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Design Squad Nation: Evaluation Report

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CEG

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Chapter 1: Overview

Design Squad Nation

Premiering on PBS in January 2011, *Design Squad Nation* (DSN) is a 10-part series of TV shows and video blogs that build on the success of the award-winning PBS reality competition series *Design Squad* to get kids excited about engineering. DSN is high-energy, high-drama reality TV led by Judy and Adam, two professional engineers who work with kids around the world to make their wishes come true through engineering. From creating a park for skaters at the White Mountain Apache Reservation in Arizona to building a playground in a rural village in Nicaragua's northern mountains, the goal of DSN is to inspire viewers to take on their own hands-on engineering activities.[1]

The specific educational goals of the DSN television series, website and outreach events are to: (1) Increase students' knowledge of engineering and the design process, (2) Improve the public image of engineering, and (3) Encourage further exploration. The DSN website extends the concepts presented on the show and provides viewers with an opportunity to explore engineering through a variety of social media experiences including an online community, a place to share their design creations, and video blogging. Engineers and teachers have partnered with *DSN* to help support kids as they engage in the project's hands-on activities.

Evaluation

Concord Evaluation Group (CEG) was hired to conduct an evaluation of DSN in 2011. The evaluation was designed to measure WGBH's success in achieving the following impacts on students and teachers:

[1] WGBH's description of the series from the DSN website http://pbskids.org/designsquad/

Intended Impacts on Students

After using the DSN resources…

- Middle school students will increase their knowledge of science and engineering concepts and the design process.
- Middle school students' attitudes towards engineering will improve.
- Middle school students' interest in engineering will increase.
- Middle school students' awareness of engineering work will increase.[2]
- Middle school students, especially girls and minorities, will see engineering as creative, rewarding, and socially relevant.

Intended Impacts on Teachers

After using the DSN resources…

- Teachers' awareness of the design process will increase.
- Teachers' knowledge of engineering careers will increase.
- Teachers' interest in using hands-on engineering activities in their classrooms will increase.
- Teachers' comfort level with providing engineering activities to their students will increase.

In addition to assessing these impacts, another major goal of the evaluation was to collect formative data that could be used to redesign the DSN web resources for a future study. In a separate study we are planning to explore the engineering pathways that middle schoolers follow. The cornerstone of the proposed study is an enhanced DSN website with more activities, more challenges, and more social interaction designed to support students who are learning about engineering at home or at school.

For the current evaluation, we performed three separate data collection activities. First, we assessed the impact of the TV episodes through a home viewing study. We conducted a pre-post test study with a national sample of kids in middle school (grades 6-8). Once kids were enrolled in the study, we provided them with access to a pre-test survey that they completed online at home. Following the pre-test survey, we mailed a set of DSN episodes to the kids' homes. After viewing the episodes, the kids completed an online post-test.

[2] This impact was originally intended to assess the degree to which student awareness of career opportunities would increase, but we changed its focus because middle school students are not typically concerned with career choices at such a young age.

Second, we assessed the impact of the full range of DSN resources on students and teachers in formal and informal settings. Four science classrooms and two technology classrooms from across the country participated in the study. At the start of the study, we administered an online pre-test survey to students. After administering the pre-test surveys, teachers spent a full semester using the range of materials in class, including use of the website, interactive tools, hands-on activities, at-home activities, and viewing the episodes.

WGBH repackaged the digital resources on its website to create pathways through existing assets for sustained exploration of engineering, both in school and at home. WGBH created six web-based thematic units that provide a succession of activities that built on each other to motivate students to explore a series of related topics in greater depth, embedded in an overarching game experience. *The game format was intended to provide a user-friendly approach to implementing the resources in the classroom, but it was not required that teachers play the game as prescribed.* Throughout the study:

- Teachers introduced design challenges to students in the classroom using digital resources such as video clips and animated demonstrations,
- Students were able to try out the engineering challenges in the classroom,
- Teachers provided students with bonus challenges to try at home (either via text message, email or other methods),
- Students were able to post their design sketches and pictures to the DSN website to share with other students in their classes and with all DSN website users, and
- Some teachers awarded and kept track of the points that students earned in the challenges.

Teachers were instructed to try out the activities in any order and to use as many of the challenges as possible. At the end of the semester, we collected post-test survey data from teachers and students.

Finally, we also conducted a second annual survey through the DSN website for the purpose of collecting data about the demographic and background characteristics of DSN's website visitors. We invited all unique visitors to respond to the survey. Over 1,000 individuals responded.

The balance of this report provides the detailed findings from these three data collection activities.

Chapter 2: Impact of DSN Episodes at Home

Objectives

Concord Evaluation Group (CEG) performed a home viewing study in an attempt to better understand how kids at home experienced DSN and how the show impacted their learning and attitudes. Of the project impacts listed in Chapter 1, we used the home viewing study to assess the following:

- Middle school students will increase their knowledge of science and engineering concepts and the design process.
- Middle school students' attitudes towards engineering will improve.
- Middle school students' interest in engineering will increase.
- Middle school students, especially girls and minorities, will see engineering as creative, rewarding, and socially relevant.

In addition to assessing these impacts, through the home viewing study, we also hoped to:

- Assess how much kids liked watching DSN at home;
- Determine specifically what they liked and did not like about the show;
- Assess what kids learned from watching the show;
- Determine kids' level of interest in watching future episodes of the show; and
- For those kids who were interested in watching future episodes, record the delivery modes they expected to use (e.g., TV, Web, mobile).

Methods and Procedures

We conducted a single group pre-test post-test study with a national sample of kids in middle school (grades 6-8). We recruited the sample primarily through CEG's existing database of parents who have participated in prior studies or have indicated their interest in participating in a study. We contacted parents to let them know about the study and directed them to a web survey they could complete so that we could screen their kids for eligibility. We invited qualified kids to participate by contacting their parents to enroll them in the study.

Once kids were enrolled in the study, we provided them with access to a pre-test survey that they completed online (see Appendix). Following the pre-test survey, we mailed a set of 4 DVDs containing DSN episodes to the kids' homes. We asked kids to view the DVDs for a period of 1-3 weeks. Their parents let us know when the kids were done watching the episodes. After viewing the episodes, we granted the kids access to an online post-test (see Appendix). Each of the 4 episodes in summarized on the following page.

Apache Skateboard

On the premiere episode of *Design Squad Nation*, Ronnie—a 17-year-old skateboarder from the White Mountain Apache Reservation in Whiteriver, Arizona—teams up with co-hosts Judy and Adam to build a skateboarding street course. Engineered to be modular, durable, and weather-resistant, this is the skate park of Ronnie's dreams.

Engineering Content: Innovation, invention, and engineering improve people's lives.
Science Content: Motion and Forces; Structures
Expert: Dustin Craig, Owner of Fourwheelwarpony, Skateboarder

Garden to Go

Judy and Adam travel to London, England to meet Mariam and Bert, two young members of Global Generation—a community organization that grows fruits and vegetables in one of London's largest construction sites. Bringing new meaning to the phrase "eat locally, build globally," Mariam and Bert work with Adam and Judy to design and build a pedal-powered mobile garden that will help them sell their produce to nearby restaurants.

Engineering Content: Engineers dream up creative, practical solutions and build things that matter.
Science Content: Understanding Relationship among Organisms and their Physical Environment; Simple Machines
Expert: Paul Richens, Global Generation, Garden Manager

It's Alive

Judy and Adam join forces with Jennifer—a young pastry chef from Boston, MA—to create the cake of her dreams for the cast party of "Young Frankenstein: The Musical." With guidance and inspiration from master baker Jorg Amsler of Truly Jorg's Patisserie in Saugus, MA, the team engineers a cake that is part delicious, part electronic, and part mad scientist—wowing the musical's cast and crew.

Engineering Content: Engineering connects to a broad range of careers (including those that are food related).
Science Content: Electricity; Simple Machines
Expert: Jorg Amsler, Master Baker, Truly Jorg's Patisserie

Trash to Treasure

For the season finale, *Design Squad Nation* asked kids across the country to recycle, re-use, and re-engineer everyday materials into the next big invention in the 2010 Trash to Treasure contest. Three grand-prize winners visit Boston to work with professional engineers at Continuum, a global innovation and design consultancy, to see their original ideas become real products.

Engineering Content: Innovation occurs at the intersection of a vision, problem, creative thinking, materials, and persistence.
Science Content: Simple Machines; Force, Buoyancy; Technology, Tools, Materials, and Devices
Expert: Rich Ciccarelli, Model Manager/Engineer, Continuum

Sample

Demographic and Background Characteristics

We recruited 56 kids from across the country to participate in the study. The final sample included 47 kids—28 boys and 19 girls.[3] The sample included kids in grades 6, 7 and 8 including 17 (36%) sixth graders, 16 (34%) seventh graders and 14 (30%) eighth graders (see Table 1).

The majority of the kids participating in the study lived in suburban settings (n = 24, 51%). Eleven (23%) of the kids lived in a rural setting, and 12 (26%) lived in an urban setting (21% of U.S. citizens live in rural settings).

With respect to race and ethnicity, the majority of the kids in the study were white (n = 31, 66%), but at a lower proportion than the proportion of white individuals in the U.S. (80%). Eighteen percent of the kids (n = 9) in the study were Hispanic and 21% (n = 10) were Black or African-American (Hispanics and Blacks comprise 15% and 13% of the U.S. population, respectively). In addition, 1 participant identified herself as Asian (2%), 1 participant as American Indian (2%) and 3 participants as Native Hawaiian (6%). Six kids (13%) indicated that they identified with two or more races and/or ethnicities.

We used parental educational attainment as a proxy for household income in this study due to the positive correlation between education and income in the US. In our sample, the highest level of education attained for the participants' parents was as follows: high school (n = 9, 19%), some college (n = 9, 19%), associate's degree (n = 5, 11%), college graduate (n = 17, 36%) and master's degree (n = 7, 15%).

[3] Nine girls dropped out of the study for unknown reasons after completing the pre-test and receiving the DVDs, despite repeated attempts to communicate with them. The girls were not significantly different from the rest of the girls in the sample in regard to grade, race, locale, highest parental education level, favorite TV shows, or pre-test scores on attitude or cognitive measures.

Table 1:

Characteristics of Kids in the Sample of the Home Viewing Study

(Sample Size = 47)

Characteristics	Number and Percentage
Gender	
Boys	28 (59.6%)
Girls	19 (41.4%)
Grade Level	
6th	17 (36%)
7th	16 (34%)
8th	14 (30%)
Locale	
Suburban	24 (51%)
Urban	12 (26%)
Rural	11 (23%)
Race and Ethnicity	
White or Caucasian	31 (66%)
Black or African American	10 (22%)
Hispanic, Latino, or Spanish	9 (18%)
Two or more races and/or ethnicities	6 (13%)
Native Hawaiian or Other Pacific Islander	3 (6%)
Asian	1 (2%)
American Indian or Alaskan Native	1 (2%)
Parents' Highest Educational Level	
College graduate	17 (36%)
High School	9 (19%)
Some College	9 (19%)
Master's degree	7 (15%)
Associate's degree	5 (11%)

Finally, as shown in the map below (Figure 1), the participants represented 20 different states across the U.S., including Hawaii.

Figure 1. Study participants were from 20 different states across the US.

Television Viewing Habits

The kids in our sample reported that they were regular TV viewers. Forty-five out of the 47 kids (96%) in the study reported that they watched TV daily, while 2 (4%) said they watched weekly. As summarized in the table below, kids reported watching educational TV far less frequently than other types of TV. For example, 96% of kids reported daily TV viewing, but only 19% reported watching educational TV daily.

Table 2:

Frequency of TV Viewing (General versus Educational)

Frequency	TV Generally: Number and Percent (N = 47)	Educational TV: Number and Percent (N = 47)
Daily	45 (96%)	9 (19%)
Weekly	2 (4%)	14 (30%)
Once a month	0 (0%)	4 (9%)
Several times per year	0 (0%)	1 (2%)
Almost never	0 (0%)	6 (13%)
Don't know	0 (0%)	13 (28%)

We asked kids to report on how they typically watched shows. Most reported watching shows on TV, DVD or the Web (Table 3). In decreasing order, kids watched shows on TV (98%), on DVDs (87%), on the Web using a computer or laptop (79%), on TV using DVR (38%), on the Web using a mobile device such as a mobile phone, tablet or iTouch (23%), at school (23%), using podcasts or vodcasts (11%) or other, unspecified means (4%).

Table 3:

Types of Device on Which Kids Typically Watch TV Shows

Type of Device	Number and Percent (N = 47)
TV	46 (98%)
DVDs	41 (87%)
On the Web using a computer or laptop	37 (79%)
On TV using DVR	18 (38%)
On the Web using a mobile device such as a mobile phone, tablet or iTouch	11 (23%)
At school	11 (23%)
Using a podcast or vodcast	5 (11%)
Other	2 (4%)

When asked "If you watch shows online, how do you find the shows?" most kids reported that they locate shows using You Tube (79%), Netflix (55%), Hulu (26%), and show websites (26%).

Table 4:

Types of Media on Which Kids Typically Watch TV Shows

Type of Media	Number and Percent (N = 47)
You Tube	37 (79%)
Netflix	26 (55%)
Hulu	12 (26%)
Show websites	12 (26%)
I don't watch shows online	2 (4%)
Other	2 (4%)

We asked kids what type of shows they were most likely to watch (educational versus others). Most of the kids in our sample told us that they were either "on the fence" or were "less likely" to watch educational shows versus other types of shows (Table 5).

Table 5:

Types of Shows Kids Most Likely to Watch, Educational versus Others

Type of Show Kids Most Likely to Watch Educational v. Others	Number and Percent (N = 47)
Definitely more likely to watch educational shows	0 (0%)
Somewhat more likely to watch educational shows	3 (6%)
In the middle	28 (60%)
Somewhat more likely to watch non-educational shows	6 (13%)
Definitely more likely to watch non-educational shows	9 (19%)
No response	1 (2%)

In response to the question "How much do you like to watch educational shows?", most kids reported that they were "in the middle."

Table 6:

How Much Kids Said They Liked Educational Shows

How Much Kids Said They Like Educational Shows	Number and Percent (N = 47)
"I love them."	9 (19%)
"I like them."	12 (26%)
"In the middle."	19 (40%)
"I don't really like them."	6 (13%)
"I don't like them at all."	1 (2%)

We asked kids to list up to 3 shows they liked to watch. These could be on TV, online, at school or on a mobile device. The kids cited 91 different TV shows. The shows receiving the greatest number of mentions are listed below and do not include any educational shows. The full list of kids' favorite shows is available in the Appendix.

Table 7:

Kids' Favorite Shows (Educational or Other)

Kids' Favorite Shows	Number and Percent (N = 47)
Wizards of Waverly Place	9 (19%)
SpongeBob SquarePants	6 (13%)
Suite Life On Deck	6 (13%)
Shake It Up	5 (11%)
The Simpsons	5 (11%)
Glee	4 (9%)

We asked the kids in our sample whether they had watched *Design Squad* or DSN prior to the study. The majority had never watched either show (72%). Two (4%) reported they had watched *Design Squad*, 3 (6%) reported they had watched DSN, 3 (6%) reported they had watched both shows, and 5 (11%) were not sure whether they had ever seen *Design Squad* or DSN.

Of the 13 kids who reported having possibly watched one or both shows, all reported that they were infrequent viewers: 10 (21%) reported they had seen the show(s) only "a couple of times" while 3 (6%) reported that they only "sometimes" watched.

We asked kids to list up to 3 educational shows they like to watch. The kids cited 54 different educational TV shows. The top shows the kids listed were "Mythbusters," "How It's Made," and 4 shows which were mentioned twice and are listed below (including DSN). The full list is available in the Appendix.

