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Character Portrayals in STEM-focused Educational Television Shows and their Impact on Children's Attitudes Towards STEM

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Abstract

Developing an interest in science, technology, engineering, and mathematics (STEM) is an important precursor to pursuing a STEM career. Given the United States' relatively low standings in science and math compared to similar industrialized nations and its desire to be competitive in an increasingly STEM-based global economy, policy makers are calling for more creative ways to encourage interest in STEM from a young age. In response to this call, there has been a recent surge in educational television shows that claim to support early STEM skills. While high-quality educational television can stimulate interest in topics that young children might not otherwise encounter (Fisch, 2004), the impact of STEM television programming on young children's interest in STEM has not yet been empirically established.

In the U.S., interest in STEM is especially low for female and minority children, which leads to less STEM participation for these groups later in life (National Science Board, 2010). These gender and race gaps are likely exacerbated by the mass media; content analyses reveal that characters engaging in math and science on TV are overwhelmingly male and White (Long, Boiarsky, & Thayer, 2001). Stereotypical portrayals not only impact the self-efficacy of girls and children of color, they also lead to society-wide beliefs about who can and should participate in STEM (Bandura, 1986b; Gerbner, 1998). However, there is potential for counter-stereotypical portrayals to counteract these traditional stereotypes (Aubrey & Harrison, 2004). Some educational television shows created in recent years have begun to feature more diverse characters, but the effect of these positive portrayals is yet unknown. The goals of this dissertation are to understand the current landscape of characters featured in STEM television for young children and to investigate whether children's engagement with these programs can have a positive impact on their attitudes towards STEM.

Study 1 presents a content analysis of 1,086 characters in 30 STEM-focused television shows for children ages 3-6 (three episodes per show, 90 episodes total). Results show that compared to the U.S. population, female and minority characters are underrepresented. Male characters are correspondingly overrepresented; however, White characters are not. This imbalance is caused by the inclusion of many racially ambiguous characters and characters with non-human skin colors. No significant differences by gender or race were found for characters' on-screen STEM engagement or prominence in the show. Representation becomes more equal when looking only at child characters, suggesting that recent efforts to increase the diversity of character portrayals have been somewhat successful.

Study 2 presents a pre/post, between-subjects experimental investigation of the effect of repeated exposure (8 weeks, 2-3 times per week) to a STEM television show that features a diverse group of highly STEM-engaged characters on children's ($N = 48$, $M_{age} = 6.57$ years) attitudes towards STEM, gender and race-based occupational attitudes, and self-identification with STEM behaviors. Though no differences were found between treatment and control groups, several individual differences emerged as significant predictors of attitude change. Children who were more familiar with STEM television shows at pretest had less positive STEM attitudes at posttest, likely due to their greater consumption of more stereotypical programming. Children who had a greater understanding of the educational intent of the stimulus program and children who developed strong relationships with the stimulus characters experienced more positive STEM attitude change from pretest to posttest.

Results of the two studies suggest that exposure to diverse portrayals of STEM occupations is important, and that today's STEM television landscape does provide some diversity in terms of gender and race. However, results also suggest that one strong counter-stereotypical example may not be sufficient to change children's worldviews about what types of people hold STEM careers. An overrepresentation of diverse, counter-stereotypical portrayals may be needed in order for children to believe that people of all genders and races belong in STEM.

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I. Introduction and Theoretical Frameworks

The domains of science, technology, engineering, and mathematics — known collectively as STEM — are essential for preparing American children for the U.S. workforce. For example, the U.S. Department of Education predicted significant increases in the need for STEM-related jobs through 2020 (National Center on Education and the Economy, 2008; US Department of Education, 2010). Yet, in recent years, children in the United States have continued to fall behind their international peers in both math and science. In 2009, the Programme for International Student Assessment (PISA) found that the U.S. ranked 20th of 67 countries in science, well below the international average. In 2012, the U.S. ranking dropped an additional four spots. In addition to poorer performance on math and science assessments, American students show less interest in STEM learning compared to their international peers (President's Council of Advisors on Science and Technology, 2009). In light of these findings, educators and policymakers have called for innovative educational initiatives to increase STEM engagement and learning across grade levels. This is especially needed in early childhood settings, where STEM topics have been historically underrepresented (Ginsburg & Golbeck, 2004).

