fun and Enjoyment	35%	*"Those were fun; I liked the one where you're building a robot."* (male, 17)
Engagement (creatively, cognitively, and physically)	60%	*"Fun to play with all the things and buttons."* (female, 10)
Informative	17%	*"Good mix of all on computers vs. models, hands-on math."* (male, 29)
Age Appropriateness	11%	*"Awesome. The best part. It was engaging for all ages."* (female, 42)

Table F6: How visitors described the value of the videos, Interviews, Franklin Institute (N=76 groups)

Value	% of visitors (n=128 groups)	Example quote
Fun and Enjoyment	18%	*"My favorite part."* (male, 20)
Engagement: Cognitive	38%	*"As an adult, it was most interesting to learn about the roles in movie-making."* (female, 39)
Informational Content	46%	*"Walks you through the process and how things evolve like motion. Not just linear. You can put emotion in it and make it lifelike."* (male, 43)

Figure 34: Representation of STEM-related skills involved in animation in groups' post-exhibition interviews, Franklin Institute (N=76 groups)

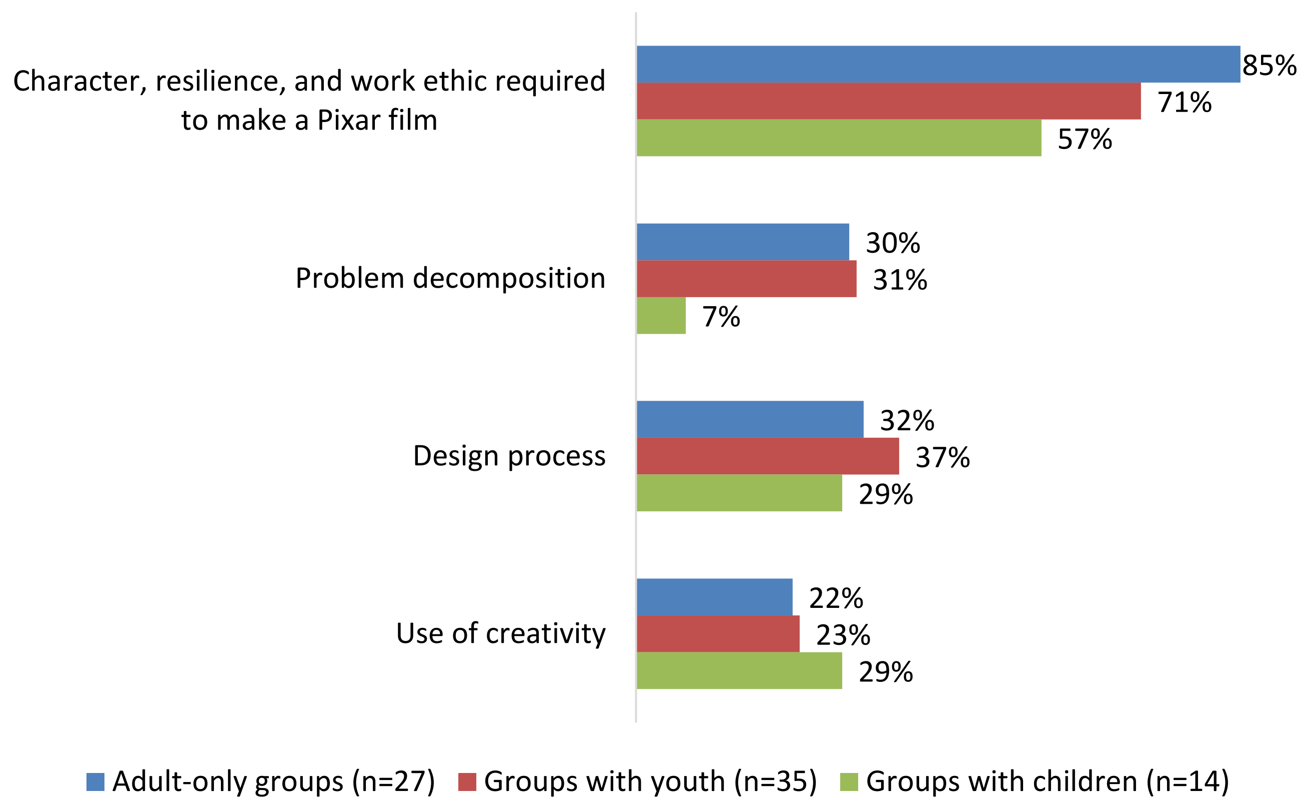


Table F7: Interest in learning about, creating, or using animation, computer programming, or math in their career; Pre-exhibition and post-exhibitions surveys (N=240 groups)[98]

		Pre-exhibition surveys (n=121)	Post-exhibition surveys (n=112)
Animation	Learning about	56%	61%
	Creating	50%	49%
	Using or doing professionally*	13%	32%
Computer programming	Learning about*	37%	48%
	Creating	33%	36%
	Using or doing professionally*	20%	31%
Math	Learning about	30%	33%
	Creating	30%	29%
	Using or doing professionally	23%	27%

Table F8: Visitors' understandings of the skills involved in programming, Post-exhibition compared to pre-exhibition survey control group, Franklin Institute (N=233 groups)[99]

	Pre-exhibition surveys (n=120)	Post-exhibition surveys (n=113)
Programmers break problems into smaller parts and solve them one at a time*	36%	48%
Programmers can create almost anything they can imagine	41%	50%
There are many different ways to solve any given computer programming problem.	48%	49%