Table 8:

Kids' Favorite Educational Shows

Kids' Favorite Shows	Number and Percent (N = 47)
Mythbusters	5 (11%)
How Is It Made	3 (6%)
1,000 Ways to Die	2 (4%)
Between the Lions	2 (4%)
Cyber Chase	2 (4%)
Design Squad Nation	2 (4%)

Twenty-eight percent (n = 13) of the kids reported watching educational shows on PBS. Otherwise, the kids were most likely to report watching educational shows on these other channels: Animal Planet (38%), History Channel (34%), and National Geographic (28%).

Table 9:

Networks on Which Kids Watch Educational TV Shows

Channel	Number and Percent (N = 47)
Animal Planet	18 (38%)
History	16 (34%)
National Geographic	13 (28%)
PBS	13 (28%)
Disney	11 (23%)
Science	10 (21%)

Channel	Number and Percent (N = 47)
Nickelodeon	7 (15%)
TLC	7 (15%)
Family	5 (11%)
Weather	5 (11%)
A & E	1 (2%)
DIY	1 (2%)
Food Network	1 (2%)
G4tv	1 (2%)
Netflix	1 (2%)
Spike	1 (2%)
Sprout	1 (2%)
Travel	1 (2%)
TruTV	1 (2%)

We asked the kids to explain how much they liked educational shows. In all, 19 (40%) kids responded that they liked educational TV including 8 (17%) who said they *"liked to learn"*, 2 (4%) liked the History Channel and Civil War biographies, 2 (4%) liked a *"mix of programming"* including educational TV, and 2 (4%) liked the educational show Design Squad Nation because it was *"entertaining."* One kid remarked "*I love watching educational shows because they make learning easier and more enjoyable."* Eight (17%) kids also wrote that they liked educational TV but they qualified their statements *"if the shows are fun,"* (6%) or *"shown at school"* (2%).

Among the kids who said they didn't like educational TV, 6 (13%) noted that educational TV was boring, and 4 (9%) said they preferred other types of shows. Two (4%) other kids noted that educational TV can be *"cool"* but *they "think of preschool shows when they think of educational TV"* and one (2%) did not like preschool shows.

Kids' Perceptions of DSN

What Kids Liked about DSN

We asked participants to rate each episode they watched on a scale from 0 ("I didn't like it." to 4 ("I loved it."). The episode "It's Alive" received the highest ratings, while "Garden to Go" was the kids' least favorite episode. The average scores (and standard deviations) for each episode are listed below:

"It's Alive" = 3.30 (standard deviation = 1.041)
"Trash to Treasure" = 3.25 (standard deviation = .962)

"Apache Skateboard" = 2.83 (standard deviation = 1.204)
"Garden to Go" = 2.57 (standard deviation = 1.110)

We asked kids to tell us what they liked about DSN. This question yielded a range of responses including kids who highlighted the shows' creativity/good ideas (26%), the fact that the shows included kids (26%), educational nature (15%), engineering features (13%), the observation that normal people/regular kids could do engineering out of ordinary materials (13%), that engineering helped/cared for the world (9%), and other comments (15%).

Table 10:

Aspects of DSN the Kids Liked

Aspects	Number and Percent (N = 47)
Creativity / Good ideas	12 (26%)
Kids' involvement	12 (26%)
Educational nature	7 (15%)
Engineering features	6 (13%)
Normal people / Regular kids could do engineering out of ordinary materials	6 (13%)
Engineering helped / Cared for the world	4 (9%)
Other	7 (15%)

What Kids Disliked about DSN

In response to the question "What did you *not* like about the episodes?" the kids' responses were divided between comments about the format and content. We should note that more than one quarter (26%) of the kids reported that they "liked" the episodes and that there was "nothing" they did not like.

Eight of the kids reported that they wanted "more" from the show: a longer show, more explanations of the building process, and *"more engineering not just ideas."* One kid told us: *"Talk more with the kids and let them explain what they are going to do and how it will help people."*

Nine kids (19%) described the show as *"boring,"* while 6 kids (13%) noted that they didn't like the topics portrayed. The remainder of the responses had to do with the format of the show. Four kids (9%) said the show was *"repetitive"* or "*slow."* Five kids (11%) noted the introduction or opening took too long (where the list of show sponsors is provided) indicating they didn't like: *"Showing the sponsors at the beginning because it*

takes a while before the show actually starts." Another kid commented that there weren't any "kids" in the "Garden to Go" episode.

Episode Length

We asked kids what they thought about the length of the episodes: whether they were "just right" (n = 36, 77%), "too short" (n = 8, 17%) or "too long" (n = 3, 6%). In the largest group, those who thought the episodes were "just right," the kids made a range of comments: 8 kids (17%) mentioned that the episode length was typical for shows, 7 kids (15%) thought the episodes were *"long enough to show everything needed,"* 7 others (15%) thought the episodes struck the right balance between keeping the kids interested and being long enough to explain the ideas. This idea was characterized by one participant: *"I think that the length of the episodes was perfect because any longer I would have gotten bored, but any shorter it would have been too brief."* The remaining 4 kids (9%) said the shows were a good length of time. Seven kids (15%) felt the episodes were too short, with 3 (6%) indicating they felt the episodes were not formatted the way they would have liked. The kids offered formatting suggestions: one kid wanted fewer explanations at the beginning and more later on when the inventions had been built, another kid wanted more inventions and the third wanted more kids involved. The remaining 4 (9%) thought more time was needed for each episode to *"explain more how things were built,"* or to have two shows combined to a 1-hour episode. The 3 kids (6%) who thought the episodes were too long all mentioned that they were slow or repetitive.

What Did Kids Learn from Watching DSN?

We assessed learning directly and indirectly. To measure learning directly, we included two objective, content-related questions in the pre-test and post-test surveys. The first question assessed how well kids could identify things that engineers might work on. We provided kids with the following list of items and asked the kids to choose all the items that could be improved with the help of an engineer:

- Toothbrushes (worth 1 point)
- Cell phones (1 point)
- Highways (1 point)
- Sports equipment (1 point)
- Websites (1 point)

Students could earn a total of 5 points on the question. We compared kids' scores at the pre-test and post-test, and found evidence that the kids learned about the types of work engineers might do after watching the DSN episodes; the pre-test average score was 2.66

(standard deviation = 1.24), which increased 26% to a post-test average of 3.34 (standard deviation = 1.40).[4]

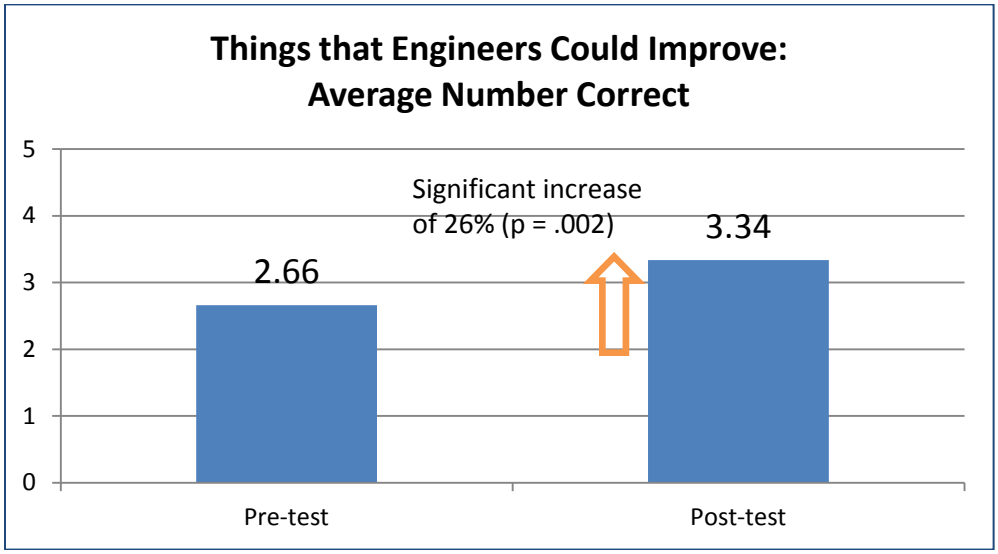


Figure 2. Kids' knowledge scores about engineers' work improved 26%.

The second question also assessed kids' understanding of engineering by requiring them to indicate their agreement with a statement intended to represent a true fact about engineering: *Engineers FIRST find out what people need and THEN they design and build things to fill those needs* on a scale of 1 (strongly disagree) to 5 (strongly agree).

We found that kids showed a definite improvement in their understanding that engineers design and build things to meet people's needs after viewing the DSN episodes; the pre-test average score was 3.91 (standard deviation = 0.915), which increased 7% to a post-test average of 4.20 (standard deviation = 0.749).[5]

[4] One-tailed paired t-test $_{(df=46)}$ = -3.194, p = .002 (effect size = 0.47).
[5] One-tailed paired t-test $_{(df=45)}$ = -2.050, p = .023 (effect size = 0.31).

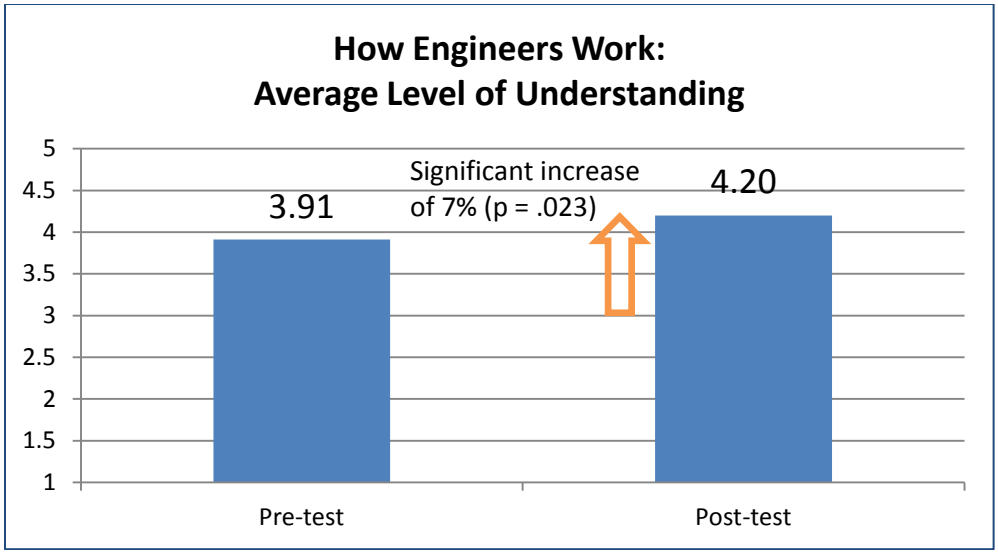


Figure 3. Kids' understanding of how engineers work improved 7%.

To measure learning indirectly, we asked kids to tell us anecdotally what they thought they learned from watching each episode. Their responses follow.

It's Alive

When we asked kids to tell us what they learned from watching the "It's Alive" episode, the kids' comments varied widely. The most common response from kids (n = 12, 26%) was different variations on the theme: "*Engineering could be used in new ways.*" Nine kids (19%) talked about the commitment and perseverance it took to complete the robotic cake. Typical of the comments were: *"I learned that with engineering skills even Frankenstein can come to life."* and *"That if you commit yourself to something anything can happen!"* Next, 8 kids (17%) mentioned specific content they learned such as cake decorating. Five kids (11%) reported the episode was *"cool,"* while three others (6%) made general comments like *"It is good to create."* and "*There is always something to learn."* Three kids (6%) said they didn't learn anything and 7 kids (15%) did not provide a response.

It's Alive

"I learned that with engineering skills even Frankenstein can come to life." – 7th grade boy

"I learned how to make stuff move." – 7th grade boy

"…that any dream of yours can happen." – 6th grade girl

Trash to Treasure

The kids in the study made the greatest number of comments on the "Trash to Treasure" episode (52 total). The comments fell into two general categories: their personal reactions, and the content they learned. Many kids made two or more comments. Fifteen kids (32%) were impressed with how materials were reused and made into new items, while 13 (28%) commented on the creativity employed in building the kids' inventions. A number of the kids (n = 9, 19%) remarked that they learned specific content such as water conservation and how to make a sibling soaker. Kids also noted how the episode harnessed the kids' dreams (n = 3, 6%), required commitment/perseverance (n = 4, 9%) and engaged their sense of fun (n =3, 6%). Five kids (11%) did not respond and 1 kid (2%) reported not learning anything.

Trash to Treasure

"I learned how to use simple things to make cool experiments." – 7th grade girl

"Engineering isn't just sitting on a computer it is going out and building and creating things." – 7th grade boy

"I learned that regular kids can come up with cool ideas for new products." – 6th grade girl

…"that u can build whatever u dream." – 7th grade boy

Apache Skateboard

After watching the "Apache Skateboard" episode, 7 kids (15%) reported that they learned to be empowered or encouraged: *"You can make it yourself."* and "*It wasn't that hard to build a skateboard park."* Thirteen kids (28%) commented on specific content they learned— 8 of the 13 (17%) mentioned they learned how to do an "Ollie" and others said they learned about the concepts involved in designing a skateboard park. Three kids (6%) mentioned, "*It was possible to have fun without drugs."* Two kids (4%) reported they learned that kids can make a difference. Eight kids (17%) made other comments such as *"You can use engineering in most anything."* and *"You should have teamwork."* and *"It's nice to help people."* Eight of the kids (17%) had no response, and 5 (11%) said they didn't learn anything.

Apache Skateboard

"You can use engineering in most anything." – 6th grade girl

"If there is something you want or need you can make it." – 8th grade boy

"If you can dream it you can make it." – 7th grade girl

Garden to Go

In general, the kids mentioned that they learned about specific gardening and environmental content in the "Garden to Go" episode. Kids mentioned learning about the environment (n =7, 15%), gardening (n =6, 13%), about worms and worm juice (n = 6, 13%), mobile gardens (n = 5, 11%), that gardens can grow anywhere (n = 4, 9%), and the value of locally grown food (n= 3, 6%). Eight kids (17%) provided miscellaneous responses such as "Good to create.", "Life science.", and "With a big imagination you can make anything happen." Eight kids (17%) did not provide a response, 2 (4%) said they didn't learn anything.

Garden to Go

"I learned that you don't need a lot of space to enjoy a garden. I made one and planted beans in it today." – 6th grade girl

"With a big imagination you can make anything happen." – 7th grade girl

What Impact Did DSN Have on Attitudes?

The pre- and post-test surveys included a set of questions designed to assess kids' attitudes toward and beliefs about engineering (including some stereotypes). As summarized in the table below, we observed several significant and positive shifts in kids' attitudes after they viewed the DSN episodes. After viewing DSN, kids were:

- *Significantly MORE likely to…*

  …believe that engineers have cool jobs.
  …believe that engineers come up with new ideas and inventions.
  …believe that engineers help make people's lives better.

- *Significantly LESS likely to…*

  …view engineering as boring.
  …believe that men are better at engineering than women.
  …believe that only super smart people can be good at engineering.