Educational television is one tool that allows for new and innovative ways of approaching informal education. While there is empirical support for the potential of educational television to facilitate learning and exposure to new ideas in areas such as literacy and numeracy (e.g., Fisch & Truglio, 2001; Jennings, Hooker, & Linebarger, 2009; Wright et al., 2001), few research studies specifically investigate the medium’s role in STEM education for preschool aged children. Thus, this dissertation project presents (1) a quantitative analysis of the state of

STEM television for young children today and (2) an experimental test of the ability of exposure to STEM-focused children's television programs to increase young children's interest in STEM.

In addition to the U.S.'s general standings in science and math, one area of particular concern is the underrepresentation of women and minorities in STEM career fields. According to the U.S. Bureau of Labor Statistics, women account for only 30% of professional scientists and engineers. Yet, they make up 47% of the U.S. workforce. Similarly, while African Americans make up 11% of the total workforce, they account for only 5% of professional scientists and engineers. While there are many contributing factors to these disparities, media likely plays a central role by providing role models and cultivating an acceptance of the status quo (Bandura, 1971; Gerbner, Gross, Morgan, & Signorielli, 1986). Content analyses from the past several decades consistently show that women and racial minorities are vastly underrepresented in the media (Busby, 1975; Greenberg, Mastro, & Brand, 2002; Mastro & Greenberg, 2000), and the characters that hold professional occupations on television are overwhelmingly male and white (Long et al., 2001; Signorielli & Bacue, 1999).

Much of the existing literature suggests that the influence of these character portrayals is often in a negative, stereotypical direction. However, Aubrey and Harrison (2004) argue that television can contribute to both stereotypical and non-stereotypical attitude formation depending on the behaviors modeled by on-screen characters. Encouragingly, children's television shows created in recent years are beginning to better reflect the diverse population of the U.S (Dobrow, Gidney, & Burton, 2018). It is important that all children be exposed to these diverse representations because the success of girls and minorities in STEM is dependent on everyone believing that these underrepresented groups can and should participate equally in STEM fields

(Blickenstaff, 2005). Thus, the secondary goal of this dissertation is to look not only at STEM shows for children broadly, but particularly to look at shows that feature female and non-white characters engaging in science and math, to see if these counter-stereotypical portrayals can have a positive effect on children's attitudes towards STEM learning and their beliefs about who holds STEM careers.

Media as a Tool for Early Intervention

Media portrayals begin to affect viewers from an early age. Research suggests that young children are likely to develop occupational schemas that reflect the images they see on television (Signorielli, 2009) and that gender- and race-based occupational schemas are in place by age six (Bigler, Averhart, & Liben, 2003; Liben, Bigler, & Krogh, 2001). Concurrently, research demonstrates that gender and race achievement gaps in math and science are prevalent beginning in early childhood (Curran & Kellogg, 2016; Morgan, Farkas, Hillemeier, & Maczuga, 2016). In a longitudinal study of nearly 8,000 elementary school children in the U.S., Morgan and colleagues (2016) discovered that general knowledge scores upon entering kindergarten were highly predictive of science achievement scores in third through eighth grades. Large gaps in science achievement persisted throughout elementary school as a function of students' race/ethnicity and socioeconomic status. In another recent study, Curran and Kellog (2016) discovered that a gender gap in science achievement emerged between kindergarten and first grade. The authors of these two studies conclude that early interventions delivered before children enter primary school are necessary to address these achievement gaps.

There are many factors that contribute to these achievement gaps and to the development of gender- and race-based occupational schemas, and, thus, many opportunities for early childhood intervention. Bronfenbrenner's (1977) ecological systems theory posits that everything in a child's environment affects the way the child grows and develops. While parents, siblings, and caretakers have the most direct influence, media and digital technologies are part of the child's exosystem, exerting influence via their presence in the home and school environments. In a recent policy statement, the American Academy of Pediatrics (AAP) noted that "media are a dominant force in children's lives" (American Academy of Pediatrics, 2013). Indeed, recent estimates suggest that children spend more time with screens than they do at school (American Academy of Pediatrics, 2013; Rideout, 2013). Importantly, the AAP points to both negative and positive effects of media on children's health, knowledge, and social connectedness. Because digital media have such prevalence in children's lives and are found to have both positive and negative effects on children, it is important to consider media as a fruitful vehicle for early intervention.

