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Impact of Exposure to a Counter-Stereotypical STEM Television Program on Children's Gender- and Race-Based STEM Occupational Schema

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Abstract: Gender and racial diversity in STEM has been deemed an essential need for a sustainable future, but girls and children from underrepresented racial/ethnic backgrounds continue to show less interest in STEM than their White and male counterparts. Media has been shown to reflect children's occupational schema from an early age, and therefore might be used to help broaden children's beliefs about who participates in STEM. In this field-based pre/post-experimental study, children in kindergarten and first grades (N = 48, 62.5% female, M_{age} = 6.57) viewed episodes of a STEM-focused educational television series that features a diverse group of protagonists two to three times a week for eight weeks. Their occupational schema were measured before and after exposure. Results suggest there was no quantifiable change in their attitudes. However, qualitative analysis of their open-ended responses sheds light on how children's beliefs about who participates in STEM are shaped, i.e., by both mediated and real-world exposure.

Keywords: occupational attitudes; STEM identity; gender; race; children's television

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1. Introduction

Knowledge, skill, and efficacy in science, technology, engineering, and mathematics (STEM) are essential for preparing children for an increasingly technological global workforce, which in turn is essential for a sustainable future [1,2]. The likelihood that school-age children will participate in the STEM workforce later in life is highly dependent on their early attitudes toward STEM subjects [3,4]. However, U.S. students' interest in STEM is relatively low when compared to their international peers, which contributes to the U.S. lagging behind other countries in STEM achievement [5–7]. This is true not only for American children, but also for children in similarly industrialized countries where quality of life is generally high and pressure to pursue specific careers is low [5]. In order to address this 'STEM gap' and to move towards achieving the UN's Sustainable Development Goals, it is essential that we better understand how children's early attitudes towards STEM are formed and what factors might influence children to want to pursue a STEM career later in life.

Media is one environmental factor shown to shape children's attitudes and beliefs [8]. Educational television, especially, has been found to boost children's positive attitudes towards learning and specific school subjects. Fisch [9] explains that one of the ways that educational television can supplement formal education is by encouraging positive attitudes toward academic subjects, especially among populations that are less likely to pursue those subjects on their own. This idea that educational television can promote learning and attitudes towards learning is well documented [10–13]. However, it is unclear

from extant research whether educational television can have a measurable impact on children's career interests and occupational schema. This paper presents an experimental study that investigates the ability of a STEM-focused educational television show to shape children's expectations about who participates in STEM and in STEM careers.

1.1. Early Attitudes towards STEM Careers

Historically, the association between STEM interest and participation in STEM career pathways has been studied most rigorously in the context of postsecondary education [14,15]. However, there is recent mounting evidence that attitudes towards STEM develop early and persist into adulthood. Maltese and Tai [16] found that eighth-grade students who believed science would be useful in their future and who were interested in a science career were more likely to earn degrees in STEM. Sadler, Sonnert, Hazari, and Tai [17] found that students' career interests when entering high school were the strongest predictors of their career interests when leaving high school. Going even younger and looking at elementary/primary school children, Auger, Blackhurst, and Wahl [18] found that first-graders' self-reported career aspirations were just as specific and realistic as those of fifth graders. Selkow [19] investigated kindergarten and first-graders' occupational choices and found significant differences as a result of maternal employment status, suggesting that even as early as kindergarten, children's occupational interests have real, concrete connections to their real-world exposure and experience. These findings, combined with the knowledge that achievement gaps in science and math begin before first grade [20,21], provide strong reason to investigate the ability of educational media to influence young children's attitudes and beliefs about who participates in STEM.

1.2. Media and the Development of Occupational Schema

Much of the existing work on the presence of occupational portrayals in the media has focused on adult-directed television. For example, Signorielli [22] found that women on television, and particularly African American women, had the least diversity and the least prestige in terms of the occupations in which they were portrayed. A 2012 report by the Geena Davis Institute on Gender in Media specifically investigated sex roles and occupational portrayals in children's television and family films. The authors found that despite women comprising 47% of the U.S. labor force, they represented only 25% of employed characters in children's television shows [23].

These media portrayals begin to have an effect on viewers from an early age [24]. Research suggests that young children are likely to develop occupational schemas that reflect the images they see on television [22], and that gender- and race-based occupational schemas are in place by age six [25,26]. Jeffries-Fox and Signorielli [27] found that middle school children who watched more television were more likely to want more glamorous and high-status jobs, like those most often portrayed on TV. Similarly, Signorielli [28] found that high school students who watched more television aspired to high-status jobs that allowed them to make a lot of money, much like the TV characters they frequently viewed. In 1974 study, Beuf [29] looked at preschoolers' gendered occupational aspirations in relation to the amount of television they viewed. She found that children held sharply contrasting beliefs about which occupations should be held by men and which should be held by women. For example, on average, children reported that doctors and telephone repairpersons could only be men, while feeding a baby was a woman's job. Though the specific examples used in that study are now somewhat dated, the major finding of Beuf's [29] study that is still relevant today was that the more television the children watched, the more likely they were to apply gender stereotypes to careers and household work roles.