Table 11:

Kids' Attitudes toward and Beliefs about Engineering

	Pre-test average & standard deviation	Post-test average & standard deviation	t value	df	Significance (p value), one-tailed	Effect size
Engineering is boring.	**2.43 (.878)**	**1.62 (.968)**	**4.392**	**46**	**.000**	**.64**
Engineers have cool jobs.	**3.98 (.830)**	**4.39 (.614)**	**-3.367**	**45**	**.001**	**.49**
Engineers come up with new ideas and inventions.	**4.34 (.815)**	**4.68 (.515)**	**-2.693**	**46**	**.005**	**.39**
Men are better at engineering than women.	**2.13 (1.035)**	**1.66 (.962)**	**2.607**	**46**	**.006**	**.35**
Engineers help make people's lives better.	**4.45 (.503)**	**4.64 (.486)**	**-2.142**	**46**	**.019**	**.31**
Only super smart people can be good at engineering.	**2.49 (1.101)**	**2.17 (1.129)**	**1.657**	**46**	**.052**	**.24**
Engineers figure out the best materials to use and how to turn them into the things we use every day.	4.35 (.566)	4.48 (.752)	-1.000	45	.161	.15
Engineers figure out the best materials to use and how to turn them into the things we use every day.	4.35 (.566)	4.48 (.752)	-1.000	45	.161	.15

We did not observe any difference over time in kids' beliefs about whether "engineers figure out the best materials to use and how to turn them into the things we use every day." Kids strongly agreed with this statement at pre-test and at post-test.

Will Kids Watch DSN Again?

We asked kids to indicate how interested they were in watching DSN again. Most kids reported they were "interested" or "very interested" in watching DSN (70%). The results are summarized in the figures below:

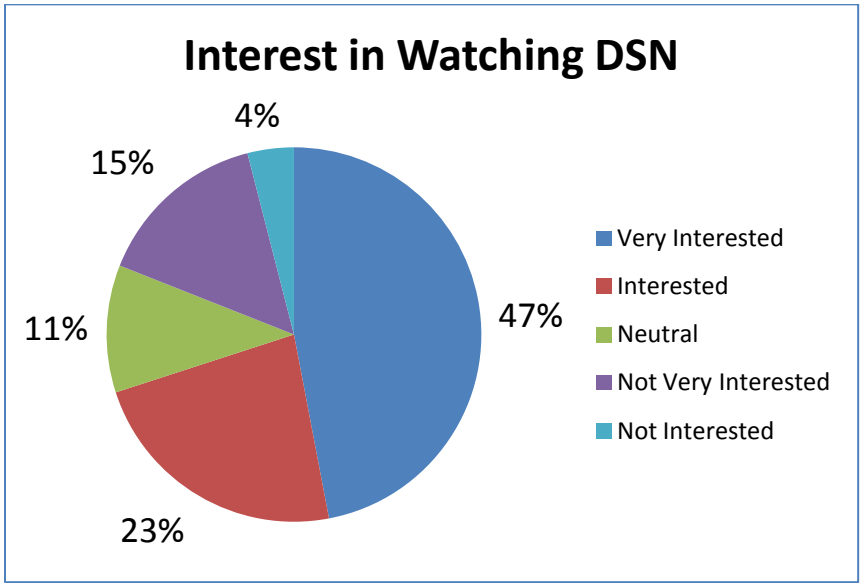


Figure 4. 70% of kids were interested in watching DSN again.

We asked the kids to explain their interest or disinterest in watching the shows. Ten kids (21%) said they wanted to watch DSN again because they liked it. Three (6%) out of the 10 said they'd like to try watching *Design Squad* based on liking DSN. One kid (2%) mentioned liking *Design Squad* prior to the study. Six kids (13%) reported that they thought the show was interesting or creative, and 4 (9%) thought it was *"a fun way to learn"* or *"a great learning experience."* An 8th grade boy thought the show was interesting but probably better suited to younger kids.

> "I think we should watch them at school because they are a more fun way to learn about this stuff than just from your teachers." – 8th grade boy

There were three other responses including one kid who thought DSN was *"okay,"* another who thought *"it got old, but would try Design Squad*" and a third who said he did not have cable TV and was not able to use the Internet unsupervised, so suggested the shows be available as free downloads on iTunes and on Netflix.

Related to this point, we asked to kids to tell us on what devices they would like to watch *Design Squad* or DSN again. Most kids reported that they would like to watch the shows

on TV (55%), on DVD (36%), on the Web using computer or laptop (36%), on TV using a DVR (28%), On Demand (26%), or at school (26%).

Table 12:

Types of Devices on Which Kids Said They Would Watch DSN/DS

Type of Device	Number and Percent (N = 47)
TV	26 (55%)
DVDs	17 (36%)
On the Web using a computer or laptop	17 (36%)
On TV using DVR	13 (28%)
On Demand	12 (26%)
At school	12 (26%)
On the Web using a mobile device such as a mobile phone, tablet or iTouch	7 (15%)
Using a podcast or vodcast	5 (11%)
Other	2 (4%)

Anecdotally, when we spoke with parents throughout the study to confirm data collection details, parents of the kids who were interested in watching DSN again confirmed their kids' interest in the DSN episodes. For example, one parent told us: *My kids love the DVD's! They all sat quietly and watched them. This NEVER happens!*

Chapter 3: Impact of DSN Challenges at School and at Home

Objectives and Background

CEG conducted a study in spring of 2011 to determine whether *Design Squad Nation* (DSN) could have a positive impact on students in formal (school) and home settings who:

- Interacted with the website, blogs and other Web 2.0 components; and
- Participated in hands-on engineering activities at home and at school.

The specific impacts that we measured included:

- Middle school students will increase their knowledge of science and engineering concepts and the design process.
- Middle school students' attitudes towards engineering will improve.
- Middle school students' interest in engineering will increase.
- Middle school students' awareness of engineering work will increase.
- Middle school students, especially girls and minorities, will see engineering as creative, rewarding, and socially relevant.
- Teachers' awareness of the design process will increase.
- Teachers' knowledge of engineering careers will increase.
- Teachers' interest in using hands-on engineering activities in their classrooms will increase.
- Teachers' comfort level with providing engineering activities to their students will increase.

In addition to assessing these impacts, another goal of the study was to collect formative data that could be used to redesign the DSN web resources for a future study. In a separate study, we are planning to explore the engineering pathways that middle schoolers follow. The cornerstone of the proposed study is an enhanced DSN website with more activities, more challenges, and more social interaction designed to support students who are learning about engineering at home.

For the current study described in this report, WGBH repackaged the digital resources on its website to create pathways through existing assets for sustained exploration of engineering, both in school and at home. WGBH created six web-based thematic units that provide a succession of activities that built on each other to motivate students to explore a series of related topics in greater depth, embedded in an overarching game experience. *The game format was intended to provide a user-friendly approach to implementing the resources in the classroom, but it was not required that teachers play the game as prescribed.* Throughout the study:

- Teachers introduced design challenges to students in the classroom using digital resources such as video clips and animated demonstrations,
- Students were able to try out the challenges in the classroom,
- Teachers provided students with bonus challenges to try at home (either via text message, email or other methods),
- Students were able to post their design sketches and pictures to the DSN website to share with other students in their classes and with all DSN website users, and
- Teachers awarded and kept track of the points that students earned in the game challenges.

Teachers were instructed to try out the activities in any order and to use as many of the challenges as possible.

Methods and Procedures

To recruit middle schools for the study, WGBH sent an email invitation to hundreds of middle schools who use or have used *Design Squad* materials. From among the schools that were interested, we randomly selected a sample of four science classrooms and two technology classrooms. After enrolling the schools, CEG provided teachers with a one-hour training session to explain the details of the study and answer their questions. Next, teachers sought parental consent for student participation in the surveys in districts where required (CEG provided forms in English and Spanish). Then, we administered an online pre-test survey to students.

After administering the pre-test surveys, teachers were asked to begin using DSN resources. We provided teachers a full semester to use the range of materials in class,

including use of the website, interactive tools, hands-on activities, and viewing the episodes.

At the end of the semester, we collected post-test survey data from teachers and students. We provided each teacher with a stipend of $100 to offset the cost of materials. The survey items are located in the Appendix.

Sample

The teacher's demographic and background characteristics are summarized below. Two thirds of the sample was female, and all but one teacher reported they had earned a Master's degree. Teachers varied in their own backgrounds: two studied technology education, one elementary/special education, one mechanical engineering and two biology/ecology. All but one of the teachers (a science teacher) reported that they were familiar with the engineering design process.

Table 13:

Teacher Demographic and Background Characteristics

Characteristic	Number & Percent (N = 6)
Gender	
Female	4 (67%)
Male	2 (33%)
Education level	
Bachelor's degree	1 (17%)
Master's degree	5 (83%)
Course type	
Science	4 (67%)
Technology	2 (33%)
Major field of study	
Technology education	2 (33%)
Elementary/special education	1 (17%)
Mechanical engineering	1 (17%)

Characteristic	Number & Percent (N = 6)
Biology, ecology	2 (33%)
Familiarity with the design process	
Very familiar	3 (50%)
Familiar	2 (33%)
Unfamiliar	1 (17%)

The schools in our sample were located across the country, with half located in the eastern U.S., two located in the western U.S., and one located in the central U.S. Most of the schools were located in suburban locations, while one was urban and one was rural. Almost half of the kids in the sample schools were eligible for free or reduced price lunch (ranging from 20% to 65%).

Table 14:

School Background Characteristics

Characteristic	Proportion (N = 6)
Geographic region (Number and percent)	
Eastern US	3 (50%)
Central US	1 (17%)
Western US	2 (33%)
Setting (Number and percent)	
Urban	1 (17%)
Suburban	4 (67%)
Rural	1 (17%)
Proportion of kids eligible for free or reduced price lunch	
Percent	41.3%

There were 135 students in the sample, most of whom (over 90%) were sixth or eighth graders. The majority of the students identified themselves as white or Caucasian (71%), while an additional 34% identified themselves as non-white.

Table 15:

Students' Demographic and Background Characteristics

Characteristic	Treatment Group Number & Percent (N = 135)
Gender	
Female	69 (51.1%)
Male	65 (48.1%)
Missing	1 (0.7%)
Grade	
Sixth	76 (56.3%)
Seventh	11 (8.1%)
Eighth	48 (35.6%)
Race/ethnicity	
White or Caucasian	96 (71.1%)
Hispanic, Latino, or Spanish	17 (12.6%)
Black or African-American	5 (3.7%)
Asian	8 (5.9%)
American Indian/Alaskan Native	12 (8.9%)
Native Hawaiian/Other Pacific Islander	4 (3.0%)

Note: Some students identified with more than one race/ethnicity.

For contextual purposes, we asked students to tell us the types of engineering activities in which they participated inside and outside of school (before participating in the DSN study). Most students (64%) reported that they had had experience building or designing things in the classroom or at home prior to the DSN study. Almost one-quarter (24%) also reported having tried engineering activities in a summer program. The table below summarizes the types of engineering activities the students reported participating in prior to the DSN study.

Table 16:

Types of Engineering Activities Students Had Experienced Prior to DSN Study

Engineering Activities	Number & Percent (N = 135)
Designed and built things in my classroom	87 (64.4%)
Designed and built things at home	86 (63.7%)
Designed and built things in a summer program	32 (23.7%)
Joined an engineering club or after-school program	11 (8.1%)

We asked students to report on how engineering activities were integrated by their teachers at school into their classroom activities before the DSN study. More than half of students (59%) reported that their teachers sometimes let the students solve engineering challenges in a self-directed manner; while almost as many (57%) reported that their teachers sometimes directed the class about how to design or build something. More than one-quarter (27%) reported that their classrooms engaged in engineering competitions, while less than one-tenth (9%) reported playing engineering games as a class. Sixteen percent of students reported that they had been assigned homework that required them to design or build something at home. The student responses are summarized in the table below.

Table 17:

How Engineering Activities are Integrated into the Classroom

Engineering in the Classroom	Number & Percent (N = 135)
My teacher gives us a problem to solve, but lets students come up with their own ideas.	79 (58.5%)
My teacher tells the class what to build and how to build it.	77 (57.0%)
We have engineering or "design and build" competitions.	36 (26.7%)
We do homework that requires us to design and build something at home.	22 (16.3%)
We play engineering or "design and build" games as a class.	12 (8.9%)

How Teachers Integrated the DSN Resources

DSN Resources

WGBH provided teachers with a set of DSN resources that they could use to supplement their existing curricula as they saw fit. The DSN resources were designed to be supplemental and were intended to be flexible enough that teachers could use them at any point in their curriculum as needed. Below is a summary of the resources that were available to the teachers:

- WGBH provided an online **DSN Guide** which was a website designed to support teachers with detailed instructions on how to implement the DSN challenges and contained all the digital resources needed to play the "DSN game" if they chose to use that approach.

- WGBH encouraged teachers to have students create a **Web account** for themselves on the DSN website so they could submit sketches and photos to the website throughout the DSN study. Students were also able to place virtual "stickers" on other students' posted material as a way of indicating designs they liked.

- WGBH encouraged teachers to help their students complete a series of design challenges with the goal of earning the maximum number of points. Teachers were encouraged to download and print a **Scorecard** to keep track of all the players' points. WGBH suggested the following points system, but teachers were encouraged to develop their own, if they preferred to do so. For each challenge, a player could earn up to a total of 10 points:

3 Points	Brainstorm / Build - This activity is done as a class. It may include group discussion at the start of a challenge, collaborative building, and sharing at the end of challenge. If a player is active in this collaborative process, 3 points should be awarded.
5 Points	Challenge - This section is the central "creation" part of the challenge done outside of class. This section may include building something, sketching something etc. If a player is active in this collaborative process, 5 points should be awarded.
2 Points	Bonus - The bonus activity is a related challenge that players can respond to outside of class. The Bonus challenge is issued via mobile phone or email. If a player is active in this collaborative process, 2 points should be awarded.
10 Points	**Total points possible for a single challenge**

- WGBH encouraged teachers to send bonus challenges to their students via text messaging. This approach required students/their parents to opt into the text messaging system.

Below is a description of the six design challenges:

1. **Pop Fly:** Engineers design and build machines that help make people's lives easier. For example, they make cars for us to get around in, appliances to help with household tasks, and farm equipment to grow our food. Most machines use one or more **simple machines**, such as levers and pulleys. In this hands-on challenge, students explore **simple machines** by inventing a game based on a lever. In the process, they put the **law of the lever** and the **design process** into practice and develop an experiential basis for these concepts.
2. **Green Design:** Engineers find ways to improve existing products. One way to make an item better is to use fewer raw materials to make it. In this hands-on challenge, students consider ways to repurpose materials and invent an environmentally friendly beverage can holder. In the process, they consider what it means to be "**green**," identify low-impact alternatives for common items, and use the **design process** to devise a "green" packaging system for beverage cans.
3. **Playground:** Engineers find out what people want or need and then design and build products that people will like. In this hands-on challenge, students consider the needs of a client and invent a zip line-based playground ride. In the process, they use the **design process** and explore **force, center of gravity, and friction.** Students follow up the activity by interviewing other kids about ideas for improving playground equipment or for new playground features.
4. **Paper Structures:** Engineers design most of the things in our world—the buildings, toys, roads, electronic devices, cars, etc. They figure out the best materials to use and how to turn them into the things we use every day. In this hands-on challenge, students consider ways to **strengthen a weak material**—paper—and use it to make a sturdy paper table. In the process, they see how changing a material's shape affects its strength and experiment with how **supports reinforce a structure**. Students also conduct a **peer review** of the prototypes and, following the **design process**, revise, test, and improve their tables.
5. **Dance Pad:** Engineers figure out ways to apply science concepts, such as electricity, to make things people that want and need. In this hands-on challenge, students explore **circuits** by inventing a foot-operated dance pad, similar to Dance Dance Revolution® and Cyber Groove™. In the process, they learn about **electric switches** and use the **design process** to develop a pad that responds to their dance moves.
6. **Make a Difference:** In this final challenge, kids experience firsthand how **engineers solve problems to help improve people's lives and make the world a better place.** First students watch a DSN episode in which the show hosts use engineering to fulfill the dreams of three different kids. Then they choose a wish that has been posted on the DSN website and sketch a solution.