[98] Using or doing animation professionally, *U*=5842, *Z*=-2.50, *p* = .001;
Learning about computer programming, *U*=5924, *Z*=-2.21, *p* = .05;
Using or doing computer programming professionally, *U*=5842, *Z*=-2.50, *p* = .05

[99] Programmers break problems into smaller parts and solve them one at a time: *U*=5644, *Z*=-2.29, *p* = .05

Table F9: Attitudes and beliefs math and programming, Pre-exhibition and post-exhibition surveys (N=233 groups)[100]

		Pre-exhibition (n=121)	Post-exhibition (n=112)
Computer Programming	Importance to know	25%	18%
	Creativity involved	53%	66%
	Career usefulness	47%	49%
Math	Importance to know*	47%	38%
	Creativity involved	33%	30%
	Career usefulness	65%	63%

Table F10: Reasons for likelihood to recommend score, Post-exhibition surveys (N=89 groups)

Visitor reasons	% of groups
Educational	37%
Interactive	16%
Entertaining	16%
General response	16%
Works well for certain age groups	15%
Recommend with stipulations (mainly age-related)	13%
Family group	12%
Well organized	9%
Pixar/Disney affinity	8%

[100] Math is one of the most important things to know: U=5795, Z=-2.07, p = .05

Table F11: Visitor responses for "Which exhibit did you find most interesting?" Franklin Institute (N=76 groups)

Exhibit	% of groups
Stop-Motion Animation	20%
Pipeline	11%
Lighting Immersive	11%
Surface Appearance Workstation	9%
Lighting Design Basics	8%
Simulation Immersive	8%
Virtual Lighting Workstation	8%
Build a Robot	5%
Sets and Cameras Immersive	4%
Set Layout Workstation	4%
Sculpt by Numbers	4%
Face Rigging Workstation	3%
Crowd Simulation Workstation	3%
Virtual Modeler Workstation	1%
Programming Natural Variety	1%
Surfaces Immersive	1%
Rendering Immersive	1%
Computer Animation Workstation	1%
Limit Complexity	1%

APPENDIX G: STUDENT VIGNETTES

VIGNETTE 1

An elementary school student's experience in *SBP*

Samuel attended *SBP* with his fifth grade class from a suburban elementary school. He identified himself as a Latino male, and is about 10 or 11 years old. Coming into the exhibition, he felt confident in his math knowledge, rating himself an 8 on a scale from 0 to 10, but far less so in computer programming, for which he rated himself a 0.5 out of 10. This affinity for math was accompanied by some interest in learning about it, using it creatively, and applying it to a career. Samuel agreed that math is important and useful in careers but disagreed that it can require creativity.

In computer programming and animation, Samuel's initial interest level was consistent with his math ratings with respect to learning more about them, using them creatively, and pursuing them in careers. When asked about his attitudes and perceptions about computer programming, he agreed or strongly agreed in its usefulness in careers and solving problems, its dependency on creativity, its importance, and computer programmers' agency. However, he did not have an opinion on whether solving programming-related problems requires breaking them down into manageable parts.

Samuel spent 39 minutes in *SBP*, and engaged with all the exhibit component types during that time, though the majority of his visit was spent at the interactive exhibits. Observational field notes indicated his experience as being very active and collaborative, as he moved quickly among the exhibits. He only settled a couple of times, using most exhibits with a group of classmates and working with them to grasp the concepts. Due to this team strategy, Samuel was more often not the student interacting directly with the exhibits. He, instead, watched his classmates while providing suggestions and insight about what to do. A number of times, chaperones guided his group to certain interactives, influencing the path of his visit. Samuel's experience is mapped in Figure 27 (page 72).

Samuel showed evidence of skill engagement in his observational data. Additionally, his responses to survey and interview questions suggested that he used, acknowledged, and strengthened the skillsets established in the exhibition goals. When asked what was most interesting and memorable about *SBP*, he said, "*I liked when we designed our own studio. We got to animate our own room. [I] learned that animation is pictures, but in 3D, but it's more complex than in 2D*." His response conveys that he engaged both with design process and creative skills using the *Set Layout Workstation* interactive.

The understanding of the significance of creative skills also had a strong presence in Samuel's follow-up survey. When asked how he would explain the steps in animation, he wrote, "*Creativity, it is a harder than you think*." He also strongly agreed that creativity is vital in computer programming, as he had initially, but also recognized this creativity in math, whereas he had not before the field trip. Furthermore, his interest in using math, computer programming, and animation creatively increased, as well as using the latter two subjects when talking about careers. His interest in pursuing a math-related career did not change. When asked about the best part of *SBP*, he again addressed how he had been able to take part in the creative process of making the animations.

SBP also positively impacted Samuel's perception of STEM importance, its applicability outside of the exhibition, and his desire to learn more. Along with the majority of his classmates, Samuel exhibited a positive change in his belief that computer programming is useful in careers. Additionally, his attitude improved with respect to the variety of ways programmers solve problems, the importance of math, and math's usefulness in careers. He made connections between the exhibition and his life, reporting that *SBP* relates to the systems he learns about in school. He also recognized making connections to *SBP* when talking to his friends and family, in class, and when seeking further information relevant to the exhibition content. His self-efficacy in computer programming increased after visiting *SBP*.