Educational Television as Informal Learning

Though children's media use is increasingly spread across numerous devices, television viewing still remains the most prevalent form of screen time for children age eight and under (Rideout, 2017). Sixty-seven percent of American 2- to 8-year-olds watch television every day, at an average of just over one hour per day. Television programs that are considered educational are particularly popular among this age group (Rideout, 2014). American parents view educational television as a relatively harmless, and perhaps even beneficial, way to keep their young children entertained (Wartella, Rideout, Lauricella, & Connell, 2014). Because educational television can have a great impact on school-readiness skills, which, in turn, affect subsequent development (Anderson, Huston, Schmitt, Linebarger, & Wright, 2001), there is a need for understanding the full educational potential of this popular type of television.

While educational media is not intended to replace formal school-based initiatives, research has shown that high-quality, research-based television programs have had positive effects on children's learning across many domains (Anderson, 1998; Fisch & Truglio, 2001; Fisch, Truglio, & Cole, 1999; Mares & Woodard, 2005). Fisch (2004) explains that educational media are intended to supplement formal education by exposing children to topics that they might not otherwise encounter and providing compelling experiences that encourage children to spend additional time exploring concepts that they are studying in school. Prior work on the role of educational media in early learning has focused on topics such as early literacy (Jennings et al., 2009; Linebarger, Kosanic, Greenwood, & Doku, 2004), prosocial skills acquisition (Mares & Woodard, 2005), and adoption of healthy behaviors (Borzekowski & Macha, 2010). Few studies have examined the role of educational television in early STEM learning, however. This dissertation addresses that gap.

Educational Media and Preschoolers' STEM Engagement

Much of the empirical focus on STEM learning has occurred in the K-12 sector (Parette, Quesenberry, & Blum, 2010). However, studies show that preschool-aged children are naturally inclined to explore STEM concepts that are embedded in everyday life, such as finding patterns, building structures, and asking "how" and "why" questions (Brenneman, Stevenson-Boyd, & Frede, 2009; Callanan & Oakes, 1992). Importantly, children also have the cognitive capacity to link these real world experiences to the underlying scientific concepts, provided that they have appropriate scaffolding (Bonawitz, van Schijndel, Friel, & Schulz, 2012; Carey, 1985).

A few recent studies have demonstrated that STEM-focused educational television can have positive impacts on preschool-aged children. Many of these are reports on media properties funded by the U.S. Department of Educations' Ready To Learn (RTL) initiative. For example, a

2014 study looked at engagement with and learning from PEG+CAT episodes and interactive games (Moorthy, Hupert, Llorente, & Pasnik, 2014). PEG+CAT is a transmedia property produced by PBS Kids that is designed to teach early mathematics and problem solving. This pre-post experimental study found modest gains in understanding of an early math concept on program-specific assessments as well as a standardized math assessment. In another RTL study, McCarthy and colleagues (2013) investigated the effects of four PBS Kids transmedia suites on children's mathematics knowledge. The authors found significant improvement in three-year-olds' performance on the Child Math Assessment after viewing episodes of science and math shows and completing related at-home activities with their parents over the course of ten weeks (McCarthy et al., 2013). Similarly, in a randomized control trial where first and second graders were assigned to either an RTL-based transmedia math learning condition or a control condition, the researchers found that all children significantly improved in their performance on four different math skills; the RTL group showed significantly greater improvement than the control group on one of those four skills (Michael Cohen Group, 2015). While it is difficult to determine the unique effects of the individual media properties tested in these studies, taken together, these studies show that educational media can in fact be influential in preschoolers' engagement with early STEM concepts.

Television as an Agent of Socialization

In his introduction to the Sage Handbook of Child Development, Multiculturalism, and Media, Berry (2008) calls television "one of the most influential agents of socialization among children" (p. xxvi). Indeed, decades of research on media effects has shown that television can and does shape viewers' attitudes and beliefs about themselves and the world (Gerbner, 1998), and that children are especially susceptible to this type of influence (Anderson & Pempek, 2005;

Calvert, 2008; Valkenburg, 2004). How do these socialization effects occur? Greenberg (1982) writes that television influences society by displaying certain family roles, sex roles, race roles, job roles, and age roles. Regular exposure to these role portrayals alters our beliefs about how the world works and our assumptions about how we should behave – a phenomenon known as cultivation (Gerbner, 1998; Greenberg, 1982; Potter, 1993).

Cultivation. Cultivation theory (Gerbner et al., 1986) covers a wide range of suppositions, but the main tenet 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 (Gerbner et al., 1986). Following this logic, children who are regularly exposed to television that presents science and math as fun and accessible should be more likely to believe that science and math are indeed fun and accessible.

