Impact of *Code: SciGirls!* Shows on Girls’ Code-related Interests, Beliefs, and Behavioral Intentions:

An exploratory study of narrative involvement

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**Knight Williams Inc.**

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Executive summary

*Code: SciGirls! Media for Engaging Girls in Computing Pathways (Code: SciGirls!)* was a three-year transmedia and outreach project funded by the National Science Foundation (NSF) and directed by Twin Cities Public Television (TPT) in partnership with the National Girls Collaborative and Code.org. A key media resource produced as part of the project was a set of five new half-hour *Code: SciGirls!* shows for the ongoing *SciGirls* series on *PBSKids*. The shows were designed to be story- and character-driven, building on TPT’s prior four seasons of *SciGirls*, all of which follow a narrative story framework that incorporates both young and adult role model characters working together. In the *Code: SciGirls!* shows, groups of girls work with female professionals to use coding to solve community problems.

The NSF funding further supported an exploratory research study on the *Code: SciGirls!* shows to better understand young girls’ experience of narrative involvement with the shows, and the relationship of such involvement to study outcomes. While meta-analyses of narrative studies indicate that adults with more involvement in a story and its characters are more likely to adopt story-consistent beliefs, attitudes, and behaviors, such a relationship has yet to be shown with children. This study considered whether and how girls’ involvement with the *Code: SciGirls!* shows’ narratives, and in particular the stories and characters, was related to and influenced their enjoyment of the shows and their interests, beliefs, and behavioral intentions toward coding and code-related careers.

The study employed a one-group pre-post at-home design, subsequent to a pilot phase that assessed study procedures and examined the psychometrics of the survey scales. Recruiting from ten different states across the country, a total of 81 5th grade girls, closely matching census diversity statistics, participated in the final study sample. Participants completed recruitment questions and a pre-survey, viewed three *Code: SciGirls!* shows within a one-week period, and completed a post-survey.

Paired *t*-tests of coding outcomes, mixed-effects models, correlational analysis, and partial least squares structural equation modeling of quantitative narrative involvement ratings and coding outcomes were used to investigate the impact of the shows on girls’ gains in code-related outcomes and whether narrative involvement is related to and positively influences these outcomes. Content analysis of responses to open-ended qualitative questions asked of random halves of the participant sample addressed how girls perceived that the narrative involvement dimensions of stories or girl characters influenced coding outcomes. Key findings for the study’s five research questions are summarized below.

- **Research question 1 asked: What is the impact of viewing the shows on girls’ coding outcomes?** Viewing three *Code: SciGirls!* shows produced significant and positive gains in four of the six coding outcomes measured in the study, including girls’ interest in coding activities, interest in coding applications, interest in code-related jobs/careers, and belief in their ability to code. Although girls also showed increased belief that a code-related career was possible for them and increased intention to engage in future coding activities after viewing the shows, neither increase was statistically significant. With respect to background variables, prior coding experience significantly impacted gains in all six coding outcome areas, while prior acquaintance with someone who codes had no such impact.
• **Research question 2 asked:** *To what extent do girls experience narrative involvement while viewing the shows?* In response to rating scales, girls reported experiencing a high level of overall narrative involvement while watching the three Code: SciGirls! shows. They also reported high levels of involvement with each individual dimension comprising overall narrative involvement: story, character, and attentional focus.

• **Research question 3 asked:** *What is the relationship between narrative involvement and show enjoyment?* On average, girls reported experiencing a high level of narrative involvement and a high level of show enjoyment watching the shows. Overall narrative involvement and each involvement dimension were found to be positively and significantly correlated with and to have a significant direct positive effect on show enjoyment. Girls who experienced higher levels of overall narrative involvement and who experienced higher levels of story involvement, character involvement, and attentional focus, respectively, also showed significantly higher levels of show enjoyment.

• **Research question 4 asked:** *Do narrative involvement and show enjoyment positively influence the coding outcomes?* Overall narrative involvement had a significant direct positive effect on pre-post gain in interest in coding activities, indicating that girls who experienced higher levels of narrative involvement also showed greater change in their interest in coding activities. Girls’ involvement with the shows’ girl characters also had a significant direct positive influence on their interest in coding activities, but no significant effects were found for the dimensions of story involvement or attentional focus. Three additional coding outcomes were indirectly positively influenced by overall narrative involvement, including pre-post gains in interest in code-related jobs/careers, belief in ability to code, and behavioral intention to do coding activities in the future. In each case, the effects were fully mediated by show enjoyment, indicating that narrative involvement positively influenced show enjoyment, which in turn positively influenced these three coding outcomes. Each of the three narrative dimensions also had an indirect positive effect on these same three coding outcomes, fully mediated by show enjoyment.

Neither narrative involvement nor show enjoyment had significant effects on pre-post gains for two of the coding outcomes, including interest in coding applications and belief that a code-related job or career is possible.

• **Research question 5 asked:** *How do girls perceive the influences of story and of girl characters on coding outcomes?* To further interpret the quantitative results reported above, half of the participants were asked about the influence of the stories and half about the influence of the girl characters. Almost all girls felt that watching the stories or girl characters positively affected their interest in coding and positively affected their belief in their ability to learn coding. Three-quarters of girls felt that the stories or girl characters positively affected their belief that a coding job or career is possible for them, whereas two-thirds thought that the stories or girl characters positively affected their interest in code-related jobs or careers. Both those asked about the effects of watching the stories or girls most often described how their viewing experience highlighted how coding works and what it can do, motivated them to code, informed them about coding applications, and showed that this kind of job/career could be fun, interesting, helpful, or creative.
Additionally, those asked about the effects of watching the girl characters also noted that they were inspired by the girls’ excitement about coding; stated that if the girls onscreen could code, so could they; and appreciated the girls’ approach to their coding task, such as their perseverance, confidence, and/or teamwork.

In conclusion, with respect to coding outcomes, watching three *Code: SciGirls!* shows produced significant and positive gains in four of the six outcomes measured in the study. These findings add to results from evaluations of prior seasons of *SciGirls* that have similarly shown positive impacts on girl viewers’ STEM interests and beliefs. Taken together, the results lend support to the value of the series as a form of informal science entertainment-education for positively influencing young audiences who typically view the program on PBSKids.

With respect to narrative involvement, the results with children are consistent with theoretical models based on adult narrative research studies that emphasize that the extent to which individuals are involved in a world of both story and characters persuades them to modify their beliefs and behavioral intentions toward those presented in the narrative. This exploratory study breaks new ground in the field of narrative involvement by demonstrating that 5th grade girls experienced a high level of narrative involvement watching entertainment-STEM education programming designed for children, and that such involvement was significantly and positively predictive of their enjoyment of the shows and with pre-post gain in their interest in coding activities. These findings also contribute to the field of narrative studies more broadly, as there is no mention in prior meta-analyses of studies looking at changes in interest in content or messages as they might relate to narrative involvement.

Finally, the findings of indirect effects of overall narrative involvement, via show enjoyment, on the coding outcomes of interest in code-related jobs/careers, belief in ability to code, and behavioral intention to do coding activities in the future reflect results of one prior study with young adults in which program enjoyment mediated the positive effect of narrative involvement on behavioral intentions after viewing a television program on health topics (Quintero Johnson & Sangalang, 2017).

Acknowledging the study limitations of a small sample size and lack of a comparison or control group, the findings from this exploratory study are promising. Future media research with youth can build on many facets of this study’s design, measures, and results. Among the study’s key media design implications are that story- and character-driven entertainment-STEM education shows can be an effective way to involve young viewers, elicit show enjoyment, and significantly impact STEM outcomes.
Introduction

While women constitute half of the STEM\(^1\) workforce, they remain underrepresented in computer occupations at 25%, unchanged since 2016 (Kennedy et al., 2021). Analyses by the Bureau of Labor Statistics (2021) project strong growth in computer-related occupations for the period of 2019 to 2029, faster than the average for all occupations; thus, increasing female participation in this field seems critical for the country's economy. A large survey about computer science (CS) education with U.S. students, parents, teachers, principals, and superintendents revealed that “while girls have the same access as boys, social barriers exist with girls reporting lower awareness of CS opportunities outside of classes, less encouragement from teachers and parents, and less exposure to CS role models in the media” (Wang & Moghadam, 2017, p. 615).

To address some of these social barriers for upper-elementary and middle-school girls, Code: SciGirls! Media for Engaging Girls in Computing Pathways (Code: SciGirls!) was developed as a three-year transmedia and outreach project. The project was funded by the National Science Foundation (NSF) and directed by Twin Cities Public Television (TPT) in partnership with the National Girls Collaborative and Code.org.

One of the key media resources produced as part of the Code: SciGirls! project was a set of five new half-hour Code: SciGirls! shows for the ongoing SciGirls series on PBSKids.\(^2\) The shows were designed to be story- and character-driven, building on TPT’s prior four seasons of SciGirls, all of which follow a narrative story framework that incorporates both young and adult role model characters working together. In the Code: SciGirls! shows, groups of girls work with female professionals using coding to solve community problems. As described in the NSF proposal (TPT, 2016):

> At the heart of all SciGirls’ programming is a half-hour story that follows a group of real middle school girls and their female STEM mentors as they investigate relevant science and technology questions. These narratives are bookended by Izzie and Jake, two animated tween characters whose STEM adventures connect to the main story (p. 2).

To explore whether and how young viewers’ involvement with the shows’ narratives impacts their show enjoyment and code-related interests, beliefs, and behavioral intentions, the NSF funding supported an exploratory research study on the Code: SciGirls! shows. The study was conducted by Knight Williams Inc., an independent firm that specializes in the research, development, and evaluation of informal science multimedia and outreach projects.

\(^1\) STEM is an acronym for the fields of science, technology, engineering, and mathematics.

\(^2\) In addition to the new Code: SciGirls! shows, the project also produced an online interactive Code Quest game and an 8-unit coding curriculum to support a nationally distributed community-based outreach program. All project materials were designed to impact 5th – 8th grade girls’ coding-related interests, beliefs, and behavioral intentions. The NSF funding also supported a third-party summative evaluation of the outreach effort (Knight Williams Inc., 2021a) and a research study of the game (Knight Williams Inc., 2021b). The three Code: SciGirls! studies involved independent samples of girl participants.
**Background literature**

**Narrative involvement**

Narrative as applied in this study adheres to Hinyard and Kreuter’s definition (2007, p. 2) of “any cohesive and coherent story with an identifiable beginning, middle, and end that provides information about scene, characters, and conflict; raises unanswered questions or unresolved conflict; and provides resolution.” The *SciGirls* series follows this classic three-act story framework of setup, confrontation, and resolution. Each *Code: SciGirls!* show presents female youth and adult real-life characters who use coding to solve a community problem.

Narrative researchers contend that engagement with a story and with its characters are related psychological processes but distinct in that one can be involved with a story but not necessarily with its characters (Moyer-Gusé & Nabi, 2010), and the two processes can be influenced separately (Tal-Or & Cohen, 2010). In their consideration of how people process persuasive content in an entertainment-education narrative, Slater and Rouner (2002) also emphasize the importance of engagement with the narrative and identification with characters. Additionally, in this study, participants viewed *Code: SciGirls!* shows in a home environment, so an important third dimension to narrative involvement is attentional focus, defined as “viewers’ focus on or distraction from the program” (Busselle & Bilandzic, 2009, p. 325). Attentional focus has been shown to be positively related with outcomes considered in this study, such as show enjoyment, beliefs, and behavioral intentions (Busselle & Bilandzic, 2009; Quintero Johnson, 2011; Quintero Johnson & Sangalang, 2017; Van Leeuwen et al., 2017). Thus, narrative involvement with *Code: SciGirls!* is assessed with the three dimensions of story involvement, character involvement, and attentional focus.

**Impacts of narrative involvement**

Children’s educational television series that focus on STEM have utilized a variety of formats, including story- and character-driven narratives like that of *SciGirls*. Summative evaluations of narrative-based STEM television series with upper elementary school viewers have documented impacts of increased STEM interest and knowledge as well as positive changes in STEM beliefs (ARC Consulting, 1995; Fay et al., 1995; Fisch, 2003). Additionally, experiment-based evaluations with girl viewers of prior seasons of *SciGirls* have shown cause-effect relationships between the shows and outcomes of STEM interest, knowledge, and beliefs (Flagg, 2010, 2012, 2016). The positive impact of STEM television narratives on children’s interests, knowledge, and beliefs is not in doubt; however, none of the aforementioned evaluations measured the extent of viewers’ attentional focus and involvement in the storyline and with the characters. It is this relationship of the association and influence of these dimensions of viewer narrative involvement in outcomes that is explored in this study.

In the early 21st century, multiple theoretical models and measures of narrative effects have coalesced to address the extent to which individuals become involved in a story world and the mechanisms and impact of that involvement. The major models include the Narrative Transportation Theory (Green, 2006; Green & Brock, 2000), Model of Narrative Comprehension and Engagement (Busselle & Bilandzic, 2008), Extended Elaboration Likelihood Model (Slater & Rouner, 2002), and the Entertainment Overcoming Resistance Model (Moyer-Gusé & Nabi, 2010). These four models vary in their details but have commonalities that are drawn upon for the foundation of this study. The models propose and have supporting research that the extent to
which individuals are transported, immersed, engaged, or involved in a world of both story and characters is a primary mechanism of persuading them to modify their beliefs and behavioral intentions towards those presented in the narrative.