VIGNETTE 2

A middle school student's experience in *SBP*

Alice is an eleven-year-old female who visited *SBP* on a field trip with her fifth grade science class. In her home district, fifth grade is included in the middle schools. She identifies racially as white and remembers her last visit to the museum being one or two years before her visit to *SBP*. Before coming to the exhibition, she had high confidence in her math and computer programming abilities, rating herself and 8 and 7 on a scale from 0 to 10, respectively. She was confident that she would be able to make a computer program if she took the right classes or used a manual for help. Though she was secure in her abilities, her interest in the exhibition topics was a bit scattered. She was highly interested in learning about and creating animations, but only somewhat interested in creating computer programs or pursuing a career in animation. She had little or no interest in learning about computer programming or math, using math creatively, or considering computer- or math-based careers.

Before coming to the exhibition, some of Alice's perceptions about math and computer science were also muted or neutral. Alice agreed that creativity is evident in computer programming and math, that math is useful, and that computer programmers have substantial agency. She had no opinion on how computer programmers solve problems and disagreed that computer programming and math are two of the most important subjects to know. Alice's interest in animation was supported by her expectations, when she explained, "*I hope to see and learn how [Pixar employees] work the animations*."

Over the course of 33 minutes, Alice engaged with immersive experiences and interactive exhibits primarily, and watched one *Behind the Scenes* video. She only spent about 5 minutes wayfinding and socializing, suggesting that she was engaged with the exhibit and content most of the time. Observational data noted that her visit was strongly guided by her chaperones and a worksheet that she was determined to complete. Her focus on the worksheet content resulted in her being more of an observer at the exhibits, instead of directly engaging with them. See Figure 27 (page 72) to see Alice's path around the exhibition.

When her class left the exhibition, Alice again illustrated her high interest in animation and identified specific exhibits as the most interesting and memorable parts of the exhibition:

> *I liked animation and everything. I liked Sully and Mike and how [an exhibit] showed [you] could move [an] arm for Mike. That was cool … I liked how in [the] movie UP--had scenes [here] and could change light.*

Alice continued to express her attraction to animation weeks after the field trip. Her interest in learning about, creatively using, and pursuing careers in math and computer programming increased somewhat, but did so highly pertaining to animation. *SBP* provided her an opportunity to interactively learn about animation and this continued to resonate with her, as she stated, "*I think the best part was the activities*."

Retrospective feedback revealed that Alice was slightly more enthusiastic about using computer programming and math herself after her field trip, but her attitudes and perceptions about these two topics did not change or were negatively impacted. For example, she was more likely to disagree that math is useful in careers and that computer programmers can create almost anything after visiting the exhibition. Whereas she had agreed that creativity exists in computer programming and math initially, she had no opinion 4-6 weeks later. The only two instances in which Alice exhibited a positive change in her attitudes toward these topics were in agreeing that computer programming is useful in careers and that math is a priority subject to understand, the former being a statistically significant trend in her age group.

Despite her mixed reactions in interest and attitude toward math and computer programming, Alice's confidence in her abilities did not change, as her self-efficacy rating stayed constant between pre-exhibition and follow-up surveys. Additionally, her overall varied retrospective feedback did not deter her from thinking about the exhibition and its content in her daily life. She reported thinking about her experience at *SBP* during class, when watching films, making her own projects, and seeking further information.

VIGNETTE 3

A high school student's experience in *SBP*

Joseph is a high school student from a Massachusetts suburb who attended *SBP* with his art class. He identifies as a 14-year-old Lebanese male. He had a high initial interest in the content addressed by the exhibition. For example, he was very interested in learning about computer programming and math, creating his own animations and computer programs and using computer programming and math in his future career. He was only a little interested in using math in creative projects and applying animation to a career.

Additionally, Joseph was enthusiastic in his perceptions about math and computer programming, strongly agreeing that creativity exists in computer science and math, that math is useful and important, and that computer programmers can create most anything they imagine. He did not have any strong expectations for the exhibition, and when asked what he was hoping to see, do, or learn, responded, "*I don't know, I will see.*"

Joseph spent a total of 78 minutes in the exhibition. During his visit he interacted with most exhibit types. See Figure 27 (page 72) for a visual of Joseph's visit, with respect to how he physically navigated the exhibition. Observation notes pertaining to Joseph's behavior revealed a social component to his experience that is not necessarily typical of other general audience groups. Thirty-five of his 78 minutes in the exhibition were spent socializing with classmates, receiving instruction from teachers, and using his phone, as opposed to being explicitly engaged in the exhibits and content. This is an important consideration in field trip experiences and how student behavior can differ in this context.

When his class departed, Joseph shared that he thought the most interesting part of *SBP* was *"…[that] humans make movies on a computer. I thought it was the computer*." He said learning "*how they make reflection and color. It's a lot of work; I know movies take a lot of time*" was the most memorable part.

A few weeks after visiting the exhibition, Joseph again reflected on the extensive input employees must contribute to making an animated movie. When asked how the exhibition related to school, Joseph shared, "*[The] first time I was thinking the computer makes the movie, but the Science Behind Pixar shows us that it is the humans*." However, this reoccurring acknowledgement did not deter his affinity for the content. His interest in using animation, computer programming, and math in his future career increased a little, but his initial interest in the latter two was high initially. He was much more intrigued about using math in his own creative projects and creating his own computer programs. Overall, Joseph's curiosity and enthusiasm increased, inspiring him to seek further information following his visit. In accordance with the patterns of his age group, Joseph's pursuit of more information aligned with an increase in self-efficacy in computer programming.