Social Cognitive Theory. While cultivation theory provides a strong framework for long-term attitude change, an alternative theory is necessary to explain short-term attitude change, and moreover, behavior change. The assumption present in nearly all research on children and media is that human beings can and do learn from television, a principle derived from the other major theoretical paradigm in this body of literature: Bandura's social learning theory. Social learning theory posits that people learn not only through their own experiences, but also through their observations of others' actions, including those of media figures, and the consequences of those actions (Bandura, 1971). If the individual observes positive rewards associated with a behavior, he or she will be more likely to model the behavior. If the individual observes punishments associated with a behavior, he or she will be motivated to avoid the behavior. In the context of the current study, social cognitive theory explains how children might learn from behaviors they see modeled on screen in STEM shows; if characters model STEM participation, and are rewarded either intrinsically or extrinsically, children exposed to this modeling are likely to learn that STEM participation is a rewarded behavior that should be copied.

The Relationships Between Interest, Attitudes, and Behavior

While a few of the studies mentioned previously did find concrete learning gains, they all also included key summary findings about children's interest and engagement with STEM. This is because, as discussed earlier, one of the main goals of many educational media programs is to expose children to new topics and encourage further exploration of topics they may learn about in school (Fisch, Kirkorian, & Anderson, 2005). Therefore, while children's knowledge of, and performance in, STEM are certainly important, it is also important to look at their interest in STEM and their attitudes towards engaging in STEM activities.

An empirical focus on attitudes as a primary outcome variable is supported by Fishbein's (1979) theory of reasoned action (TRA). The TRA posits that a person's attitudes toward a behavior are strongly related to their intention to perform the behavior, which, in turn, is a strong predictor of actual behavior. Following this logic, in order to achieve the societal goal of increasing participation in STEM, it is necessary to boost children's attitudes toward participating in STEM. Indeed, some studies have found attitudes to be a better predictor of STEM participation than performance on STEM assessments. Catsambis (1995) found that among eighth graders, girls performed better than boys on science achievement tests. However, despite their lower test scores, male students held more positive attitudes toward science and were thus more likely to engage in extracurricular science programs and more likely to aspire to a scientific career.

Other studies have found direct links between interest and knowledge gains. Chew and Palmer (1994) studied interest in the context of the knowledge gap hypothesis, which addresses the acquisition of new technologies for high-income populations versus low-income populations (Tichenor, Donohue, & Olien, 1970). One of Chew and Palmer's main arguments was that interest in a particular topic determines attention to information about that topic, and that interest could, therefore, stabilize knowledge gaps between various populations. They found that participants' interest in health and fitness was a strong predictor of knowledge gain from a health-related television program. Ainley, Hidi, and Berndorff (2002) conceptualized interest as an enduring predisposition to reengage with a particular object, event, or idea. Using this definition, the researchers have found links between interest and learning in children. In a study of eighth and ninth grade students using science texts, topic interest was found to be a predictor of persistence with a text, which was, in turn, a strong predictor of learning. Considered together, these studies demonstrate that interest in STEM and attitudes toward STEM are important precursors to both STEM learning and STEM participation.

Specific Aims of the Dissertation

Based on the literature presented above, this dissertation seeks to establish a relationship between STEM-focused educational television and children's interest in STEM learning and STEM careers. This is accomplished via two studies. Study 1 is a content analysis of currently available STEM television shows for young children. This content analysis provides a quantitative understanding of the character portrayals in children's STEM television shows, with a particular focus on race and gender presentations. Study 1 lays the groundwork for the investigation of causal effects in Study 2, an experimental study designed to test the effects of regular exposure to a STEM show that features diverse character portrayals on children's attitudes toward STEM learning and STEM careers.

II. STUDY 1. A Content Analysis of Character Portrayals in Children's STEM-focused Educational Television

In recent years, there has been a noticeable increase in the number of television programs for young children that claim to teach STEM (science, technology, engineering, and math) or early STEM skills. This recent surge of STEM shows was likely spurred by policymakers calling for media producers to create more math- and science-focused television for children. For example, the Department of Education's Ready to Learn (RTL) initiative originally called for literacy-based programming, but recent cycles of RTL have called for more math and science programming in addition to literacy programs. Thus, several new shows have been developed in recent years that have math- and science-based curricula (Beaudoin-Ryan, Lovato, Olsen, & Pila, 2016). Because this is a relatively recent phenomenon, little research has been done to formally investigate the content and potential effects of these programs. This study presents a content analysis of STEM television shows available to children today, with a focus on the characters featured in these programs.