Two meta-analyses of narrative studies based on the theoretical models noted above support the influence of narrative involvement on adult outcomes. Van Laer et al. (2014) implemented a meta-analysis of effect sizes of 76 studies with adults and text stimuli, concluding that narrative transportation has significant positive effects on affective responses and story-consistent thoughts, beliefs, intentions, and attitudes. Tukachinsky and Tokunaga (2013) reported a meta-analysis of 35 education-entertainment media studies with adults in the areas of health and social/political issues, using text or audiovisual stimuli. Examining effect sizes, the authors found that narrative involvement resulted in the greatest change in behaviors or behavioral intentions, followed by message-consistent attitudes and knowledge.

The meta-analyses indicate that adults with more involvement in a story and its characters are more likely to adopt story-consistent beliefs, attitudes, and behaviors; however, such a relationship has yet to be shown with children. An extensive search of the literature revealed only one study that looked at narrative involvement as a persuasion mechanism with youth. With middle school students, Leung et al. (2017) found greater transportation in reading a manga comic promoting fruit consumption compared with reading newsletters, but such involvement did not mediate differences in outcome expectations, self-efficacy, or knowledge. Despite this discouraging single result with youth and text stimuli, the story and character dimensions of narrative revealed to influence adult outcomes are apparent in the SciGirls shows. As entertaining narratives have also been thought to lower resistance to messages compared to traditional educational stimuli (Green & Clark, 2013; Moyer-Gusé & Nabi, 2010), exposure to Code: SciGirls! story-based shows may yield increased interest in coding and more positive assessment of code-related careers as possible for themselves. Additionally, since vicarious observation and identification with story characters can lead to enhancements in self-efficacy (Bandura, 2001; Moyer-Gusé et al., 2011), if young viewers of Code: SciGirls! identify with the on-screen female role models who successfully code, they may be more likely to increase assessment of their coding ability and likelihood to do code-related activities after viewing.

One of the primary goals of Code: SciGirls! is to stimulate interest in code-related activities, applications, and careers. In their four-phase theory of the development of interest, Renninger and Hidi describe the early phases of interest as situational interest, triggered by the environment, which then may be a precursor to maintained situational interest, in which children are motivated toward future engagement with similar content (Renninger & Hidi, 2011, 2020). We note that there is no mention in the above meta-analyses of changes in interest in content or messages as they might relate to narrative involvement. Fitzgerald and Green (2017) point out in a review of narrative persuasion that the majority of existing research deals with belief, attitudes, and behavioral change, with no reference to interest outcomes. Perhaps this is a result of the focus on adult media, whereas children’s television has a long proven history of fostering children’s interest in science content (e.g., Chen, 1994; Fisch, 2004; Mares et al., 1999). Evaluations of prior SciGirls shows have revealed a positive influence on 5th grade girls’ interest in carrying out science investigations (Flagg, 2012), in doing hands-on robotics engineering (Flagg, 2013), and in citizen science (Flagg, 2016); thus, this study breaks new ground in exploring relationships between interest and narrative involvement.
Finally, this study also explores the relationship between enjoyment and narrative involvement, as multiple studies with adults have shown that narrative involvement is positively correlated with enjoyment of videos (Busselle & Bilandzic, 2009; Hall & Bracken, 2011; Quintero Johnson, 2011; Tal-Or & Cohen, 2010; Woolley, 2012). The present study builds on prior work by including a measure of show enjoyment to explore its relationship to narrative involvement and other study outcomes.

**Influence of individual background variables**

Individual background variables that have been identified under some conditions as significantly relevant to narrative involvement for adults include gender, education, prior knowledge, and/or personal experience with the narrative content (Busselle & Bilandzic, 2009; Caputo & Rouner, 2011; Green, 2004; Green et al., 2008; van Laer et al., 2014). The *Code: SciGirls!* study reported here limits gender and education to 5th grade girls and includes measures of prior coding experience and personal acquaintance with coders. Additionally, for descriptive background, girls were also asked about their prior exposure to the *SciGirls* television series.

**Study questions**

Drawing on prior theory and research on narrative involvement, this study explores the impact of viewing *Code: SciGirls!* shows on 5th grade girls’ coding outcomes; the extent to which they experience narrative involvement while viewing; the relationship between narrative involvement and show enjoyment; how narrative involvement and show enjoyment influence coding outcomes; and how participants perceive the influence of story and girl characters on coding outcomes. The study addresses the following research questions (RQ):

**RQ1.** What is the impact of viewing the shows on girls’ coding outcomes?
   a. What is the impact of the shows on girls’ coding interests, beliefs, and behavioral intentions?
   b. What is the relationship among coding outcomes?
   c. What is the impact of prior coding experience and prior acquaintance with coders on girls’ coding outcomes?

**RQ2.** To what extent do girls experience narrative involvement while viewing the shows?
   a. To what extent do girls experience narrative involvement overall?
   b. To what extent do girls experience the dimensions of story involvement, character involvement, and attentional focus?
   c. Is there a relationship among the narrative involvement dimensions of story involvement, character involvement, and attentional focus?

**RQ3.** What is the relationship between narrative involvement and show enjoyment?
   a. To what extent do girls experience show enjoyment?
   b. Is there a relationship between narrative involvement and show enjoyment?
   c. Do overall narrative involvement and its three dimensions positively influence show enjoyment?
RQ4. Do narrative involvement and show enjoyment positively influence the coding outcomes?
   a. Do overall narrative involvement and show enjoyment positively influence the coding outcomes?
   b. Do the three dimensions of narrative involvement positively influence the coding outcomes?

RQ5. How do girls perceive the influences of story and of girl characters on coding outcomes?

**Method**

**Study design**

A one-group pre-post study with a sample of 81 5th grade girls investigated the five research questions listed above. Girls completed recruitment questions and a pre-survey, viewed three *Code: SciGirls!* shows, and completed a post-survey. The study design is illustrated below in Figure 1.

The research was exploratory given that including a control or non-narrative comparison group was both beyond the scope of the grant and considered premature in light of the lack of prior narrative research with children, and because the study materials comprised grant-produced shows that were not specially designed for research purposes.

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3 The study conformed to IRB requirements (E&I Review Services, # 21128 - 01).
Pilot study

In the summer of 2021, 25 girls who were entering 5th grade participated in an at-home pilot study to assess the study procedures and examine the psychometrics of the survey scales. The girls were drawn from four states. Their ages ranged from 9 to 11, with an average and median age of 10 years. The pilot sample's racial/ethnicity distribution included 60% White (non-Hispanic), 24% Hispanic (any race), 12% multiracial (two or more non-Hispanic races), and 4% African American/Black. The pilot study procedures of recruitment, pre-survey, viewing, and post-survey were completed satisfactorily, and only minor wording revisions to clarify recruitment issues were necessary for implementation of the full study. Ordinal reliability coefficients of internal consistency of each scale were acceptably high for the pilot sample; thus, all scales were considered reliable for this sample and retained for the full study. Given that the pilot study resulted in no revisions to treatment procedure or surveys, the pilot sample of 25 girls was integrated into the full study sample, which is described in the following section.

Study participants

Recruitment

In addition to the 25 pilot girls, another 56 5th grade girls were recruited in the fall of 2021 to obtain a full study sample of 81 girls. Recruitment involved outreach to parents via two methods. Emails briefly summarizing the study were sent to parents of potential participants directing them to an online Information letter and Interest form and to elementary schools and after-school organizations serving upper-elementary girls to ask them to direct their interested parents to the Information letter and Interest form. To prevent unintended early access to SciGirls, only PBS media, not SciGirls, was referred to in all recruitment communications.

Information letter. The Information letter described the study purpose, the organizations involved, and the study requirements of 5th grade girls participating at home with a desktop or laptop and keyboard in three 30-minute online media sessions daily within a period of one week and completing an online opinion survey before and after the media treatment. The letter reviewed benefits and possible minimal risks of the study, confidentiality of information, and indicated that girls would receive a $60 gift certificate to Amazon, Target, or Walmart upon completion of all study activities. Finally, the letter noted that the study had limited resources but the researchers would attempt to include everyone who wanted to participate. Recruitment was implemented on a rolling basis so the study could include all interested girls.

Interest form. After reviewing the Information letter, parents and daughters interested in participating in the PBS media study both completed an online Interest form. Parents provided contact information and reported their daughter's grade, age, racial/ethnic background, and access at home to an internet-connected desktop or laptop computer.

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4 The original plan of action in the NSF proposal included an in-school large sample pilot study but COVID-19 restrictions required a smaller at-home study.
5 In this report, the term "parents" refers to parents or guardians, as noted in recruitment and consent documents.
with a keyboard with which to experience the media and answer online surveys. Obtaining information from parents about racial/ethnic background was necessary so the sample would include a racial/ethnic distribution close to that of the 2019 census statistics for 5th grade girls.\(^6\) Attempting to match the census distribution increases the generalizability of the study’s results.

The Interest form then included a section for the girls to complete, after telling them that the PBS media in the study covered a few basics of coding or programming but that coding experience was not a requirement to participate. Following this information, the girls answered questions to affirm their interest in participating in the study and to establish their prior coding experience and prior acquaintance with someone who codes. Obtaining information from girls about their prior coding experience was necessary in order to invite a participating sample with a range of prior coding experience. Questions in the Interest form relating to prior coding experience yielded a possible score of 12. Girls were recruited whose prior experience score ranged from 0 to 12.

**Permission form.** After submission of the Interest form, parents were contacted with a Permission form. This form again reviewed the study information and the viewing and survey activities required of participating girls as well as activities that parents would be responsible for, e.g., sharing with their daughter study emails that provide links to shows and instructions for signing in and out of a viewing session. Parents were asked to agree to their daughter’s participation in the study procedure, with the understanding that she could withdraw at any time and her name would not be identified with her opinions or in the study report. Subsequent to parental agreement, girls completed an assent form and a pre-survey, which is described in the Procedure section of this report.

**Attrition**

A total of 83 girls who completed the Interest form with their parents proceeded to complete the pre-survey. All but two of these girls completed all subsequent phases of the study (98%). Of the two who did not complete, one girl did not proceed to watch Show 1, with her parent reporting she became too busy to participate in the study, and the other girl watched Show 1 and Show 2 after which she opted out due to lack of interest in the topic, as reported by her parent.

**Demographics**

A total of 81 5th grade girls participated in the study.

**Age.** The sample of 81 5th grade girls included 9-year-olds (5%), 10-year-olds (86%), and 11-year-olds (9%), with an average and median age of 10 years.

**Racial/ethnic diversity.** The sample of participants closely matched the October, 2019 census diversity statistics for 5th grade girls.\(^6\) The study sample included 48% White (non-

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\(^6\) Table 2 at [https://www.census.gov/data/tables/2019/demo/school-enrollment/2019-cps.html](https://www.census.gov/data/tables/2019/demo/school-enrollment/2019-cps.html) Data in the six spreadsheets of Table 2 reveal that 5th grade girls in U.S. schools are 48% White (non-Hispanic), 29% Hispanic (any race), 13% African American/Black, 5% Asian, and 5% multiracial (two or more non-Hispanic races) (October, 2019).
Hispanic), 23% Hispanic (any race), 11% African American/Black, 9% Asian, and 9% multiracial (two or more non-Hispanic races) participants.

**State.** The participants resided in ten different states spread across the country in three geographical regions: West (33%), Midwest (30%), and East (37%).

**Individual background variables**

As noted in the background literature review (p. 10), the individual variables of prior knowledge and personal experience with the narrative content have been identified under some conditions as relevant to narrative involvement. Thus, questions about these variables were asked of the participating girls and included in the analyses as outlined under Analysis (p. 25). Girls were also asked about their prior exposure to the *SciGirls* television series for descriptive purposes. See Measures (p. 18) for more detail about these questions.

**Prior coding experience.** Participants answered questions to establish their experience with coding prior to viewing *Code: SciGirls!,* familiarity with coding or programming and familiarity with using or writing code themselves, prior use of code to do any of five activities, and prior use of any of five coding languages. With a possible prior experience score of 12, the scores for the participants ranged from 0 to 12, with a mean of 3.9 and a median of 4.0.

**Prior acquaintance with coders.** Over half (53%) of participants reported that they knew someone who writes code or programs on a computer. Coders whom participants knew included parents, siblings, other relatives, friends, classmates, and technology teachers at school.

**Prior exposure to *SciGirls* series.** More than two-thirds (69%) of participants had never heard of the *SciGirls* television series prior to this study. Other girls (16%) had heard of the series but not watched it, 6% reported having watched the series once, and 9% had watched more than once.

**Materials**

The *SciGirls* series follows the classic three-act screenwriting narrative structure of setup, confrontation, and resolution, illustrated in Figure 2 (Field, 1979). The first act of setup introduces the main characters, their world, and goals; the second act of confrontation addresses the obstacles to achieving the goals; and the third act of resolution presents the final outcome. Each of the *Code: SciGirls!* shows presents a three-act narrative as a
team of girls works with female mentors to use coding to solve a community problem. Each show presents different teams of girls and different mentors, with diverse racial/ethnic backgrounds. Additionally, interspersed in each show are autobiographical videos about each girl in a team and a secondary story of two cartoon characters, Izzie and Jake, who solve a related problem of their own. Summaries of the three-act narratives for each show and representative screenshots follow on pages 15-16.

To help maximize study implementation fidelity with respect to girls viewing the same number of 30-minute shows within a one-week viewing period, we opted to have girls view a subset of three shows rather than all five shows produced as part of the project. This decision was also informed by studies of SciGirls episodes from prior seasons, which had shown three episodes to be a sufficient treatment to impact planned outcomes (Flagg, 2012, 2016). The research team reviewed the content of the five Code: SciGirls! shows to decide which three addressed the study outcomes most completely. Participants viewed each of the three shows via a private Vimeo link. The initial teaser, end credits, and teaser to the next show were removed from each video to shorten the viewing and eliminate information about other Code: SciGirls! shows; thus, the duration of each Vimeo show was 26:10 minutes.