Different Approaches

The teachers in the study took different approaches to integrating the resources. Some teachers used the challenges and the overarching game format almost exactly as it was prescribed in the DSN Guide, while the others used only some of the designated DSN resources to supplement existing lesson plans or activities. The table below summarizes which resources were used by the 6 teachers.

Table 18:

DSN Resources Used by Classrooms

Classroom	DSN Challenges	Full Episodes	Brief Video Clips	Upload Pics	Points	Texting	At-Home Activities
A	X	X	Some	X	X		X
B	X	X	Some	X	X		X
C	X	X	Some				X
D	Non-DSN						
E	X		Some				
F	Non-DSN						

DSN Challenges

None of the classrooms tried all six of the DSN challenges. Four classrooms attempted *Pop Fly*, *DIY Playground*, and *Paper Table*. Three tried *Building Green* and *Make a Difference*. Two classrooms tried the *Dance Pad* challenge. Two classrooms used the *Hidden Alarm* challenge, which was not a challenge for the study. All the challenges used are listed in the table below.

Two teachers did not use the DSN challenges we specified for the study, but instead integrated other *Design Squad* challenges from the website because they believed that these were a better match with their standards and curricula than the ones we suggested.

It is important to note that in all of the classrooms, teachers indicated that the science and engineering concepts covered by the challenges were not new to their students. All teachers indicated that the topics covered by the challenges had been covered at their schools in previous courses or earlier in the current academic year. For purposes of the study, teachers reported that they integrated the DSN challenges into existing lesson plans whenever possible, but that in many cases, the DSN challenges were a review of previously covered material for the students in their classrooms.

Table 19:

DSN Challenges Used by Classrooms

DSN Challenges	Number of Classrooms
Pop Fly (students explore simple machines by inventing a game based on a lever)	4
DIY Playground (students consider the needs of a client and invent a zip line-based playground ride)	4
Paper Table (students consider ways to use paper to make a sturdy table)	4
Building Green (students consider ways to repurpose materials and invent an environmentally friendly beverage can holder)	3
Make a Difference (students experience how engineers solve problems to help improve people's lives and make the world a better place)	3
Dance Pad (students explore circuits by inventing a foot-operated dance pad)	2
Non-DSN Challenges	**Number of Classrooms**
Hidden Alarm (students build a circuit to power an alarm so small that you can hide it)	2
Rubber Band Car (students make a two-wheeled car powered by a rubber band)	1
Watercraft (students build an unsinkable boat out of straws and plastic wrap)	1
Zip Line (students design a way to get a Ping-Pong ball from the top to the bottom of a zip line string)	1
Paddle Power (students build a boat that can paddle itself across a container of water)	1
Touch Down (students build a spacecraft with a shock absorber that will protect marshmallow astronauts when they land)	1
On Target (students modify a paper cup so it can zip down a line and drop a marble on a target)	1

Video Resources

Half of the classrooms viewed the full length episodes, while the other half did not. The table below summarizes the number of classrooms that used each of the full-length videos.

Table 20:
Classroom Use of Full-length Videos

Episode	Streamed from the Web	Watched on DVD	Watched Part of this One	Did Not Watch
Apache Skateboarders	1	1	1	3
Trash to Treasure	2	1		3
DIY Playground	1	1	1	3
Cardboard Furniture	2	2		2
Bodies Electric	1			5

The table below summarizes the number of classrooms that watched the brief video clips. On average, half of the classrooms used the clips, while the other half did not.

Table 21:
Classroom Use of Short Video Clips

Episode	Watched	Did Not Watch
Pop Fly Challenge Demo	4	2
Baseball Bats: Curtis Cruz & Becky O'Hara	2	4
Giant Pop Fly	2	4
Eco-Electronics: Erin Gately	2	4
Package Design: Jennifer Chua	3	3
Roller Coasters: Chris Gray	3	3
Paper Table Demo	4	2
DIY Hidden Alarm Demo	2	4

Website

All teachers reported that they relied on the web-based DSN Challenge Guide and that it was "helpful" or "very helpful" to them.

Three of the classrooms attempted to post photos or sketches to the DSN website. The remaining teachers reported that they didn't have time during class to both try the challenges and post to the website. Of the classrooms that did post to the website, teachers reported that website limitations on file sizes made the experience of posting less interactive and less useful than intended. Teachers told us:

- (Once posted) it's impossible to find them!!! There are 9000 and you can search for a particular username so I had my kids do paper copies of everything they posted.
- It was difficult to find their sketches. The sketching software was really limited (and kids complained about this). It really limited their brainstorms, though I made them use it to try something different. It would be better to use MS paint and upload, but the only place to upload was for the prototype (and a sketch isn't really a prototype). Pics wouldn't often upload due to image size, although we would change the image size and it still wouldn't work.
- Students were not able to post pictures and this was a problem. We took pictures of their projects and could not post, so they were bummed. The students did some clever sketches and posted.
- Once we discovered that we could not post pictures, we did not integrate them. It would have been nice to be able to post. The game could be more interactive if we could upload our pictures.

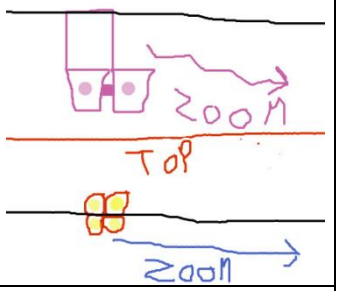
We asked students whether they posted photos or sketches to the DSN website. As summarized in the table below, more than half reported that they did not post anything to the website. Twenty-three percent reported that they posted stickers on other kids' sketches or photos online. About 20% posted a sketch, roughly 16% posted a sketch and a photo, and 9% posted photos only.

Table 22:

Students Interaction with the DSN Website

Activity	Number & Percent
Did not post anything to the website	72 (53.3%)
Posted a sticker on other students' sketches or photos	31 (23.0%)
Posted sketches only	28 (20.7%)
Posted photos and sketches	22 (16.3%)
Posted photos only	9 (6.7%)
Unknown / Missing	4 (3.0%)

Below are some samples of the photos and sketches that students posted online.

		
Ballaz Cup: Simple. Cheap. Effective. (In response to Judy's wish: I wish for a zip line to carry objects around my house.)	**The Wable:** I think this is a good idea because it will add supports so that the heavy object doesn't break (In response to Judy's wish: I wish for furniture made of paper.)	**Side and top view of my zipline:** Has four cups and can hold two balls in each cup (In response to Adam's wish: I wish for an eco-friendly holder for my soda cans!)

Point System

Four teachers reported that they did not use the DSN game point system at all. Two others reported that they awarded points, but that they modified the point system. They told us:

- It worked okay, but I awarded extra points to groups that cooperated well and were the first to complete a task while following all of the rules.
- The point system was too small. I changed it and used a system where each part of the challenge was broken down to more specific steps for 10 points each. Then students and/or teachers voted on the winning designs (as if a client). 1st place got 50 pts, 2nd had 30 pts, and 3rd received 10 pts. It worked out really well.

Texting Component

The texting component was not integrated into any of the classrooms with success. Half of the teachers did not attempt to integrate it at all due to resistance from parents and / or the school. The other half experienced other problems that led them to stop using it:

- My students opted out after a few times. Many of them chose not to do it in the first place. I didn't find the texting to be useful at all. The posting was okay, but there is a big delay from when they post and when the postings appear.
- The students were really pumped about it.... but when we started to have some problems and they (the messages) wouldn't go through only a handful of them followed through. I forgot that I needed to figure whose number was whose, so I asked that they include their FULL NAME in the text body as well to receive credit. They would forget how to text (I left extra copies of instructions and offered to allow them to bring phone to class to help with any problems).
- The text messaging did not work for us. My personal phone went on the blink in February, so I could not text and could not preview what the kids were doing with texting, so I did not encourage it. I also had a lot of trouble getting parental approval to do activities, because of texting.
- The students were very motivated. The students had a little fun online, though they had trouble searching to find other friends and I had trouble to find their sketches. The texting part definitely has potential, although it would have really been cool if they could maximize the potential of mobile media. They could upload videos or pics via their phones. Texting was just the tip of the iceberg. Still it is a great way to get them excited about engineering.
- I confess, I need more guidance to model for students how to interact online with the site.

Rather than sending students the bonus challenges via text message, most teachers posted the bonus challenges in the classroom or distributed the challenges on paper.
We asked students which bonus activities they attempted. Eighty-nine students (66%) reported that they tried at least one of the following bonus activities. Sixty-nine (51%) of the students tried "Paper Table", 67 (50%) tried "Pop Fly," 17 (13%) tried "Building Green," 16 (12%) tried DIY Playground, while 12 (9%) tried "Make a Difference" and lastly, six (4%) tried "Dance Pad."

Table 23:

Bonus Challenges Attempted by Students

Bonus Challenges	Number & Percent
Paper Table (What's one way to improve how you build something?)	69 (51.1%)
Pop Fly (Design equipment for a game or sport that uses a lever.)	67 (49.6%)
Building Green (What's the most enviro-friendly package you have found?)	17 (12.6%)
DIY Playground (Design a new playground feature.)	16 (11.9%)
Make a Difference (What are the top 3 inventions that changed your life?)	12 (8.9%)
Dance Pad (What if your dance pad was a real product?)	6 (4.4%)

At-Home Challenges

Finally, three teachers reported that they assigned students the at-home activities and bonus activities. Three teachers did not assign at-home activities at all. Of the 135 students in the sample, 92 kids (68.1%) reported that they tried at least one of the at-home activities.

Table 24:

At-Home Activities Students Reported Doing

Activity	Number & Percent
Paper Table (Find ways to make your design better.)	65 (48.1%)
Pop Fly (Find an example of a lever outside school.)	63 (46.7%)
Make a Difference (Go online to grant wishes posted on the DSN site.)	29 (21.5%)
Building Green (Find examples of products that could be more environmentally friendly.)	24 (17.8%)
DIY Playground (Interview kids at a local playground.)	19 (14.1%)
Dance Pad (Develop original dance moves to use with your dance pad.)	6 (4.4%)

Findings

Knowledge of Engineering Concepts and the Design Process

To assess student knowledge of engineering concepts and their understanding of the design process, we asked students to answer a series of 9 questions at pre-test and post-test. On both surveys, students could earn a minimum of 0 points (none correct) up to a maximum of 9 points (9 correct). The questions required kids to:

- Show that they understood that toothbrushes could be made better with the help of an engineer (1 point).
- Show that they understood that cell phones could be made better with the help of an engineer (1 point).
- Show that they understood that highways could be made better with the help of an engineer (1 point).
- Show that they understood that sports equipment could be made better with the help of an engineer (1 point).
- Show that they understood that websites could be made better with the help of an engineer (1 point).
- Show that they understood that engineers FIRST find out what people need and THEN they design and build things to fill those needs (1 point).
- Name one thing built by an engineer that has changed their life (1 point).
- Name one thing that an engineer could design with a "lever" and describe what it would do (1 point).
- Name one thing that an engineer could design with a "battery-powered circuit and a switch" and describe what it would do (1 point).

To explore learning outcomes over time (from pre-test to post-test), we performed a hierarchical linear model analysis. We included kids' scores on the assessment items as the dependent variables, with time (pre-test and post-test) as the repeated measure. The repeated measures were modeled with a compound symmetry covariance structure, which means that the residual variation in kids' scores within the same class were considered independent for different kids, but correlated between the two time points for each kid. This accounts for the fact that for some kids, both pre- and post-test scores are higher than for other kids, even within the same school.

Likewise, because kids are nested within schools in the design, we needed to account for the fact that within a school, the scores were likely to be more similar than they would be if kids came from different schools (measured by the intraclass correlation). To do this, we separately estimated the variation among kids' scores who attended the same school and the variation in scores between schools.

Students' scores on the pre-test measure ranged from 1 to 9, with an average score of 5.64.[6] Students' scores on the post-test measure ranged from 0 to 9, with an average score of 6.41.[7] **We observed a statistically significant increase of 14% in knowledge scores over time**:

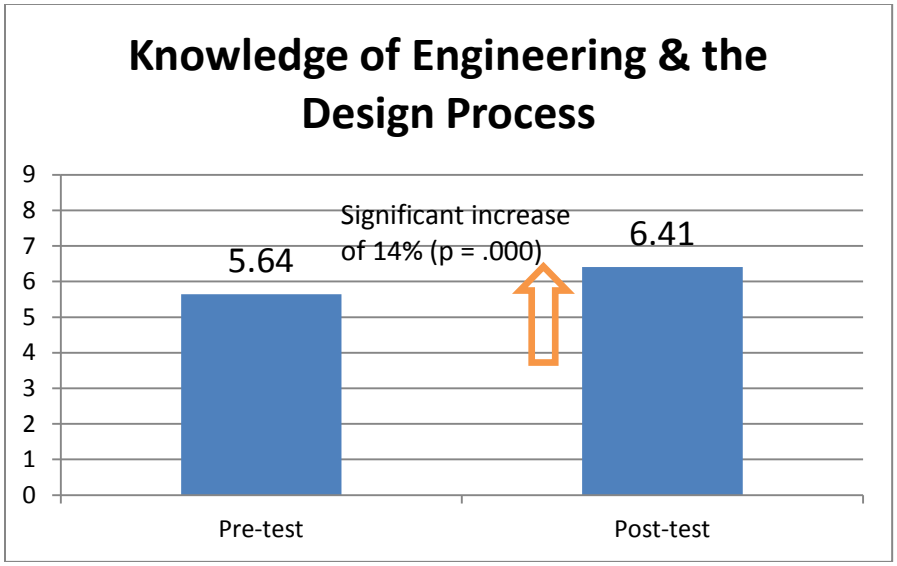


Figure 5. There was a significant increase in knowledge scores over time, $F_{(1, 135)} = 14.800$, p = .000, effect size = .369.

We asked students to tell us, in their own words, what they learned from the DSN challenges. Some students told us they helped them learn more about the various stages of the design process:

- It helped me learn the steps of designing and working with others to solve problems.
- It made it easier to understand engineering.
- It helped me design and redesign my creation.
- I learned to work together and compromise with others to get work done.
- I learned to be open to others ideas they may work better than your own.
- I learned that teamwork can make a huge difference.
- I learned a lot more about making a design efficient to specific needs.

Some students told us that the challenges helped them learn to be more creative, persevering, and to think about new ways to approach problems:

- Helped me think out of the box and came up with really great ideas.
- To be more creative and practice designing.

[6] Standard deviation = 2.10.
[7] Standard deviation = 2.07.

- It made me become more creative by designing my own things.
- You learn about how to build things and get ideas on how to build new things.
- It just made me think outside the box a little.
- It helped me learn to persevere.
- It helped me learn that I am not amazing at building but I am still good.
- It helped me learn by teaching me how to build with confidence.
- It helped me learn because it showed me different ways to build things and different things to use.
- By showing me I can build and I have potential.
- By showing me how to design stuff and giving me confidence.

> It helped me learn the steps of designing and working with others to solve problems.
>
> -- Student

In addition, some teachers described the changes they observed in their students as a result of completing the DSN challenges:

- They were more willing to take risks and put things together. They worked great as a team. They were willing to try new challenges. They didn't give up. They sketched more, brainstormed more and were much more involved.
- Students became more confident, curious, persistent and successful as they worked through DSN challenges.
- My students worked together as teams to solve the challenges. I kept the same teams together and after initial complaints about who wanted to work with who, I saw a lot of teamwork. They also improved in their planning and redesigning, and learned to "make do" with the materials that they were provided to work with.