1.3. The Need for Diverse STEM Portrayals

Not only are American children's attitudes towards STEM concerningly low [5,30], their ideas about who participates in STEM are also quite narrow. A meta-analysis by Miller and colleagues [31] showed that, despite gradual improvement over the last fifty years, when children are asked to draw a scientist, the majority of drawings still depict

White men. These impressions are not inaccurate as women and people of color are largely underrepresented in STEM fields in the United States and other western industrial nations [32]. Blickenstaff [33] writes that there is no singular reason why this is the case, but that it is a complex and multi-faceted problem. The underrepresentation of female characters and racially diverse characters in STEM television shows [34,35] is likely one contributing factor.

It is not only critical that girls and children of color believe they can pursue STEM, but also that all children believe that girls and children of color can pursue STEM. Studies show that women, and particularly women of color, often drop out of the STEM pipeline even after receiving STEM degrees in higher education because of hostile work environments [17,36]. In other words, it is not that they do not believe they are smart enough or capable enough; the problem often lies in the fact that their White male colleagues do not see them as equal and valuable. Many studies have looked at ways to increase girls' self-efficacy in STEM, e.g., [37–39], or racial minority students' self-efficacy in STEM, e.g., [40,41], but in addition to boosting self-efficacy for individuals from these underrepresented groups, we must also work to broaden all children's ideas about who participates in STEM. Accordingly, this study utilizes a sample of children that roughly reflects the population of the U.S. in terms of gender and race in order to investigate whether exposure to a STEM television show that features girls and racially diverse characters can impact children's ideas about who holds STEM careers.

1.4. Television Viewing and Attitude Change

1.4.1. Theoretical Frameworks

The relationship between television exposure and attitude change is complex, but significant effects have been shown across many domains, from political attitudes and beliefs to health attitudes and behaviors [42,43]. For children specifically, researchers have found effects of television exposure on social attitudes [44], racial attitudes [45], sex role attitudes [46], and attitudes towards learning [11]. Cultivation theory [47] and social cognitive theory [48] are two useful frameworks for understanding the relationship between exposure and attitudes. Cultivation theory suggests that heavy television viewers are more likely to adopt attitudes that are consistent with the themes portrayed on television. Via long-term, cumulative media exposure, we come to view the world through the perspective that is most dominant in the media [47]. Social cognitive theory posits that people learn not only through their own experience, but also through the observation of others' actions, including those of media figures, and the consequences of those actions [49]. In the context of the current study, both of these theories would suggest that exposure to programs that portray all different types of characters modeling STEM behaviors, and, importantly, showing intrinsic and extrinsic rewards for STEM participation, would lead children to believe that they also can and should participate in STEM, whether they are boys, girls, Black, White, etc.

1.4.2. Single vs. Repeated Exposure

Specifically looking at exposure to a science show and children's reported interest in science, Mares, Cantor, and Steinbach [50] found that while one-time exposure did not affect attitudes, repeated exposure over the course of eight weeks did have a significant effect on attitudes towards science. Other studies have similarly found long-term and/or regular exposure to be more effective at influencing attitudes than short-term or one-time exposure. Interestingly, Bond [37] found that a single, one-time exposure was enough to influence attitudes in a negative, stereotypical direction. However, there were no effects of one-time exposure for children who were exposed to positive, counter-stereotypical STEM depictions. The author points out that more research is needed to determine if long-term and/or repeated exposure to counter-stereotypical STEM depictions might influence children in a positive way. Building from that work, and guided by the tenets of cultivation and social cognitive theories, the current study investigates the effects of eight weeks of

exposure to counter-stereotypical depictions of STEM engagement. Figure 1 presents a graphical depiction of the theory of change undergirding this study.