**Acts 1-3 for High Tech Tide**

<table>
<thead>
<tr>
<th>Act 1 Setup</th>
<th>Girls and their female mentor go on a research vessel to obtain tracking data for spotted eagle rays. The girls decide to investigate if red tide affects the rays, using computer code to make graphs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Act 2 Confrontation</td>
<td>As they plot data using the programming software R, the girls discuss their coding choices, note troubles they have with writing code correctly, and celebrate their successes.</td>
</tr>
<tr>
<td>Act 3 Resolution</td>
<td>To classes throughout the U.S., the girls give a livestream presentation of their final graphs and results of red tide and rays.</td>
</tr>
</tbody>
</table>
### Acts 1-3 for *Super Sensors*

<table>
<thead>
<tr>
<th>Act 1 Setup</th>
<th>After learning about data-capture cameras from adult mentors during tours of NASA and a natural history museum, girls decide to build and code a camera to take animal pictures.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Act 2 Confrontation</td>
<td>As the girls code with Python and test their camera actions, they discuss the challenges of coding.</td>
</tr>
<tr>
<td>Act 3 Resolution</td>
<td>The girls make a website of their animal photos and present their final project to museum visitors.</td>
</tr>
</tbody>
</table>

### Acts 1-3 for *Cartoon Coders*

<table>
<thead>
<tr>
<th>Act 1 Setup</th>
<th>With guidance from their female mentor, girls brainstorm ideas and create storyboards to teach kids about STEM Justice. The girls decide to use the coding language Alice to create their animation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Act 2 Confrontation</td>
<td>The girls show the steps they take to code and test their characters’ movements. They discuss their mistakes and successes in coding their animation.</td>
</tr>
<tr>
<td>Act 3 Resolution</td>
<td>The girls help their school classmates do a simple coding activity and present their final STEM Justice animation.</td>
</tr>
</tbody>
</table>
Procedure

After recruitment, participating girls completed the study procedure of pre-survey, viewing of shows, and post-survey, as described below. All online surveys were hosted on Survey Monkey. Scale ratings in pre- and post-surveys all provided five-point response choices, and statements in scales were randomized for each participant to minimize order effects, except where noted in the Measures section of this report.

Pre-survey

After parents gave consent for their daughters to participate (see Permission form description, p. 13), the girls also provided their assent to participate in the study, and subsequently completed six rating scales addressing the study outcomes: Interest in coding activities, coding applications, and code-related careers; Belief in their own ability to code and that a code-related career is possible for themselves; and Behavioral intention to do coding activities in the future. The pre-survey also included rating scales that assessed the variables of coding experience and acquaintance with someone who codes.

Viewing treatment

The morning after completing the pre-survey, parents received an email to share with their daughters. The email asked that girls reserve 30 minutes of uninterrupted time to view the shows, provided a Vimeo video link to the first show, and requested that girls click on the link at the end of the video to pull up a sign-out page. The sign-out page asked for their name and informed them that an email with the link to the next show would be available on the next day. The same email/sign-out procedure was followed for the second and third shows.

Treatment verification. To help verify treatment fidelity, the following steps were taken:

- All participants clicked to each Vimeo video link from a Constant Contact email that recorded the time the Vimeo link was clicked. This start time was compared to the end time when participants clicked on a link embedded in the Vimeo video to move to the sign-out page. Comparing these two times confirmed girls completed their show viewing and signed out within the 30-minute time frame planned.
- All Vimeo videos were private so that they did not show up in a search engine and were visible only to girls who had the private link. The videos also could not be downloaded or embedded on any site. Viewers could not advance, rewind, or speed up the videos, although they could pause.

Post-survey

To help encourage reflection on all three shows rather than the third and final show just watched, participants were sent the online post-survey one day after they viewed the third and final show based on their sign-out record. All participants completed the survey within 1-3 days of seeing the third show, with 80% completing it one day after viewing, 14% completing it two days after viewing, and 7% three days after viewing. The survey took participants 15-20 minutes to complete, with an average survey time of 18 minutes.

The post-survey included rating scales that assessed the narrative involvement variables of story involvement, character involvement, and attentional focus; the outcome variable of
show enjoyment; and the six repeated pre-survey scales focused on the outcome variables of coding interests, beliefs, and behavioral intentions. The survey also included a background question that assessed prior exposure to SciGirls shows. Additionally, random halves of the participant sample reflected in open-ended questions on how watching the stories or the girls in the shows affected their interest in coding, interest in a code-related job or career, belief in their ability to code, and their seeing a code-related job as possible for them. Splitting the sample in two to answer either question about stories or girls kept the survey within a reasonable length for this age group. Upon completion of the post-survey, girls received a $60 gift certificate to Amazon, Target, or Walmart.

**Measures**

**Individual background variables**

The study measured individual background variables identified as relevant to narrative involvement, including the background variables of prior coding experience, personal acquaintance with coders, and acquaintance with the SciGirls series. Appendix 1 includes the questions as presented in the survey.

**Prior coding experience.** In the recruitment phase, girls answered questions to establish their experience with coding. The initial question drew from the phrasing of a prior experience measure used by Green (2004) in narrative involvement research and asked girls to rate on a five-point scale from not at all to very familiar their familiarity with coding or programming and their familiarity with using or writing code themselves. Two subsequent questions asked girls to indicate their prior use of code to do any of five randomly-presented activities and their prior use of any of five alphabetically-presented coding languages. Response choices for these two questions included yes, I have; no, I haven’t; and I don’t recall. The listed coding activities and languages are ones that 5th graders might have been exposed to in school; for example, using code to make a graph or using the language Blockly (“Hour of Code”). From the above described questions, a score of prior coding experience was developed. Familiarity ratings of 1, 2, or 3 contributed zero points to the score, and ratings of 4 or 5 contributed one point. Answers of yes, I have contributed one point to the score, and answers of no, I haven’t or I don’t recall contributed zero points.

**Prior acquaintance with coders.** Participants were asked if they knew someone who writes code or programs on a computer. If they answered yes, participants were asked who they knew who writes code or programs on a computer. This question drew upon the phrasing of personal experience questions in Green (2004) and Caputo and Rouner (2011).

**Prior familiarity with SciGirls series.** After viewing the shows, participants reported how familiar they were with the SciGirls series before their viewing of the coding shows. Responses included never heard of; heard of but had not watched it; watched the television series once; and watched the television series more than once.
Narrative involvement
The study measured narrative involvement with three dimensions: story involvement, character involvement, and attentional focus. The 25 statements in the three scales detailed below were presented in a five-point agree-disagree format from strongly disagree to strongly agree. All scale psychometrics reported below were calculated on the post-survey responses of the final sample of 81 girls. Appendix 2 includes each scale as presented in the survey.

**Story involvement scale.** In a prior *SciGirls* study with middle school girls (Knight Williams Inc., 2017), the authors found low reliability for the five-item Video Transportation Scale ($a = .40$), which has been previously used with adults viewing brief movie clips (Cherrington et al., 2015; Sestir & Green, 2010; Williams et al., 2010). In the same *SciGirls* study, the authors found much higher reliability for a six-item researcher-produced story involvement scale ($a = .87$). Thus, the format of the latter scale was employed in this study.

This researcher-produced story involvement scale reflects the conclusions of media effects theories that individuals process stories both cognitively and emotionally, and also recognizes the typical three-act story structure of many narratives, which is not taken into account by adult narrative scales. The story involvement scale builds on statement beginnings related to both cognitive and affective involvement (e.g., *I wanted to discover...* or *I cared about...*). The endings of these statements are then modified for a specific story’s three acts and content. As presented in the Materials section (p. 15-16), each *Code: SciGirls!* show introduces the team of girls and their coding goal in the setup, presents the challenges of coding in the confrontation, and describes their final coding project in the resolution. Presented in a five-point agree-disagree format, the scale comprised a total of six cognitive and affective statements for setup, confrontation, and resolution, respectively, as shown in Figure 3. The statements were not presented randomly but in order of the three acts with the cognitive statement first, followed by the affective statement.

![Figure 3. Story involvement scale statements in relation to three-act narrative structure of *Code: SciGirls!* shows](image)

<table>
<thead>
<tr>
<th>ACT I Setup</th>
<th>ACT II Confrontation(s)</th>
<th>ACT III Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I wanted to discover what the girls would do with code.</td>
<td>It was interesting to learn about the challenges of coding.</td>
<td>I wanted to find out how the girls’ coding projects turned out.</td>
</tr>
<tr>
<td>Affective</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seeing that the girls would use coding pulled me into the stories.</td>
<td>I was happy to see the girls work through their coding problems.</td>
<td>I cared about seeing the girls present their coding projects successfully at the end of the shows.</td>
</tr>
</tbody>
</table>

Psychometric analysis for the full sample of 81 girls showed that internal consistency for the scale was high ($a = .88$, 95% CI [0.84; 0.92]).
Character involvement scale. Building on the theory that those who identify with characters are more likely to adopt their interests, beliefs, and behaviors (Bandura, 2001), the Code: SciGirls! shows present the onscreen girls as “characters” with whom to identify, as the girls describe their backgrounds as well as their feelings, motivations, and goals related to coding. Moyer-Gusé (2008) points out that involvement with characters may include five categories: liking, similarity, identification, wishful identification, and parasocial identification. The first two – liking and similarity – are judgments about the character, whereas the latter three are feelings with the character. As parasocial identification tends to develop over longer exposures with recurring characters, it was not considered relevant to this study.

To cover the four categories of involvement shown in Table 1, the study's scale drew from a broad base of character identification research in children's television to include 15 statements.

<table>
<thead>
<tr>
<th>Table 1. Character involvement scale statements and categories</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Liking</strong></td>
</tr>
<tr>
<td>• I liked the girls.</td>
</tr>
<tr>
<td>• There are things I liked about the girls.</td>
</tr>
<tr>
<td>• The girls were fun to watch.</td>
</tr>
<tr>
<td><strong>Character similarity</strong></td>
</tr>
<tr>
<td>• I felt like I had things in common with the girls.</td>
</tr>
<tr>
<td>• The girls and I are similar in some ways.</td>
</tr>
<tr>
<td>• The girls reminded me of myself.</td>
</tr>
<tr>
<td><strong>Character identification</strong></td>
</tr>
<tr>
<td><strong>Empathy</strong></td>
</tr>
<tr>
<td>• I felt the emotions that the girls expressed.</td>
</tr>
<tr>
<td>• I could relate to what the girls were feeling.</td>
</tr>
<tr>
<td><strong>Cognitive</strong></td>
</tr>
<tr>
<td>• I understood why the girls made the choices they did.</td>
</tr>
<tr>
<td>• I understood the girls’ interest in their activities.</td>
</tr>
<tr>
<td><strong>Motivational</strong></td>
</tr>
<tr>
<td>• I wanted the girls to reach their goals.</td>
</tr>
<tr>
<td>• I wanted the girls to be successful.</td>
</tr>
<tr>
<td><strong>Wishful identification</strong></td>
</tr>
<tr>
<td>• I would like to do the kinds of things the girls did.</td>
</tr>
<tr>
<td>• The girls are the sort of people I want to be like myself.</td>
</tr>
<tr>
<td>• I wish I could be more like the girls.</td>
</tr>
</tbody>
</table>

The basis for the set of 15 statements is described below:

- **Liking** refers to an attraction to the characters (Hoffner & Cantor, 1991): *I liked the girls; There are things I liked about the girls; and The girls were fun to watch.*

- **Similarity** is a judgment of the extent to which characters share characteristics with oneself (Cohen et al., 2018; Maccoby & Wilson, 1957): *I felt like I had things in common with the girls; The girls and I are similar in some ways; and The girls reminded me of myself.*

- **Identification** includes aspects defined by Cohen (2001): empathy, in which viewers share feelings of a character (*I felt the emotions that the girls expressed and I could relate to what the girls were feeling*); cognitive, in which viewers understand a character’s perspective or motivation for actions (*I understood why the girls made the choices they did and I understood the girls’ interest in their activities*); and motivational, in which viewers relate to a character's goals (*I wanted the girls to reach their goals and I wanted the girls to be successful*).
• **Wishful identification** addresses characters as role models and the degree to which one wants to emulate characters (Hoffner, 1996; Steinke et al., 2012): *I would like to do the kinds of things the girls did; The girls are the sort of people I want to be like myself; and I wish I could be more like the girls.*

Psychometric analysis for the full sample of 81 girls showed that internal consistency for the scale was high \((a = .95, 95\% CI [0.94; 0.97])\).

**Attentional focus scale.** To measure attentional focus, the scale used in this study drew on the Likert-style attentional focus statements employed with adults by Busselle and Bilandzic (2009), Kim et al. (2017), and Williams et al. (2010). However, most statements for adults were negatively worded, focusing on distraction; in contrast, the statements used in this study were positively worded for children, focusing on attention for ease of interpretation. The scale included four statements presented in a five-point agree-disagree format from *strongly disagree* to *strongly agree*: *The shows really grabbed my attention; I found it easy to concentrate on viewing the shows; My mind was focused on the shows as I watched; and I paid attention to what was going on in the shows.* Analysis of the scale’s psychometric properties with the final sample of 81 girls showed that internal consistency for the scale was high \((a = .88, 95\% CI [0.84; 0.93])\).

**Show enjoyment**

Busselle and Bilandzic (2009) asserted “It is reasonable to assume that more engaging narrative experiences are more enjoyable...thus any scale measuring engagement should predict enjoyment” (p. 326-327). A show enjoyment scale is included in this study to explore how narrative involvement is related with or predictive of enjoyment.