Representation on Screen

Many scholars have conducted content analyses to document the stereotypical ways in which television often portrays reality. As seen through these content analyses, television writers and producers rarely deploy intersectionality when creating and developing characters; instead, they tend to present characters as one-dimensional archetypes of their social group.

Racial bias on television. A long line of content analyses shows that racial minorities are underrepresented and misrepresented in the media (Greenberg et al., 2002; Mastro & Greenberg, 2000; Stroman, Merritt, & Matabane, 1989), and particularly in children's media (Klein &

Shiffman, 2006; Roberts, 2004). Ward (2004) reports that although the presence of African Americans on television has slowly increased in the last several decades, numbers still fall short of the national population. Even as the frequency of television appearances for African Americans approaches proportional representation, the types of roles relegated to Black actors and actresses still present a problem (Stroman, 1991; Stroman et al., 1989). It is considered a huge production risk to cast an actor of color in a leading role, and so actors and actresses who are members of minority groups are perpetually cast as the sidekicks and comic relief to their white counter-parts, or, alternatively, in their own all-Black comedies (Stroman et al., 1989). In a content analysis of children's cartoons from the 1930s to the 1990s, Klein & Shiffman (2009) found that only 8.7% of characters in the study sample were racial minority group members, a significantly disproportionate percentage compared to the national average of 14.8% of the American populace averaged across the study period. Looking at quality of portrayals, analyses of programming from the 1970s (for reviews, see Graves, 1996; Merritt & Stroman, 1993; Stroman, 1991) showed that Blacks were commonly portrayed as poor, jobless, lazy, unintelligent, and incompetent (Graves, 1996; Stroman, 1991; Stroman et al., 1989). Similarly, an analysis of prime-time programming from 1996 found that African Americans, in comparison to Whites, were shown to be more provocative and less professional in dress, more passive, and were judged as the laziest and least respected ethnic group (Mastro & Greenberg, 2000). The aggregate effect of these portrayals has been linked to lowered self-esteem in African American adolescents (Ward, 2004) as well as a devaluation of African Americans in society at large (Klein & Shiffman, 2009).

Gender bias on television. As with racial biases, content analyses have consistently found many gender biases present across all television genres, and especially in children's television programs (Signorielli, 1990). A report by the Geena Davis Institute on Gender in Media (Smith, Choueiti, Prescott, & Pieper, 2012) showed that children's programming was one of the most gender imbalanced genres in prime time television, with less than a third of all speaking characters coded as girls or women. Across all children's and family-oriented genres, not only do male characters usually outnumber female characters by a ratio of at least 2:1 (e.g., Aubrey & Harrison, 2004; Smith & Cook, 2008), but there are also clear and fairly consistent differences in the types of portrayals. Specifically, female characters are less likely to occupy leading roles or positions of responsibility and more likely to show affection and defer to male characters (Leaper, Breed, Hoffman, & Perlman, 2002; Sternglanz & Serbin, 1974; Streicher, 1974; Thompson & Zerbinos, 1995). Male characters, meanwhile, are more likely to engage in problem solving activities, exhibit assertive behaviors, and show leadership; and are less likely to express emotions (Leaper et al., 2002; Sternglanz & Serbin, 1974; Streicher, 1974; Thompson & Zerbinos, 1995).

These gendered portrayals have been shown to have behavioral and attitudinal effects on children. Signorielli and Lears (1992) found that fourth and fifth graders' television viewing was significantly related to their attitudes towards household chores being particularly male- or female-oriented. In other words, boys and girls who watched more television were more likely to say that washing the dishes, cleaning the house, and making the bed were "girl chores," and mowing the lawn, taking out the garbage, and helping with repairs were "boy chores." The study also showed a significant interaction between television viewing, attitudes, and behaviors, such that children who watched more television had a stronger relationship, on average, between stereotypical sex role attitudes and actual performance of chores that matched their traditional gender category. While Signorielli and Lears (1992) looked at domestic work in the form of household chores, other scholars have extended that line of research to look at work and roles outside of the home.

Occupational portrayals. Much of the existing work on the presence of occupational portrayals in the media has focused on adult-directed television. For example, Signorielli (2009) 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 (Smith et al., 2012).

Importantly, research has demonstrated a relationship between television viewing and how children think about the occupational images they are exposed to on television. For example, Jeffries-Fox and Signorielli (1978) 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 (1993) 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 an earlier study, Beuf (1974) 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 somewhat dated, a major finding of Beuf's (1974) 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.