APPENDIX H: PRE-EXHIBITION SURVEY, STUDENT

We hope you enjoy your field trip to *The Science Behind Pixar!*

Please complete this brief survey to help us improve our exhibits and programs for you and other students like you. There are no right or wrong answers to any of the following questions**.** Thank you for sharing your thoughts and ideas with us.

1. **Please rate your interest in each of the following:**

	Not **at all** interested	**A little** interested	**Somewhat** interested	**Very** interested
Learning about animation	❐	❐	❐	❐
Learning about computer programming	❐	❐	❐	❐
Learning about math	❐	❐	❐	❐
Creating my own animations	❐	❐	❐	❐
Creating my own computer programs	❐	❐	❐	❐
Using math in my own creative projects	❐	❐	❐	❐
Doing animation as part of my career	❐	❐	❐	❐
Doing computer programming as part of my career	❐	❐	❐	❐
Doing math as part of my career	❐	❐	❐	❐

Use the scales from 0-10 to answer the following questions.

2. Do you think you could **write brand new programs or software** (like apps for smartphones or tablets)…

	0	1	2	3	4	5	6	7	8	9	10
2a. …if you took the right classes in school?	No way										Definitely
2b. …if you could ask an expert or use a manual for help?	No way										Definitely
2c. …with no manual or outside help?	No way										Definitely

3. **What do you hope to see, do, or learn at *The Science Behind Pixar?***

4. **Please rate the following statements based on your beliefs about math and computer programming:**

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
Knowing how to do computer programming is useful in many careers.	❒	❒	❒	❒	❒
There is a lot of creativity involved in computer programming.	❒	❒	❒	❒	❒
There are many different ways to solve any given computer programming problem.	❒	❒	❒	❒	❒
Computer programming is one of the most important subjects for people to know.	❒	❒	❒	❒	❒
Computer programmers can create almost anything they imagine.	❒	❒	❒	❒	❒
When solving a problem, computer programmers break it into smaller parts and solve them one at a time.	❒	❒	❒	❒	❒
Mathematics is one of the most important subjects for people to know.	❒	❒	❒	❒	❒
Knowing how to do math is useful in many careers.	❒	❒	❒	❒	❒
There is a lot of creativity involved in math.	❒	❒	❒	❒	❒

Please answer the following questions about yourself.

1. **How old are you? ___________**

2. **What is your gender? ____________**

3. **Please rate your own level of knowledge or experience in math and computer science or programming.**

	Not at all knowledgeable										Extremely knowledgeable
Math	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Computer science / programming	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

4. **When was the last time you visited the Museum of Science?**
   - ❑ Within the past three months
   - ❑ 3-6 months
   - ❑ 6 months to within the last year
   - ❑ 1-2 years ago
   - ❑ 2-5 years ago
   - ❑ 5-10 years ago
   - ❑ More than 10 years ago
   - ❑ Never
   - ❑ Not sure

5. **What is your race or ethnicity? ____________________**

APPENDIX I: FOLLOW-UP SURVEY, STUDENT

We hope you enjoyed your field trip to *The Science Behind Pixar*! To help improve our exhibits and programs for you and other students like you, please complete this short survey. There are no right or wrong answers to any of these questions**. Thank you for sharing your thoughts and ideas with us.**

1. **How would you explain the steps involved in making a Pixar film to your favorite teacher?**

2. **Please explain how *The Science Behind Pixar* relates to things you have learned about or done in school.**

3. **Please rate the following statements again, based on your beliefs about math and computer programming.**

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
Knowing how to do computer programming is useful in many careers.	❐	❐	❐	❐	❐
There is a lot of creativity involved in computer programming.	❐	❐	❐	❐	❐
There are many different ways to solve any given computer programming problem.	❐	❐	❐	❐	❐
Computer programming is one of the most important subjects for people to know.	❐	❐	❐	❐	❐
Computer programmers can create almost anything they imagine.	❐	❐	❐	❐	❐
When solving a problem, computer programmers break it into smaller parts and solve them one at a time.	❐	❐	❐	❐	❐
Mathematics is one of the most important subjects for people to know.	❐	❐	❐	❐	❐
Knowing how to do math is useful in many careers.	❐	❐	❐	❐	❐
There is a lot of creativity involved in math.	❐	❐	❐	❐	❐

4. In what situations, if any, have you <u>thought about</u>, <u>talked about</u>, or <u>used</u> what you learned or experienced in *The Science Behind Pixar*? <u>Please select all that apply.</u>

- ❒ While I was watching a video or film.
- ❒ While talking to friends, families, or other people.
- ❒ During a class or an activity.
- ❒ While I was working on my own projects.
- ❒ While I was looking for other information or ways to learn more.
- ❒ Other - Please explain: ____
- ❒ Since my visit, I have <u>not</u> thought about what I learned or experienced in *The Science Behind Pixar*.

5. Please rate how, if at all, *The Science Behind Pixar* <u>changed</u> your interest level in each of the following:

After seeing *The Science Behind Pixar*, I feel:

	<u>Much less</u> interested	**<u>A little less</u>** interested	**<u>Same</u>** as I did before	**<u>A little more</u>** interested	**<u>Much more</u>** interested
Learning about *animation.*	❒	❒	❒	❒	❒
Learning about *computer programming.*	❒	❒	❒	❒	❒
Learning about *math.*	❒	❒	❒	❒	❒
Creating my own *animations.*	❒	❒	❒	❒	❒
Creating my own *computer programs.*	❒	❒	❒	❒	❒
Using *math* in my own creative projects.	❒	❒	❒	❒	❒
Doing *animation* as part of my career.	❒	❒	❒	❒	❒
Doing *computer programming* as part of my career.	❒	❒	❒	❒	❒
Doing *math* as part of my career.	❒	❒	❒	❒	❒

Use the scales from 0-10 to answer the following questions.