**Show enjoyment scale.** To assess the extent to which girls enjoyed watching the three *Code: SciGirls!* shows together, we adapted an age-appropriate activity interest scale from a prior *SciGirls* research study (Flagg, 2016), which drew on the interest/enjoyment subscale from Deci and Ryan’s Intrinsic Motivation Inventory (n.d.). The scale included four statements presented in a five-point agree-disagree format from *strongly disagree* to *strongly agree*: *I enjoyed the shows very much; I had a lot of fun viewing the shows; I thought the shows were very interesting; and I would like to watch more shows like these.* Psychometric analysis for the final sample of 81 girls showed that internal consistency for the scale was high \((a = .93, 95\% CI [0.90; 0.95])\). Appendix 3 includes this outcome scale as presented in the survey.

**Coding interests, beliefs, and behavioral intention outcomes**

Pre-post rating scales and post-only open-ended questions were developed to address the planned outcomes of interests, beliefs, and behavioral intentions toward coding and code-related careers. A review of the literature revealed many existing scales applied to the broader arenas of “computers” and “computer science” or to specific programming languages like “Scratch”, but very few age-appropriate scales focused on “coding” itself, which is at the core of the *Code: SciGirls!* shows. Even so, we utilized existing scales, referenced below, as idea sources to generate age- and gender-appropriate scale statements, adapting the language to the shows’ coding content.
For the purposes of the study, separate scales were developed to assess interest in coding activities, coding applications, and code-related jobs or careers, as well as scales to assess belief in ability to code, belief that a coding-related job or career is possible, and behavioral intention to do coding activities. Scale psychometrics reported below were calculated on the pre-survey responses of the final sample of 81 girls. Appendix 3 includes each outcome scale as presented in the survey.

**Interest in coding activities scale.** In considering interest in the field of informal science learning, Renninger (2007) noted that “interest evolves in the interaction of the person with the environment and as a result can be supported to change” (p. 4) and “interest is always identified with particular content (e.g., science)” (p. 5). In this study, the environmental interaction occurs with the three television shows and the particular content is coding. Participants rated randomly presented statements using a five-point range from not at all interested to very interested. Six coding activities were included based on activities implemented in the Code: SciGirls! shows: using code to create animation; using code to make a graph; using code to control technologies like robots, sensors or cameras; writing your own code; solving or figuring out coding challenges; and playing an online game to learn or practice coding. Psychometric analysis showed that internal consistency for the scale was high (α = .89, 95% CI [0.85; 0.92]).

Additionally, to support interpretation of the quantitative scale in relation to involvement with story and characters, an open-ended question placed before the rating scale asked half of the participant sample about the influence of the stories (n = 41) and half about the influence of watching the girls on their interest in coding (n = 40), as follows: *Please describe how watching the stories/girls affected your interest in coding.*

**Interest in coding applications scale.** Participants rated randomly presented statements using a five-point range from not at all interested to very interested. Four applications of coding were included based on the projects that appear in the Code: SciGirls! shows: how coding can address real world problems; how coding is used in the sciences, like astronomy or ecology; how coding can be used to inspire action; and how coding is used in the arts, like animation or music. Psychometric analysis revealed that internal consistency for the scale was high (α = .88, 95% CI [0.83; 0.92]).

Additionally, to support interpretation of the quantitative interest scales in relation to involvement with story and characters, the open-ended question asked about interest in coding in the previous section served to help interpret both the interest in activities and applications scales.

**Interest in code-related jobs or careers scale.** Participants rated randomly presented statements using a five-point range from not at all interested to very interested. Three areas were included to capture broad career areas addressed in the Code: SciGirls! shows: learning about coding jobs or careers; exploring what is involved in preparing for careers that use coding; and working on coding projects in a future job or career. The last statement drew from a scale administered to teens by Kang et al. (2021). Psychometric analysis showed that internal consistency for the scale was high (α = .93, 95% CI [0.91; 0.96]).
Additionally, to support interpretation of the quantitative scale in relation to involvement with story and characters, an open-ended question placed before the rating scale asked half of the participant sample about the influence of the stories (n = 41) and half about the influence of watching the girls on their interest in a code-related job/career (n = 40), as follows: *Please describe how watching the stories/girls affected your interest in a code-related job or career.*

**Belief in ability to code scale.** Bandura’s Social Cognitive Theory (2001) proposes that a belief in one’s task capability (or self-efficacy) is in part influenced by vicarious observation of social modeling of the sort that the girls present in the *Code: SciGirls!* shows. Bandura (2006) instructs that a scale to assess the strength of the belief system underlying self-efficacy should list different activities in a specific performance domain and request of participants how confident they are that they can do those activities at that time.

Although the *Code: SciGirls!* shows do not directly teach coding skills, the girl teams do model coding activities on-screen; thus, this study includes questions about participants’ beliefs in their own coding ability. The coding activities included in this study’s scale were modeled by the girls in the shows and have as their foundation the computational thinking framework of Brennan and Resnick’s (2012) concepts of sequence and loop, practices of testing and debugging, and perspective of questioning. On a five-point scale of *not at all confident* to *very confident*, participants rated how confident they were that they could do seven coding activities, listed in the following order: *use code to control robots, sensors, or cameras; choose the correct code to move an object on a computer screen; create code sequences that tell a computer what to do; choose a correct code to make a computer repeat the same actions over and over; test the results of a sequence of code; fix your coding when your program doesn’t work; and use coding to solve a specific problem.* Psychometric analysis showed that internal consistency for the scale was high (*a* = .97, 95% CI [0.96; 0.98]).

Additionally, to support interpretation of the quantitative scale in relation to involvement with story and characters, an open-ended question placed before the rating scale asked half of the participant sample about the influence of the stories (n = 41) and half about the influence of watching the girls on their belief in their ability to learn to code (n = 40), as follows: *Please describe how watching the stories/girls affected your confidence in your ability to learn to code.*

**Belief that a coding-related job or career is possible scale.** Possible selves theory (Markus & Nurius, 1986) as applied in this study refers to participants’ self-knowledge about their potential and their future identities. The scale statements generated for this study were inspired by the *Code: SciGirls!* shows’ inclusion of coding role model mentors, media research by Steinke et al. (2009) that concluded that viewing televised scientist characters as vicarious role models led to a positive change in adolescent girls’ views of themselves in a future science career, and scales focused on possible selves and STEM careers (Kang et al., 2021; Lips, 2007; National Center for Women and Information Technology, 2020; Rachmatullah et al., 2020; Wonch Hill et al., 2017).

Although the *Code: SciGirls!* shows do not elucidate the range of jobs or careers available to those with coding skills, the girl teams do discuss with female mentors their professional
activities; thus, this study includes questions about the possibility of a coding-related job or career in the future. For the purposes of the study, the scale assessed beliefs of girls’ future selves in a coding-related job or career. Participants were asked the following randomly-presented agree-disagree statements on a five-point scale from strongly disagree to strongly agree: I think like a coder; I could become a coder if I wanted to; People like me could do well in coding jobs; I believe I can be successful in a career in coding; I can picture myself as a coder; and I believe that a code-related job is possible for me. Psychometric analysis showed that internal consistency for the scale was high (\(a = .89, 95\% \text{ CI } [0.85; 0.93]\)).

Additionally, to support interpretation of the quantitative scale in relation to involvement with story and characters, an open-ended question placed before the rating scale asked half of the participant sample about the influence of the stories (\(n = 41\)) and half about the influence of watching the girls on their beliefs (\(n = 40\)), as follows: Please describe how watching the stories/girls affected your seeing a code-related job as possible for you.

Behavioral intention to do coding activities scale. Studies with adults have shown that narrative involvement can be important to intentions to change individuals’ behaviors related to smoking, sun exposure, bone marrow donation, and environmental activity, for example (Fitzgerald & Green, 2017). The coding intention behaviors included in this study’s scale are coding activities thought to be within the reach of most girls. Participants were asked to report their likelihood to do coding activities in the future, if given the opportunity, on a five-point scale of not at all likely to very likely. The following randomly-presented activities included: ask someone who knows about coding what you can do to get better at coding; play an online game to learn or practice coding; sign up for an out-of-school activity about coding; take a school class in coding; try to use coding in a project at school or home; and use or watch online coding tutorials or videos. Psychometric analysis showed that internal consistency for the scale was high (\(a = .87, 95\% \text{ CI } [0.82; 0.91]\)).

Analysis

Quantitative data analysis

As described under Measures (p. 18), quantitative data were generated from recruitment and pre-survey questions about participants’ coding background and acquaintances; pre- and post-survey questions about participants’ coding related interests, beliefs, and behavioral intentions, and post-survey questions about their narrative involvement and show enjoyment while viewing the three shows. As participants answered all questions, item non-response did not need to be addressed.

The data set included a total of six pre-post scales and four post-only scales. A reliability analysis was performed on each scale, the results of which are reported in the report's Measures section. Statistical analyses were conducted on both the survey scale data and individual background variables using R Statistical Software (v4.1.2; R Core Team 2021), as follows:

- Descriptive statistics were used to summarize the demographic and background characteristics of participants and their rating responses to survey scales. The
following descriptive terms are used in the text to summarize the ranges for mean ratings on the 1-5 scales: *moderately high* for 3.5-3.99, *high* for 4.0-4.49, and *very high* for 4.5-5.0.

- Two-tailed bootstrapped paired *t*-tests comparing the pre and post coding outcome scales were used to assess the impact of the shows on the six coding outcome areas outlined under Measures. To determine if prior coding experience or prior acquaintance with coders had a significant effect on the coding outcomes, mixed-effects models were run for each outcome, while modeling time as a fixed effect and study participant as a random effect to account for the dependency in the pre-post measures.

- Correlational analysis was used to investigate relationships among measured variables. Correlation coefficients and confidence intervals are reported in the text and tables, as applicable. Appendix 4 includes a full correlation matrix for all study variables.

- Finally, partial least squares structural equation modeling (PLS-SEM) was used to examine whether narrative involvement influenced the study outcomes with respect to coding and show enjoyment outcomes. The PLS-SEM tests were one-tailed given the study's interest in whether and how narrative involvement positively affected study outcomes. The individual background variables of prior coding experience and prior acquaintance with coders were included as control variables in all PLS-SEM models by adding paths to each of the dependent variables, including show enjoyment as a mediating variable and each of the six coding outcomes.

An alpha level of .05 was used for all statistical tests. A 95% confidence interval which does not contain zero is reported as "statistically significant." To help determine whether a significant difference is of practical concern, effect sizes were computed and reported where appropriate, together with confidence intervals. Following Lovakov & Agadullina’s (2021) empirically derived guidelines for interpreting effect size studies in social psychology, Cohen’s *d* of 0.15, 0.36, and 0.65 are interpreted as small, medium, and large effects.

**Qualitative data analysis**

Content analyses were performed on the qualitative data generated in the open-ended questions by three coders. The analysis was both deductive, drawing on the study’s goals and objectives, and inductive, looking for overall themes, keywords, and key phrases.
Results

RQ1: Impact of viewing shows on study outcomes

Research question 1 asked: *What is the impact of viewing the shows on girls’ coding outcomes?* After viewing the three shows, girls’ interest in coding activities, applications, and code-related jobs increased significantly. Girls’ belief in their ability to code also increased significantly, whereas belief that a code-related job or career is possible was not significantly changed by viewing the shows. Viewing the shows did not significantly increase girls’ behavioral intention toward doing coding activities in the future.

With respect to background variables, prior coding experience significantly impacted gains in all six coding outcome areas, while prior acquaintance with someone who codes had no such impact.

Before and after viewing the set of three shows, girls completed pre- and post-questions based on a five-point rating scale about their coding-related interests, beliefs, and behavioral intentions. Paired *t*-tests of these pre and post coding questions addressed RQ1a: *What is the impact of the shows on girls’ coding interests, beliefs, and behavioral intentions?*

Figure 4 presents the pre and post mean ratings for each of the six coding outcome scales. Girls’ interest in coding activities, applications, and code-related jobs, and their belief in their ability to code, all increased significantly after viewing the three *Code: SciGirls!* shows. Their code-related job beliefs and intentions toward doing coding activities in the future also increased, but not significantly.