Representation in Educational Television

These media portrayals begin to have an effect on viewers from an early age (Chambers, Kashefpakdel, Rehill, & Percy, 2018). Research suggests that young children are likely to develop occupational schemas that reflect the images they see on television (Signorielli, 2009), and that gender- and race-based occupational schemas are in place by age six (Bigler et al., 2003; Liben et al., 2001). Content analyses from the past several decades consistently show that women and racial minorities are vastly underrepresented in the media (Busby, 1975; Greenberg et al., 2002; Mastro & Greenberg, 2000), and that the characters who hold professional occupations on television are overwhelmingly male and white (Long et al., 2001; Signorielli & Bacue, 1999). Most of these content analyses, however, have looked at adult-directed television, or television for young audiences broadly. Very little research has documented the character portrayals in educational television specifically, and even fewer have focused on STEM media. Because educational television has been known to stimulate interest in topics that young children might not otherwise encounter (e.g., Fisch & Truglio, 2001; Jennings et al., 2009; Wright et al., 2001), it is an important genre to consider in the context of supporting children's interest in STEM. Thus, this study presents a quantitative analysis of the character portrayals in STEM television for young children, with the goal of documenting any race or gender disparities that may be reflected and exacerbated in this genre.

There is some anecdotal evidence in recent popular press articles that suggests there may be more diverse characters featured in children's television today than in children's shows of decades past (e.g., Dobrow et al., 2018; Eakin, 2014; Henderson, 2016; Meade, 2013). The authors of these articles, who represent both parents and researchers, state that parents today are finding more television options for their children with greater representation of gender and race. However, this trend has not been systematically documented.

Prior to this relatively recent trend of including more diverse characters, Long, Boiarsky, and Thayer (2001) conducted one of the few existing content analyses of portrayals of scientists in children's educational television. They found that males and females were equally likely to be portrayed as scientists, but that male characters in these shows significantly outnumbered female characters. They also found that minority characters were significantly less likely than Caucasian characters to be labeled as scientists, minority scientists spent much less time on screen than Caucasian scientists, and there were significantly fewer minority characters than Caucasian characters in these shows. While this study represents an important building block in this area of research, it was very limited in sample and scope.

The current study expands upon the existing literature in several ways. First, it analyzes a much larger sample of television shows than had been included in prior research. For example, Long et al.'s (2001) sample included only four science shows for children. In comparison, the current study sample includes 30 STEM television programs for children, thus giving a broader picture of the STEM portrayals available on television for children today. Second, STEM participation is conceptualized in a more holistic way than it had been previously. Prior studies looked specifically at characters portrayed as "scientists" (Long et al., 2001; Steinke & Long, 1996). However, STEM skills, especially for young children, encompass much more than science as traditionally conceptualized (i.e., in a lab, wearing a lab coat, handling beakers and pipettes). Foundational building blocks of STEM include problem solving, scientific inquiry, and early math skills (Center for Children and Technology, 2014; NGSS, 2015), and so it is important to look at all of these types of behaviors when they are exhibited by characters in STEM shows.

This study provides an analysis of current children's STEM shows, with a focus on the character portrayals in these shows. More specifically, analyses were guided by the following research questions:

RQ1: What is the representation of gender and race/ethnicity in STEM television shows for young children, and how does it compare to the U.S. population?

RQ2: Are there differences by gender or race in who is featured as modeling STEM activities and behaviors in these shows?

RQ3: What types of STEM occupations are depicted in STEM shows for young children?

Method

Sample

The sample for this study is based on the sample used for the 2016 content analysis conducted by the Center on Media and Human Development (Lovato, Sheehan, Beaudoin-Ryan, Lauricella, & Wartella, 2017), which investigated the topic areas covered in STEM shows for children aged 3-6. The current study, which focuses on the characters in the shows, utilizes and extends Lovato et al.'s (2017) sample.

Base sample. To construct their sample, Lovato and colleagues obtained a Nielsen list of all children's shows aired in the United States on broadcast or cable channels between January 2013 and August 2014. That original list contained 348 titles of television programs targeting children ages 2 to 11. Their final list of shows contained 20 programs targeted at children aged 3-6 that mentioned STEM curricula in the tag line, program/episode descriptions, or other marketing materials, or that were recognized by resources such as Common Sense Media as shows that feature STEM content. Next Generation Science Standards (NGSS) for children entering kindergarten through second grade were used to identify keywords that qualified as STEM-related topics, including: "physical sciences," "life sciences," "earth and space sciences," "engineering," "technology," "patterns," "cause and effect," "energy and matter," and "applications of science." If any of those keywords were mentioned in a show's tagline or program description, it was included in the sample. Since the focus of their study was on pre-kindergarten and kindergarten STEM learning, they then removed programs that were targeted to older children (e.g., Disney sitcoms) as well as programs that were not designed to teach STEM content (e.g., Doc McStuffins, which, though seemingly STEM-related, was created to promote themes such as imaginative play, caring for others, and personal hygiene).