6. **Do you think you could <u>write brand new programs or software</u> (like apps for smartphones or tablets)**

	0	1	2	3	4	5	6	7	8	9	10
6a. …if you took the right classes in school?	No way										Definitely
6b. …if you could ask an expert or use a manual for help?	No way										Definitely
6c. …with no manual or outside help?	No way										Definitely

7. **What would you say was the <u>best</u> part of *The Science Behind Pixar?***

8. **What is one thing you think should be <u>improved</u> about *The Science Behind Pixar?***

Thank you for sharing your thoughts and ideas with us!

APPENDIX J: FLASH INTERVIEW, STUDENT

Intro: I hope you enjoyed your visit! As part of our evaluation, I'd like to ask you each two quick questions about your visit. Just to let you know, if you do not have parental consent for the evaluation, we will not write down your responses, even though you're still welcome to participate with your group. There are no right or wrong answers to these questions. By sharing your thoughts with us, you'll help us make better exhibits and programs for other visitors like you. Do you have any questions for me?

Name:	Q1: What did you learn at this exhibit that you found most interesting or engaging, and why?	Q2: What would you say is the most memorable part of the exhibition, and why?

APPENDIX K: SUPPLEMENTAL STUDENT AND EDUCATOR DATA

Table K1: Distribution of subjects taught by educators, School VXM (N=199) and educator workshop surveys (N=45)

School subject	Attended *SBP* (n=82)	Did not attend *SBP* (n=117)	Educator workshop attendees (n=45)
Math	34%	26%	47%
Technology / engineering	29%	11%	13%
Integrated science	23%	21%	18%
Earth science / astronomy	23%	24%	33%
Life science / biology	22%	28%	31%
Physical science / physics	21%	20%	22%
Art	18%	3%	13%
Chemistry	13%	13%	18%
Other	11%	12%	13%
Language arts	9%	17%	13%
All subjects	5	21%	11%
Social studies / history	4%	13%	11%
Computer science	-----	-----	11%
None of the above	2%	5%	-----

Table K2: Distribution of grades taught by attendees, Educator workshop surveys (N=45)

Grade band	Proportion of attendees
Early elementary (Pre-K – Grade 2)	7%
Late elementary (Grades 3 – 5)	24%
Middle School	69%
High School	18%

Table K3: Past experience with MOS field trips, School VXM (N=199) and educator workshop surveys (N=45)

	Attended *SBP* (n=82)	Did not attend *SBP* (n=117)	Educator workshop attendees (n=45)
Attended and planned previously	54%	62%	37%
Only attended previously	30%	28%	47%
Only planned previously	0%	2%	4%
Neither attended nor planned previously	16%	8%	16%

Table K4: Distribution of initial student interest, Pre-exhibition surveys (N=232)

Please rate your interest in each of the following.		HS students (n=31)				E/MS students (n=136)			
		Not at all	A little	Somewhat	Very	Not at all	A little	Somewhat	Very
Animation	Learning	10%	23%	39%	29%	2%	16%	29%	53%
	Using creatively	13%	19%	35%	32%	4%	4%	17%	75%
	Using in career	42%	19%	13%	26%	21%	25%	34%	20%
Computer programming	Learning	19%	32%	29%	19%	5%	25%	30%	40%
	Using creatively	17%	27%	33%	23%	5%	13%	29%	53%
	Using in career	47%	17%	17%	20%	25%	36%	19%	20%
Math	Learning	45%	23%	23%	10%	31%	23%	17%	28%
	Using creatively	42%	39%	16%	3%	26%	25%	28%	20%
	Using in career	52%	29%	10%	10%	39%	21%	26%	14%

Table K5: Student expectations for *SBP*, Pre-exhibition surveys (N=232)[101]

What do you hope to see, do, or learn at *SBP*?	**HS students (n=36)**	**E/MS students (n=184)**	**Example quotes**
Learn about Pixar Animation Studio's animation process	69%	73%	*"I want to see how you create animations." (female, 10)*
Have a hands-on / interactive experience.	8%	15%	*I hope I do a lot of hands-on games to learn about Pixar animation." (female, 10)*
Have a fun / interesting experience	6%	5%	*"I hope to learn about animation because it looks very fun and I think it will be fun to learn it." (female, 10)*
Learn about science	3%	2%	*'I'm excited to learn how art and science go together to create animations in movies." (HS student)*
Learn about technology / computer science	11%	15%	*"About computer coding and animation." (male, 10)*
Learn about math	6%	1%	*"I hope to learn how math is used in animation." (female, 10)*
Learn about creativity	6%	1%	*"How to apply the techniques to my own creative projects." (female, 15)*
Learn about art	11%	4%	*"…sketches and drawings of Pixar characters." (male, 10)*
Relate the exhibition to aspects of own life	8%	2%	*"I want to learn everything because my life-long dream is [to] work for Pixar." (male, 11)*
Relate the exhibition to familiar Pixar films	3%	9%	*"…see Pixar characters." (female, 14)*
I don't know	3%	2%	*"I don't know?" (male, 11)*
General comments	8%	3%	*"I hope to see things amazing" (male, 17)*
Other	8%	7%	*"I've already been." (female, 15)*

[101] Responses to, "Q3: What do you hope to see, do, or learn at *SBP*?"