![Figure 4. Pre and post mean ratings of girls’ coding interests, beliefs, and behavioral intentions (N = 81)](image)

**Figure 4. Pre and post mean ratings of girls’ coding interests, beliefs, and behavioral intentions (N = 81)**

<table>
<thead>
<tr>
<th>Interest in coding activities</th>
<th>Interest in coding applications</th>
<th>Interest in code-related jobs or careers</th>
<th>Belief in ability to code</th>
<th>Belief that code-related job or career is possible</th>
<th>Intention to do coding activities in the future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Mean ratings</td>
<td>3.0</td>
<td>4.0</td>
<td>3.0</td>
<td>3.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

**Mean ratings**
Specific scale findings are presented below.

- **Interest in coding activities.** Girls indicated a significantly higher interest in coding activities after viewing the three shows ($M = 3.94$, $SD = 0.83$) than before viewing ($M = 3.63$, $SD = 0.88$). The mean increase in interest rating was 0.31 with a 95% confidence interval ranging from 0.07 to 0.55. The effect size was small ($d = 0.28$).\(^7\)

- **Interest in coding applications.** Girls indicated a significantly higher interest in coding applications after viewing the shows ($M = 3.85$, $SD = 0.79$) than before viewing ($M = 3.47$, $SD = 1.02$). The mean increase in interest rating was 0.38 with a 95% confidence interval ranging from 0.15 to 0.60. The effect size was medium ($d = 0.37$).\(^8\)

- **Interest in code-related jobs or careers.** Girls indicated a significantly higher interest in code-related jobs or careers after viewing the shows ($M = 3.11$, $SD = 1.30$) than before viewing ($M = 2.83$, $SD = 1.14$). The mean increase in interest rating was 0.28 with a 95% confidence interval ranging from 0.05 to 0.53. The effect size was small ($d = 0.25$).\(^9\)

- **Belief in ability to code.** Girls indicated a significantly higher belief in their ability to code after viewing the shows ($M = 3.62$, $SD = 1.05$) than before viewing ($M = 2.86$, $SD = 1.25$). The mean increase in belief rating was 0.76 with a 95% confidence interval ranging from 0.54 to 1.01. The effect size was large ($d = 0.71$).\(^10\)

- **Belief in a code-related job or career being possible.** Girls indicated higher belief in attaining and succeeding at a code-related job or career after viewing the shows ($M = 3.58$, $SD = 0.84$) than they did before viewing ($M = 3.48$, $SD = 0.75$), but the increase was not statistically significant.\(^11\)

- **Behavioral intention to do coding activities in the future.** Girls indicated higher likelihood to do coding activities after viewing the shows ($M = 3.78$, $SD = 1.06$) than before viewing ($M = 3.60$ $SD = 0.88$), but the increase was not statistically significant.\(^12\)

\(^7\) $M_{diff} = 0.31$, BCa 95% CI [0.07, 0.55], $p = 0.015$, $d_z = 0.28$, BCa 95% CI [0.05, 0.50]

\(^8\) $M_{diff} = 0.38$, BCa 95% CI [0.15, 0.60], $p < .001$, $d_z = 0.37$, BCa 95% CI [0.15, 0.59]

\(^9\) $M_{diff} = 0.28$, BCa 95% CI [0.05, 0.53], $p = .02$, $d_z = 0.25$, BCa 95% CI [0.03, 0.47]

\(^10\) $M_{diff} = 0.76$, BCa 95% CI [0.54, 1.01], $p < .001$, $d_z = 0.71$, BCa 95% CI [0.47, 0.91]

\(^11\) $M_{diff} = 0.10$, BCa 95% CI [-0.06, 0.25], $p = .21$, $d_z = 0.14$, BCa 95% CI [-0.08, 0.36]

\(^12\) $M_{diff} = 0.16$, BCa 95% CI [-0.04, 0.38], $p = 0.13$, $d_z = 0.17$, BCa 95% CI [-0.05, 0.39]
Relationships of coding outcomes

Correlational analysis addressed RQ1b: *What is the relationship among coding outcomes?* Pre-post gains of all six scales were positively and significantly correlated with one or more other coding outcome scales, as presented in Table 2.

<table>
<thead>
<tr>
<th>Table 2. Correlations among coding outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Outcome</strong></td>
</tr>
<tr>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>1. <em>Interest in coding activities</em></td>
</tr>
<tr>
<td>2. <em>Interest in coding applications</em></td>
</tr>
<tr>
<td>3. <em>Interest in code-related jobs/careers</em></td>
</tr>
<tr>
<td>4. <em>Belief in ability to code</em></td>
</tr>
<tr>
<td>5. <em>Belief in code-related job/career being possible</em></td>
</tr>
<tr>
<td>6. <em>Behavioral intention to do coding activities in future</em></td>
</tr>
</tbody>
</table>

*(p value significance levels are as follows: * .05, ** .01, *** .001)*

Impact of prior experience and acquaintance with coders on coding outcomes

Mixed-effects models were run for each coding outcome to address RQ1c: *What is the impact of prior coding experience and prior acquaintance with coders on girls’ coding outcomes?* Prior coding experience significantly impacted pre-post gains in all six coding outcomes: interest in coding activities,$^{13}$ interest in coding applications,$^{14}$ interest in code related jobs/careers,$^{15}$ belief in ability to code,$^{16}$ belief in a code-related job/career being possible,$^{17}$ and behavioral intention to do coding activities in the future.$^{18}$

Prior acquaintance with coders did not have a significant effect on any of the coding outcomes.

$^{13} b = 0.07, 95\% \text{ CI } [0.02, 0.12], t(156) = 2.68, p = .008$

$^{14} b = 0.10, 95\% \text{ CI } [0.04, 0.16], t(156) = 3.45, p = .001$

$^{15} b = 0.10, 95\% \text{ CI } [0.01, 0.18], t(156) = 2.18, p = .031$

$^{16} b = 0.23, 95\% \text{ CI } [0.16, 0.30], t(156) = 6.64, p < .001$

$^{17} b = 0.12, 95\% \text{ CI } [0.07, 0.18], t(156) = 4.60, p < .001$

$^{18} b = 0.15, 95\% \text{ CI } [0.09, 0.22], t(156) = 4.77, p < .001$
Research question 2 asked: *To what extent do girls experience narrative involvement while viewing the shows?* Girls reported experiencing a high level of narrative involvement while watching the shows. They also reported high levels of involvement with each individual dimension comprising narrative involvement: story, character, and attentional focus. All three dimensions were significantly and positively associated.

**Overall narrative involvement scale**

After viewing all three shows, girls used a five-point scale from *strongly disagree* to *strongly agree* to rate their level of agreement with 25 statements for overall narrative involvement, comprising the three narrative involvement dimensions of story involvement, character involvement, and attentional focus. Mean scale ratings of these post-survey measures were used to address RQ2a: *To what extent do girls experience narrative involvement overall?* Girls reported experiencing a high level of overall narrative involvement while viewing the shows. The mean scores ranged from 2.0 to 5.0, with an overall mean of 4.1 and median of 4.2.

**Narrative involvement scale dimensions**

Mean scale ratings are presented below for the three scale dimensions to address RQ2b: *To what extent do girls experience the dimensions of story involvement, character involvement, and attentional focus?*

**Story involvement dimension**

Girls responded to a six-item agree-disagree scale about their cognitive and emotional involvement with the three-act story of the shows. Figure 5 presents the mean results for the six statements in order of the story arc. On average, girls experienced a high level of story involvement while watching the shows. The mean scores ranged from 2.2 to 5.0, with an overall mean of 4.2 and median of 4.3.

<table>
<thead>
<tr>
<th>Scale from 1.0 (strongly disagree) to 5.0 (strongly agree)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
</tr>
<tr>
<td>I wanted to discover what the girls would do with code.</td>
</tr>
<tr>
<td>Seeing that the girls would use coding pulled me into the stories.</td>
</tr>
<tr>
<td>It was interesting to learn about the challenges of coding.</td>
</tr>
<tr>
<td>I was happy to see the girls work through their coding problems.</td>
</tr>
<tr>
<td>I wanted to find out how the girls’ coding projects turned out.</td>
</tr>
<tr>
<td>I cared about seeing the girls present their coding projects successfully at the end of the shows.</td>
</tr>
</tbody>
</table>
**Character involvement dimension**

Girls completed a 15-item agree-disagree scale about their involvement with the girl characters in the *Code: SciGirls*! shows based on four categories of character involvement: liking, similarity, identification (empathy, cognitive, and motivational), and wishful identification. Figure 6 presents the mean results for the 15 statements. On average, girls experienced a high level of character involvement while watching the shows. The mean scores ranged from 1.7 to 5.0, with an overall mean of 4.0 and median of 4.1.

**Figure 6. Girls’ mean ratings of character involvement (N = 81)**

Overall mean rating (*M* = 4.0, *SD* = 0.64)

Scale from 1.0 (strongly disagree) to 5.0 (strongly agree)

1. I wanted the girls to be successful.
2. I wanted the girls to reach their goals.
3. The girls were fun to watch.
4. I liked the girls.
5. There are things I liked about the girls.
6. I understood the girls’ interest in their activities.
7. I understood why the girls made the choices they did.
8. I would like to do the kinds of things the girls did.
9. I felt the emotions that the girls expressed.
10. I could relate to what the girls were feeling.
11. The girls and I are similar in some ways.
12. The girls are the sort of people I want to be like myself.
13. I felt like I had things in common with the girls.
14. I wish I could be more like the girls.
15. The girls reminded me of myself.
**Attentional focus dimension**

Girls responded to a four-item agree-disagree scale about their attentional focus while watching the shows. Figure 7 presents the mean results for the four statements. On average, the girls experienced a high level of attentional focus. The mean scores ranged from 2.3 to 5.0, with an overall mean of 4.3 and median of 4.5.

![Figure 7. Girls' mean ratings of attentional focus (N = 81)
Overall mean rating (M = 4.3, SD = 0.64)](image)

### Relationship among narrative involvement dimensions

Correlational analysis of the post-survey narrative involvement rating scales addressed RQ2c: *Is there a relationship among the narrative involvement dimensions of story involvement, character involvement, and attentional focus?* The analysis found all three dimensions were significantly and positively associated, as presented in Table 3.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Story involvement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Character involvement</td>
<td>.76***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Attentional focus</td>
<td>.64***</td>
<td>.68***</td>
<td></td>
</tr>
</tbody>
</table>

*(p value significance levels are as follows: *.05, **.01, ***.001)*

|
RQ3: Relationship of narrative involvement and show enjoyment

Research question 3 asked: *What is the relationship between narrative involvement and show enjoyment?* On average, girls reported experiencing a high level of enjoyment viewing the shows. Overall narrative involvement and each of the three involvement dimensions were positively and significantly correlated with show enjoyment and each also had a significant direct positive effect on show enjoyment.

Show enjoyment scale

After viewing all three shows, girls used a five-point scale from *strongly disagree* to *strongly agree* to rate their level of agreement with four statements relating to their enjoyment of the shows. An overall mean scale rating was used to address RQ3a: *To what extent do girls experience show enjoyment?* Figure 8 presents the mean result for the overall scale and the four statements. On average, girls reported experiencing a high level of enjoyment while viewing the shows. The mean ratings ranged from 1.8 to 5.0, with an overall mean of 4.2 and median of 4.3.

![Figure 8. Girls' mean ratings of show enjoyment (N = 81)](image)

Overall mean rating ($M = 4.2, SD = 0.60$)

Scale from 1.0 (strongly disagree) to 5.0 (strongly agree)

I thought the shows were very interesting.

I enjoyed the shows very much.

I had a lot of fun viewing the shows.

I would like to watch more shows like these.

Relationships between narrative involvement and show enjoyment

Correlational analysis addressed RQ3b: *Is there a relationship between narrative involvement and show enjoyment?* As shown in Table 4, narrative involvement was significantly, positively and highly associated with show enjoyment, as were the three dimensions of story involvement, character involvement, and attentional focus.

<table>
<thead>
<tr>
<th>Correlations between show enjoyment and narrative involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Show enjoyment</strong></td>
</tr>
<tr>
<td><strong>Narrative involvement</strong></td>
</tr>
<tr>
<td>.85***</td>
</tr>
<tr>
<td><strong>Story involvement</strong></td>
</tr>
<tr>
<td>.77***</td>
</tr>
<tr>
<td><strong>Character involvement</strong></td>
</tr>
<tr>
<td>.80***</td>
</tr>
<tr>
<td><strong>Attentional focus</strong></td>
</tr>
<tr>
<td>.75***</td>
</tr>
</tbody>
</table>

*p value significance levels are as follows: *.05, **.01, ***.001*
Influence of narrative involvement on show enjoyment

PLS-SEM analysis addressed RQ3c: *Do overall narrative involvement and its three dimensions positively influence show enjoyment?* As illustrated in Figure 9, narrative involvement had a significant direct positive effect on show enjoyment.¹⁹

![Figure 9. The positive influence of narrative involvement on show enjoyment](image)

As illustrated in Figure 10, significant direct positive effects were also found for all three dimensions. In order of relative strength, character involvement,²⁰ attential focus,²¹ and story involvement each positively influenced show enjoyment.²²

![Figure 10. The positive influence of narrative involvement dimensions on show enjoyment](image)

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²⁰ $\beta = .44 \ [ .25 , 1 ]$, $t = 3.99$
²¹ $\beta = .30 \ [ .15 , 1 ]$, $t = 3.18$
²² $\beta = .23 \ [ .08 , 1 ]$, $t = 2.57$

---

¹⁹ $\beta = .87 \ [ .80 , 1 ]$, $t = 21.53$
RQ4: Influence of narrative involvement and show enjoyment on coding outcomes

Research question 4 asked: Do narrative involvement and show enjoyment positively influence the coding outcomes? Overall narrative involvement and the dimension of character involvement each had a direct effect on pre-post gain in interest in coding activities. Additionally, overall narrative involvement and the three involvement dimensions each had an indirect effect on pre-post gains in interest in code-related jobs/careers, belief in ability to code, and behavioral intention to do coding activities in the future. These indirect effects were fully mediated by show enjoyment.

Overall narrative involvement, the three dimensions of involvement, and show enjoyment did not have significant direct or indirect effects on the outcomes of interest in coding applications and belief that a code-related job or career is possible.

PLS-SEM analysis addressed RQ4a: Do overall narrative involvement and show enjoyment positively influence the coding outcomes? As illustrated in Figure 11, overall narrative involvement had a significant direct positive effect on pre-post gain in interest in coding activities\(^{23}\) and a significant indirect positive effect, fully mediated by show enjoyment, on interest in coding jobs/careers,\(^{24}\) belief in ability to code,\(^{25}\) and behavioral intention to do coding activities in the future.\(^{26}\) As neither overall narrative involvement nor show enjoyment had significant effects on the outcomes of interest in coding applications and belief that a code-related job or career is possible, these relationships are not included in the figure.