Some teachers also described how the DSN challenges strengthened their students' ability to identify and discuss the science concepts they applied:

- They were more willing to see the science concepts in the world around them and apply their knowledge and the science concepts we discussed. It helped them talk about their real world and the engineering in it.
- Required them to see how engineering connects to science.
- Some evidence of better conceptual understanding now.
- The challenges gave the students the opportunity to discuss their findings using scientific vocabulary.
- They were able to discuss what they had previously learned (forces and motion, in particular).
- My 6th grade classes were absolutely jazzed about science because of Design Squad. I was excited because it gave me great ideas.

> My 6th grade classes were absolutely jazzed about science because of Design Squad.
>
> --Teacher

All teachers reported that the DSN challenges strengthened their students' ability to explain and use the engineering design process:

- It reinforced the design and engineering process that we use in my class.
- It really helped with the brainstorming process. Often students will not think outside the box. There was a lot more variety in designs when they tried to use information from the real world.
- Much better understanding of engineering design process through viewing and critiquing the DS challenges.
- This was the engineering design process in action. I overheard tables of students discussing "brainstorm", "plan", and "redesign." It also gave them practice using limited resources, e.g., only 2 paper cups even if they wanted to use more.
- It reinforced what they have done in tech/engineering class.
- Students were talking about different types of engineering. They were discussing relatives who were engineers and what they do. It opened their minds to learn about different career options.
- When they designed the NASA moon launcher, for example, they were discussing how engineers needed to design shock absorbers so that they didn't hurt astronauts.
- The students now have specific examples and they can talk in engineer terms. Practice and looking at other classmates' ideas was very powerful.

> The students can now talk in engineer terms.
>
> --Teacher

We asked teachers to tell us in what ways, if at all, the bonus challenges supported or reinforced the learning that was taking place in the classroom. They told us:

- Looking for levers in the real world really reinforced the Pop Fly challenge, and was a great match. I think it would have been great for Paper Table if they had looked at different tables and desks and the ways they had been designed or reinforced. The Zipline challenge interview was a great way to involve their community, but there was not direct follow through. This could be a good one for the Make a Difference/Building Big.
- It offered students a chance to think apart from their peers and consider other materials.
- The at home challenges forced students to look at their world and be aware of engineering.

Attitudes toward and Interest in Engineering

At pre-test and post-test, we also explored students':

- Interest in engineering careers or activities;
- The extent to which students perceive engineering as creative, rewarding, and socially relevant; and
- Attitudes towards engineering.

We asked students to report the extent to which the DSN challenges changed their interest in engineering, if at all. Over half of the students (52.6%) reported that they were more interested in engineering after completing the DSN challenges. Another quarter of the sample (27.4%) reported that their interest level did not change because they were already interested in engineering to begin with. Ten percent (10.4%) of the sample said their interest did not change because they were not interested to begin with. Finally, fewer than 5% (4.5%) reported that they were less interested in engineering after the DSN challenges.

Table 25:

Students' Self-reported Interest in Engineering after Completing DSN Challenges

Change in Interest Level	Number & Percent
Was much greater	26 (19.3%)
Was a little greater	45 (33.3%)
Did not change – I was interested to begin with and still am	37 (27.4%)
Did not change – I was not interested to begin with and still am not	14 (10.4%)
Was much lower	4 (3.0%)
Was a lot lower	2 (1.5%)
Missing / Unknown	7 (5.2%)

At post-test, we asked kids to tell us how "cool" it would be to be an engineer. About half of the kids (45.9%) reported that it would be "cool" or "very cool" while 40.7% were neutral.

Some students told us the DSN challenges helped them learn about what engineers do and about engineering careers:

- It helped me learn what engineers actually do.
- It taught me that you can take something simple and make it into something useful.
- I learned what engineering really was and that it's many different ways then just using technology. I learned some new tools that I never even heard of.

- It helped me learn about how engineers work.
- I didn't know you could be a certain engineer. So I learned about that and that was cool.

Some students also told us that the DSN challenges helped them see engineering as fun and interesting and something that can impact the world:

- That engineering is cool.
- That engineering can be kinda fun but it's a challenge at the same time.
- That science is fun.
- It helped me learn by showing me that the activities can change people's lives.
- I learned that even though I am a kid I can have fun building and designing things.
- How to design things at home that might make a difference.
- Helped me learned that there are more ways to learn than writing and reading.

At pre-test and at post-test, we asked students to indicate which of the following engineering-related activities they might be interested in doing. **We observed a statistically significant increase in the proportion of students who reported being interested in designing and buildings things in their classrooms and during the summer.** The table below summarizes the proportion of students who expressed interest in the activities before and after participating in the DSN challenges.

Table 26:
Student Interest in Engineering-related Activities

Activity	Pre-test Number & Percent	Post-test Number & Percent	Statistically Significant?	p value (Binomial test)
Designing and building things in the classroom.	**78 (57.8%)**	**94 (69.6%)**	**Yes**	**p = .003**
Designing and building things during the summer.	**48 (35.6%)**	**64 (47.4%)**	**Yes**	**p = .003**
Designing and building things at home.	71 (52.6%)	61 (45.2%)	No	p = .051
Joining an engineering club or after-school program.	19 (14.1%)	22 (16.3%)	No	p = .265

To further assess students' interest in and attitudes toward engineering, we also asked students to report their level of agreement with the following statements on a scale of 1 (strongly disagree) to 5 (strongly agree). We found that students were *more* likely to agree that engineers help make people's lives better after participating in DSN than before. We also found that students were *less* likely to report that they liked to learn about technology after participating. There were no other observed differences.

Table 27:

Student Interest in and Attitudes toward Engineering

Interest or Attitude	Pre-test Average (standard deviation)	Post-test Average (standard deviation)	Statistically Significant?	p value
Engineers help make people's lives better.	**4.25 (.730)**	**4.46 (.732)**	**Yes**	**$F_{(1, 134.575)} = 6.982$, p = .009**
I like to learn about technology.	**3.98 (.980)**	**3.76 (1.101)**	**Yes**	**$F_{(1, 133.602)} = 5.429$, p = .021**
I like to learn how to build things.	3.85 (1.115)	3.81 (1.070)	No	$F_{(1, 133.773)} = 0.135$, p = .714
In my future job, I would like to design or build things.	3.00 (1.119)	3.13 (1.243)	No	$F_{(1, 133.552)} = 1.391$, p = .240
Engineering is boring.	2.11 (1.016)	2.21 (1.087)	No	$F_{(1, 132.343)} = 1.924$, p = .168
Engineers come up with new ideas and inventions.	4.37 (.715)	4.45 (.633)	No	$F_{(1, 130.255)} = 0.970$, p = .327
Engineers figure out the best materials to use and how to turn them into the things we use every day.	4.18 (.774)	4.22 (.862)	No	$F_{(1, 134.842)} = 0.722$, p = .397
Men are better at engineering than women.	1.73 (1.075	1.80 (1.175)	No	$F_{(1, 134.515)} = 0.141$, p = .708
Only super smart people can be good at engineering.	1.90 (.980)	2.07 (.994)	No	$F_{(1, 132.144)} = 3.601$, p = .060
Engineers have cool jobs.	3.79 (.878)	3.71 (.974)	No	$F_{(1, 130.958)} = 0.753$, p = .387

Student Feedback on the DSN Challenges

We asked students to report whether they enjoyed completing the DSN challenges. As summarized in the figure below, most students (69%) reported that they had fun participating in the DSN challenges with their classes.

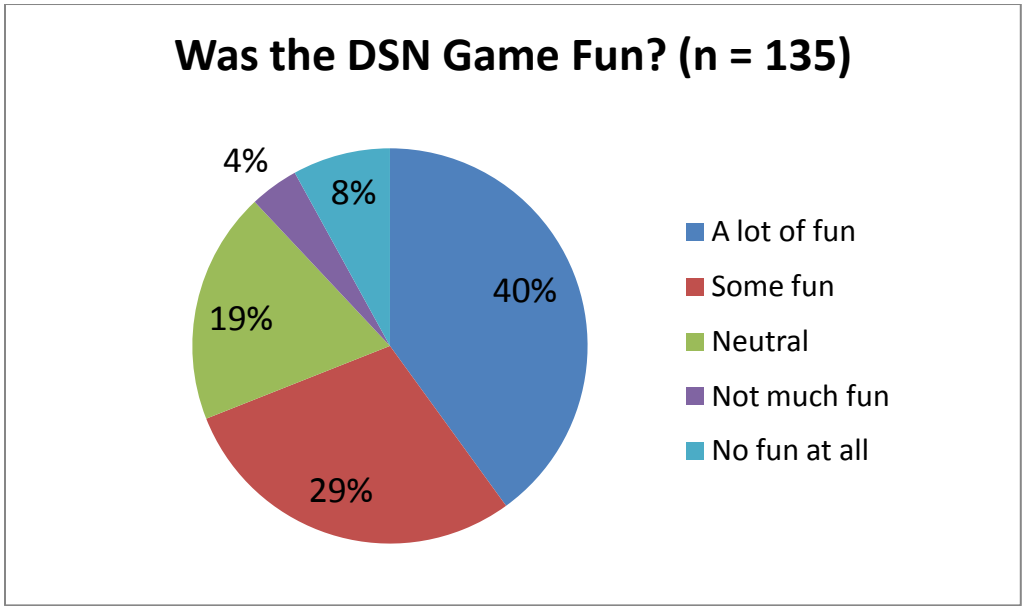


Figure 7. Most students reported that the DSN challenges were fun.

All six teachers reported that they believed their students would be interested in doing DSN challenges again at school.

One aspect of the DSN study that differed from previous *Design Squad* challenges was the at-home component. We asked students to report how the at-home challenges were different from their normal homework, if at all. Most students told us that the biggest difference was that the at-home activities were "hands-on" rather than typical paper-and-pencil homework tasks:

- You wouldn't really have to write anything you would just build things.
- They are hands on and more fun.
- The work is "hands on" so you can experiment. There is no right or wrong answer to experimenting.
- You got to work with things.
- They were hands on.
- They took longer and were more hands on.
- They actually required me to search for things.

- The at home challenges we did with Design Squad were a lot more fun and creative.
- It was not paper and pencil writing and there was no right answer. We could be more creative.
- It involved building and not just writing on paper.
- It caused me to be more creative.
- Finding a lever was hard, but fun. You normally don't see that.
- We got to build rubber band cars and that would never be in my normal homework.

Many students also reported that the DSN at-home challenges were more fun than regular homework:

- This was fun and homework isn't.
- You had more fun.
- You get to do something that is fun instead of a boring worksheet.
- They were very fun and I enjoyed them.
- They were funner (sic).
- They were a little more fun.
- More fun than math stuff.
- It was more fun.
- We were having fun while doing it :)

To see whether the interactive aspects of the DSN challenges resonated with students, we asked them to report their agreement with the following sentence: "I would like my schoolwork more if I could interact and discuss school projects with other kids online." This concept was appealing to more than one-third of the students (36%).

Finally, we asked students to tell us how the DSN challenges could be improved. Of the students who responded, the most popular suggestion was to add more challenges:

- Make more challenges!
- Add more things that you can do with things in your home and that are easy to do.
- Add more engineering challenges.
- Add more challenges.
- More projects that involve building.
- Put more engineering games on there.
- Make new challenges for us to do.
- A Rube Goldberg game would be cool.

Some students suggested adding more difficult challenges or challenges that were geared toward older kids:

- The last challenge was kind of childish to eighth graders such as myself because a lot of the wishes were too abstract or impossible to actually do and were from like 7 year old kids.
- A lot of the wishes online were for much younger kids so maybe that challenge should be optional as it was not really age appropriate.
- When we posted on wishes some of them didn't make sense because I'm in 8th grade.
- The sketching of wishes was not that age appropriate.
- More hard things.
- Make it more appropriate for teenagers as well.
- Make it better for older kids.
- Building harder stuff.

Impact on Teachers

Overall, teachers were very positive about the DSN experience. Teachers told us that they liked the following aspects:

- I liked using the challenge board and I projected this as students worked through the challenges, so as they showed me something new that worked when they redesigned.... they could see their instant points. I like the organization of the handouts, leading them through the design process. I like the demo videos and the kids love Design Squad episodes.
- Hands-on activities. Relatively simple and do-able for middle school students.
- The students became very interested and excited about science and engineering. I think they now see engineering as a "cool" career; one student said that engineers get to "play" all the time.
- I think the challenges in class were the best part. I randomly paired students and they worked together really well.

> The challenges and activities were my favorite teaching moments. I had no tools to teach engineering before and now I am equipped.
>
> --Teacher

Five of the six teachers reported that they would recommend the DSN challenges to other teachers. Teachers told us:

- I love the handouts as they take students through the design and problem solving process. I have already shown the other two tech ed teachers in my district. They are quite interested. The videos and the handouts are a huge help! In fact, all the reference materials are awesome! Great work DSN!
- I loved the whole concept of the challenges and the connection to the website. I plan on incorporating these and additional challenges next year beginning in Sept.
- I recommend the Design Squad site and activities. This is the best way to excite students into the world of engineering.

One other teacher admitted that he just didn't have enough experience with the DSN game to recommend it.

Teachers told us that the DSN challenges had an impact on their approaches to teaching:

- It gave me some real-world design challenges to lead students through. It helped me to give students a reason to learn science concepts as they applied them to their zipline carriers, popfly devices, or paper tables. Hands-on learning taught students to problem solve a normally closed circuit rather than a normally open circuit for a hidden alarm on a door. I found myself thinking on the fly and giving students a real reason to learn. It supported my hands-on approach, where there are always multiple ways to solve a problem.
- (It caused me to place) More emphasis on engineering as hands-on, applied science.
- Doing the challenges made me realize that the more "hands on" an activity is, the more engaging. The website's portraits of engineers in various occupations was especially useful in eliminating stereotypes.
- I really liked the quick challenges in class. We could do more of these when I start teaching physics next year.
- The activities gave me energy.

Four of the six teachers reported that s/he were *more interested* now in integrating hands-on design challenges into their classrooms after using the DSN challenges. These same four teachers also told us that the DSN challenges helped them to feel *more comfortable* providing engineering activities to their students. The other two teachers reported that they were already comfortable doing this and would continue to do so.

At pre-test, one the six teachers reported at pre-test that they did not have a solid understanding of the engineering design process. Two others reported that they understood it, but did not have a strong understanding of it. After using the DSN challenges, all the teachers reported that they understood the engineering design process and two of the six reported that their understanding was much better now as a result of using the DSN challenges.

We asked teachers to tell us how the DSN challenges impacted their knowledge of engineering careers, if at all. Four teachers told us they *know more* about engineering careers now, while two reported that their knowledge did not change because they knew about engineering careers before using the DSN challenges.

We asked teachers how likely they were to use the DSN challenges again without the game format versus with the game format. All six teachers reported that they were very likely to use the DSN challenges again. Only half of the teachers reported that they would use the DSN challenges with the game format again. Teachers told us:

- I'm not sure that the game itself is necessary and am not sure how to improve it. For my class, the home component and the texting weren't useful (and actually deterrents) but the challenges were great, and I will use them next year.
- I'd rather not keep track of points--keeping the score/grade for each challenge separated would work better for me.
- I don't have the classroom technology and time to play the game.

Finally, teachers also provided some specific feedback on ways to enhance the various components:

- Let teachers access the sketches and prototypes more efficiently.
- The Design Squad Student project website and online sketch program needs an update with a search option to find friends and projects.
- The projects and videos are great for ages up to 8th grade, but the Design Squad website for students to sketch and upload pics and prototypes was a bit more elementary still.
- The text challenges could be clearer. I would suggest it to be used as part of the brainstorm process, feeding all these texts to a format where all the ideas could be seen on a website, in a collaborative effort. A wiki might be a great way to include viewers and students to collaborate ideas and compete against other cities, etc. ..... or other social media.
- There was a lot of confusion in what they should do at home, text or do the other at home challenge. It is good for students to have options, for example bring a paper sketch if they can't get online at home.... but students needed consistency and clarity in the directions.

