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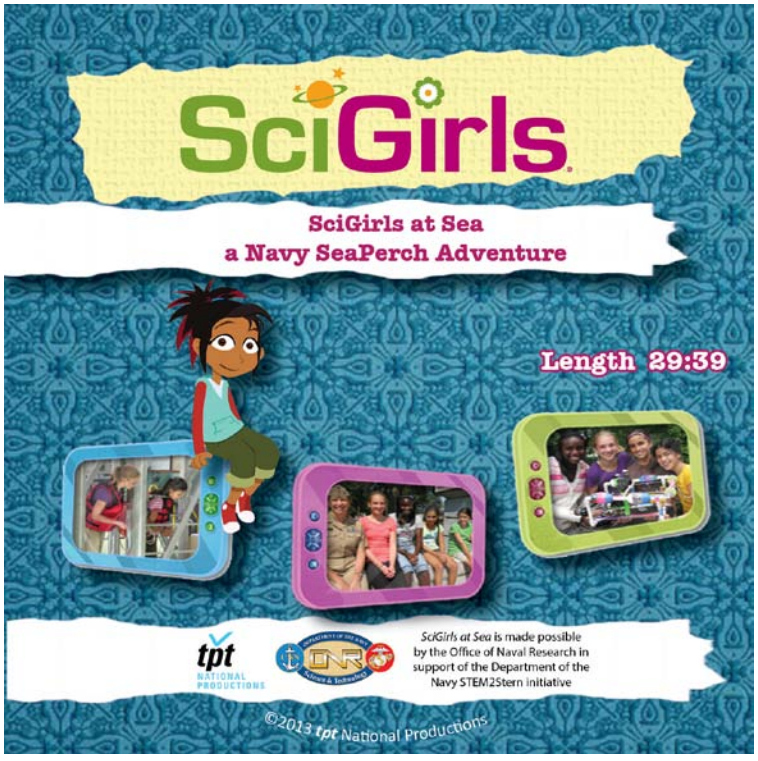
Summative Evaluation of *SciGirls at Sea: A Navy SeaPerch Adventure* Television Episode & Webgame



Report for Twin Cities Public Television
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Report No. 13-009
May 17, 2013

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INTRODUCTION

Produced by Twin Cities Public Television, St. Paul, MN, and sponsored by the National Science Foundation (NSF), *SciGirls* is a multimedia project for upper grade-school and middle-school tweens. Weekly half-hour programs with both animated and live action are accompanied by web and outreach activities in the fields of science, technology and engineering (STEM).[1] The overall goals of the multimedia project are to 1) to foster a greater interest and confidence in STEM among girls ages 8 to 13 and their parents; 2) to deepen understanding of the most effective ways to engage girls in STEM activities and encourage them to pursue STEM careers; and 3) to connect girls to existing quality STEM education opportunities in their communities.

Each half-hour episode of the television series follows a different group of enthusiastic, *real* middle school SciGirls who collaborate, communicate, investigate, engineer and discover. They are accompanied by two animated characters – a plucky SciGirl named Izzie and her best friend Jake, who tie the series together with their ongoing adventures. Each episode begins with a story in which Izzie and Jake discover they have some problem that science can solve. Reaching out to the SciGirls, Izzie surfs the *SciGirls* website to find a science or engineering problem related to her own. While the real girls model the science inquiry process or engineering design process to solve their real-life problem, Izzie and Jake solve their problem based on what Izzie learns from observing the SciGirls' experiences.

The Season Two episode, *SciGirls at Sea: A Navy SeaPerch Adventure,* was made possible by the Office of Naval Research in support of the Department of the Navy STEM2Stern initiative. In the *SeaPerch* episode, a team of four SciGirls meet with women mentors at the US Naval Academy to learn how to design and build an underwater robot - a "SeaPerch" remotely-operated vehicle (ROV) - to investigate artificial oyster reefs in Chesapeake Bay. Associated with the episode is an online game called *Aquabot* in which players build and test a neutrally buoyant ROV and then drive it to discover items underwater.

This report presents results from a quasi-experimental study by Multimedia Research, an independent evaluation group, examining the impact on fifth grade girls of viewing the half-hour *SeaPerch* episode and playing the associated *Aquabot* online game. Pre-post interviews focused on the engagement outcomes of appeal of the episode and game; engagement with the episode/game connectivity; and interest in participating in a hands-on robotics experience as well as outcomes of learning about buoyancy, the engineering design process, and jobs that women do in the Navy.

[1] See http://pbskids.org/scigirls/

METHOD

Sample

Girls in fifth grade were recruited around four national sites, including Miami, FL; Baltimore, MD; Austin, TX; and Milwaukee, WI. Evenly distributed across the sites, the 20 participants had access at home to a DVD player to view the *SeaPerch* episode and a fast (not dialup) Internet connection to go online to play the *Aquabot* game.

The written permission letter inviting parents and children to participate asked questions about the girls' demographics and interest and ability in science. Minorities comprised 25% of the sample. The girls rated their interest in science as "a lot" (45%), "somewhat" (50%) or "a little" (5%). Any girls who were "not" interested in science were not included in the evaluation sample. The girls also self-rated how well they performed in science in school as "really well" (30%), "pretty good" (65%), or "okay" (5%).

Prior to participating, three girls (15%) had seen one or more broadcast episodes of the *SciGirls* series but not the *SeaPerch* episode. Two girls (10%) had visited the *SciGirls* website prior to participation but reported that they had not played the *Aquabot* game.