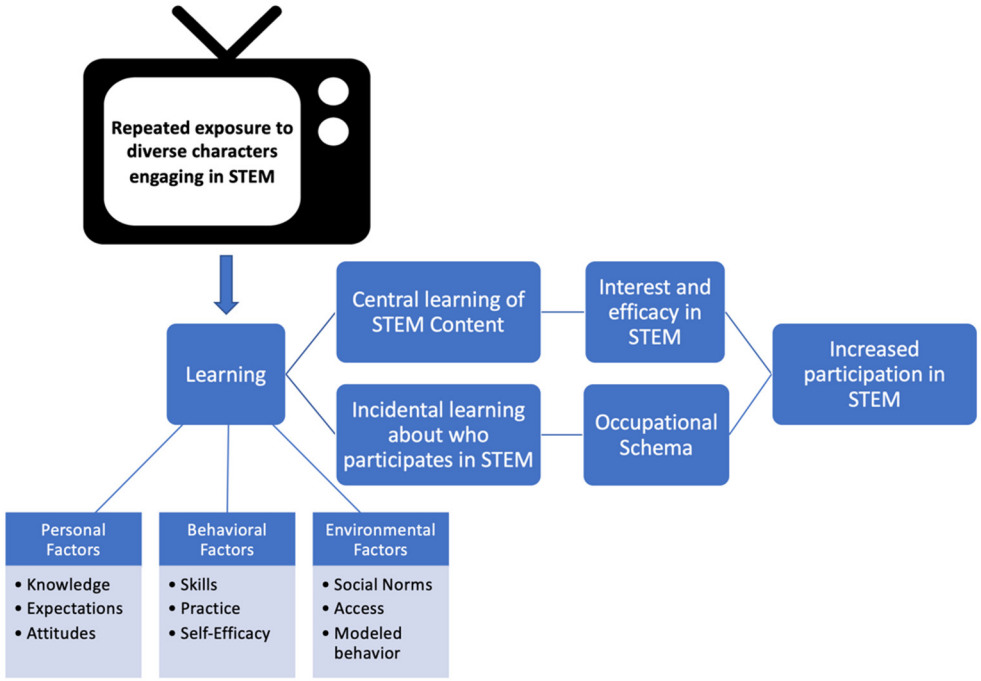

Figure 1. Theoretical model of the effects of repeated exposure to STEM-focused educational television featuring diverse characters. This model incorporates elements of Bandura's social cognitive theory and Gerbner's cultivation theory.

1.5. The Current Study

Based on the theoretical frameworks presented above and the limited extant literature in this area, we hypothesized that repeated exposure to counter-stereotypical STEM portrayals might in fact positively influence young children's attitudes and beliefs about who participates in STEM. Specifically, we hypothesized:

Hypothesis 1 (H1). *Repeated exposure to a counter-stereotypical STEM program will be related to broader ideas about women and girls participating in STEM compared to a control group.*

Hypothesis 2 (H2). *Repeated exposure to a counter-stereotypical STEM program will be related to broader ideas about individuals from underrepresented racial/ethnic backgrounds participating in STEM compared to a control group.*

Given the relative dearth of research exploring children's race- and gender-based occupational attitudes, we also sought to explore how children themselves would describe and/or explain their biases in these areas. Specifically, we asked:

RQ1: (a) How do children articulate their explicit attitudes and beliefs about who participates in STEM? (b) What information to they draw from to form judgments about who participates in STEM?

2. Materials and Methods

2.1. Study Design

To address our hypotheses and research questions, we conducted a pre/post-experimental study that took the shape of a media intervention. The study was conducted in before- and after-school childcare centers in a suburb of a large city in the Midwestern United States. Over the course of eight weeks, participants in the treatment group regularly viewed episodes of *Cyberchase*, a STEM show that features main characters who are diverse

in terms of race and gender and exhibit high levels of STEM engagement. Participants in the control group went about business as usual. All participants completed assessments before and after the eight-week exposure period.

2.2. Study Sites and Recruitment

After approval of the study by the university's Institutional Review Board, three local childcare programs were contacted and informed about the study and agreed to take part. These childcare centers provide before- and/or after-school care for elementary school-aged children. The programs are relatively unstructured; students can engage in a variety of games and activities, do homework, and eat snacks. Center directors sent consent forms home to parents of all kindergarten and first graders at their centers. Parents who consented to have their child participate were also asked to complete an online survey to provide demographic information about their family. One center had two participating locations, resulting in four study sites. The study sites were randomly assigned to either the treatment or control condition.

2.3. Participants

A total of 55 children were recruited into the study across the three participating centers. Of the 55 children whose parents granted consent, 48 successfully completed all components of the study (i.e., pretest assessment, posttest assessment, and, for treatment group, viewed at least 50% of the episodes) and, thus, could be included in analyses. The final sample of 48 children (n = 25 treatment, n = 23 control) were 62.5% female and ranged in age from 5.5 to 7.53 years (M = 6.57, SD = 0.52). The sample was quite diverse in terms of race/ethnicity and also included some socioeconomic diversity (i.e., about 20% of the sample reported household incomes between USD 60,000 and 85,000, whereas the median household incomes in the school districts we sampled from range from USD 85,469 to 123,618). Table 1 presents demographic information of the treatment and control groups. *t*-tests revealed no significant differences between treatment and control groups on any demographic variables.

Table 1. Participant Demographics.