Chapter 4: Website Users' Survey

Objectives

WGBH hosted a Web-based survey on the home page of the *Design Squad Nation* (DSN) website for the purpose of collecting data about the demographic and background characteristics of its website visitors. We invited all unique visitors to respond to the survey. The survey was brief and collected the following data:

1. Gender
2. Age
3. Race/ethnicity
4. Locale (urban, rural, suburban)
5. State of residence
6. Zip code[8]
7. Type of school (collected from children only)
    a. Public school
    b. Charter school
    c. Private school
    d. Home school
8. In which role/capacity they visited the website (collected from adults only)
    a. Classroom teacher
    b. After-school teacher
    c. Librarian
    d. Volunteer
    e. Camp counselor
    f. Parent
    g. Engineer
    h. Other

[8] We have not included a list of zip codes in this report as it encompasses several hundred different codes, but will share the full list directly with WGBH.

9. Perceived socioeconomic status, SES (collected from adults only)[9]
    a. Low income
    b. Middle income
    c. High income

The survey was launched in May 2011 and represents the second annual survey of its kind that we have conducted. The survey was made available for a period of about two weeks, with a goal of collecting responses from 1,000 unique respondents. We collected data from 1,328 respondents. Over 320 records (24%) contained significant amounts of missing data (responded to only one question) or the data were suspect (response patterns indicated the respondents did not take the survey seriously). After deleting records with significant missing and suspect data, we had a sample of 1,005 responses.

What States were Represented?

As shown in Table 28, our sample included individuals from every state in the US plus the District of Columbia, except Wyoming. The states that were the most heavily represented in our sample (Texas, Florida, Massachusetts, California, and New York) mirror closely the states that are represented most frequently in the web statistics that WGBH collects on a regular basis (California, Texas, New York, and Florida) as well as closely matching our 2010 survey of website users.

[9] Rather than pre-defining SES for respondents based on a set income level that does not take into account community-level variables like cost of living, this question asks respondents to report how they perceive their situation (i.e., do they consider themselves to be low, middle or high income?).

Table 28:

Proportion of Website Visitors from Each State

State	Number	Percent	State	Number	Percent
TX Texas	86	8.6%	OR Oregon	12	1.2%
CA California	82	8.2%	IA Iowa	9	0.9%
FL Florida	52	5.2%	LA Louisiana	9	0.9%
MA Massachusetts	50	5.0%	KY Kentucky	8	0.8%
NY New York	48	4.8%	NH New Hampshire	8	0.8%
OH Ohio	47	4.7%	AR Arkansas	7	0.7%
IL Illinois	43	4.3%	HI Hawaii	6	0.6%
MN Minnesota	39	3.9%	ID Idaho	6	0.6%
PA Pennsylvania	39	3.9%	KS Kansas	6	0.6%
NC North Carolina	36	3.6%	MS Mississippi	6	0.6%
GA Georgia	34	3.4%	NM New Mexico	6	0.6%
VA Virginia	34	3.4%	OK Oklahoma	6	0.6%
CO Colorado	31	3.1%	NE Nebraska	4	0.4%
MD Maryland	31	3.1%	NV Nevada	4	0.4%
MI Michigan	31	3.1%	MT Montana	3	0.3%
AZ Arizona	28	2.8%	SD South Dakota	3	0.3%
WI Wisconsin	24	2.4%	VT Vermont	3	0.3%
WA Washington	23	2.3%	WV West Virginia	3	0.3%
IN Indiana	20	2.0%	AK Alaska	2	0.2%
TN Tennessee	19	1.9%	DC Dist. of Columbia	2	0.2%
UT Utah	18	1.8%	DE Delaware	2	0.2%
NJ New Jersey	17	1.7%	RI Rhode Island	2	0.2%
CT Connecticut	14	1.4%	ME Maine	1	0.1%
MO Missouri	14	1.4%	ND North Dakota	1	0.1%
SC South Carolina	14	1.4%	WY Wyoming	0	0.0%
AL Alabama	12	1.2%	**Total**	**1005**	**100.0**

Visitor Demographics

As summarized in Table 29, more of the website visitors in 2011 were female (66%) than male (34%). We observed a similar ratio of females to males in the 2010 survey. While more than half of the website visitors in 2011 were white (65%), 11% reported that they were of Hispanic, Latino or Spanish origin and 13% reported they were African-American. Other ethnic groups included Asians (12%), American Indian or Alaskan Natives (5%), and Native Hawaiian or other Pacific Islanders (2%).

Table 29:

Demographic and Background Characteristics of Website Visitors

Characteristic	2011 Data (N = 1005)	2010 Data (N = 912)	Compared to US Demographics[a]
Gender			
Female	667 (66.4%)	585 (64.1%)	50%
Male	338 (33.6%)	300 (32.9%)	50%
Missing/Unknown	0 (0.0%)	27 (3.0%)	N/A
Race / ethnicity			
White or Caucasian	651 (64.8%)*	520 (57.0%)	80.0%
Hispanic, Latino, or Spanish	115 (11.4%)	147 (16.1%)	12.9%
Black or African-American	127 (12.6%)	116 (12.7%)	12.9%
Asian	119 (11.8%)	102 (11.2%)	4.4%
American Indian or Alaskan Native	48 (4.8%)**	59 (6.5%)	1.0%
Native Hawaiian or Other Pacific	17 (1.7%)	23 (2.5%)	0.2%
Location			
Suburban	510 (50.7%)	394 (43.2%)	Not defined
Urban	375 (37.3%)	329 (36.1%)	79.2%
Rural	120 (11.9%)	121 (13.3%)	20.8%
Missing/Unknown	0 (0.0%)	68 (7.5%)	N/A

NOTE: Totals may add up to greater than 100% in cases where respondents can choose more than one answer.
[a] US demographic data obtained from the US Census Bureau (http://www.fhwa.dot.gov/planning/census/cps2k.htm) and the CIA World Factbook (https://www.cia.gov/library/publications/the-world-factbook/geos/us.html).
* The difference between 2010 and 2011 was statistically significant at the p<.01 level, which means that a greater proportion of respondents identified themselves as White in 2011 than in 2010.
** The difference between 2010 and 2011 was statistically significant at the p<.05 level, meaning that fewer respondents identified themselves as American Indian or Alaskan Native in 2011 compared to 2010. This is likely reflective of a problem with the order of the response options we provided in 2010 that we corrected for the 2011 survey. Thus, we contend that the 2011 responses are more accurate.

As summarized in Table 29, the majority of the website visitors reported that they lived in suburban settings (51%). More than one third of website visitors (37%) reported that they lived in urban settings, while 12% reported they lived in rural settings. These proportions did not differ significantly from the proportions we observed in 2010.

We also asked students to report the type of school they attended (Table 30). Most students reported that they attended public schools (73%), similar to the 2010 survey.

Table 30:

Students' Self-Report School Types

School Type	2011 Data (N = 666)	2010 Data (N = 602)	Compared to US Students[a]
Public school	487 (73.1%)	426 (70.8%)	85%
Home school	73 (11.0%)	66 (11.0%)	3%
Private school	64 (9.6%)	63 (10.5%)	11%
Charter school	27 (4.1%)	25 (4.2%)	2%
Missing/Unknown	15 (2.3%)	22 (3.7%)	N/A

[a] Data obtained from the National Center for Education Statistics (http://nces.ed.gov/programs/digest/d09/tables/dt09_100.asp) and (http://nces.ed.gov/programs/digest/d09/tables/dt09_002.asp)

In terms of age, the sample respondents ranged in age from 6 to 70 years old. The average age was 20 years and the median age was 12 years (almost exactly the same as the 2010 survey).

We asked the adults in our sample to indicate in what role/capacity they were visiting the website (Table 31). The majority of website visitors reported that they were visiting the site as teachers (51.9%). Other key groups included parents (18.3%) and volunteers (5.9%). Fewer than 5% of the adults reported that they were visiting the website in any one of the following capacities:

- Engineer (4.7%)
- After-school teacher (4.1%)
- High school or college student (4.1%)
- Curriculum designer, coach or consultant (2.7%)
- Librarian (2.1%)
- STEM outreach coordinator (1.8%)
- School administrator (1.2%)

- "Lifelong learner" (1.2%)
- Scout leader or staff (0.9%)
- Camp counselor (0.6%)
- Career counselor (0.6%)
- Museum staff (0.6%)
- Viewer (0.6%)

Other, individual respondents reported they were visiting the website as a(n)…

- 4-H leader
- Afterschool network coordinator
- Grandparent
- Inventor
- KEEN school representative (higher education)
- Sustainable product design professional/researcher

Table 31:

Characteristics of Adult Visitors to the Website

Characteristic	2011 Data (N = 339)	2010 Data (N = 265)
Role		
Classroom teacher	176 (51.9%)	121 (45.7%)
Parent, including home school	62 (18.3%)	42 (15.8%)
Engineer	16 (4.7%)	26 (9.8%)
After-school teacher	14 (4.1%)	11 (4.2%)
Volunteer	20 (5.9%)	11 (4.2%)
Student	14 (4.1%)	4 (1.5%)
Librarian	7 (2.1%)	4 (1.5%)
Camp counselor	2 (0.6%)	2 (0.8%)
Other	38 (11.2%)	20 (7.5%)
Missing/Unknown	33 (3.3%)	24 (9.1%)

Characteristic	2011 Data (N = 339)	2010 Data (N = 265)
Income level		
Middle income	245 (72.3%)	175 (66.0%)
Low income	34 (10.0%)	37 (14.0%)
High income	31 (9.1%)	34 (12.8%)
Missing/Unknown	29 (8.6%)	19 (7.2%)

Finally, we also asked the adult respondents to report their perceived socioeconomic status. The majority of respondents perceived themselves to be middle income (72%), followed by low income (10%) and high income (9%). While the proportion of middle income website users seems higher in 2011 than 2010, the difference was not statistically significant.[10]

[10] There are no reliable national data on the proportion of US adults who believe that they are low, middle, or high income. However, we do know that the official poverty rate according to the Census Bureau was 13.2% in 2008.[10] So, the proportion of website visitors who perceived themselves to be low income is consistent with the US poverty rate, according to the Census Bureau.

Chapter 5: Summary and Implications

Overview of Intended Impacts

The DSN evaluation was designed to measure the extent to which WGBH achieved the following impacts on middle school students and teachers:

Intended Impacts on Students

After using the DSN resources…

- Middle school students will increase their knowledge of science and engineering concepts and the design process.
- Middle school students' attitudes towards engineering will improve.
- Middle school students' interest in engineering will increase.
- Middle school students' awareness of engineering work will increase.
- Middle school students, especially girls and minorities, will see engineering as creative, rewarding, and socially relevant.

Intended Impacts on Teachers

After using the DSN resources…

- Teachers' awareness of the design process will increase.
- Teachers' knowledge of engineering careers will increase.
- Teachers' interest in using hands-on engineering activities in their classrooms will increase.

- Teachers' comfort level with providing engineering activities to their students will increase.

Below is a summary of our evaluation findings organized by impact as well as a discussion of the implications of these findings for future study.

Summary of Observed Student Impacts

Impact 1: Middle school students increased their knowledge of science and engineering concepts and the design process.

We found evidence that DSN had a positive impact on student learning in the classroom and at home. In the classroom study, we found a 12% (effect size = .37) increase in students' ability to solve science problems and demonstrate an understanding of the engineering design process. We also asked students to tell us, in their own words, what they learned from the DSN challenges. Some students told us they helped them learn more about the various stages of the design process:

- It helped me learn the steps of designing and working with others to solve problems.
- It made it easier to understand engineering.
- It helped me design and redesign my creation.
- I learned to work together and compromise with others to get work done.
- I learned to be open to others ideas they may work better than your own.
- I learned that teamwork can make a huge difference.
- I learned a lot more about making a design efficient to specific needs.

All teachers also described how the DSN challenges strengthened their students' ability to identify and discuss the science concepts they applied:

- They were more willing to see the science concepts in the world around them and apply their knowledge and the science concepts we discussed. It helped them talk about their real world and the engineering in it.
- Required them to see how engineering connects to science.
- Some evidence of better conceptual understanding now.
- The challenges gave the students the opportunity to discuss their findings using scientific vocabulary.
- They were able to discuss what they had previously learned (forces and motion, in particular).
- My 6th grade classes were absolutely jazzed about science because of Design Squad. I was excited because it gave me great ideas.

> My 6th grade classes were absolutely jazzed about science because of Design Squad.
>
> --Teacher

All teachers reported that the DSN challenges strengthened their students' ability to explain and use the engineering design process:

- It reinforced the design and engineering process that we use in my class.
- It really helped with the brainstorming process. Often students will not think outside the box. There was a lot more variety in designs when they tried to use information from the real world.
- Much better understanding of engineering design process through viewing and critiquing the DS challenges.
- This was the engineering design process in action. I overheard tables of students discussing "brainstorm", "plan", and "redesign." It also gave them practice using limited resources, e.g., only 2 paper cups even if they wanted to use more.
- It reinforced what they have done in tech/engineering class.
- Students were talking about different types of engineering. They were discussing relatives who were engineers and what they do. It opened their minds to learn about different career options.
- When they designed the NASA moon launcher, for example, they were discussing how engineers needed to design shock absorbers so that they didn't hurt astronauts.
- The students now have specific examples and they can talk in engineer terms. Practice and looking at other classmates' ideas was very powerful.

> The students can now talk in engineer terms.
>
> --Teacher

In the home viewing study, 26% of kids told us that they learned "engineering could be used in new or different ways." Thirty-two percent reported that they learned how in engineering materials could be reused and made into new items.

Impact 2: Middle school students' attitudes towards engineering improved.

Among kids in the home viewing study, we observed significant and positive shifts in kids' attitudes after they viewed the DSN episodes. After viewing DSN, kids were significantly more likely to believe that engineers have cool jobs and that engineers come up with new ideas and inventions than before they viewed the episodes. Likewise, kids were significantly less likely to view engineering as boring, believe that men are better at engineering than women, and believe that only super smart people can be good at engineering after viewing DSN than before viewing it.

Among a sample of kids in the classroom study, we did not observe any changes in attitudes toward engineering among students. The student pre-test attitudes were positive at the start of the study and at the end of the study, and thus, we did not see any growth. It appears that there was a greater opportunity to impact kids' attitudes at home than in school settings where the teachers who chose to be in the study were already addressing attitudes toward STEM.

Impact 3: Middle school students' interest in engineering increased.

We observed that the DSN challenges demonstrated a positive impact on student interest in engineering in both classroom and home settings. For example, we asked students in the classroom study to report the extent to which the DSN challenges changed their interest in engineering, if at all. Over half of the students (52.6%) reported that they were more interested in engineering after completing the DSN challenges. At post-test, we asked kids to tell us how "cool" it would be to be an engineer. About half of the kids (45.9%) reported that it would be "cool" or "very cool."

Some students also told us that the DSN challenges helped them see engineering as fun and interesting:

- That engineering is cool.
- That engineering can be kinda fun but it's a challenge at the same time.
- That science is fun.
- I learned that even though I am a kid I can have fun building and designing things.
- Helped me learned that there are more ways to learn than writing and reading.

In addition, we observed a statistically significant increase in the proportion of students who reported being interested in designing and buildings things in their classrooms and during the summer.

Over half of the students reported they would be interested in watching DSN again and using the website again. Moreover, all six teachers reported that they believed their students would be interested in doing engineering challenges like DSN again at school.