Procedure

Upon collection of parent and child signed consent forms, field researchers delivered DVDs of the *SeaPerch* episode to the participants' homes, showed the girls how to access the *Aquabot* game on their home computers, and implemented the pre-interview. Within the subsequent two week period, participants viewed the episode and played the *Aquabot* game online as many times as they wished. Participants were interviewed again within three days of completing their viewing/playing task. Both the pre and post interviews asked about participants' interest in designing and building a small robot that could operate under water; how they would design and build such a robot; what the terms 'buoyancy' and 'neutral buoyancy' mean; and what jobs women in the Navy do. The post interview also asked about engagement with the episode and game; user friendliness of the game; reactions to the episode/game combination and general learning from the episode.

Data Analysis

Where appropriate, quantitative data were examined for statistically significant differences with non-parametric statistics (Spearman Rank Order Correlation, McNemar Test of Paired Proportions, Wilcoxon Signed-Ranks Test). Non-parametric statistics are used when the assumptions of parametric tests may not be met, small samples are used, and when data are in ordinal or nominal scales. In this report, footnotes present a definition of a statistic when first used in the report and also present the statistical test results. Only differences significant at the $p < .05$ level are reported. Qualitative interview responses were sorted by theme and keywords and are presented with frequencies and illustrative quotes. Quotes from oral interviews are presented verbatim but with numerous instances of "like" and "um" removed for easier reading.

In addition, the Appendix of this report presents data from an earlier *SciGirls* series evaluation,[2] in which 87 fifth grade girls viewed three *SciGirls* episodes including the PBS broadcast version of *SeaPerch*. Due to PBS program length requirements, the broadcast version tested in the earlier evaluation does not include the short scene in the middle of the episode where the girls talk to their mentors about Navy careers.

Episode & Game Descriptions

Sea Perch Episode. The oyster population in the Chesapeake Bay is shrinking; and that's a problem for the SciGirls. New restored reefs have been created to help revive the oyster population. The girls investigate if the oysters in the new reefs are making the bay healthier. Diving into underwater robotics at the US Naval Academy, the girls build a "SeaPerch" ROV to investigate artificial oyster reefs in Chesapeake Bay. In the process, SciGirls learn about jobs that women have in the Navy. Izzie learns from the SciGirls about underwater robot building and the importance of buoyancy and builds her own ROV to help Jake recover his grandfather's prized football championship ring from the bottom of an aquarium. [3]

[2] Flagg, B.N. (December 19, 2012). Summative evaluation of *SciGirls* season two television series and website. Multimedia Research Report No. 12-014. Available at http://www.tpt.org/science/evaluations/

[3] http://www.pbs.org/teachers/scigirls/episodes/

Aquabot Online Game. The online game builds on the Izzie and Jake storyline of Jake having dropped a ring in the aquarium and Izzie helping to build an ROV to retrieve the ring. In the game, the player is given access to a variety of arms, batteries and floats (top game screen) to build an ROV and test it for neutral buoyancy in the test tank (middle screen).

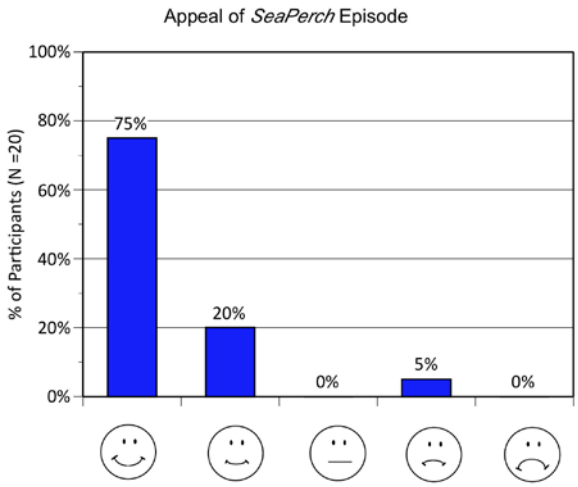
Once a neutrally buoyant ROV is successfully designed, the player can decorate it and then drive it underwater through a maze to recover Jake's ring before the battery runs out. While underwater, electric eels recharge the battery (bottom screen). Blue fish and pearls give extra points but hitting jellyfish remove points. A second level of the game gives the player a light to explore a sunken ship for hidden treasures, which requires a redesign and retesting of the ROV's buoyancy.

RESULTS: ENGAGEMENT OUTCOMES

Appeal of *SeaPerch* Episode

I liked how it taught you how to make one of those robots and also that they were interested in helping the ocean. I thought it was interesting that they got to go to the Naval Academy.

Almost all viewers enjoyed the *SeaPerch* episode. They most liked seeing real girls their own age designing and testing the robot and helping the environment with their oyster experiment. Viewers were surprised by the repeated testing of the engineering process and by the girls' visit to the Naval Academy.



Appeal rating. To assess engagement, interviewers asked the girls to chose one face on a five-face appeal scale that showed how much they enjoyed the *SeaPerch* episode. **Almost all (97%) of the participants liked the show, as illustrated in the chart to the right, with 75% liking it "a lot."**

What was liked. In response to an open-ended question about what they liked, a majority of viewers mentioned the engineering process of building and testing the SeaPerch. **They enjoyed seeing real girls near their own age working together, having fun, and helping the environment with their oyster experiment.**

- 60% enjoyed the ***engineering process***; for example:
  I like the way that they, when they were designing the robot, how - 'okay, this doesn't work and we are going to go back and try it again' – that process.
  I liked how it showed you how when you are making a robot that you have to think of buoyancy and not sink to the bottom. They did an actual test on how to build a robot and test it. I think that it shows that certain things, if just one little thing is wrong, it cannot work out.

I liked the part where they tested the underwater robot.
How they explained how they – what the problems were with their float.
I like how it taught you how to make one of those robots. It wasn't like most shows that are just like a show with people talking and stuff. Here they taught you about something instead of just dialogue.