Variable	Control		Treatment	
	Mean (SD)	**Percent**	**Mean (SD)**	**Percent**
Child Age (in years)	6.29 (0.67)		6.83 (0.48)	
Gender				
Males		43.5		45.4
Females		56.5		54.5
Race				
White		56.5		66.7
Black		26.1		16.7
Asian		4.3		4.0
Hispanic		4.3		16.7
Other		8.6		8.0
Household Income				
USD 60,000–84,999		21.3		18.2
USD 85,000–99,999		9.0		0.0
>USD 100,000		69.7		81.8
Parental Education				
Bachelor's Degree		43.5		36.4
Master's Degree		29.1		36.4
Professional/Doctorate Degree		27.4		27.2
Parent Age (in years)	37.30 (4.76)		39.91 (2.43)	
Parent's Relationship to Child				
Mother		78.3		64.0
Father		21.7		36.0

2.4. Procedure

2.4.1. Pre- and Posttest

Participants were interviewed in a quiet space in their childcare classroom. Each one-on-one interview session lasted approximately 15–20 min. In addition to the occupational attitudes measure reported in this study, participants also completed several additional measures reported in a separate study: program and genre familiarity, attitudes towards STEM, program appeal, and parasocial relationships. Interviews were audio recorded for later transcription. It took approximately two weeks to complete pretest interviews for all participants across the three centers. After exposure, posttest interviews took an additional two weeks.

2.4.2. Exposure

Participants in the treatment condition watched an episode of *Cyberchase* two or three times a week for eight weeks (the exposure length was determined based on research by Mares et al., 1999). Viewing sessions were conducted by the lead researcher or a trained research assistant. For each viewing session, the researcher took the participating students to one side of the classroom or an adjacent classroom. The episodes were shown using a classroom projector with children sitting on a rug approximately four to six feet in front of the screen. Viewing occurred in groups of 8–14 children at a time. The researcher took attendance at each viewing session to ensure that all participating children watched at least two episodes every week. In order to accomplish that goal, sometimes the researcher would need to come in on a third day, which resulted in some children occasionally viewing three episodes in a week. Children were instructed to sit and watch the video quietly. Most children were excited about the opportunity to watch the show, and thus were quite attentive throughout. There was often laughter at jokes, and occasionally children made remarks aloud such as, "Why are they doing that". The researchers would reply with a reminder to keep watching, such as "I don't know, let's keep watching and see what happens".

During the eight-week exposure period, children in the control condition went about business as usual. They did not view any videos during their before- or after-school programs. They participated in activities that were very similar to what children in the treatment group did when they were not in viewing sessions, such as coloring, reading books, making jewelry, playing board games, etc.

2.5. Stimulus

The stimulus program for this study was chosen using data from a prior content analysis of children's STEM-focused television [34]. Our goal was to select a STEM program that (A) showed high levels of STEM engagement from main characters (i.e., modeling of STEM behaviors such as asking questions, making observations, investigating, and problem solving), and (B) did a particularly good job of featuring characters that were diverse in terms of both gender and race. To accomplish this goal, we created a mathematical formula that ranked each of the 30 STEM programs included in the content analysis on both of those features. Since the main unit of analysis in coding was the individual character, the value of a show was posited to be the sum of the value of each individual character within that show. Each character's value was calculated as the sum of their STEM engagement weighted by the centrality of the character to the show (i.e., major characters were weighted more heavily than minor characters), with multipliers for female and minority characters. A show value for each program was then calculated as the sum of all character values, and the 30 programs were ranked based on their show values. Creation of the formula was an iterative process that included several stages of trial and error to ensure that the rankings produced by the formula both matched expectations of face validity and took the form of a roughly normal distribution with appropriate variance, skew, and kurtosis. The program that came out as number one in the final ranking (as well as in several other iterations of the formula and rankings) was *Cyberchase*, and thus, this was chosen as the stimulus program.

Cyberchase is an animated PBS show designed to teach math concepts "in a fun way that kids can understand" (http://www.pbs.org/parents/Cyberchase/about-Cyberchase/, accessed on 17 March 2018). The main team of protagonists includes Jackie, an African American girl, Inez, a Latin-American girl, and Matt, an Irish-American boy. These three main characters, often referred to as the Cybersquad, are accompanied by Digit, a "cybird" who helps them solve problems in order to defeat the evil villain Hacker. Along the way, they learn that math is everywhere and that it is a useful tool for solving problems. In "For Real," the live-action segment following each animated episode, adults show the viewers how math can help solve life's problems in the real world. Common Sense Media rates *Cyberchase* as appropriate for children ages 5 and up, which made it perfectly appropriate for the kindergarten and first graders in the study sample. Participants were shown a random selection of episodes from the two most recent fully available seasons of *Cyberchase* (seasons 8 and 9). The episodes were shown in relative sequential order, though the narratives are not interdependent, so missing an episode did not pose any comprehension problems for the participants. Anecdotally speaking, participants were unfamiliar with *Cyberchase* before the study, but seemed to enjoy the show quite a bit, and were always excited when it was time to watch another episode.

2.6. Measures

2.6.1. "Me/Not Me" Self-Identification Task

In order to have an understanding of the individual contexts participants were bringing into the study, it was important to know how the children self-identified, both in terms of gender and race, and in terms of their relationship to STEM. Self-identification was measured using the "Me/Not Me" task, adapted from Rogers and Meltzoff [51]. The task included the following social identity labels: boy, girl, daughter, son, brother, sister, Asian, Black, Latino/a, White, student, athlete, artist, scientist, problem solver, investigator. Following the procedure used by Rogers and Meltzoff (2017), the order of presentation was held constant for each participant. For each card, the child was asked, for example, "Are you a [boy]?" and told to sort the card into the "Me" pile if the label described them and into the "Not me" pile if it did not. After all cards were sorted in this manner, the researcher verbally went through each pile again and gave the child an opportunity to revise any selections. Labels placed into the "Not Me" pile were coded as 0, and labels placed into the "Me" pile were coded as 1.