The findings from the home viewing study were also positive—most kids reported they were "interested" or "very interested" in watching DSN again (70%). Anecdotally, when we spoke with parents throughout the study to confirm data collection details, parents confirmed their kids' interest in the DSN episodes. For example, one parent told us: *My kids love the DVD's! They all sat quietly and watched them. This NEVER happens!*

Impact 4: Middle school students' awareness of engineering careers increased.

We found evidence that the kids in the home viewing study did learn about the types of work engineers might do after watching the DSN episodes—we observed a 26% increase in awareness scores over time (effect size = .47).

Students in the classroom study told us the DSN challenges helped them learn about what engineers do and about engineering careers:

- It helped me learn what engineers actually do.
- It taught me that you can take something simple and make it into something useful.

- I learned what engineering really was and that it's many different ways then just using technology. I learned some new tools that I never even heard of.
- It helped me learn about how engineers work.
- I didn't know you could be a certain engineer. So I learned about that and that was cool.

In the home viewing study, we found that kids showed a significant improvement in their understanding that engineers design and build things to meet people's needs—we observed a 7% increase in their scores over time (effect size = .31).

Impact 5: Middle school students, especially girls and minorities, viewed engineering as creative, rewarding, and socially relevant.

Among girls, minorities, and all subgroups in the evaluation, we found evidence that DSN helped students to see engineering as creative, rewarding, and socially relevant. For example, in the home viewing study kids were significantly more likely to believe that engineers help make people's lives better after viewing the DSN episodes. Kids reported that they appreciated DSN's creativity/good ideas and the idea that engineering helped/cared for the world.

Students in the classroom study reported that the DSN challenges helped them learn that engineering involves creativity and perseverance:

- Helped me think out of the box and came up with really great ideas.
- It made me become more creative by designing my own things.
- You learn about how to build things and get ideas on how to build new things.
- It helped me learn to persevere.
- By showing me how to design stuff and giving me confidence.

> It helped me learn the steps of designing and working with others to solve problems.
>
> -- Student

Students in the classroom study also told us that the DSN challenges helped them see engineering as a field that can potentially impact the world:

- It helped me learn by showing me that the activities can change people's lives.
- How to design things at home that might make a difference.

The DSN website users' survey confirms that DSN is appealing to a diverse audience that includes girls and minorities. Based on two years of data, it appears that DSN, through its website, reaches traditionally underserved audiences such as non-white, ethnic minorities, girls, and low income audiences. Over the past two years, visitors to the website were:

- Racially, ethnically, and economically diverse (over 40% non-white, ethnic minorities in 2010 and 2011; Fourteen percent perceived themselves to be low-income (consistent with the U.S. poverty rate of roughly 13% in 2008).
- Representative of a diverse array of individuals from across the country. During the past two years, the website received visitors from all 50 states plus the District of Columbia and Puerto Rico. The following states were the most heavily represented—Texas, Florida, Massachusetts, California, and New York.
- More likely to be homeschoolers than might be expected based on the national proportion of homeschoolers (11% of website visitors versus 3% nationally).

Impact 6: Teachers' awareness of the design process increased.

After using the DSN challenges, all the teachers reported that they understood the engineering design process and two of the six reported that their understanding was much stronger as a result of using the DSN challenges. Five of the six teachers reported that they would recommend the DSN challenges to other teachers. Teachers told us:

- I love the handouts as they take students through the design and problem solving process. I have already shown the other two tech ed teachers in my district. They are quite interested. The videos and the handouts are a huge help! In fact, all the reference materials are awesome! Great work DSN!
- I loved the whole concept of the challenges and the connection to the website. I plan on incorporating these and additional challenges next year beginning in Sept.
- I recommend the Design Squad site and activities. This is the best way to excite students into the world of engineering.

Impact 7: Teachers' knowledge of engineering careers increased.

We asked teachers to tell us how the DSN challenges impacted their knowledge of engineering careers, if at all. Four teachers told us they *know more* about engineering careers now, while two reported that their knowledge did not change because they knew about engineering careers before using the DSN challenges.

Impact 8: Teachers' interest in using hands-on engineering activities in their classrooms increased.

Four of the teachers told us that the DSN challenges had an impact on their approaches to teaching:

- It gave me some real-world design challenges to lead students through. It helped me to give students a reason to learn science concepts as they applied them to their zipline carriers, popfly devices, or paper tables. Hands-on learning taught students to problem solve a normally closed circuit rather than a normally open circuit for a hidden alarm on a door. I found myself thinking on the fly and giving students a real reason to learn.

It supported my hands-on approach, where there are always multiple ways to solve a problem.
- (It caused me to place) More emphasis on engineering as hands-on, applied science.
- Doing the challenges made me realize that the more "hands on" an activity is, the more engaging. The website's portraits of engineers in various occupations was especially useful in eliminating stereotypes.
- I really liked the quick challenges in class. We could do more of these when I start teaching physics next year.
- The activities gave me energy.

Four of the six teachers reported that s/he were *more interested* now in integrating hands-on design challenges into their classrooms after using the DSN challenges.

Impact 9: Teachers' comfort level with providing engineering activities to their students increased.

Four teachers reported that the DSN challenges helped them to feel *more comfortable* providing engineering activities to their students. The other two teachers reported that they were already comfortable doing this and would continue to do so.

- I liked using the challenge board and I projected this as students worked through the challenges, so as they showed me something new that worked when they redesigned.... they could see their instant points. I like the organization of the handouts, leading them through the design process. I like the demo videos and the kids love Design Squad episodes.
- The hands-on activities were relatively simple and do-able.
- I think the challenges in class were the best part.

> The challenges and activities were my favorite teaching moments. I had no tools to teach engineering before and now I am equipped.
>
> --Teacher

Conclusion

Summary of Findings

These studies found evidence that DSN had a positive impact on students and teachers. For instance, after using DSN resources, middle school kids were *significantly MORE likely to…*

- Demonstrate an understanding of key science and engineering concepts and demonstrate an ability to identify and discuss the science concepts they applied.

- Demonstrate an understanding of the engineering design process and demonstrate an ability to explain and use the engineering design process.
- Understand the type of work that engineers do.
- Believe that engineers have cool jobs.
- Believe that engineers come up with new ideas and inventions.
- Understand that engineers design and build things to meet people's needs.
- Believe that engineers help make people's lives better.
- Report an interest in designing and buildings things in their classrooms and during the summer.

After using DSN, the kids were *significantly LESS likely to…*

- View engineering as boring.
- Believe that men are better at engineering than women.
- Believe that only "super smart" people can be good at engineering.

In addition, roughly half the kids reported that they…

- Were more interested in engineering after completing the DSN challenges.
- Thought it would be "cool" or "very cool" to be an engineer someday.

These studies also found evidence that DSN had a positive impact on teachers.

- Four of the six teachers reported that s/he were *more interested* now in integrating hands-on design challenges into their classrooms after using the DSN challenges.
- These same four teachers also told us that the DSN challenges helped them to feel *more comfortable* providing engineering activities to their students.
- All the teachers reported that they understood the engineering design process and two of the six reported that their understanding was much better now as a result of using the DSN challenges.
- Four teachers told us they *know more* about engineering careers after using DSN.
- All six teachers reported that they were very likely to use the DSN challenges again.
- Five of the six teachers reported that they would recommend the DSN challenges to other teachers.

Implications for Future Study

In addition to assessing the impacts of DSN on students and teachers, another major goal of the evaluation was to collect formative data that could be used to redesign the DSN web resources for a future study. In a separate study, we are planning to explore the

engineering pathways that middle schoolers at home follow in pursuing their engineering interests. The cornerstone of the proposed study is an enhanced DSN website with more activities, more challenges, and more social interaction designed to support students who are engaging in engineering.

The evaluation results support the concept that kids can enjoy learning about STEM at home and that the DSN activities can be used successfully in a home setting. For instance, kids in the evaluation reported that they enjoyed the at-home activities. Even though the DSN activities were technically homework assignments, the kids reported that they viewed them as different from their typical homework because the DSN activities were more "hands-on" and "fun":

- They are hands on and more fun.
- The work is ''hands on'' so you can experiment. There is no right or wrong answer to experimenting.
- You got to work with things.
- They actually required me to search for things.
- The at home challenges we did with Design Squad were a lot more fun and creative.
- It was not paper and pencil writing and there was no right answer. We could be more creative.
- It involved building and not just writing on paper.
- It caused me to be more creative.
- Finding a lever was hard, but fun. You normally don't see that.
- We got to build rubber band cars and that would never be in my normal homework.
- This was fun and homework isn't.
- You get to do something that is fun instead of a boring worksheet.
- They were very fun and I enjoyed them.
- More fun than math stuff.
- We were having fun while doing it :)

More than one-third of the kids (36%) in the study also found appealing the idea of interacting and discussing school projects with other kids online, one feature that is currently planned for the proposed DSN study.

It was also interesting to note that we found a large proportion of DSN website visitors were more likely to be homeschoolers than we might expect based on the national proportion of homeschoolers (11% of website visitors versus 3% nationally)--supporting the notion that these activities can be used successfully in a home setting.

Finally, the median age of the website visitors (12 years old) matches well with DSN's target audience (9-12 year olds), thus, it seems appropriate for the proposed study to target kids in this age range.

The DSN website is already being used by a middle school audience, including kids and families who are integrating STEM learning into their home environments. It will be important to explore how the DSN resources that are available on the Web help to nurture or guide kids along engineering pathways. The results of the evaluation studies described in the full evaluation report have several implications for the proposed study:

- The DSN website should offer more challenges, including more complicated challenges: Students in the school/home study reported that they would like to see even more challenges added to the website, in addition to some more difficult challenges that older kids might enjoy.
- The DSN website should be enhanced to make pictures and sketches easier to post and find: Of the classrooms that did post to the website, teachers reported that website limitations on file sizes made the experience of posting less interactive and less useful than intended.
- The DSN website should continue to provide an extensive set of challenges, but should offer an improved DSN game format (one that individuals can play rather than, or in addition to, whole classrooms): The challenges themselves were essential to impacting learning and attitudinal change in the evaluation. The game format was not necessary for learning or attitudinal change. That said, an improved game format may offer a better way to engage and sustain kids' interest in learning about engineering.

Appendix A: Home Viewing Study Survey Items

Home Viewing Survey Items

1. **[Pre and post]** In your opinion, which of the following things could be made BETTER with the help of an engineer? **(Circle all that apply)**
    a) Rocks and stones
    b) Toothbrushes
    c) Cell phones
    d) Highways
    e) Sports equipment
    f) Dogs
    g) Websites
    h) None of these could be made better
    i) I don't know what an engineer does

2. **[Pre and post]** Can you think of one thing built by an engineer that has changed your life?
    a) No
    b) Not Sure
    c) Yes (please specify) _____

3. **[Pre and post]** Below are some sentences about engineering. We want to know whether you agree or disagree. Please read each sentence carefully and circle your answers. There are no right or wrong answers!

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
a. Engineers help make people's lives better.					
b. Engineering is boring.					
c. Engineers come up with new ideas and inventions.					
d. Engineers figure out the best materials to use and how to turn them into the things we use every day.					
e. Men are better at engineering than women.					
f. Only super smart people can be good at engineering.					
g. Engineers have cool jobs.					

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
h. Engineers FIRST find out what people need and THEN they design and build things to fill those needs.					
i. Kids can design and build things that are useful.					

4. **[Pre and post]** Please name one thing that an engineer could design and build with a "lever"? What would it do?

5. **[Pre and post]** Please name one thing that an engineer could design and build with a "battery-powered circuit and a switch"? What would it do?

6. **[Pre and post]** Below are some sentences about you. We want to know whether you agree or disagree. Please read each sentence carefully and circle your answers.

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
a. I am good at building things.					
b. I am good at designing things.					
c. I am good at solving problems.					
d. I am good at brainstorming (thinking of ideas).					
e. I like to learn about how to build things.					
f. I like to learn about technology.					
g. In my future job, I would like to design or build things.					

7. **[Post-test only]** Do you ever watch educational shows? (These can be on TV, on line, at school, or on a mobile device.)
   a) Yes (skip next question)
   b) No

8. **[Post-test only]** If you don't watch educational shows, what are your 3 favorite shows to watch? (skip to #)

9. **[Post-test only]** How often do you watch educational shows?
    a) Almost every day
    b) Every week
    c) Once a month
    d) A few times a year
    e) Almost never

10. **[Post-test only]** (For kids who watch at least once a month) List up to 3 educational shows that you like to watch:

11. **[Post-test only]** Please check all that apply. I watch educational shows...
    a) On television (TV)
    b) On TV using a DVR
    c) On DVDs
    d) On the Web using a computer or laptop
    e) Using podcasts or vodcasts
    f) On the Web using a mobile device such as a mobile phone, tablet, or iTouch
    g) At school
    h) Other, please specify: _____

12. **[Post-test only]** (For kids who watch online) If you are watching educational shows online, how do you find the shows?
    a) YouTube
    b) Hulu
    c) Netflix
    d) Show website
    e) Other, please specify: _____

13. **[Post-test only]** Below are some sentences about educational shows. Please tell us how much you agree or disagree with each sentence. (scale will be 1 to 5)
    a) Educational shows are boring.
    b) I learn a lot from educational shows.
    c) Educational shows are hard to find.
    d) Educational shows are fun to watch with my family.
    e) I am too busy with school and other activities to watch educational shows.
    f) My friends watch educational shows.
    g) I am not allowed to have any "screen time" at home.
    h) Educational shows are the only shows my parents will allow me to watch.

i) Educational shows are too much like school.
j) I like educational shows.

14. **[Post-test only]** Did you like the episodes? Why or why not?
15. **[Post-test only]** What did you learn from each one? [remind them of the episodes]
16. **[Post-test only]** Would you be interested in watching DS at school? Why or why not?
17. **[Post-test only]** Would you typically watch a 30-minute episode of DS or would you watch for less time? If less, how many minutes would you probably watch? Why?
18. **[Post-test only]** Would you typically watch 30 minutes of any other kind of show (non-educational)?
19. **[Post-test only]** Would you watch more than one episode? Why or why not?
20. **[Post-test only]** What device would you most likely use to watch it? List devices.
21. **[Post-test only]** Would you tell your friends to watch it? Why or why not?