- 30% liked that the episode showed ***real girls working together***; for example:
That they took normal girls that were interested into finding all that information, and that they got to really learn about it, and they weren't like any special scientists, they were just normal girls. Well, they were scientists that day I guess.
I liked that they worked together so well, and that each of them had what they were good at, and they worked well making the robot together.
They had a lot of fun together, and they all got along.
I really liked watching girls my age do it, because it wasn't adults, and I think having it be kids made it more interesting. It was cool to watch.
I liked how there were kids in it, so kids could understand.

- 30% liked ***the oyster experiment***. All of those who noted enjoying the experiment gave the episode the highest face-scale appeal rating.
It was interesting, the part about when they went and collected the data. I wasn't sure how that would work, but I thought it was weird that they found eggs on the inside of oyster shells.
I actually watched the episode like 10 times. It was really interesting. I especially liked when they put the robot down in the Chesapeake Bay, and the way they wanted to help.
I liked it because there were traveling on the sea, onto the bay, and they were helping the environment.
I liked the experiment – which is the good reef and the bad reef – and how they found out.

What was surprising. When asked in an open-ended question what surprised them the most in the episode, **viewers were surprised by the repeated testing as part of the engineering process and the fact that the SciGirls worked with the Naval Academy**. A few viewers each also were surprised by the capabilities of the onscreen girls or by the experiment.

- 40% were surprised by **repeated testing as part of the engineering process**; for example:
I thought the first idea was going to work, but it turned out that it didn't have enough buoyancy to hold it up or go down.
When they tested the robot cause you know they had to make tests, and they didn't work out so well, and the last one, it worked.
How they had to modify it a lot of times. How hard it was, and how they made a thing that actually could work in real life.
Sometimes when their buoyancy wasn't right because it kept on floating and sinking.

- 25% were surprised that **the girls worked with the Naval Academy**; for example:
  I kept wondering how did these girls get to know these officers in the Navy Academy. They let them go into the Navy Academy and all that stuff. I would think it would be slightly more restricted.
  What surprised me is that they would go to the Naval school with all the trained students.
  That they went to this special place where they made the robot thing, and that they got to go to this military school. That surprised me that they got to go to there.
  That they got to work with the Navy women at those labs.

- 10% were surprised by **the capabilities of the onscreen girls**; for example:
  I was surprised at how those kids could build it and design it themselves.
  I'd say the fact that they pretty much built the ROV all by themselves. They really didn't need much help.

- 10% were surprised by **the experiment**; for example:
  Probably that there were a lot of oysters at the bottom of the bay.
  It surprised me about the lacking of clams and how dirty the water got, because the clams filter the water, and basically if there are not very many clams, the water will start getting dirty, and that's really bad.

What was not liked. Three-quarters of viewers liked everything and could not describe something that they did not like about the show. Five viewers (25%) who did not like something about the show each gave a different explanation of their feelings: one was not interested in the topic; one was confused by the experimental results; one disliked the theme song; one preferred moving the SciGirls personal information to the beginning of the show; and one expressed confusion about Izzie's onscreen activity with the Pick'mStick'm arrow.

Engagement with Episode/Game Connection

I liked it because it helps you figure out what you are going to do in the game, and how you have to do it with the robot, and it can't float too much or sink. So the TV show helped a lot with the game.

The girls thought the experience of watching a television show and then playing an online game that related to the show was fun, that seeing the show supported successful game play, and that playing the game reinforced the show content.

Viewers were asked what they thought of the experience of watching a television show and then playing an online game that relates to the show. **Half of the viewers thought the connection of the episode and online game was fun or cool.** Another quarter of viewers added that what was learned from watching the show helped them to play the game, and 15% felt that playing the game helped them understand the show content better.

- 50% felt the connection between the show and game was ***fun*** **or** ***cool***; e.g.,
  I think it was very fun.
  It was really fun. I enjoyed that there was a game to go with it.
  I think it's pretty cool, I mean, I like it.
  I think the experience was really fun and interesting.
  I think it was actually cool cuz the game wasn't just about the whole series, it was about one episode, and I think they should do that for every episode.
  I think it was really cool to build my own underwater robot and then test it and get to decorate it and play the game. I thought that was really really fun. On the show, they did the same thing, which was really cool. I was amazed at how much they related.

- 25% thought it was ***cool, fun*** **or** ***easier*** **to use what you learned from the show to play the online game**; for example:
  I think that that was fun. I never really had done that before, so I think that was cool to use your knowledge from the show in the game.
  It made it easier to play the game. It kinda made me think after watching it that it was good to pay attention to it.
  It was much easier to do the game because I knew all about the buoyancy on the robot, because I probably wouldn't have known how to build it and put it together, but it was easy to really, because I was like, "Oh, I remember that from the show."
  I liked it because it helps you figure out what you are going to do in the game and how you have to do it with the robot, and it can't float too much or sink, so the TV show helped a lot with the game.