2.6.2. Occupational Attitudes

The occupational attitudes measure, used at pre- and posttest, was created specifically for this study and was informed by previous research [25,26,29]. Due to time and space constraints of data collection, we did not use a traditional implicit association test (IAT) for this measure. Instead, we used pictorial response options and asked for children's quick 'gut reactions' as a quasi-implicit measure (adapted from [25,26]), and then asked them to verbally elaborate on their response in order to capture their explicit attitudes (adapted from [29]).

The measure consisted of 12 items, six of which were designed to capture children's adherence to gender stereotypes about STEM occupations, and the other six of which were designed to capture children's adherence to racial stereotypes about STEM occupations. For the first four items, participants were shown an illustrated picture of a boy and a girl. The boy and girl were dressed very similarly in a t-shirt and jeans and both were carrying a book and wearing a backpack (i.e., intended to look like ordinary schoolchildren), and both were Caucasian with brown hair and brown eyes (i.e., holding race as a constant while manipulating gender). Participants were asked to select "Which of these kids is more likely to grow up and become a [scientist, mathematician, engineer, computer programmer]?" Participants could answer verbally or point to the picture of the boy or girl to select their answer. After each question, the researcher asked the participant to explain why they chose the answer they gave, and responses were recorded verbatim for later analyses.

The next four questions were identical to the first four, except that rather than a picture of a boy and girl, the picture showed two boys, one White and one Hispanic, who were otherwise depicted very similarly, both with a backpack and book and similar clothing (i.e., manipulating race while holding gender as a constant). Again, participants were asked to select "Which of these kids is more likely to grow up and become a [scientist, mathematician, engineer, computer programmer]?" and were asked to explain why they thought that was true.

The final four questions consisted of four different drawings: a Black male scientist next to a Black female scientist, a White female computer programmer next to a White male computer programmer, a Black male airline pilot next to a White male airline pilot, and a Black female doctor next to a White female doctor (the former two manipulating gender and the latter two manipulating race). For each drawing, participants were asked "Which of these two people do you think really works as a [scientist, computer programmer, airline pilot, doctor]?" and "Why do you think that?". In each drawing, the two people were dressed in the same clothes and carrying the same materials and were drawn to look as identical as possible aside from the gender or race. All drawings were created specifically for this study by a locally commissioned artist to allow for a clean manipulation of only the race or gender while keeping everything else about the pictures constant. Figure 2 shows examples of the images used in this measure.

(**a**) (**b**)

Figure 2. Examples of image prompts from the occupational attitudes measure. Participants were asked "Which of these two people do you think really works as a [(**a**) computer programmer] [(**b**) doctor]?". There were twelve items total: (**a**) six items manipulated gender while holding race constant; (**b**) six items manipulating race while holding gender constant.

To create a quantitative measure of participants' gender- and race-based occupational attitudes, responses from the six gender manipulation items were summed to create a scale that measured participants' adherence to traditional gender stereotypes about STEM occupations, and responses from the six race manipulation items were summed to create a scale that measured participants' adherence to traditional racial stereotypes about STEM occupations. For each item, the more stereotypical responses (White or male) were scored as a 1 and the less stereotypical responses (non-White, female, or both) were scored as a 0, such that higher scores on the summed 0–6 scales represented greater adherence to stereotypes.

2.6.3. Coding of Open-Ended Responses

To explore RQ1, we conducted a qualitative content analysis of participants' responses to the open-ended 'why' component of the measure. Qualitative content analysis is an analytical technique that draws on the strengths of both qualitative and quantitative research by first qualitatively assigning codes to each textual unit of analysis and then analyzing the frequency of each code occurrence [52]. Following standard procedures for qualitative content analysis of interview data, responses were first transcribed from audio recordings and researcher notes. Responses were typically one or two sentences long. Two coders, the lead author and a research assistant, then read through the responses and devised separate preliminary coding schemes from this first pass through the data. Coders

then discussed their preliminary coding schemes, compared codes, and reconciled any differences to form a more refined coding scheme. The coders then double coded a sample of the data and established strong inter-rater agreement (Cohen's k = 0.938, $p < 0.001$), before individually coding the remaining responses.