Table K6: Student use of multimodal representations, Tracking and timing (N=27)

Exhibit element	HS students (n=5)		E/MS students (n=20)	
	1-2 times	3 or more times	1-2 times	3 or more times
Tactile models	1	3	9	9
Hearphones	2	1	9	6

Table K7: Distribution of student understanding of how programmers solve problems, Follow-up surveys (N=184)

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Programmers have the ability to create anything they imagine	HS students (n=31)	3%	3%	14%	47%	39%
	E/MS students (n=135)	2%	5%	16%	33%	44%
There are many different ways to solve computer programming problems	HS students (n=31)	0%	8%	8%	53%	31%
	E/MS students (n=135)	1%	6%	37%	36%	19%
Programmers break big problems into smaller parts	HS students (n=31)	3%	3%	22%	50%	22%
	E/MS students (n=135)	1%	3%	32%	41%	23%

Table K8: Distribution of students' self-reported change in interest, Follow-up surveys (N=184)

		HS students (n=31)					E/MS students (n=135)				
		Much less	A little less	No change	A little more	Much more	Much less	A little less	No change	A little more	Much more
Animation	Learning	3%	12%	27%	39%	18%	3%	5%	14%	37%	41%
	Using creatively	6%	18%	27%	33%	15%	3%	5%	8%	23%	62%
	Using in my career	12%	9%	39%	24%	15%	12%	16%	25%	23%	23%
Computer programming	Learning	3%	15%	36%	33%	12%	3%	6%	31%	29%	30%
	Using creatively	12%	6%	49%	21%	12%	3%	10%	21%	31%	36%
	Using in my career	12%	12%	39%	33%	3%	16%	16%	29%	18%	20%
Math	Learning	3%	9%	70%	18%	0%	13%	9%	45%	17%	16%
	Using creatively	3%	6%	73%	12%	6%	10%	14%	32%	27%	18%
	Using in my career	12%	15%	46%	21%	6%	20%	12%	37%	12%	19%

Table K9: Distribution of all student attitudes and perceptions about programming and math, Pre-exhibition surveys (N=232) and follow-up surveys (N=184)

		Strongly disagree		Disagree		Neutral		Agree		Strongly agree	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Math is…	Important to know.	5%	4%	8%	5%	18%	15%	31%	31%	38%	45%
	Full of creativity.	13%	11%	17%	18%	33%	32%	25%	21%	12%	17%
	Useful in careers.	4%	2%	2%	4%	7%	8%	32%	34%	55%	52%
Computer programming is…	Important to know.	7%	9%	26%	28%	38%	39%	21%	14%	8%	10%
	Full of creativity.	1%	2%	3%	2%	8%	9%	43%	44%	46%	43%
	Useful in careers.	1%	2%	4%	3%	22%	18%	52%	51%	21%	26%

Table K10: Distribution of HS and E/MS attitudes and perceptions about programming and math, Follow-up surveys (N=184)

		HS students (n=36)					E/MS students (n=148)				
		SD	D	N	A	SA	SD	D	N	A	SA
Computer programming	Usefulness	3%	0%	17%	54%	26%	1%	3%	18%	51%	27%
	Important to know	3%	17%	44%	31%	6%	10%	30%	38%	11%	11%
	Creativity	3%	3%	8%	39%	39%	1%	1%	9%	44%	44%
Math	Usefulness	3%	0%	14%	42%	42%	4%	6%	15%	28%	46%
	Important to know	3%	3%	6%	33%	56%	2%	4%	9%	34%	51%
	Creativity	11%	3%	33%	33%	19%	11%	21%	32%	18%	17%

SD = "Strongly disagree", D = "Disagree", N = "Neutral", A = "Agree", SA = "Strongly agree"

Table K10: Factors predicting initial interest and post-exhibition change in interest in animation, computer programming, and math, Pre-exhibition surveys and follow-up surveys (N=161)

	Predictor variables	β	Adj. R^2
Pre-exhibition interest in animation			
	Gender (female)	0	.05**
	Age	-.24**	
Pre-exhibition interest in computer programming			
	Gender (female)	-.23**	.08***
	Age	-.18*	
Pre-exhibition interest in mathematics			
	Gender (female)	-.21**	.05**
	Age	-.10	
Follow-up (post exhibition): Change in interest in animation			
	Pre-visit interest in animation	0.50***	.25***
	Gender (female)	-0.059	
Follow-up (post exhibition): Change in interest in computer programming			
	Pre-visit interest in programming	.52***	.31***
	Gender (female)	-.12	
Follow-up (post exhibition): Change in interest in mathematics			
	Pre-visit interest in math	.63***	.47***
	Gender (female)	-.111	

Table K11: Correlation between positive changes in self-efficacy and follow-up activities, Pre-exhibition surveys and follow-up surveys (N=156)

Predictor variables	β	Adj. R^2
Pre-exhibition self-efficacy	-.42***	.20***
Whether and how much students thought or talked about *SBP* after their visit	.21**	