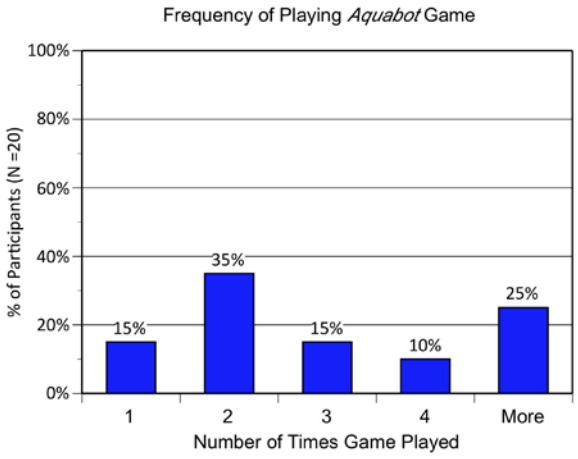
- 15% noted that **the game reinforced what they learned from the show**; for example:
  I think that it kind of helps reinforce what you just learned so that it stays fresh in your mind without having to watch the show all over again, and also it kind of reteaches it in a different way so that you can understand it in another way.
  It was fun, like first knowing about the show and then playing something that was related to it. It was better for me, so I can understand what they are doing.
  It felt like a review to me, which I kind of liked because there are some things I really didn't catch in the show. They were using the word buoyancy a lot in the show, but then when I played the game again this morning, I realized that she [Izzie] *said "buoyancy means…" and that cleared it up. I could kind of understand but it just cleared it up.*

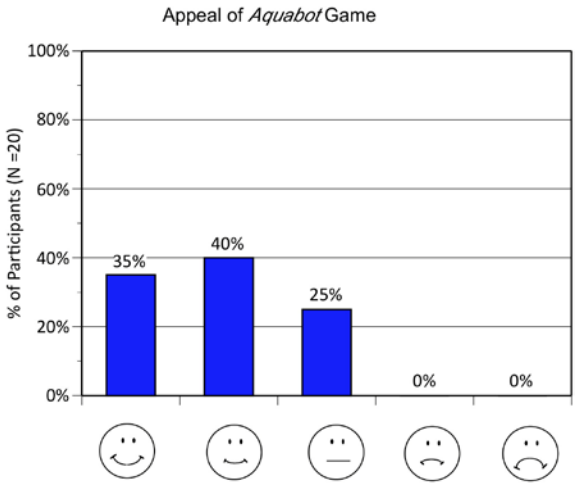
Appeal of *Aquabot* Game

I liked that they had so many options on how to build your robot, and I liked to decorate my robot. I thought it was kind of fun to have it go down in the ocean and explore and find the thing that you needed.

Three-quarters of the girls rated the *Aquabot* game as very or somewhat fun. Players enjoyed building and decorating their SeaPerch and thought the challenge of finding items underwater was fun, although some voiced frustration with the game's harder second level.

Half (50%) of the girls played the online *Aquabot* game three or more times and half played once or twice (see left-hand chart below). **Three-quarters (75%) of the girls thought the *Aquabot* game was very or somewhat fun**, and the remaining girls were neutral in their appeal response (see right-hand chart below). Less than half (43%) reported some difficulty playing the game. Game appeal was not significantly associated with frequency of game play nor with perceived game difficulty but was significantly correlated with episode appeal.[4] Higher game appeal was associated with higher episode appeal.





[4] Spearman rank-order correlation assesses the strength of association between two ranked variables, in this case game appeal and episode appeal, r_s (20) = .66, p = .001.

In the post-interviews, players identified what was fun and not fun about the game:

- 65% of the players enjoyed **the challenge of finding items underwater;** for example:
  You got to actually steer it, so it was not just a game to create and stuff, but you also got to use it.
  That you get to go underwater and find Jake's ring.
  It was fun, cuz I liked finding, I tried finding all the pearls, and it was fun searching for them.
  I enjoyed finding all the different areas to go into and finally finding the rings which was really cool and getting the bonuses from the clams. I also liked how the electric eels powered up your battery, that was really cool and creative.
  It was kind of a little bit difficult to steer. I kept playing until I got to the highest level and then my computer ran out of battery. I played like five times. I thought it was kind of fun to have it go down in the ocean and explore and find the thing that you needed.

- 55% of the players thought it was fun to **build a SeaPerch of their own;** for example:
  How I had to figure out how to create it.
  That you got to build your own SeaPerch.
  I liked that I had to use my mind to figure out what to fix to make it have neutral buoyancy.
  It was fun that you designed it. And you also got to put different parts on and then test it to make sure it worked, because that's what they were doing on the episode. They had to make sure it was the right weight, so it was buoyant enough so it didn't stay on top but it didn't sink to the bottom.

- 35% noted **decorating the robot** as a fun part of the game**;** for example:
  I liked to decorate my robot.
  The decorating part was really fun.
  You got to decorate it.

When asked what was not fun or difficult, girls focused on the game's second level or difficulty obtaining neutral buoyancy for their ROV.

- 30% voiced frustration with the game's **Level 2;** for example:
  On the second level, it just took a really long time to find the treasure, but other than that, it was fun.
  How I couldn't get past level 2. It got boring. It got a little too hard. I would get past level 1 easy, then I would spend 15 minutes on level 2 – 15, 20, 25 minutes and could not get past level 2.
  I took me a really long time to collect the things. There were so many dead ends. And it was really dark, even thought it gave you the little light, it was a little creepy, and you couldn't really tell where you were going even thought there was the little map.

- 25% described some difficulty **obtaining neutral buoyancy;** for example:
  It took awhile to find the right buoyancy and to find the perfect one without it going too high, cuz a lot of them were too heavy, even if I put on the biggest thing.

When I was creating it, sometimes it wasn't going the way I planned. When I used the floats, I used the biggest one and I used the smallest one and then I put the big battery and the smallest hand, and it didn't work.

It wasn't a problem with the game, but when I was making it, I had to go back several times, but I just couldn't get the right matches for the floats. I think that made the game fun and challenging. It actually takes a few tries. If anybody got it on one try, I would be surprised.

- 20% said the game was **difficult at first, especially without reading the directions;** for example:

At first yes [had difficulty], *that's when I realized I didn't read directions carefully. I thought that the eel was one of the things that lower your battery, then the second time I read the directions it made more sense. If you didn't know about the eels it would be hard, and you would probably get a little angry, and your battery would run out quick. People who don't read directions might get annoyed after a while.*

The page of instructions was really useful, and I think that explained it. At first, I thought it said if you touch the jellyfish, it gives you more power, because I thought it gives you electricity. I don't know what I was thinking, but then I saw the eel, and then it makes more sense now. So you just have to read the instructions well!