The final coding scheme consisted of 15 codes. The *exposure* code was given to responses that cited the media they've consumed, their family, or their own personal experience (e.g., "my grandpa is an engineer" or "I saw someone like that on a TV show"). There were two codes for race-based responses and two codes for gender-based responses. Responses that cited a character's race or gender to justify choosing the more stereotypical option (e.g., "boys are mostly better than girls at math") were coded as *race-stereotypical* or *gender-stereotypical*. Responses that cited a character's race or gender to justify choosing the counter-stereotypical option (e.g., "because girls are better than boys at math") were coded as *race-counter-stereotypical* or *gender-counter-stereotypical*. The exposure code could be combined with these race and gender codes to label responses that expressed race/gender stereotypical/counter-stereotypical beliefs due to exposure (e.g., "I saw a movie and the girl knew how to use a computer"), resulting in four additional codes: *race-stereotypical exposure*, *gender-stereotypical exposure*, *race-counter-stereotypical exposure*, and *gender-counter-stereotypical exposure*. Responses that expressed a belief about equality and picked both characters (e.g., "both boys and girls can do it") were given an *equality* code. The *visual characteristics* code was given to any response that referred to a specific visual element of the picture (e.g., "he has a book about math" or "he is smiling"). Explanations that were about a character's ability to perform the occupation (e.g., looks smarter, seems stronger, knows science/math) were given a *skills* code. Vague, non-descriptive responses (e.g., "they look like it") were coded as *non-committal*. When a child did not offer an explanation or said "don't know" when asked why, their response was coded as *don't know*. Responses that did not fit into any of the aforementioned categories were coded as *other*. Each response could only receive one code, so coders were instructed to choose the code that seemed most prominent in the response.

3. Results

3.1. Between-Groups Effects

All analyses were completed using SPSS version 24. Prior to hypothesis testing, we used regression analyses to check for differences in all variables of interest by classroom, by treatment group, and by researcher who conducted the interview. No significant differences were found, and therefore these variables were not included as covariates in the analyses.

To test the first two hypotheses, which dealt with differences between treatment and control in their change in attitudes over time, we ran Mixed Analyses of Variance (ANOVAs). A mixed ANOVA compares the mean differences between groups that have been split on two factors, or independent variables, where one is a "within-subjects" factor (in this case, time) and the other factor is a "between-subjects" factor (in this case, condition). That is, it tests whether there is a significant difference in slope of the outcome variable from pretest to posttest between the treatment group and control group.

A 2 × 2 mixed ANOVA was used to test H1, which hypothesized that participants in the treatment group would have a more positive change in their gender-based occupational STEM attitudes from pretest to posttest than participants in the control group. There was no main effect of time ($F(1, 45) = 2.28$, $p = 0.138$), no main effect of condition ($F(1, 45) = 0.297$, $p = 0.588$), and no interaction between time and condition ($F(1, 45) = 1.38$, $p = 0.247$).

A 2 × 2 mixed ANOVA was used to test H2, which hypothesized that participants in the treatment group would have a more positive change in their race-based occupational attitudes from pretest to posttest than participants in the control group. There was no main effect of time ($F(1, 46) = 0.575$, $p = 0.452$), no main effect of condition ($F(1, 46) = 1.32$, $p = 0.257$), and no interaction between time and condition ($F(1, 46) = 1.20$, $p = 0.280$). Taking the results of H1 and H2 together, we find that children who watched *Cyberchase* did not

experience a measurable broadening of their race- or gender-based occupational attitudes about who participates in STEM, compared to children in the control group.

3.2. Open-Ended Occupational Responses

Responses to the 'why' component of the occupational attitudes measure were coded to investigate RQ2. There was no observable difference of the frequency of any type of response between the treatment and control groups. Of all the types of responses, don't know was the most common, making up 26.4% of all 1152 responses. The following results exclude don't know results and look at the responses of both the treatment and control groups together.

For items that manipulated gender, responses that cited visual characteristics of the character were most common, making up 42.9% of the 438 responses. Children would often point to a character's backpack or book as a reason why they were more likely to hold a STEM occupation, despite the fact that both characters had a backpack and a book. Gender-stereotypical responses made up 7.1% (n = 31) of the total. Children who gave these responses either talked about how it was normally boys who did science and built things (e.g., "because I thought only boys could study bugs or trees or leeches", "because girls usually aren't interested in building things") or how girls did not belong in the profession (e.g., "because girls weren't expected to do it. They were expected to be nurses. Having a job was off-limits"). Only 2.7% (n = 12) of the total responses were gender-counter-stereotypical. The majority of these were expressed in relation to exposure (e.g., "because one of my great grandmas was an engineer", "I keep watching shows about girls doing engineer stuff . . . I also watched a movie about it. It was a Ghost Busters movie . . . one of the girls was an engineer"). Non-committal responses made up 22.8% and skills responses made up 12.3% of the total 438 responses. Only 1.8% (n = 8) of responses expressed a belief about equality. 9.4% of responses did not fit into any other category and were coded as other. See Table 2 for the breakdown of frequencies of each code.

Table 2. Qualitative Codes for Gender-Based Occupational Attitude Responses.