*=p<0.05; **=p<0.01; ***=p<0.001

APPENDIX L: ACCESSIBILITY

Table L1: Full descriptions of participants

The following section provides greater description about accessibility testing participants and their groups. **Cedric** (age 13): Cedric identifies as having Asperger syndrome. He attended *SBP* with his mother (age 40s) and her boyfriend (age 30). Their last visit to MOS was 1-2 years ago.
Hazel and Roxanne: Hazel (age 49) has scoliosis and a two-inch leg difference, which makes it difficult for her to walk or stand for long periods of time. Her daughter, Roxanne (age 16), has high functioning autism spectrum disorder (ASD) and ADHD. Hazel and Roxanne visited *SBP* with another family consisting of a mother and daughter. It has been over 10 years since Hazel visited MOS, but Roxanne has visited more recently, 1-2 years ago.
Ronald: Ronald (age 60) is blind and uses a wheelchair. He visited *SBP* with his wife and was accompanied by a sighted tour guide. His is last visit to MOS was 5-10 years ago.
Theresa: Theresa (age 17) has low vision and her last visit to MOS was 1-2 years ago. She arrived with her father. She was accompanied by a sighted guide during her visit to *SBP*.
Kenneth: Kenneth (age 26) has cerebral palsy and uses a motorized wheelchair. He is mostly non-verbal. He visited *SBP* with his mother and father. His most recent visit to MOS was 1-2 years ago.
Maggie: Maggie (age 60) has low vision to the point that she is almost legally blind. She has a particular issue recognizing contrast. Her most recent visit to MOS was 1-2 years ago. Maggie's family had a Museum membership and they arrived to the Museum with Maggie. However, Maggie's family headed into *SBP* before her. Maggie was accompanied by a sighted guide during her visit to *SBP* and the two of them navigated the exhibition separately from the rest of her group.
Joseph: Joseph (age 7) has mild ASD. He has particular sensitivities to loud noises and crowds. Prior to visiting *SBP*, he had been to the Museum within the past three months. He came to *SBP* with his father.
Mitchell: Mitchell (age 8) has Williams syndrome. He identifies as having learning disabilities, difficulty with emotional regulation, and sensory processing issues. His family are members of the Museum, and had visited the Museum 3-6 months before seeing *SBP*. He attended the exhibition with his sister, mother, and father. His mother accompanied him for most of his visit, while his father and sister explored the exhibition separately, for the most part.
Tom: Tom (age 25) has spina bifida, which makes it difficult for him to walk and stand for long periods of time. He also noted some difficulties with fine motor skills. During this visit, he wore a knee brace. He visited the Museum with his parents. Their most recent trip to the Museum was 1-2 years ago.

Cody and Milton: Cody (age 17) has Down syndrome and expressive-receptive language deficits. He also has difficulties with depth perception and mild hearing impairment. Milton (age 19) has a cognitive disability. Both boys attended *SBP* with their mothers. Before visiting *SBP*, Cody's last visit to the Museum occurred between six months to under a year ago.
Jermaine: Jermaine (age 14) is impacted by ASD. His most recent visit to the Museum was 1-2 years ago. He came to the exhibition with his mother and cousin (age approximately 14, female).
Judith: Judith (age 39) is deaf, but she can read lips, as well as read and speak English fairly well. Her most recent visit to MOS was 1-2 years ago. Judith navigated *SBP* on her own.
Marcia: Marcia (age 26) is impacted by ASD and a sensory processing disorder. She also experiences chronic migraines. Her most recent visit to MOS occurred between 6 months to under 1 year ago. Marcia navigated *SBP* on her own.
Walter: Walter (age 12) is impacted by hypoplastic left heart syndrome, mild to moderate hearing loss, and several cognitive disabilities. He also experiences difficulty coordinating fine motor skills and rapid involuntary movements of the eyes. Walter had visited MOS within 3 months prior to seeing *SBP*. Walter attended the exhibition with his mother and father.
Eugene and June: Eugene (age 65) identifies as legally blind. His most recent visit to MOS was 1-2 years ago. June (age 35) is blind and her most recent visit to MOS was 3-6 months ago. Eugene, June, and June's son (age 6) arrived in the same group, along with their friends Eunice and Angela, and Angela's her 4-year-old daughter, Pilar. Eugene and June navigated *SBP* separately, and Angela and Eunice each occasionally accompanied Eugene and June.
Bobby: Bobby (age 10) is impacted by Asperger syndrome. He came to the Museum with his Big Brother from the Big Brothers Big Sisters of America program. His group was not sure of their most recent visit to MOS.
Jay: Jay (age 14) is impacted by ASD. He has communication and cognitive disabilities. He also experiences severe allergies and asthma. He came to the Museum with his Big Brother from the Big Brothers Big Sisters of America program. His most recent visit to MOS was 1-2 years ago.

CONTENT AND RELEVANCE

Examples of how visitors related prior experiences, knowledge, or interests to their *SBP* experiences

At *Set Layout Workstation*, Roxanne, a 16-year-old girl with high-functioning ASD and ADHD, noted, *"I do 3D homes that's kind of like this."* She was able to connect concepts from the exhibit to real life contexts. Later, at the *Rendering (Inside Out)* and *Simulation (Brave)* immersive exhibits, Roxanne shared with her group prior knowledge related to content in these exhibits. This suggested that Roxanne comprehended the exhibit concepts and felt confident enough in her understanding to share with others.

Examples of how visitors engaged with different multimodal representations

Interactive exhibits

Tom, a 25-year-old with spina bifida, noted that he liked *"tangible, touching dimensional stuff and computer program stuff."*

When Walter, a 12-year-old child with physical and cognitive disabilities, used *Computer Animation Workstation*, he appeared excited by Mike's waving and the opportunity to try different combinations. He engaged for 3 minutes and 32 seconds.