At first, I wasn't really sure exactly what I had to do. I didn't know the eels gave you power, and I thought it was weird that the fish gave you points, because you are pretty much hitting the fish. Why would you want to hit the fish and hurt them?

- 20% reported some difficulty **steering the robot;** for example:

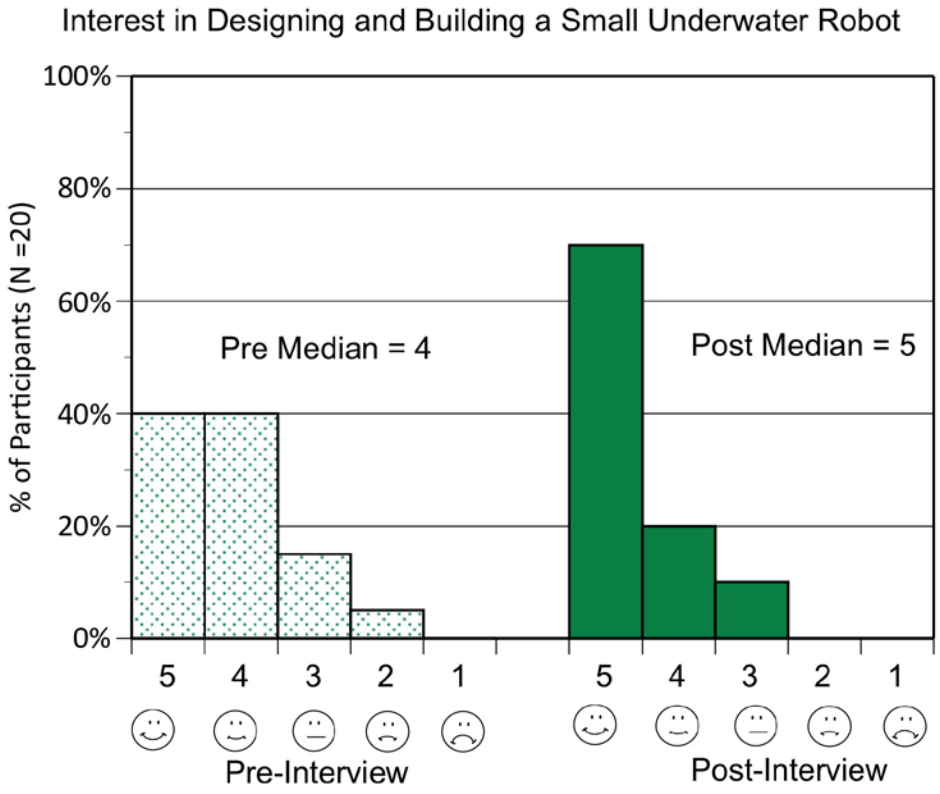
Controlling it, like how there were obstacles. When I finally got the robot right, it was hard to control it.

I had difficulty moving it with the arrow keys, and running into jellyfish.

Interest in Hands-On Robotics Experience

Girls who were "very interested" in designing and building a small robot that could operate under water increased significantly from 40% prior to experiencing the episode and game to 70% after.

In both the pre and post interviews, girls were asked to indicate on the face scale how interested they are in "designing and building a small robot that could operate under water." The chart below indicates that prior to the show and game, 40% chose the happiest face, meaning they were "very interested." After their experience, 70% were "very interested." Overall, 35% of participants increased in their interest in engineering a robot as a result of the show and game experience and no one decreased in their interest. **Viewing *SeaPerch* and playing *Aquabot* had a significantly positive impact on interest in a hands-on robotics experience.**[5]



[5] Wilcoxon Signed-Ranks Test looks at the difference between the distributions of repeated measures, in this case the pre and post interest in designing and building a robot. $N = 20$, $z = 2.46$, $p = .0069$.

RESULTS: LEARNING OUTCOMES

Uncued Learning from Episode

I learned how to make an undersea robot, that they aren't, have to be all, you know, professional, that anyone actually can build them. And I learned about the oysters, how in the Chesapeake Bay when there's more oysters, then the bay is healthier. I also learned that when you're in the Navy, you can have different jobs. You can be a meteorologist. You can be an architect, and other jobs like pilot.

Viewers of the *SeaPerch* episode mentioned learning about oysters and about buoyancy, learning how to build an underwater robot and the necessity of repeated testing, and learning about jobs for women in the Navy.

In response to the open-ended uncued question of "what if anything did you learn from watching the episode," all but one participant was able to describe something that they learned. **Viewers mostly reported learning about oysters and buoyancy, how to build a SeaPerch and some of the process of building a robot.**

- 45% recalled something about **oysters**. For example:
  I learned about the oysters and what the water did that affected how many there were in the population.
  I learned that oysters help filter the water.
  That people actually have nurseries, oyster nurseries. I never knew! I thought they were in the ocean, if anything. I thought that was really interesting.

- 45% reported learning about **buoyancy**; for example:
  How buoyancy affects the floating and the sinking of an object.
  I learned that buoyancy is how much something sinks or goes up.
  About neutral buoyancy and how to make It – which is not floating and not sinking but in the middle.

- 35% felt they learned **how to build an underwater robot**; for example:
  I learned how to make a robot that could work with currents and go in the water.
  I learned that, how I could make the aquabot at home, since I have some of the materials.

- 35% noted learning about the **repeated testing of building an underwater robot**; for example:
  That it takes a lot of tries to make it perfect, because of how many things that they had to do and redo and undo to make the robot perfect.
  You have to test it like a bunch of times. I know they tested it like 50 more times than they showed.