Figure 11. The positive influence of overall narrative involvement on coding outcomes

\(\beta = .53 \,[.25, 1], \, t = 2.91\)
\(\beta = .37 \,[.08, 1], \, t = 2.18\)
\(\beta = .45 \,[.15, 1], \, t = 2.43\)
\(\beta = .60 \,[.28, 1], \, t = 3.24\)
Narrative involvement scale dimensions

Correlational and PLS-SEM analyses also examined RQ4b: *Do the three dimensions of narrative involvement positively influence the coding outcomes?* Figure 12 illustrates the significant direct and indirect positive effects of the three narrative involvement dimensions on pre-post changes in coding outcomes. Character involvement directly influenced interest in coding activities, while all three narrative dimensions indirectly influenced interest in code-related jobs or careers, belief in ability to code, and behavioral intention to do coding activities, fully mediated by show enjoyment. As none of the dimensions had significant effects on the outcomes of interest in coding applications and belief that a code-related job or career is possible, these relationships are not included in the figure. Specific dimension results related to the coding outcomes are presented on the next page.

Figure 12. The positive influence of narrative involvement dimensions on coding outcomes
**Influence on coding interests**

As illustrated in Figure 12 on the previous page, character involvement had a direct positive effect on pre-post gain in interest in coding activities.\(^{27}\) Additionally, each of the three dimensions of narrative involvement had a significant indirect positive effect on interest in code-related jobs or careers, fully mediated by show enjoyment. In order of relative strength, character involvement,\(^{28}\) attentional focus,\(^{29}\) and story involvement each positively influenced girls’ pre-post gain via show enjoyment.\(^{30}\)

None of the scale dimensions were found to be significantly predictive of interest in coding applications.

**Influence on coding beliefs**

As also shown in Figure 12, each of the three narrative involvement dimensions had significant indirect positive effects on belief in ability to code, fully mediated by show enjoyment. In order of relative strength, character involvement,\(^{31}\) attentional focus,\(^{32}\) and story involvement each positively influenced girls’ pre-post gain via show enjoyment.\(^{33}\)

None of the scale dimensions were found to be significantly predictive of the belief that a code-related job/career is a possible outcome.

**Influence on coding behavioral intentions**

As also shown in Figure 12, each of the three narrative involvement dimensions had indirect positive effects on behavioral intention to do coding activities in the future, fully mediated by show enjoyment. In order of relative strength, character involvement,\(^{34}\) attentional focus,\(^{35}\) and story involvement each positively influenced girls’ pre-post gain via show enjoyment.\(^{36}\)

\(^{27}\) \(\beta = .50 \, [0.17, 1], \, t = 2.54\)

\(^{28}\) \(\beta = .18 \, [0.03, 1], \, t = 1.78\)

\(^{29}\) \(\beta = .12 \, [0.02, 1], \, t = 1.84\)

\(^{30}\) \(\beta = .09 \, [0.01, 1], \, t = 1.75\)

\(^{31}\) \(\beta = .24 \, [0.07, 1], \, t = 2.20\)

\(^{32}\) \(\beta = .16 \, [0.05, 1], \, t = 2.17\)

\(^{33}\) \(\beta = .12 \, [0.03, 1], \, t = 1.82\)

\(^{34}\) \(\beta = .30 \, [0.10, 1], \, t = 2.38\)

\(^{35}\) \(\beta = .20 \, [0.07, 1], \, t = 2.52\)

\(^{36}\) \(\beta = .15 \, [0.04, 1], \, t = 2.05\)
RQ5: Girls’ perceptions of the influence of story and characters on coding outcomes

Research question 5 asked: *How do girls perceive the influences of story and of girl characters on coding outcomes?* Half of the sample was asked about the influence of the stories and half about the influence of the girl characters. Almost all girls felt that watching the stories or girl characters positively affected their interest in coding and affected their belief in their ability to learn coding. Three-quarters of the girls felt that the stories or girl characters positively affected their belief that a coding job or career is possible for them. Two-thirds thought that the stories or girl characters positively affected their interest in code-related jobs or careers.

Both those asked about the effects of watching the stories or girls most often described how their viewing experience highlighted how coding works and what it can do, motivated them to code, informed them about coding applications, and showed that this kind of job/career could be fun, interesting, helpful, or creative. Additionally, those asked about the effects of watching the girl characters also noted that they were inspired by the girls’ excitement about coding; stated that if the girls onscreen could code, so could they; and appreciated the girls’ approach to their coding task, such as their perseverance, confidence, and/or teamwork.

<table>
<thead>
<tr>
<th>Table 5. Example comments about how watching the stories or characters positively affected girls’ interest in coding (n = 74)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>How stories positively affected coding interest</strong></td>
</tr>
<tr>
<td>• The stories affected my interest in coding because I saw how different types of coding worked.</td>
</tr>
<tr>
<td>• It made me want to try some of the websites that they used for coding and it made me want to discover how much I could do with coding.</td>
</tr>
<tr>
<td>• I have never thought coding could be fun and I never thought it would be something I would be interested in but the videos made it sound fun.</td>
</tr>
<tr>
<td>• It made me feel like I could actually code and not give up when a problem happened.</td>
</tr>
<tr>
<td><strong>How characters positively affected coding interest</strong></td>
</tr>
<tr>
<td>• Watching the girls affected my interest in coding because they used coding to help other people understand what it can do to help us in our daily lives. It made me want to code more often because they actually helped in real world problems and it affected how animals and people can live in a safe environment.</td>
</tr>
<tr>
<td>• When I watched on how they made a graph in the first video about red tide and the sting rays, I thought it was cool how they got to make their own graph. I would want to make a graph too.</td>
</tr>
<tr>
<td>• They made it look very fun even though they had challenges and problems, and they showed how you can make sure you don’t get a ton of mistakes by checking every line. It looked like they had fun and being very proud after finishing the project.</td>
</tr>
<tr>
<td>• The girls increased my capability of coding by showing me all of these inventions and how to make them. I also feel more confident about making codes because they showed me how great it was to share their experience to other people who want to learn the same way.</td>
</tr>
</tbody>
</table>

RQ5 asked: *How do girls perceive the influences of story and of girl characters on coding outcomes?* Given the study’s interest in understanding the influence of the shows’ stories and characters on coding outcomes, the content analyses of girls’ open-ended qualitative responses were considered to better understand how they perceived that the stories or characters influenced outcomes. As the shows did not address future coding possibilities or activities, and because of the necessity of restricting open-ended questions to not overburden participating girls, the question of how the story or girl characters affected behavioral intentions was not asked.

**Influence on interest in coding activities and applications**

To explore girls’ perceptions of how the shows’ narrative involvement dimensions of story and character affected their coding interest, half were asked to describe how watching the stories and half how watching the girl characters affected their interest in coding. To capture girls’ perspectives in
their own words and to avoid biasing their responses, this question was asked prior to participants responding to the post-survey scales of interest in specific coding activities and applications. Almost all (95%) of the girls who addressed the question (n = 78) thought that watching the stories or girl characters positively affected their interest in coding. Examples of their comments sorted by story/character are in Table 5 on the previous page. A small percentage (5%) felt their coding interest wasn’t affected and did not elaborate. Which question girls answered – story or character – did not influence their reporting of positive or neutral impact on their coding interest.

As shown in Figure 13, among those who indicated that watching the stories positively affected their coding interest (n = 36), the largest groups said they learned about how coding works and what it can do (47%) or that they were motivated to code/wanted to try coding (28%). Similarly, among those who indicated that watching the girl characters positively affected their interest in coding (n = 38), the largest groups pointed to the same two categories, learning how coding works/what coding can do (45%) and saying they were motivated to code/wanted to try coding (32%). In each case, smaller groups indicated that coding looked fun, cool, or not hard (stories 17%, characters 13%), or that they liked the girls’ approach to coding tasks in the shows, such as their perseverance and teamwork (stories 8%, characters 11%). The distributions across coding categories of positive impact responses were not significantly influenced by whether participants answered about stories or about girl characters.

Influence on interest in code-related jobs/careers

To explore girls’ perceptions of how the shows’ narrative involvement dimensions of story and character affected their coding job/career interest, half were asked to describe how watching the stories and half how watching the girl characters affected their interest in a code-related job or career. To capture girls’ perspectives in their own words and to avoid biasing their responses, this question was asked prior to their responding to the post-survey scale of interest in specific facets of coding jobs/careers. Of those girls who addressed the open-ended question (n = 78), two-thirds (65%) thought that watching the stories or girl characters positively affected their interest in code-related jobs or careers. Over one-third (35%) said their interest in this area wasn’t affected, either because they weren’t interested in this kind of job/career or because they were interested in coding activities but had little to no interest in working in this field. Examples of both types of comments sorted by story/character are in Table 6 on the next page. Which question girls answered – story or character – did not influence their reporting of positive or neutral impact on their interest in a code-related job.
As shown in Figure 14, among those who indicated that watching the stories positively affected their interest in code-related jobs/careers (n = 26), the largest groups said they felt more informed about coding applications (38%), that the stories portrayed coding as fun or cool (23%), that they were more interested in a code-related job/career without elaborating as to why (23%), or that they were inspired by the girl characters (8%).

Among those who indicated that watching the girl characters positively affected their interest in code-related jobs/careers (n = 25), the largest group similarly said they were more informed about coding applications (36%), while the next largest group described being inspired by girls in the show, particularly by their confidence and excitement about coding (24%). A fifth (20%) said they were more interested as a result of watching the girl characters but did not elaborate as to why, and one-sixth (16%) said watching the girl characters showed that coding is fun or cool. Smaller groups (stories 8%, characters 4%) said they were more interested, giving different reasons. The distributions across coding categories of positive impact responses were not significantly influenced by whether girls answered about stories or about characters.

Table 6. Example comments about how watching the stories or characters affected girls’ interest in code-related jobs/careers (n = 78)

<table>
<thead>
<tr>
<th>How stories affected interest in code-related jobs/careers</th>
<th>How stories positively affected interest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Watching the stories made me more interested in a coding job or career because it looked like there were a lot of different things you could do with coding.</td>
</tr>
<tr>
<td></td>
<td>• It affected my interest because it showed me that coding is fun and it made me like coding better.</td>
</tr>
<tr>
<td></td>
<td>• I wasn’t very interested in a code-related job before, but now I am somewhat interested.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How stories didn’t affect interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>• They didn’t affect my interest. I have my heart set on: Art, House or Fashion design.</td>
</tr>
<tr>
<td>• I don’t want coding to be my job, I want to do something else BUT I am still interested in learning more about it.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How characters affected interest in code-related jobs/careers</th>
<th>How characters positively affected interest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• I did code once and didn’t really like it but seeing all the things you can do might make me like it more. I really like art, so knowing that you can do a lot with code from seeing the girls made me see that maybe you can do code with art.</td>
</tr>
<tr>
<td></td>
<td>• I think watching the girls made me more interested in having a code-related job because they were so confident and excited to make their code and have fun doing it. And when they accomplished their goal it showed how happy they were to present it to help other people and it would be exciting to teach others about how you can change the world with code.</td>
</tr>
<tr>
<td></td>
<td>• They made hard challenges look fun.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How characters didn’t affect interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Not at all, I don’t want to be a coder..</td>
</tr>
<tr>
<td>• I think that by completing the projects and being so happy about it, I think it made me want to maybe do something like what they were doing but I still don’t think I want to have a code-related job or career.</td>
</tr>
</tbody>
</table>

Figure 14. How the stories and characters positively affected girls’ interest in a code-related job/career (n = 51)

<table>
<thead>
<tr>
<th>Percentage of girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
</tr>
<tr>
<td>10%</td>
</tr>
<tr>
<td>20%</td>
</tr>
<tr>
<td>30%</td>
</tr>
<tr>
<td>40%</td>
</tr>
<tr>
<td>50%</td>
</tr>
</tbody>
</table>

- More informed about coding applications
- More interested, no reason given
- Showed coding is fun or cool
- Inspired by girls
- More interested, other reason given

- Girls asked about the stories (n = 26)
- Girls asked about the characters (n = 25)
Influence on belief in ability to code

To explore girls’ perceptions of how the shows’ narrative involvement dimensions of story and character affected their belief in their ability to learn coding, half were asked to describe how watching the stories and half how watching the girl characters affected their confidence in their ability to learn code. To capture girls’ perspectives in their own words and to avoid biasing their responses, this question was asked prior to their responding to the post-survey scale of specific items related to their belief in their ability to code.

Of the participants who addressed the open-ended question (n = 77), almost all (90%) thought that watching the stories or girl characters positively affected their belief in their ability to learn coding. Examples of their comments sorted by story/character are in Table 7. About one-tenth (9%) said they weren’t affected, most often explaining that they were already confident or that their confidence was the same. A couple said they were negatively affected (3%) because they found some aspect of coding confusing. Which question participants answered – story or character – did not influence their reporting of positive, neutral, or negative impact on their belief in their ability to learn coding.

As shown in Figure 15, among those who indicated that watching the stories positively affected their belief in their ability to learn coding (n = 34), about a fifth each said they were motivated to code (21%), that coding looked fun or easy (21%), or that if the onscreen girls could code, then they could too (18%): whereas one-sixth (15%) focused on the onscreen girls’ approach to their coding tasks.

### Table 7. Example comments about how watching the stories or characters positively affected girls’ belief in their ability to learn to code (n = 69)

**How stories positively affected belief in ability to learn coding**
- The stories affected me by kinda making me want to try when I am older because the girls knew more than I did.
- Watching the stories made me more confident about learning coding because I realized it might be easier than I thought.
- Watching the shows gave me more of a confidence booster to know that I can code seeing them do it.
- It made me realize how challenging coding is but when they powered through their problems with coding it showed me how to find a mistake you made and how to power through challenges.