Videos

Walter listened to hearphones at several videos, noting that he liked that they *"told us how they made things and what they did."*

Hazel, a 49-year-old with scoliosis, noted that she liked *"the jobs, [you can] learn about every job everyone did"* when talking about the *Working at Pixar* videos.

Educator-led experiences

Theresa, a visitor who has low vision, noted that the educator-led activities were *"really cool. Sometimes people need hands-on things to know how it works."*

June stated that the *Fire and Light* educator-led activity was one of her favorites, adding that she would have liked even more description. She stated, *"I liked it, but it was limited. I wish there was more description of what happens as you create the image of fire. It was very interesting though."*

Examples of how multimodal representations enhanced visitor experiences

At *Build a Robot*, June, a 35-year-old woman who is blind, and her 6-year-old son engaged together at the exhibit for 4 minutes, 32 seconds. June used the exhibits by feeling and putting together the tactile pieces on the table while listening to the information and instructions on the hearphone. She exclaimed, *"I like this, this is cool. Wow!"*, and cited it as one of her favorite exhibits, noting that *"they were hands on. I liked how you could really feel how you can pose the different parts."*

Sculpt by Numbers also provided opportunities for families to engage together by presenting different multimodal representations. At this exhibit, Walter, a child with fine motor skill issues and cognitive disabilities, and his whole group worked toward completing the challenge that was described on the exhibit instructions. Walter's mother talked about the call-outs on the graphic labels, while his father helped Walter plot points on the 3D coordinate system.

APPENDIX M: KEY TERMS

Click to return to Methods (page 8), Public Audience Impact section (page 15), School Group Audience Impact section (page 63), Accessibility section (page 97), or the Conclusion (page 124).

Terminology for this report is defined below:

This report will address the following audiences that visited *SBP*:

- **General public visitors** were divided into three categories ("types"), in accordance with the age ranges of interest to this summative evaluation:
  - **Groups with children**: Any group with children age 7 and younger, and accompanying parents. Usually the child group member led the group experience.
  - **Groups with youth**: Groups that only consisted of children ages 8-17 and adults.
  - **Adult-only groups**: Groups with only visitors ages 18 and older.
- **School groups:**
  - Three unrelated school groups participated in the *SBP* evaluation: one high school (HS) class and two elementary/middle school (E/MS) classes. One of these E/MS classes came from an elementary school, and the other from a middle school.
  - An educator workshop sample included teachers who attended one of two full-day workshops. These workshops were geared towards educators interested in attending *SBP* on a field trip, and introduced them to the exhibition and related educational resources developed by MOS.
- **Visitors with disabilities:** Study participants were strategically recruited to participate in the evaluation of the accessibility of the *SBP* exhibition. This sample was not intended to provide a comprehensive view of the experience of all visitors with disabilities, but rather a representative view. Recruitment drew visitors with a range of abilities, ages, and familiarity with MOS. For detailed descriptions of the 20 focus participants and their groups, see Appendix L (page 181).

Multimodal representations: Exhibit elements designed to help visitors successfully engage with exhibition content.

- **Tactile models:** Included at some exhibits and videos, these features delivered content and ideas in a touchable format. This included physical molds, such as small-scale character models and raised pictorial instructions.
- **Kinesthetic experiences:** Opportunities for visitors to engage with exhibits through full-body movement.
- **Audio labels:** Every exhibit had a built-in hearphone consisting of a handset and two buttons. The square button read aloud the exhibit's printed text. The triangle button read aloud the printed text interspersed with audio description of the exhibit and images, as well as instructions on how to interact with the exhibit. Audio labels were particularly designed to support accessibility for visitors who were blind or have low vision, as well as pre-readers, non-native English speakers, and people for whom reading is difficult.
- **Broadcast audio:** Instructions and content delivered through a speaker that projected sound to multiple listeners. Information read aloud to the visitor was the same content seen on the text-based labels.

- **Graphic labels:** Images, diagrams, or text-based information (instructions and/or content) accompanying exhibits and most videos. This information could be located on a label surrounding the exhibit or on-screen. These elements were included at all exhibits except for *Working at Pixar* videos.
- **Touchscreens:** Computer screens with virtual controls that visitors could touch in order to operate the exhibit. A **More Info** button, present at many touchscreen exhibits, provided additional, in-depth information related to the exhibit concepts.

As the study progressed, data fell into the following themes related to learning:

Problem decomposition: The skillset required to solve complex or multi-part problems. Problem decomposition skills included close observation, pattern recognition, breaking things into steps, creating models or algorithms, creating variables, and using formulas.

Design process skills: Evidence of visitors demonstrating steps of the design process: researching, planning, testing, experimenting, iterating, and using creativity to achieve goals.

Engagement: Ways in which visitors interacted or connected with the exhibition.

- **Physical engagement:** Evidence that visitors are able to physically interact with an exhibit and/or appreciate the hands-on nature of the experience.
- **Cognitive engagement:** Evidence that visitors are learning, thinking, paying attention, and/or expressing content ownership.
- **Creative engagement:** Evidence that visitors recognize opportunities to create, make, build, or animate their own work. Visitor sees opportunities to engage in the content as if they were animators themselves.
    - **Creative ownership:** Evidence of visitors creating, making, building, or animating something of their own.