- 20% talked about **jobs for women in the Navy**; for example:
  There's a lot more jobs for the girls in the Navy than I expected, which is good.
  I learned some of the jobs they do in the Navy.

Learning about Jobs Women in the Navy Can Do

They can be a pilot, drive a boat, and be an oceanographer.

Viewers of *SeaPerch* learned that women in the Navy can do many jobs, most particularly drive ships or submarines, pilot helicopters, jets, or airplanes and be an oceanographer.

The *SeaPerch* episode noted many different jobs that women in the Navy do, including Doctor; Drive ships/submarines; Engineer; Leader; Meteorologist; Naval Architect; Ocean Engineer; Oceanographer; and Pilot. Both before and after the experience of viewing the video and playing the game, study participants were asked to describe what kind of careers they think women in the Navy have, what kind of jobs Navy women do. Table 1 indicates the pre and post frequency of job categories mentioned by participants, ordered by pre-post gain/loss.

Table 1. Pre-Post Jobs Navy Women Do

Job category	Pre %	Post %	Gain/Loss
Drive ships, submarines	0%	45%	45%
Pilot of helicopter, jet, airplane	15%	55%	40%
Oceanographer	0%	25%	25%
Engineer/Naval architect/Architect	25%	45%	20%
Leader	5%	15%	10%
Meteorologist	0%	5%	5%
Doctor	10%	10%	0%
Rescue, help, nurse people	40%	5%	-35%
Fight	45%	5%	-40%

After seeing *SeaPerch*, 90% of viewers recalled a job noted in the video. Compared with before viewing, the girls after viewing were significantly more likely to mention that Navy women can "drive ships, submarines,"[6] "pilot a helicopter, jet, airplane"[7] and be an "oceanographer."[8] Post-viewing increases that did not reach statistical significance were also seen in the mention of "engineer," "leader," and "meteorologist." The girls were significantly less likely to mention the following categories in their post-interview: "rescue, help, nurse people"[9] and "fight."[10]

Some examples of pre-post responses follow:

Pre: *I think they would also fight with the men. And maybe help out with the injured sometimes if they were the nurses. Or maybe like fill out papers, if there were papers.*
Post: *That they are not just little things, like they can be the Commander. They can be pilots. Oh, this is cool, an oceanographer, and they can steer the ship.*

Pre: *If they go off to war, they probably first have to take care of the big ship they're on, maybe rescue if any ships get damaged. If there's a war going on , then they have to fight.*
Post: *They can be a pilot, so they can drive helicopters and planes. They can be architects, so they can fly to other countries and build, if they need any sea ports or anything. They can be a meteorologist on the ship. They can actually steer the ship. They can drive submarines and steer ships.*

Pre: *Probably some things like designing equipment and building it, a lot like engineering.*
Post: *I learned there are a lot of different ones, from being an engineer to a pilot, or someone who drives boats. So there are a lot of different choices.*

[6] McNemar Test of Paired Proportions, as applied here, assesses the significance of the difference between two proportions (pre and post) from the same sample of participants, $p = .002$.
[7] McNemar Test of Paired Proportions, $p = .02$
[8] McNemar Test of Paired Proportions, $p = .03$
[9] McNemar Test of Paired Proportions, $p = .02$
[10] McNemar Test of Paired Proportions, $p = .004$

Learning about Buoyancy and Neutral Buoyancy

Buoyancy is how something floats, because if it has low buoyancy, it doesn't float that well and sinks to the bottom, and if it has high buoyancy, it floats to the top. **[Neutral buoyancy?]** ***It doesn't float to the top and doesn't sink to the bottom. It just stays in the middle, so it has neutral buoyancy.***

Exposure to the video and game resulted in a significant increase in understanding of the terms "buoyancy" and "neutral buoyancy."

Both before and after their experience, girls were asked: "When you build a robot to operate under water, you might think about something called buoyancy. What does the word 'buoyancy' mean to you?" A follow-up question asked the girls what the term "neutral buoyancy" meant to them. Table 2 presents the distribution of pre and post answers related to buoyancy.

Table 2. Pre-Post Meaning of "Buoyancy"

	Don't Know, Incorrect	Something floats	Neither sinks nor floats, stays in middle	How much something floats or sinks
Pre	60%	25%	0%	15%
Post	5%	33%	15%	60%
	Incorrect			Correct
Pre	85%			15%
Post	40%			60%

Prior to their experience with the video and game, 60% of girls showed no concept of the meaning of buoyancy; for example, *It can operate underwater* or *Sounds like balance or steady.* A quarter (25%) of the girls suggested buoyancy referred to something that floats, whereas 15% gave a more correct answer related to how much something floats or sinks; for example, *How something floats or sinks* or *Something that can float or sink in the water.*

Exposure to the video and game resulted in a significant increase in the percentage of girls noting that buoyancy relates to how much something floats or sinks (40% pre vs 60% post).[11] In the post-interview, 30% focused on how much something floats or sinks (e.g., *How much something sinks or goes up; How something floats or sinks*), and another 30% went further to elaborate about positive and negative buoyancy, for example:

How much it floats, like if it is negative buoyancy, it doesn't float at all, but if it is positive, it is all the way at the top.

[11] McNemar Test of Paired Proportions, $p = .006$.

The ability to float or sink. There's positive buoyancy and negative buoyancy . Negative buoyancy is sinking and positive buoyancy is floating.

Buoyancy means how much it floats, like if there is a lot of buoyancy, it will float at the top, and if it doesn't have any, it will sink to the bottom.

Exposure to the video and game also resulted in a significant increase in the percentage of girls noting that an object that is neutrally buoyant neither sinks nor floats but stays in the middle (30% pre vs. 70% post; see Table 3).[12] Correct answers, for example, included:

It doesn't float to the top and doesn't sink to the bottom. It just stays in the middle, so it has neutral buoyancy.