Code	Frequency	Percent
Visual characteristics	188	42.9
Non-committal	100	22.8
Skills	54	12.3
Other	41	9.4
Gender-stereotypical	28	6.4
Equality	8	1.8
Gender-counter-stereotypical exposure	7	1.6
Exposure only	5	1.1
Gender-counter-stereotypical	5	1.1
Gender-stereotypical exposure	3	0.7
Total	438	100

Note: This table excludes don't know responses.

For items that manipulated race, responses that cited visual characteristics were also most common, making up 33.9% of the 410 responses. As with questions about gender, children often used books and backpacks to differentiate the characters, despite the fact that both characters had identical accessories. Race-stereotypical responses made up 7.1% (n = 29) of the total. There were a variety of justifications for these responses. Some children held ideas that linked race to ability (e.g., "White skinned people take extra care of their people [patients]"), a few children held ideas about whether a particular job was appropriate for Black people (e.g., "Because doctors don't accept Blacks into medical school—Blacks don't get very good jobs"), and a couple of children came up with nonsensical explanations (e.g., "he had White skin, so rain won't show on his hands" as an explanation for picking a White pilot over a Black pilot). Only 1.5% (n = 6) of responses were race-counter-stereotypical (e.g., one child thought that it was "mostly Black people who go

to become doctors"). Non-committal responses made up 29.5%, and skills responses made up 14.4% of the total. Beliefs about equality were expressed in 2.9% (n = 12) of responses, and 9.8% of responses did not fit into any other category and were coded as other. See Table 3 for the breakdown of frequencies of each code.

Table 3. Qualitative Codes for Race-Based Occupational Attitude Responses.

Code	Frequency	Percent
Visual characteristics	135	33.9
Non-committal	121	29.5
Skills	59	14.4
Other	40	9.8
Race-stereotypical	24	5.9
Equality	12	2.9
Race-stereotypical exposure	5	1.2
Exposure	4	1.0
Race-counter-stereotypical	4	1.0
Gender-stereotypical	3	0.7
Race-counter-stereotypical exposure	2	0.5
Gender-counter-stereotypical	1	0.2
Total	410	100

Note: This table excludes don't know responses.

Across the gender and race questions, responses that cited skills often talked about 'knowing' and 'smartness'. One other oft-cited skill was strength, though this was exclusively in relation to questions about being an engineer. There were no observable differences in the frequency of any type of response between pre-test and post-test for the treatment group or the control group.

4. Discussion

4.1. Summary and Interpretation of Results

The importance of a diverse and technologically skilled workforce for our future existence has been well documented in the sustainability literature [2,53,54]. Thus, many programs have been developed in recent years to engage girls and children from diverse backgrounds in STEM from an early age. One way to reach children en masse is via the mass media. Specifically, curriculum-backed public television has been shown to have positive effects on children's learning across many domains. Yet, connections between STEM-focused educational television and young children's career interests and aspirations have been yet untested. To investigate the effect of repeated exposure to a counter-stereotypical STEM show on children's occupational attitudes about who participates in STEM and hold STEM careers, we conducted a pre/post-, between-subjects experimental study with 48 children in kindergarten and first grades. For eight weeks, participants in the treatment group regularly viewed episodes of *Cyberchase*, a children's television program that models high levels of STEM engagement from a diverse group of characters. Participants in the control group went about business as usual. All participants completed assessments before and after the eight-week exposure period.

Our two hypotheses were not supported. Analyses revealed no significant differences between treatment and control groups in their change in occupational attitudes. There was also no main effect of time; for both treatment and control groups, attitudes, on average, did not change from pretest to posttest. This was true whether students started out with high or low attitudes, was true for boys and girls, as well as for younger and older children.

However, to probe this issue a bit further and investigate children's reasoning behind their responses, we conducted an exploratory qualitative content analyses of children's open-ended responses to the occupational attitudes measure. The results across gender and race questions were very similar. With both kinds of questions, many children pointed to superficial visual characteristics of the images to explain their choices. Additionally,

many children also gave non-committal responses, which might reflect their inability or reluctance to articulate ideas of race and gender or their compulsion to give an answer for the sake of the researcher. Only a minority of children articulated ideas about race and gender, but when they did, it was most-often in a stereotypical way. Of those gender- and race-based responses, a recurrent theme was that their belief was based on some kind of exposure; a handful of children cited media they had consumed, some referred to what their family members did, and others mentioned what they had seen personally.

It was clear that these open-ended data presented a very different picture than the closed-ended response data. Unlike with our quantitative measure of attitudes, which did not show any clear patterns, explicit race and gender stereotypes were quite prevalent in children's open-ended responses, showing that children in this age group do express constrained beliefs about who participates in STEM. Encouragingly, there were also some counter-stereotypical ideas put forth by the children, such as expressions of equality and efficacy for all types of people to participate in STEM. However, these were much less frequent than the stereotypical responses. As with the quantitative measure, there did not appear to be any differences between responses from participants in the treatment and control groups. Taken together, these findings provide valuable contributions to theory and practice, but must be considered in light of some study limitations.