**How characters positively affected ability to learn coding**
- It built my confidence that I can do more coding. It also helped that if other girls can code, I can do it too.
- Watching the girls affected my confidence in coding because they never gave up. Coding seems hard, but by watching these girls code a lot of cool things, they make it seem so easy. I know it’s not, but while coding, the most important rule is to never give up.
- I feel more confident to code and even get a few of my friends so we can code together like they did.
- It gave me a lot of confidence because it made me see clearly what coding was and how I had done it before without realizing it was called coding.

---

![Figure 15. How the stories and characters positively affected girls' belief in their ability to learn coding (n = 69)](chart.png)
Of those who indicated that watching the characters positively affected their belief in their ability to code (n = 35), two-fifths (40%) thought that if the girls onscreen could code, so could they, whereas three-tenths (29%) focused on their approach to their coding task, such as their perseverance, confidence, and/or teamwork. Other responses were shared by smaller groups, including learning how coding works/what it can do (stories 12%, characters 9%), feeling confident (stories 15%, characters 6%), being motivated to code/want to try coding (characters 11%), and coding looked fun/easy (characters 6%). The distributions across coding categories of positive impact responses were not significantly influenced by whether participants answered a question about stories or about girl characters.

Influence on belief that a code-related job/career is possible

To explore girls’ perceptions of how the shows’ narrative involvement dimensions of story and character affected their belief that a coding job/career is possible, half were asked to describe how watching the stories and half how watching the girl characters affected their seeing a code-related job as possible for them. To capture girls’ perspectives in their own words and to avoid biasing their responses, this question was asked prior to their responding to the post-survey scale about their beliefs regarding specific facets of coding jobs/careers being seen as possible.

Of those participants who addressed the open-ended question (n = 78), almost three-quarters (73%) thought that watching the stories or girl characters positively affected their belief that a coding job/career is possible. Examples of their comments sorted by story/character are in Table 8. One-quarter (26%) said their belief wasn’t affected by the stories or characters, with most of these girls only briefly elaborating that they didn’t see coding as a “good” or “interesting” job/career for them or that nothing “changed” for them as a result of the viewing experience. Which question participants answered – story or character – did not influence their reporting of positive or neutral impact on their belief that a code-related job/career is possible.

As shown in Figure 16 on the next page, among those who indicated that watching the stories positively affected their belief that a coding job/career is possible (n = 26), the largest groups thought the stories showed that this kind of job/career could be fun, interesting, helpful, or creative (38%) or indicated they believed this future was more possible but didn’t elaborate as to why (27%).

<table>
<thead>
<tr>
<th>Table 8. Example comments about how watching the stories or characters positively affected girls’ belief that a coding job/career is possible (n = 57)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>How stories positively affected belief that career is possible</strong></td>
</tr>
<tr>
<td>Watching the stories made me want to do code as a job so that I could create different things.</td>
</tr>
<tr>
<td>Now that I’ve watched the videos I think that having a code related job is now much more possible than about a week ago.</td>
</tr>
<tr>
<td>It helped me understand the basics of coding and helped me realize that I could be a coding person for my job.</td>
</tr>
<tr>
<td><strong>How characters positively affected belief that career is possible</strong></td>
</tr>
<tr>
<td>They made it very fun and each one was about a different type of code and showed how each one was used. For each one they gave you a little info of what to make sure during your coding. One thing that I really liked is that they worked in 3’s, and I like working with other people and I thought coding was more independent work. But they showed how you can work with a group.</td>
</tr>
<tr>
<td>I guess I’m almost their age anyways so maybe for the first part of my years I could be a coder.</td>
</tr>
<tr>
<td>When I was watching the girls do the robotics, it made me feel like I could do it with them and I can learn a lot from it and possibly do it as a job.</td>
</tr>
</tbody>
</table>
Similarly, those who indicated that watching the girl characters positively affected their interest in coding (n = 31) most often pointed to finding the careers fun, interesting, helpful, or creative (42%) or said they believed this future was more possible without elaborating (35%). Smaller groups who said the stories or girl characters positively affected their belief that a coding job/career was possible said they had more confidence (stories 15%, characters 16%) or that they believed that the job was more possible but not desirable (stories 19%, characters 6%). The distributions across coding categories of positive impact responses were not significantly influenced by whether participants answered a question about stories or about characters.
Discussion

The Code: SciGirls! shows viewed by 5th grade girls in this study are story- and character-driven narratives, presenting groups of girls working with female professionals to use coding to solve community problems. Major theoretical models of media effects and research on adults agree that the extent to which individuals are involved in and attend to a world of both story and characters is a primary mechanism of persuading them to adopt messages presented in the narrative. This exploratory study expands that work to children by seeking to understand whether and how young girls’ involvement with the Code: SciGirls! shows’ narratives, and in particular the shows’ stories and characters, was related to and influenced their enjoyment of the shows and their coding interests, beliefs, and behavioral intentions toward coding and code-related careers.

Results related to coding outcomes

Viewing three Code: SciGirls! shows produced significant and positive gains for a diverse sample of 5th grade girls in four of the six coding outcomes measured in the study: interest in coding activities, interest in coding applications, interest in code-related jobs or careers, and belief in their ability to code. These pre-post gain results support the findings from numerous studies summarized in the background literature section that have shown that children who view narrative-based STEM television – including prior seasons of SciGirls shows – demonstrate increased interests and beliefs related to the media content. With respect to background variables, prior coding experience significantly impacted gains in all six coding outcome areas, while prior acquaintance with someone who codes had no such impact.

Viewing the three shows produced significant positive gains in all three interest scales: interest in coding activities, interest in coding applications, and interest in code-related jobs or careers. In open-ended responses, girls most often described how their viewing experience of the stories or girl characters highlighted how coding works and what it can do, motivated them to code, informed them about coding applications, and showed that this kind of job/career could be fun, interesting, helpful, or creative. These interest triggers parallel sources of situational interest summarized by Renninger and Hidi (2011), including features such as novel information, intensity, and meaningfulness. In their theory of the development of interest, Renninger and Hidi (2020) describe the early phases of interest as including both engagement with content (in this case, coding) as well as motivation to continue to seek opportunities to engage with that content.

After viewing the shows, the 5th grade girls demonstrated increased intention to do coding activities in the future, but such quantitative gain was not statistically significant. Although the six coding activities listed in the behavioral intention scale were thought to be within reach of most girls, the non-significant increase in coding intentions could reflect girls’ belief that they lack the opportunity in their communities to participate in some of the scale’s specific activities. We note, however, that in response to open-ended questions, about one-third of girls described that the stories or girl characters generally motivated them to code or want to try coding.
Viewing of the three shows positively and significantly increased girls’ belief in their own ability to code, with a large effect size. Although the Code: SciGirls! shows do not directly teach coding skills, the girl teams do model coding activities. In open-ended responses, two-fifths of the viewers who thought that watching the girl characters in the shows positively affected their belief in their ability to learn coding observed that if the onscreen girls could code, so could they. These results reinforce social cognitive theory and identification research (Bandura, 2001; Moyer-Gusé et al., 2011), which note that the vicarious experience of characters whom individuals can perceive as similar to themselves and who perform tasks novel to themselves leads to more positive feelings about their ability to do similar tasks.

Media research by Steinke et al. (2009) concluded that viewing televised scientist characters as vicarious role models led to a positive change in adolescent girls’ views of themselves in a future science career. Viewing Code: SciGirls! increased 5th grade girls’ belief that a code-related career was possible for them, but the gain was not statistically significant. The non-significant increase might be explained by the fact that the shows do not present a wide range of jobs or careers available to those with coding skills or by the fact that many young viewers noted in open-ended responses that they were already committed to a different career path. However, high correlations revealed that as girls demonstrated increased interest in code-related jobs, belief in their ability to code, and intention to do coding activities in the future, so too they showed increased belief that a code-related career was possible.

Results related to the influence of narrative involvement

Girls reported experiencing a high level of show enjoyment and overall narrative involvement while watching the Code: SciGirls! shows as well as high levels of involvement with each individual dimension comprising overall narrative involvement: story involvement, character involvement, and attentional focus. Overall narrative involvement and each involvement dimension were positively and significantly correlated with and had a significant direct positive effect on show enjoyment. Girls who experienced higher levels of overall narrative involvement and who experienced higher levels of story involvement, character involvement, and attentional focus, respectively, also showed significantly higher levels of show enjoyment. These results are comparable to results of studies of adults’ narrative involvement and enjoyment of video stimuli (Busselle & Bilandzic, 2009; Hall & Bracken, 2011; Quintero Johnson, 2011; Tal-Or & Cohen, 2010; Woolley, 2012).

In consideration of the central question of this study of how narrative involvement and show enjoyment influence coding outcomes, the study found both significant direct and indirect positive effects on pre-post gains for four of the six measured outcomes. Since interest is often noted as a precursor to changes in beliefs and behaviors, particularly among youth, the study included three interest outcomes. This study is the first to examine interest outcomes related to narrative involvement, as meta-analyses and reviews (Fitzgerald & Green, 2017; Tukachinsky & Tokunaga, 2013; van Laer et al., 2014) indicate a focus of the field on outcomes of beliefs and behaviors. Overall narrative involvement and the individual dimension of character involvement had significant direct positive effects on girls’ pre-post gain in interest in coding activities. Additionally, mediated fully by show enjoyment, overall narrative involvement and each of the three narrative dimensions had indirect effects on pre-post gains in interest in code-related jobs or careers. The third outcome of interest in coding
applications was not significantly influenced by overall narrative involvement, its individual dimensions, nor show enjoyment.

The meta-analyses of narrative studies with adults conclude that the more involvement in a story and its characters, the more likely individuals are to adopt story-consistent beliefs and behaviors. This study revealed that as girls are more involved with the Code: SciGirls! shows, the more they enjoyed the shows and the more they showed gains in their belief in their ability to code and their behavioral intention to do coding activities in the future. As multiple studies with adults have shown that narrative involvement is positively correlated with enjoyment of videos (Busselle & Bilandzic, 2009; Hall & Bracken, 2011; Quintero Johnson, 2011; Tal-Or & Cohen, 2010; Woolley, 2012), the present study built on this work by including a measure of show enjoyment to explore its relationship to narrative involvement and other study outcomes with children. Overall narrative involvement, via show enjoyment, indirectly influenced girls’ belief in their ability to code and their behavioral intention to do coding activities in the future. Belief that a code-related job or career is possible was not significantly influenced by overall narrative involvement, its individual dimensions, nor show enjoyment.

Limitations and future directions

Sample considerations

The study sample was restricted to 5th grade girls in order to limit the number of demographic and background factors considered in the analysis, which controlled for coding background and acquaintance with someone who codes. This design choice, in combination with the reliance on convenience sampling and the limited sample size, also limits the generalizability of the results. Additionally, while the sampling strategy aimed for and achieved a sample of participants that closely matched the October, 2019 census diversity statistics for 5th grade girls, other demographic and background factors were not formally addressed that might be important to consider in future studies with children.

As one example, since the participating girls accessed the Code: SciGirls! shows at home on computers with internet access, the study did not specifically address challenges that girls from low income families may face in online access. Although this was an initial concern, data presented in a 2016 Cooney Center study found that a vast majority of low- and moderate-income families with children in the SciGirls age range report online access via a mobile device or computer, even high-speed home access (Rideout & Katz, 2016). Online access likely has improved more recently due to the demands of pandemic-related virtual schooling, indicating this will be less of a factor in the future.

Study design

The study design had limitations in that the research questions were exploratory and relied on a one-group pre-post design, as detailed in the report. Future research could include experimental studies with non-narrative control or comparison groups to assess media experiences with youth that feature different levels or types of narrative. A recent meta-analysis that focused on such experimental narrative studies (Oschatz & Marker, 2020) found that narrative messages had a stronger influence on participants’ attitudes, intentions, and behaviors than non-narrative messages immediately after exposure and up to six months later. The authors concluded:
The current meta-analysis underscores the persuasive potential of narrative messages. Further research is needed to shed light on the mechanisms that facilitate the long-term persuasive effects of narrative communication and contribute to our understanding of the development of the persuasive effects over time and their boundary conditions. Experimental studies need to consider the diverse concepts of narrative involvement and, given their great variety, clearly state what concepts were used and which measures were applied (p. 490).

These meta-analysis findings pertain to adults, however. To date only one study with youth has evaluated such a comparison (narrative comic vs. non-narrative newsletter and attention control), but the authors did not find the same influence of narrative involvement as this study (Leung et al., 2017). Overall, the findings from the present study support Quintero Johnson’s (2011) conclusion that “audience involvement with EE [entertainment-education] television programs is multifaceted and influential. Future research should take into account the many ways in which people become involved with both the stories and story characters in EE programs” (p. 121).

An additional design limitation of the present study is the focus on immediate outcomes only. Whether the observed impacts with respect to coding interests and beliefs are sustained and the behavioral intentions translated into actual engagement in coding activities are unknown. The addition of a follow-up could be another design enhancement in future studies, drawing on the above meta-analysis finding that narrative impacts have been shown to persist well beyond the time of exposure (Oschatz & Marker, 2020).

**Scale development**

Although the original study plan proposed building on narrative transportation theory and scales previously developed and tested with adults, the validation process to expand scale use to a SciGirls’ youth audience with the shows required more than 300 5th grade student respondents, which was not possible during the COVID-19 pandemic. Instead, the research study implemented a pilot study to assess the applicability of adapting a unique three-act story arc involvement scale and character involvement scale to the Code: SciGirls! episodes that we previously developed and utilized with girl viewers of an earlier season of SciGirls programming (Knight Williams Inc., 2017). This study found the reliability of the involvement scales was high, as was the reliability for the other scales generated to assess coding interests, beliefs, and behavior intentions. These measures could be further developed in future evaluation or research more formally, as was initially planned.