Being able to float where it's put, stay in one place under water, and not float or sink in the water.

It doesn't float to the bottom or the top. It stays in the middle.

Means that it floats right in the middle, just right, like in the center, so it's neutral buoyancy.

Table 3. Pre-Post Meaning of "Neutral Buoyancy"

	Don't Know, Incorrect	Neither sinks nor floats, stays in middle
Pre	100%	0%
Post	30%	70%

[12] McNemar Test of Paired Proportions, $p = .00006$.

Learning about Engineering Process

> ***First I would buy the right materials and research what would be the best materials. Second I would make a plan and discover what would be the best float and materials to use to have neutral buoyancy. Third I would build it, and fourth I would test it out. I would test it out to make sure it has neutral buoyancy, and if it doesn't, then I would – if it sunk, then I would take something off, and if it floated, then I would add a heavier thing.***

Viewing *SeaPerch* and playing the associated online game significantly increased the number of engineering process steps that participants described to design and build an underwater robot. Of four engineering process steps assessed, the step of planning and designing showed significant increased mention in the post-interview.

In *SciGirls* episodes, the engineering process steps are not treated didactically but are instead embedded in the actions and dialogue that support the development and implementation of each engineering project. In the *SeaPerch* video specifically, the SciGirls model the steps as follows:

1. *Identify problem*: The girls considered what they needed to collect oyster data for their experiment.
2. *Consult experts or a mentor, research, and brainstorm*: The SciGirls consulted with two Navy mentors and brainstormed about what their SeaPerch was required to do and what it might look like.
3. *Plan, Draw a design*: The SciGirls drew their ROV design.
4. *Build:* The SciGirls built their SeaPerch ROV.
5. *Test, evaluate, redesign*: The SciGirls tested their SeaPerch, evaluated the results in the tank, redesigned, and then they repeated that process several times.

Step 4 (Build) and Step 5 (Test, evaluate, redesign) are also steps experienced by players of the online *Aquabot* game.

To explore the extent to which the engineering process above was assimilated by study participants, the pre and post interviews presented an episode-related problem: "Assuming that you could get any materials and tools that you need, describe the steps you would take to design and build a small robot that could operate under water." Three non-specific probe questions followed to elicit a more complete answer: (1) "I would like a bit more detail about the steps you would take. What is the very first thing you would do to design your underwater robot?" (2) "What would you do after that?" (3) "Would you do anything else to design and build your underwater robot?"

Since step 1 in the engineering process – Identify problem – is provided by the interview question, the pre and post responses were coded for the presence and absence of language reflecting steps 2 to 5; for example, the participant in Table 4 below described two of the four steps in her pre-interview and all four steps in her post-interview.

Table 4. One Participants' Steps to Design and Build Underwater Robot

	Pre-Interview	Post-Interview
Step 2. Consult expert or mentor, Research, Brainstorm		*First, I would look at other ideas.*
Step 3. Plan, Draw a design		*Then I would design and draw a design of what I would like to do, so I'd have it planned out.*
Step 4. Build	*I guess first I would get materials that would protect the inside of the robot so it wouldn't get wet. Then I would put them together and start making it. I guess I would want to make it a robot that could interact with you in the water, that you could play with the robot. First I would get the waterproof materials, put something in the robot to interact and react to things. I guess I would put together all the pieces…*	*Then I would put that together and probably make not exactly like they made in the video, but something along those lines.*
Step 5.Test, evaluate, redesign	*…and then try it, experiment with it, and then I would retest it to make sure it works.*	*Then I would test it and retest it.*

The chart below shows the distribution of the number of engineering process steps that participants included in their pre and post interviews. In the pre-interview, the median number of steps was two out of four, and in the post-interview, the median number of steps increased significantly to three.[13] **Between the pre and post interviews, 40% of the girls increased in the number of steps they used to describe their engineering of an underwater robot.**

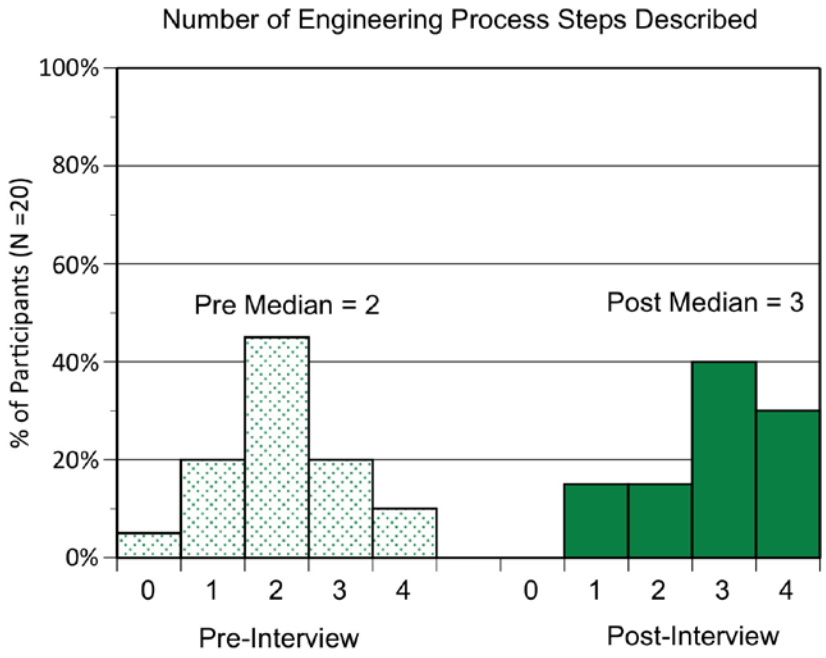


Table 5 presents the percentages of participants describing each of the different steps in their pre and post interviews. Although all the steps showed an increased presence in the post-interview compared with the pre-interview, only Step 2, Plan/Design, showed a statistically significant increase.[14] **Exposure to the video and game significantly increased participants' use of the step of planning and designing in describing the engineering process.**

Table 5. Pre-Post Steps of Engineering Process

	Consult, research, brainstorm	Plan, design	Build	Test, evaluate, redesign
Pre	10%	45%	95%	60%
Post	30%	80%	100%	75%

[13] Wilcoxon Signed-Ranks Test, $N = 20$, $z = 2.47$, $p = .0067$.