Extended sample. The current study expanded upon Lovato et al.'s sample in two important ways: (1) in order to have as up-to-date a sample as possible, we added in any new STEM shows for preschoolers that aired between August of 2014 and October of 2016; (2) we included any shows that fit the original age and content criteria but were available on streaming platforms such as Amazon Video, Netflix, or Hulu (and thus excluded in Lovato et al.'s sample, which only included shows airing on broadcast television). Streaming services are widely used among parents of the target demographic, and thus are important to include in the sample. From these two expansion criteria, 10 additional shows were identified, resulting in a final list of 30 programs (see Appendix A).

For each of the 30 programs, three episodes were selected using simple random sampling from the latest available full season (as of the fall of 2016), resulting in a final sample of 90 episodes. Episodes ranged in length from 11 minutes to 22 minutes. Importantly, if an episode contained two separate narratives (e.g., one 22-minute episode comprised of two separately-titled

11-minute story arcs) only the first narrative of each episode was coded. Given that characters would be coded for their STEM participation, it seemed most appropriate to compare only one individual story arc to another.

Coding

Three coders were trained on the coding manual using non-sample episodes of the shows in the sample. Once acceptable inter-rater reliability (Cohen's kappa > 0.7) was established, 20% of the sample was double coded, and the rest was split between the three coders for individual coding. Table 1 presents reliability statistics for all variables.

Every character that appeared on screen during an episode was coded. A group of characters that acted as a single unit (e.g., a chorus of singing raindrops) was listed as one group character. Each character or group was coded across the 16 codes that are described below. As past content analyses have shown (e.g., Baker & Raney, 2007; Long et al., 2001), it is important to look not only at presence on screen, but also quality of on-screen interactions and adherence to traditional stereotypes. Therefore, for the current study, codes were created to capture both demographic and physical character attributes as well as depth of the character's STEM participation.

Speaking versus non-speaking characters. Similar content analyses done in the past have quantified only speaking characters (e.g., Long et al., 2001; Smith et al., 2012; Smith & Cook, 2008). We thought, however, that it was important to look at both speaking and non-speaking characters for the sake of capturing a more accurate picture of representation (e.g., to answer questions such as, "are females and minorities more often relegated to non-speaking roles?"). Therefore, in this study, all characters that appeared on screen were recorded, and their speaking status was also coded. A "speaking character" was defined as any character who spoke or made speech-like animal utterances and had at least two communicative exchanges or one STEM-relevant communicative exchange. A "non-speaking character" was any character who appeared on screen and either did not speak at all (e.g. an animal sidekick to a human cast) or spoke one line that was not relevant to the STEM content of the episode (e.g., an anthropomorphized sun whose only line is "Hi! I'm the sun").

Table 1. Reliability Statistics for All Variables

Variable	Cohen's Kappa
Character-level Variables	
Speaking vs. Non-Speaking Character	0.95
Character Attributes	
Gender	0.93
Age	0.86
Animated or Live	0.97
Type	0.97
Race/Ethnicity	0.91
Hair Color	0.89
Eye Color	0.97
Role	0.65
STEM Participation	
Active Learning	0.78
Passive Learning	0.76
Teaching	0.75
Questioning	0.81
Making Observations	0.74
Investigating	0.90
Problem Solving	0.83

Character attribute variables were created to capture the physical and/or demographic representation of each character in the episode. These categorical variables included: gender (male, female), age (baby, child, teen, adult, elderly adult), type of filming (animated, live action, puppet), type of character (human/humanoid, animal, robot, nature object, vehicle, monster, inanimate object), race/ethnicity (White, Black, Asian, Hispanic/Latino, Native/Indigenous, Middle Eastern, multi-racial), hair color, eye color, and character role (walk-on character, minor/supporting character, major character, protagonist). Coders used visual and auditory information present in the episode to code each of these variables. For variables that were difficult to code based solely on information in the episode (e.g., race/ethnicity), coders were allowed look up information in the program description on the show's website or on the Internet Movie Database (IMDB). Each variable included an "other/unsure" option for situations where the code could not be determined, as well as a "group" option for situations where there was more than one code present in a group (e.g., a chorus of puppets and live action characters or a crowd of children and adults). There was also an "irrelevant" option for variables that only applied to humans (e.g., race/ethnicity would be coded as irrelevant for an animal character).