Appendix B: Favorite TV Shows

Top Three Shows Mentioned by Kids

(n = 47)

Top Shows	#	Top Educational Shows	#
Wizards of waverly place	9	Mythbusters	5
SpongeBob SquarePants	6	How Is It Made	3
Suite Life On Deck	6	1,000 ways to die	2
Shake It Up	5	Between the Lions	2
The Simpsons	5	Cyber Chase	2
Glee	4	Design Squad Nation	2
Family Guy	3	Phineus and Ferb	2
Good Luck Charlie	3	19 Kids and Counting	1
iCarly	3	America: The Story of Us	1
American Dad	2	Ancient Civilizations for Kids	1
Everybody Hates Chris	2	Animal Cops	1
Fish Hooks	2	Animal Planet	1
Ghost Whisperer	2	Any art program works	1
Hannah Montana	2	Any natural science show on the Science channel or Animal Planet	1
Jersey Shore	2	Are you smarter than a fifth grader	1
Minute to Win it	2	Bath Crashers	1
Mythbusters	2	Bill Nye the science guy	1
Naruto	2	Biz kids	1
Pretty Little Liars	2	Cats 101	1
Sonny With A Chance	2	Destroy, Build, Destroy	1
Star Wars: The Clone Wars	2	Dirty Jobs	1
Suite Life of Zack and Cody	2	Discovery Channel	1
Vampire Diaries	2	Discovery health with surgeries	1
19 Kids and Counting	1	Disney	1
Adventure Time	1	Documentaries	1
American Idol	1	Dog the Bounty Hunter	1
Arthur	1	Dogs 101	1
Avatar	1	Dr.G medical examiner	1
Baseball Tonight	1	Effin science	1
Ben 10	1	Electric Company	1
Big Bang Theory	1	Extreme engineering	1
Cake Boss	1	Factory Made	1
Chuck	1	Fetch with ruff ruff man	1
Codname Kid	1	Friend for change	1
Courage the Cowardly Dog	1	History in ice	1
Cribs	1	How animals survive	1
Criminal Minds	1	How the earth was made	1
CSI miami	1	I shouldn't be alive	1
Degrassi	1	Jeopardy	1
Dog the Bounty Hunter	1	Life after people	1

Top Shows	#	Top Educational Shows	#
Dogs 101	1	Man vs. wild with bear grills	1
Electric Company	1	Most extreme	1
ESPN sports	1	Unknown	1
Fairly Odd Parents	1	Nova	1
Futurama	1	Orangutan Island	1
George Lopez	1	Own	1
Good Times	1	PBS	1
H20 just add water	1	Reading rainbow	1
Hercules	1	Renovation Realities	1
Hole in the wall	1	Sliced	1
House	1	Speeders or one of those prison shows	1
how it's made	1	Storm chasers	1
Human Target	1	The electric company	1
I'm In The Band	1	The Hunt for John Wilkes Booth	1
JEOPARDY	1	The NASA channel	1
King of The Hill	1	The universe	1
Make it or Break It	1	TLC	1
Meet the Beowns	1	Travel Channel	1
Mlb Tonight	1	Untamed and Uncut	1
Modern Family	1	Weather channel shows	1
Mutant X	1	Whale wars	1
My wife and kids	1	Wheel of fortune	1
NESN SPORTSDESK	1	Zeke and Luther	1
Nitro circus	1		
Orangutan Island	1		
Phineas and Ferb	1		
Pokemon	1		
Rob Derdeks fantasy factory	1		
Say Yes to the Dress	1		
Scared Straight	1		
She gets what she wants	1		
Silent library	1		
Sports Center	1		
Storage Wars	1		
Strawberry Shortcake	1		
Survivor	1		
Sweet life	1		
That 70s Show	1		
The Cleveland Show	1		
The Cosby show	1		
Two and a Half Men	1		
Vampire Knight	1		
Victorious	1		
Waterfowler's Edge	1		

Top Shows	#	Top Educational Shows	#
White Collar	1		
Winter Wipeout	1		
Yugioh	1		
Yugioh 5ds	1		
Yugioh GX	1		
Zeke and Luther	1		

Appendix C: School-based Student Survey Items

Student Survey Items

First, please tell us what you know about engineering.

22. **[Pre and post]** In your opinion, which of the following things could be made BETTER with the help of an engineer? **(Circle all that apply)**
    k) Rocks and stones
    l) Toothbrushes
    m) Cell phones
    n) Highways
    o) Sports equipment
    p) Dogs
    q) Websites
    r) None of these could be made better
    s) I don't know what an engineer does

23. **[Pre and post]** Can you think of one thing built by an engineer that has changed your life?
    a) No
    b) Not Sure
    c) Yes (please specify) _____

24. **[Pre and post]** Below are some sentences about engineering. We want to know whether you agree or disagree. Please read each sentence carefully and circle your answers. There are no right or wrong answers!

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
j. Engineers help make people's lives better.					
k. Engineering is boring.					
l. Engineers come up with new ideas and inventions.					
m. Engineers figure out the best materials to use and how to turn them into the things we use every day.					
n. Men are better at engineering than women.					
o. Only super smart people can be good at engineering.					

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
p. Engineers have cool jobs.					
q. Engineers FIRST find out what people need and THEN they design and build things to fill those needs.					
r. Kids can design and build things that are useful.					

25. **[Pre and post]** Please name one thing that an engineer could design and build with a "lever"? What would it do?

26. **[Pre and post]** Please name one thing that an engineer could design and build with a "battery-powered circuit and a switch"? What would it do?

27. **[Pre and post]** Below are some sentences about you. We want to know whether you agree or disagree. Please read each sentence carefully and circle your answers.

	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
h. I am good at building things.					
i. I am good at designing things.					
j. I am good at solving problems.					
k. I am good at brainstorming (thinking of ideas).					
l. I like to learn about how to build things.					
m. I like to learn about technology.					
n. In my future job, I would like to design or build things.					

28. **[Pre and post]** Some schools and communities offer different engineering activities to kids. Which ones might you be interested in doing? (Circle all that apply to you)

I would like to…

a) Design and build things in my classroom.

b) Design and build things at home.
c) Design and build things during the summer.
d) Join an engineering club or after-school program.

29. **[Pre only]** Which of the following have you done before?
    a) Designed and built things in my classroom
    b) Designed and built things at home
    c) Designed and built things in a summer program
    d) Joined an engineering club or after-school program

30. **[Pre only]** Please check all the engineering activities that you do in school:
    a) My teacher tells the class what to build and how to build it.
    b) My teacher gives us a problem to solve, but lets students come up with their own ideas.
    c) We play engineering or "design and build" games as a class.
    d) We do homework that requires us to design and build something at home.
    e) We have engineering or "design and build" competitions.
    f) Other: _____

31. **[Post]** How "cool" do you think it would be to be an engineer?
    a) Very cool
    b) Cool
    c) In the middle
    d) Not very cool
    e) Not cool at all

Next, we'd like to know which of the "Design Squad" game activities you did in your classroom and at home **[Post only]**.

32. Which of the following "At Home" challenges did you do? (Check all that apply)
    a) *Pop Fly* (Find an example of a lever outside school.)
    b) *Building Green* (Find examples of products that could be more environmentally friendly.)
    c) *DIY Playground* (Interview kids at a local playground.)
    d) *Paper Table* (Find ways to make your design better.)
    e) *Dance Pad* (Develop original dance moves to use with your dance pad.)
    f) *Make a Difference* (Go online to grant wishes posted on the Design Squad Nation site.)

33. Did you post photos or sketches to the "Design Squad" website?
    a) Yes, I posted photos only

b) Yes, I posted sketches only
c) Yes, I posted photos and sketches
d) No, I did not post anything to the website (Please explain)

11. (If yes to 10) We'd like to see what you posted. Please provide your username:

12. (If yes to 10) Did other kids add stickers to the things you posted?
    a) Yes
    b) No
    c) I don't know

13. Did you add stickers to other kids' ideas online?
    a) Yes
    b) No

14. Did you receive bonus challenge text messages from your teacher? (Check all that apply)
    a) My teacher sent text messages
    b) My teacher posted the challenges in the classroom
    c) My teacher posted the challenges on the class website
    d) My teacher gave us the challenges on a piece of paper
    e) Other (please explain):

15. Which of the following bonus challenges did you do? (Check all that apply)
    a) *Pop Fly* (Design equipment for a game or sport that uses a lever.)
    b) *Building Green* (What's the most enviro-friendly package you have found?)
    c) *DIY Playground* (Design a new playground feature.)
    d) *Paper Table* (What's one way to improve how you build something?)
    e) *Dance Pad* (What if your dance pad was a real product?)
    f) *Make a Difference* (What are the top 3 inventions that changed your life?)

Finally, please tell us what you think of the "Design Squad" game.

16. How much fun did you have playing the "Design Squad" game with your class?
    a) A lot of fun
    b) Some fun
    c) In the middle
    d) Not much fun
    e) No fun at all

17. Name one way that the "At Home" challenges were different from your normal homework, if at all:

18. In what ways, if at all, did the "Design Squad" game help you to learn:

19. Did the game change your interest in engineering? "After the game, my interest in engineering…"
    a) Was much greater
    b) Was a little greater
    c) Was much lower
    d) Was a lot lower
    e) Did not change – I was not interested to begin with and still am not
    f) Did not change – I was interested to begin with and still am

20. How much do you agree with the following sentence: "I would like my schoolwork more if I could interact and discuss school projects with other kids online."
    a) Strongly agree
    b) Agree
    c) In the middle
    d) Disagree
    e) Strongly disagree

21. How interested are you in watching "Design Squad Nation" or "Design Squad" on TV or online?
    a) Very interested
    b) Somewhat interested
    c) In the middle
    d) Not very interested
    e) Not interested at all

22. How interested are you in visiting the "Design Squad" website again?
    a) Very interested
    b) Somewhat interested
    c) In the middle
    d) Not very interested
    e) Not interested at all

23. How can we make the "Design Squad" game better?

Appendix D: Teacher Survey Items

CEG

Teacher Survey Items

Challenges

1. Which "DSN Xchange" game challenges did you do? (Circle all that apply)

    a. *Pop Fly* (students explore simple machines by inventing a game based on a lever)
    b. *Building Green* (students consider ways to repurpose materials and invent an environmentally friendly beverage can holder)
    c. *DIY Playground* (students consider the needs of a client and invent a zip line-based playground ride)
    d. *Paper Table* (students consider ways to use paper to make a sturdy table)
    e. *Dance Pad* (students explore circuits by inventing a foot-operated dance pad)
    f. *Make a Difference* (students experience how engineers solve problems to help improve people's lives and make the world a better place)

2. How did you decide which challenges to do?

3. Please describe your approach to integrating the challenges into your curriculum. (For example, did you teach a lesson on electricity prior to using "DSN Xchange" or did you teach the science lessons as you used "DSN Xchange", or some other approach?)

Videos

4. Did your classroom watch the full-length episodes? If so, please indicate which ones and how you watched them:

Episode	Yes, we streamed from the Web	Yes, we watched it on DVD	We only watched part of this one	No, we did not watch it
Apache Skateboarders				
Trash to Treasure				
DIY Playground				
Cardboard Furniture				
Bodies Electric				

Please comment on any technical issues you may have experienced in watching the videos:

5. Did you also watch the shorter 1-2 minutes clips that were available on the "DSN Xchange" website? If not, please explain why (including any technical issues).

Episode	Yes, we watched this one	We only watched part of this one	No, we did not watch it
Pop Fly Challenge Demo	3		
Baseball Bats: Curtis Cruz & Becky O'Hara	1		2
Giant Pop Fly	1		2
Eco-Electronics: Erin Gately	1		2
Package Design: Jennifer Chua	2		1
Roller Coasters: Chris Gray	2		1
Paper Table Demo	3		
DIY Hidden Alarm Demo	2		1

Please comment on any technical issues you may have experienced in watching the videos:

Website

6. How helpful was the "DSN Xchange" website for teachers (AKA the online Teacher Guide that guided you through the pilot test)?

   a. Very helpful
   b. Helpful
   c. Only a little helpful
   d. Not helpful at all

   Comments:

7. Were your students able to post photos or sketches to the website? If not, why not (please describe any technical issues)?

8. How, if at all, did you integrate the photos and sketches that students posted online into the game or into your class?

Other Game Components

9. How did the "DSN Xchange" game points system work for you? Please explain how you handled any challenges.

10. How did the bonus challenge text messages work in your classroom? Please explain how you handled any challenges (including any technical issues).

11. Did your students do the "At Home" challenges? Please explain.

12. If you made any adaptations to the challenges, as they were specified in the "DSN Xchange" game, please describe what you did and why.

13. How likely are you to recommend the "DSN Xchange" challenges to other teachers?

    a. Very likely
    b. Likely
    c. Somewhat likely
    d. Not at all likely

    Please explain:

Impact on Students

14. In what ways, if at all, did the "At Home" challenges support or reinforce the learning that was taking place in the classroom?

15. What specific changes, if any, did you see in your students as a result of playing the "DSN Xchange" game?

16. In what ways did the ability to interact with you and other kids (via posting online and texting) impact the students' motivation, engagement, and interest in learning about engineering, if at all?

17. In what ways did the "DSN Xchange" challenges strengthen your students' ability to identify and discuss the science concepts they applied, if at all?

18. In what ways did the "DSN Xchange" game strengthen your students' ability to explain and use the engineering design process, if at all?

19. In what ways did the "DSN Xchange" game strengthen your students' ability to cite examples of what an engineer does, if at all?

Impact on Teachers

20. How did the "DSN Xchange" game impact the way you approach teaching, if at all?

21. How did the "DSN Xchange" game impact your understanding and awareness of the engineering design process, if at all?

    a. I understand it much better now
    b. I understand it slightly better now
    c. My understanding did not change – I understood it before
    d. My understanding did not change – I did not understand it before and I still don't
    e. I understand it less now

22. How did the "DSN Xchange" game impact your knowledge of engineering careers, if at all?

    a. I know much more about engineering careers now
    b. I know slightly more about engineering careers now
    c. My knowledge did not change – I knew about them before
    d. My knowledge did not change – I did not know much about them before and I still don't
    e. I know less about engineering careers now

23. How did the "DSN Xchange" game impact your interest in using hands-on engineering activities in your classroom, if at all?

    a. I am much more interested now
    b. I am slightly more interested now
    c. My interest level did not change – I was interested before and I still am

d. My interest level did not change – I was not interested before and I still am not interested
e. I am slightly less interested now
f. I am much less interested now

24. How did the "DSN Xchange" game impact your comfort level with providing engineering activities to your students, if at all?

a. I am much more comfortable now
b. I slightly more comfortable now
c. My comfort level did not change – I was comfortable before and I still am
d. My comfort level did not change – I was uncomfortable before and I still am
e. I am slightly less comfortable now
f. I am much less comfortable now

Satisfaction

25. How likely are you to use the "Design Squad" challenges again (without the game format)?

a. Very likely
b. Likely
c. Somewhat likely
d. Not at all likely (please explain)

26. If WGBH were to offer the challenges in a game format again, how likely would you be to use the "Design Squad" challenges again?

a. Very likely
b. Likely
c. Somewhat likely
d. Not at all likely (please explain)

27. How interested do you think your students would be in doing engineering design challenges again?

a. Very interested
b. Somewhat interested

c. They would not be interested at all
d. I don't know

28. Please summarize the main points that you liked about the "DSN Xchange" game:

29. Please tell us how we can improve the "DSN Xchange" game:

Appendix E: Website Users' Survey

Website Users' Survey

1. **Are you a:**

    a. Male
    b. Female

2. **How old are you?** (drop-down list of 1 through 70+)

3. **Are you of Hispanic, Latino, or Spanish origin?**

    a. Yes
    b. No

4. **Are you…**

    (check all that apply)

    a. American Indian or Alaskan Native
    b. Asian
    c. Black or African American
    d. Indian or Middle Eastern
    e. Native Hawaiian or Other Pacific Islander
    f. White or Caucasian

5. **In what kind of area do you live?**

    a. Urban (in a city)
    b. Suburban (near a city, but not in the city)
    c. Rural (far from any cities)

6. **In what state do you live?** (Drop down of states, including option for outside US)

7. **What is your five-digit zip code?**

8. (Not displayed for respondents 18 years and older) **What is your school like?**

    a. Public school
    b. Charter school
    c. Private school
    d. Home school

9. (Not displayed for children 17 and under) **Are you visiting the website as a…**

    a. Classroom teacher
    b. After-school teacher
    c. Librarian
    d. Volunteer
    e. Camp counselor
    f. Parent
    g. Engineer
    h. Other: _____

10. (Not displayed for children 17 and under) **WGBH wants to make sure that our website reaches people in all types of communities. How would you describe yourself? (Remember, we cannot trace your answers back to you)**

    a. Low income
    b. Middle income
    c. High income

11. **What is your favorite part of the website?** (Open response text box)

12. **On a Scale of 1-10 (where one is "Not at all" and 10 is "Extremely Useful") how would you rate the usefulness of the website?**
    a. 1
    b. 2
    c. 3
    d. 4
    e. 5
    f. 6
    g. 7
    h. 8
    i. 9
    j. 10