4.2. Limitations

The sample for this study was limited in several ways. First, the sample size was relatively small and may not have been sufficient for detecting small effects. Though the target sample size was larger, the time-intensive nature of the data collection made it impossible to recruit more participants. Additionally, though we made an effort to recruit childcare centers who cater to diverse families, and indeed had a racially diverse sample, there was not much socioeconomic diversity within the sample. Participants' parents reported relatively high education levels and household incomes. The hypotheses and research questions presented here should be further explored with a larger and more socioeconomically diverse sample in order to make more generalizable claims and to have more confidence in the observed results.

There were also some methodological limitations to this study. Most notably, the measure of occupational attitudes was created specifically for this study and therefore had not been previously validated. Since other studies have successfully used Implicit Association Tests (IATs) with young children, future research should utilize an IAT to investigate implicit gender- and race-based STEM occupational attitudes. There is also an inherent limitation of using only one stimulus program rather than a variety of television shows as stimuli. The effects of this study may be specific to the program, and thus, may not be generalizable to educational STEM television in general.

Finally, it should be noted that discussions of race and gender are highly subjective to the culture in which they are being discussed. The measures used in this study were chosen and developed specifically for a U.S. context. However, the research questions addressed are certainly globally relevant; researchers investigating these questions in different geographic contexts should be sure to use culturally appropriate adaptations of the measures used here.

4.3. Theoretical and Methodological Contributions

Despite these limitations, the results of this study provide valuable contributions to our understanding of the early development of race- and gender-based occupational attitudes. Overall, these findings suggest that a single counter-stereotype, even with repeated exposure, may not be strong enough to override the stereotypical occupational schema that are already in place by kindergarten. This runs counter to effects predicted by the drench hypothesis, put forth by Greenberg [55], which posits that a few critical portrayals of non-traditional roles can alter stereotypical attitudes. Greenberg argues that exposure to just a few salient counter-stereotypical portrayals can cut through the buildup

of traditional stereotypes to produce attitude change in viewers. The drench hypothesis was created in contrast to the drip hypothesis, which states that the dominant stereotype-laden content present in our provides a steady drip of stereotyped media portrayals, reinforcing and cultivating stereotype-based attitudes. There has been some empirical evidence that supports the drench hypothesis [56–59]. However, the results of this study suggest that the effects of the stereotypical 'drip' might in fact be too powerful to be overridden by a counter-stereotypical 'drench'.

This is much in line with what Bond [37] discovered. In his study of six- to nine-year-old girls, videos depicting stereotypical portrayals of women were very effective at altering participants' attitudes to be less favorable towards STEM. However, videos depicting counter-stereotypical portrayals were not effective at creating more favorable attitudes towards STEM. Bond explains that this is likely due to the fact that stereotypical gender schemata are already so strongly in place in children's minds that new information that maps onto those schemata is easily processed by the brain. However, without pre-existing schemata to map onto, the counter-stereotypical images did not have as strong of an effect.

One important nuance to consider is that previous studies that found support for the drench hypothesis looked at outcome measures such as recall of a counter-stereotypical character portrayal [56,59], or self-reported familiarity and comfort with an outgroup [57,58]. This study, like Bond's [37], went a step further to see if those counter-stereotypes could actually impact attitudes. Considering these findings together, it seems likely that the drench of a counter-stereotype may be helpful for recall and familiarity, but not as effective for truly altering people's worldviews.

In terms of effective exposure periods, this study adds to extant literature on television exposure and STEM attitudes by moving beyond a single exposure and looking at repeated exposure over the course of eight weeks. Eight weeks has been shown to be a sufficient time period for other similar media interventions [50,60], however, in this study we did not observe such effects. Cultivation theory does suggest that it is cumulative exposure over years that affects the way people view the world. Thus, in the case of changing occupational schema, it may be that even eight weeks is not a long enough exposure period. Future research should investigate the effects of even longer-term exposure to counter-stereotypical character portrayals to see if there might be more measurable effects.

5. Conclusions

In sum, this multi-method analysis of the effects of educational television on children's gender- and race-based STEM occupational attitudes provides nuanced, but important insights. The quantitative measure of attitudes did not reveal any patterns or trends, which may be an indication that these attitudes towards STEM careers are not yet strongly formed for children in this age group. Prior work has shown that by age six, children do have ideas in place about which genders and races perform certain occupations [25,26], but this had not been examined specifically in the STEM context. It may be that children are not familiar enough with STEM occupations to have strong ideas about who should perform them. Analysis of participants' open-ended responses showed that exposure is an important precursor to attitudes; when children had gender- or race-based beliefs about who should hold certain occupations, it was most often because they either personally knew someone who holds that occupation or had seen a relevant portrayal on TV or in a movie. Theories based in psychology and communication science certainly suggest that media can be a useful tool for pushing us towards a sustainable future, particularly in terms of children's interest in STEM. This study serves as a useful starting point, but more research is needed to continue to investigate this relationship between media exposure, children's occupational schema, and their eventual decisions about whether or not to pursue and persist in STEM.

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