**Practical implications**

The findings from this study further suggest that practitioners give strong consideration to the use of narrative-based media experiences to influence STEM outcomes in children relating to interests, beliefs, and behavioral intentions. The findings also point to the importance of formative evaluation for producers of STEM media to increase the likelihood of enjoyment of the story, close integration of STEM content in the storyline, and strong identification of viewers with characters. Most prior seasons of SciGirls have benefited from such evaluation, and this study’s findings indicate the value of even closer consideration of the narrative involvement dimensions assessed.
More broadly, the findings have practical implications for the design and implementation of informal STEM programs, and speak to design principles suggested by Habig et al. (2020) as part of a longitudinal analysis of the types of informal science education experience that foster persistence in STEM. These principles included:

(1) affording multiple opportunities to become practitioners of science; (2) providing exposure to and repeated experiences with STEM professionals such as scientists, educators, and graduate students to build social networks; (3) furnishing opportunities for participants to develop shared science identities with like-minded individuals; and (4) offering exposure to and preparation for a variety of STEM majors and STEM careers so that youth can engage in discovering possible selves (p. 1051).

The Code: SciGirls! shows, and the series in toto, incorporate elements of each of these principles by presenting project-based stories portraying diverse girl characters working together as a team and with STEM professionals on a variety of STEM topics. The findings from this study suggest that shows like SciGirls, when used in combination with other program elements, could work toward fulfilling these design principles.

**Conclusion**

In conclusion, with respect to coding outcomes, watching three Code: SciGirls! shows produced significant and positive gains in four of the six outcomes measured in the study. These findings add to results from evaluations of prior seasons of SciGirls that have similarly shown positive impacts on girl viewers’ STEM interests and beliefs. Taken together, the results lend support to the value of the series as a form of informal science entertainment-education for positively influencing young audiences who typically view the program on PBSKids.

With respect to narrative involvement, the results with children are consistent with theoretical models based on adult narrative research studies that emphasize that the extent to which individuals are involved in a world of both story and characters persuades them to modify their beliefs and behavioral intentions toward those presented in the narrative. This exploratory study breaks new ground in the field of narrative involvement by demonstrating that 5th grade girls experienced a high level of narrative involvement watching entertainment-STEM education programming designed for children, and that such involvement was significantly and positively predictive of their enjoyment of the shows and with pre-post gain in their interest in coding activities. These findings also contribute to the field of narrative studies more broadly, as there is no mention in prior meta-analyses of studies looking at changes in interest in content or messages as they might relate to narrative involvement.

Finally, the findings of indirect effects of overall narrative involvement, via show enjoyment, on the coding outcomes of interest in code-related jobs/careers, belief in ability to code, and behavioral intention to do coding activities in the future reflect results of one prior study with young adults in which program enjoyment mediated the positive effect of narrative involvement on behavioral intentions after viewing a television program on health topics (Quintero Johnson & Sangalang, 2017).
Acknowledging the study limitations of a small sample size and lack of a comparison or control group, the findings from this exploratory study are promising. Future media research with youth can build on many facets of this study’s design, measures, and results. Among the study’s key media design implications are that story- and character-driven entertainment-STEM education shows can be an effective way to involve young viewers, elicit show enjoyment, and significantly impact STEM outcomes.
References


Green, M. C. (2004). Transportation into narrative worlds: The role of prior knowledge and perceived realism. Discourse Processes, 38(2), 247-266. doi:10.1207/s15326950dp3802_5


National Center for Women and Information Technology. (July, 2020). Grade 4-12 computing program participant pre survey.
https://docs.google.com/document/d/10wsSzEDXrMTmaC2MiWZXcUHMdMS3KtqDsU6i7Fzu_w/edit#


Appendix 1. Individual background variable questions

Prior coding experience

The questions that follow ask about past experiences you may have had with computer coding or programming. Coding or programming means creating a set of written instructions in a special language to tell a computer what to do.

At this time, how familiar are you with the following relating to coding? Please select one number on the scale from 1 (not at all familiar) to 5 (very familiar).

<table>
<thead>
<tr>
<th>How familiar are you with ...</th>
<th>Not at all familiar</th>
<th>Slightly familiar</th>
<th>Somewhat familiar</th>
<th>Moderately familiar</th>
<th>Very familiar</th>
</tr>
</thead>
<tbody>
<tr>
<td>what coding or programming is?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>using or writing code yourself?</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Have you ever used code to do any of the following activities, either in school or out of school? For each activity, please select Yes, No, or I don’t recall.

<table>
<thead>
<tr>
<th>Have you ever...</th>
<th>Yes, I have</th>
<th>No, I haven’t</th>
<th>I don’t recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>played an online game to learn or practice coding?</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>used code to create a game?</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>used code to make an animation, movie, or music?</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>used code to make a graph?</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>used code to control technologies like robots, sensors, or cameras?</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
</tbody>
</table>

Have you ever used any of the following coding languages?

<table>
<thead>
<tr>
<th>Have you ever used...</th>
<th>Yes, I have</th>
<th>No, I haven’t</th>
<th>I don’t recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alice?</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>Blockly (“Hour of Code”)?</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>Python?</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>RobotC?</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
<tr>
<td>Scratch?</td>
<td>◯</td>
<td>◯</td>
<td>◯</td>
</tr>
</tbody>
</table>
Prior acquaintance with someone who codes

Do you know anyone who writes code or programs on a computer?

- Yes → If yes: Who do you know who writes code or programs on a computer?
- No

Prior acquaintance with *SciGirls* series

Before viewing the coding shows, how familiar were you with the *SciGirls* television series?

- I had never heard of the *SciGirls* television series
- I had heard of the television series but had not watched it
- I had watched the television series once
- I had watched the television series more than once
Appendix 2. Narrative involvement scales

### Story involvement

How much do you disagree or agree with each of the following statements about your experience with the shows?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Not sure</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I wanted to discover what the girls would do with code.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Seeing that the girls would use coding pulled me into the stories.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>It was interesting to learn about the challenges of coding.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I was happy to see the girls work through their coding problems.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I wanted to find out how the girls' coding projects turned out.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I cared about seeing the girls present their coding projects successfully at the end of the shows.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

### Character involvement

How much do you disagree or agree with each of the following statements about your experience with the girls in the shows? Please select one number on the scale from 1 (strongly disagree) to 5 (strongly agree).

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Not sure</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I liked the girls.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>There are things I liked about the girls.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The girls were fun to watch.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I felt like I had things in common with the girls.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The girls and I are similar in some ways.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The girls reminded me of myself.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I felt the emotions that the girls expressed.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I could relate to what the girls were feeling.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
I understood why the girls made the choices they did.

I understood the girls’ interest in their activities.

I wanted the girls to reach their goals.

I wanted the girls to be successful.

I would like to do the kinds of things the girls did.

The girls are the sort of people I want to be like myself.

I wish I could be more like the girls.

<table>
<thead>
<tr>
<th>Attentional focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much do you disagree or agree with each of the following statements about your experience with the shows?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Not sure</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>The shows really grabbed my attention.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I found it easy to concentrate on viewing the shows.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>My mind was focused on the shows as I watched.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I paid attention to what was going on in the shows.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Appendix 3. Outcome scales and questions

(Modifications for the post-survey questions appear in parentheses in the questions below)

### Show enjoyment

Indicate how much you disagree or agree with each of the following statements about your experience with the shows by selecting one number on the scale from 1 (strongly disagree) to 5 (strongly agree).

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Not sure</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I enjoyed the shows very much.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I had a lot of fun viewing the shows.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I thought the shows were very interesting.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I would like to watch more shows like these.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

### Interest in coding activities

At this time (After watching the shows), how interested are you in the following activities related to coding? Please select one number on the scale from 1 (not at all interested) to 5 (very interested).

<table>
<thead>
<tr>
<th>How interested are you in ...</th>
<th>Not at all interested</th>
<th>Slightly interested</th>
<th>Somewhat interested</th>
<th>Moderately interested</th>
<th>Very interested</th>
</tr>
</thead>
<tbody>
<tr>
<td>using code to create animation?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>using code to make a graph?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>writing your own code?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>using code to control technologies like robots, sensors or cameras?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>solving or figuring out coding challenges?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>playing an online game to learn or practice coding?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
### Interest in coding applications

At this time (After watching the shows), how interested are you in the following ways in which coding is used?

<table>
<thead>
<tr>
<th>How interested are you in ...</th>
<th>Not at all interested</th>
<th>Slightly interested</th>
<th>Somewhat interested</th>
<th>Moderately interested</th>
<th>Very interested</th>
</tr>
</thead>
<tbody>
<tr>
<td>how coding can address real world problems?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>how coding is used in the sciences, like astronomy or ecology?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>how coding can be used to inspire action?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>how coding is used in the arts, like animation or music?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

### Interest in code-related jobs or careers

At this time (After watching the shows), how interested are you in code-related jobs or careers?

<table>
<thead>
<tr>
<th>How interested are you in ...</th>
<th>Not at all interested</th>
<th>Slightly interested</th>
<th>Somewhat interested</th>
<th>Moderately interested</th>
<th>Very interested</th>
</tr>
</thead>
<tbody>
<tr>
<td>learning about coding jobs or careers?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>working on coding projects in a future job or career?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>exploring what is involved in preparing for careers that use coding?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

### Belief in coding ability

Regardless of whether or not you have learned about coding previously (After watching the shows), how confident you are at this time that you can do each of the coding activities listed below? Please select one number on the scale from 1 (not at all confident) to 5 (very confident).

<table>
<thead>
<tr>
<th>How confident are you that you can ...</th>
<th>Not at all confident</th>
<th>Slightly confident</th>
<th>Somewhat confident</th>
<th>Moderately confident</th>
<th>Very confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>use code to control robots, sensors or cameras?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>choose a correct code to move an object on a computer screen?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>create code sequences that tell a computer what to do?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Belief that coding-related job is possible for themselves

At this time (After watching the shows), how much do you disagree or agree with each of the following statements about computer coding? Please select one number on the scale from 1 (strongly disagree) to 5 (strongly agree).

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Not sure</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think like a coder.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I believe that a code-related job is possible for me.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I could become a coder if I wanted to.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>People like me can do well in coding jobs.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I can picture myself as a coder.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I believe I can be successful in a career in coding.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Behavioral intention to do coding activities in the future

(After watching the shows,) How likely are you to do the following coding activities in the future, if given the opportunity? Please select one number on the scale from 1 (not at all likely) to 5 (very likely).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Not at all likely</th>
<th>Slightly likely</th>
<th>Somewhat likely</th>
<th>Moderately likely</th>
<th>Very likely</th>
</tr>
</thead>
<tbody>
<tr>
<td>ask someone who knows about coding what you can do to get better at coding?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>play an online game to learn or practice coding?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>sign up for an out-of-school activity about coding?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Qualitative interest and belief questions

To help support interpretation of the quantitative scales in relation to involvement with story and characters, open-ended questions were interspersed between rating scales asking half of the participant sample about influence of the stories (n = 41) and half about influence of the girl characters on interest (n = 40):

Please describe how watching the stories/girls affected your interest in coding.

Please describe how watching the stories/girls affected your interest in a code-related job or career.

Please describe how watching the stories/girls affected your confidence in your ability to learn to code.

Please describe how watching the stories/girls affected your seeing a code-related job as possible for you.
Appendix 4. Correlation matrix of study variables

<table>
<thead>
<tr>
<th></th>
<th>Show enjoyment</th>
<th>Narrative involvement</th>
<th>Attentional focus</th>
<th>Story involvement</th>
<th>Character involvement</th>
<th>Interest in coding activities</th>
<th>Interest in coding applications</th>
<th>Interest in code-related job/career</th>
<th>Belief in ability to code</th>
<th>Belief in code-related job/career being possible</th>
<th>Behavioral intention to code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Show enjoyment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Narrative involvement</td>
<td>0.85***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attentional focus</td>
<td>0.73***</td>
<td>0.78***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Story involvement</td>
<td>0.77***</td>
<td>0.87***</td>
<td>0.64***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Character involvement</td>
<td>0.80***</td>
<td>0.97***</td>
<td>0.68***</td>
<td>0.76***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest in coding activities</td>
<td>0.41***</td>
<td>0.48***</td>
<td>0.36***</td>
<td>0.42***</td>
<td>0.48***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest in coding applications</td>
<td>0.10</td>
<td>0.12</td>
<td>0.04</td>
<td>0.16</td>
<td>0.10</td>
<td>0.64***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest in code-related job/career</td>
<td>0.27*</td>
<td>0.24*</td>
<td>0.16</td>
<td>0.15</td>
<td>0.26*</td>
<td>0.26*</td>
<td>0.33**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belief in ability to code</td>
<td>0.25*</td>
<td>0.15</td>
<td>0.06</td>
<td>0.22</td>
<td>0.12</td>
<td>0.06</td>
<td>0.22*</td>
<td>0.14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belief in code-related job/career being possible</td>
<td>0.33**</td>
<td>0.33**</td>
<td>0.29**</td>
<td>0.22</td>
<td>0.34**</td>
<td>0.24*</td>
<td>0.13</td>
<td>0.42***</td>
<td>0.31**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral intention to code</td>
<td>0.30**</td>
<td>0.15</td>
<td>0.20</td>
<td>0.07</td>
<td>0.14</td>
<td>0.23*</td>
<td>0.33**</td>
<td>0.49***</td>
<td>0.51***</td>
<td>0.54***</td>
<td></td>
</tr>
</tbody>
</table>

Results (p value significance levels are reported as follows: *.05, **.01, ***.001).