[14] McNemar Test of Paired Proportions, $p = .008$.

SUMMARY

Girls in fifth grade (N = 20) were recruited around four national sites to view the *SciGirls SeaPerch* episode and play an associated online game called *Aquabot*. The girls were interviewed both before and after their experience regarding interest, engagement and knowledge.

The fifth grade girls highly rated the appeal of the *SeaPerch* episode and related *Aquabot* game. They enjoyed the engineering story of real girls designing, building and repeatedly testing an ROV and using it to help understand the Chesapeake Bay oyster environment. Viewers of *SciGirls* enjoy seeing confident girls their own age accomplishing interesting things.

Viewers were surprised by the visit to the Naval Academy. After viewing the episode, one-fifth of viewers spontaneously reported learning about jobs for women in the Navy. Pre-post direct questioning revealed a significant increase in knowledge that Navy women can drive ships, pilot helicopters, and be an oceanographer. *SeaPerch* successfully raised viewer awareness of careers for women in the Navy.

The online game of building, decorating and driving a SeaPerch robot was fun, although a challenge for some in the second game level. Our participants liked the experience of watching a show and then playing a related online game because the show supported successful game play and playing the game reinforced the show content.

Beyond being just engaging and fun, the experience of watching the *SeaPerch* episode and playing the game also significantly increased participants' interest in designing and building their own small underwater robot; increased understanding of the terms "buoyancy" and "neutral buoyancy;" expanded knowledge of the engineering process and most particularly the need for a planning and designing step.

Overall, the *SeaPerch* episode with the associated online game accomplished its goals of engaging tween girls, increasing interest in robotics, raising career awareness, and improving their science and engineering knowledge.

APPENDIX

In a previous post-only evaluation,[15] 87 fifth graders viewed at home three *SciGirls* episodes from Season Two, including the *SeaPerch* episode without the Naval Academy visit and career discussion. The interview responses of the viewers were examined for references specific to the *SeaPerch* episode and the associated *Aquabot* game and are summarized in this Appendix. The results, to the extent that *SeaPerch* was singled out in girls' responses, replicate the findings of the pre-post study in the main report.

What was surprising about the episode. After viewing the three episodes, viewers who mentioned *SeaPerch* were surprised that the girls could make the underwater robot; for example:

How much the kids can do, like make the robot and stuff, and do all the experiments.

How they made the aquabot and how they got the information.

I was surprised they could make this machine this robot thing that could go under and see the coral.

They actually made a robot.

Learning from the episode. When asked what they learned from the three episodes, 36% of the viewers specifically mentioned the *SeaPerch,* focusing mostly on the engineering of how to build and test a robot but also learning from the oyster reef experiment; for example:

I learned about making the robots for underwater, and you have to try more than once to get a good product. It was interesting to learn that they all could work, and how it would act differently if there was no current and move around if there was. It was cool.

It showed me different techniques on how I can build stuff, and if something doesn't work you might only have to change a little thing to make it work. On the show, they just had to change the tubes and the float thingies, and that shows that a little thing might make a big difference.

I learned how they kept testing things out and how they put it together.

I learned how hard it is to get the right weight for the robot to go to be in the middle.

I had not known that oysters filter the water. I liked how they built the little scuba diver camera and how they had to take off the floats because of the pressure in the water. I thought it was pretty cool. It was fun.

I always thought that the reefs were just reefs. I didn't know that the amount of animals matters for the rest of the animals. I thought if you had a couple of the animals, then the other animals could live on that. So what I learned from that is that they have to make new reefs so that can happen.

[15] Flagg, B.N. (December 19, 2012). Summative evaluation of *SciGirls* season two television series and website. Multimedia Research Report No. 12-014. Available at http://www.tpt.org/science/evaluations/

The oysters are not really healthy. I never knew this.

That oysters die out. Baby oysters grow on the shells. That's why they put them in the ocean, so more little oysters could get on them, and they could keep them going in the ocean. I thought that really taught me something new that I would like to study.

And finally, one viewer – from Florida – motivated by the show and reported *trying the buoyancy thing in the pool. I got a water bottle and made it actually buoyant.*

Aquabot game. In this study, participants were required to play a different game online, but about one-quarter of the girls also played the *Aquabot* game associated with the *SeaPerch* episode. Players enjoyed making the ROV, testing its buoyancy as was shown in the episode, and then using the ROV to locate Jake's ring; for example:

I did Aquabot. I really liked the aquabot game on the website. It rocked.

It was kind of a cool game.

My favorite game was making the aquabot and testing it. The first time, I had to try five times or so, but then a couple more times, I got the hang of it. And I was finding the ring. And the second level, I had trouble, because it was a really big space to try to find it.

I had to build this thing. It has to be in the middle to see if it works or did not work be because if it went all the way down , it would be negative. You had to make the aquabot so it was the right buoyancy and test it out, and go underwater and get fish and pearls.

I learned that for the aquabot, you don't want it to totally sink, but you don't want it to float. When I did the game, you had to use what you learned in the show to add materials or take them away.