STEM participation variables were created to further investigate each character's role in the episode and how much they engaged with the STEM content that the episode presented. Two variables were designed to capture an overall sense of how actively or passively the character engaged with STEM content throughout the episode: active learning (defined as learning new information as a result of some action, such as asking a question or making an observation that is immediately addressed or answered) and passive learning (i.e., the character is present when new information is taught but did not actively solicit the information). These variables were coded on an ordinal-type scale ranging from 0 (e.g. no active learning, only passive learning) to 4 (e.g. only active learning, no passive learning).

Five additional variables were created to capture specific STEM-related actions and activities that a character might engage in during an episode: teaching (i.e., explaining STEM-related facts and/or information to other characters who are less knowledgeable), questioning (i.e., asking questions to find out STEM-related information), making observations (i.e., making observations that lead to the discovery of new STEM information), investigating (collecting and/or analyzing data as a practice of scientific inquiry), and problem solving (i.e., when a character faces a problem and subsequently designs, tests, compares, or communicates a solution to that problem). These variables were coded on a scale from 0-2, where 0 meant the character did not engage in the activity at all, 1 meant the character engaged in that activity once or twice during the episode, and 2 meant the character engaged in that activity three or more times during the episode.

Occupations. If a character was portrayed as having any type of occupation or career, this was noted in the coding document. The initial, specific occupation recordings were later coded as either STEM or non-STEM occupations by cross-checking our list of occupations with a list of STEM occupations provided by the U.S. Bureau of Labor Statistics. Occupations that were explicitly included on the Bureau of Labor Statistics list were coded as “STEM occupations.” Occupations that were not explicitly on the list, but that involved STEM skills and/or content knowledge (e.g., doctor) were coded as “borderline-STEM.” All other occupations were coded as “non-STEM.” We coded both ‘real’ occupations (e.g., an adult character who works as a doctor) and ‘pretend’ occupations (e.g., a child character who, during part of an episode, pretends to be a doctor).

Results

Datasets

A total of 1086 character entries were coded from the 30 shows across 90 episodes (3 episodes per show). From this master dataset, we created two separate datasets that were used for different parts of the analyses.

Unique Reoccuring Characters. In order to answer questions about the representation of different races and genders on screen (RQ1), we needed a dataset that would account for the fact that main characters tend to have repeated appearances across episodes. For the purposes of examining representation, we first filtered down the master dataset so that each character would be listed only once, resulting in 433 characters. Of those 433 characters, a large majority were one-off, guest-type characters. However, literature on viewers' relationships with characters suggests that repeating characters are more likely to have an effect on viewers because those characters are the ones with whom viewers are most likely to develop parasocial relationships (Calvert & Richards, 2014). Therefore, we further filtered the list to include only characters that appeared in at least two of the three sampled episodes. This list, which we call the Unique Reoccurring Characters dataset, is composed of 168 characters and includes one entry each for all major and minor characters across the programs, but excludes characters who make only a one-time appearance. The Unique Reoccurring Characters dataset includes only character attribute variables (i.e., gender, age, type, race, hair color, eye color, role) because those were able to be collapsed across the three episodes for each show (whereas STEM participation variables could differ across each episode).

Character Instances. Moving beyond character representation to consider characters' on-screen actions (RQ2 and RQ3), we also needed a dataset that would capture all of the STEM behaviors that occur across the 90 episodes in the sample. The Character Instances dataset includes all 761 individual speaking characters from the full dataset and captures every "instance" that they appear on screen. It excludes the group characters and non-speaking characters from the full dataset. Table 2 gives a comparison of the two focal datasets to the full dataset in regards to some of the basic demographics of the characters.

Table 2. Comparison of Datasets Across Major Demographic Codes

Dataset	All Characters	Gender		Age		Race	
		Male	Female	Adult	Child	White	Minority
Unique Reoccurring Characters	168	96	63	35	67	47	22
Character Instances	761	425	288	198	249	207	104
Full Dataset	1,086	496	334	246	293	237	105

Analysis Plan

To investigate the representation of gender and race on children's STEM TV shows (RQ1), we ran descriptive analyses with the Unique Characters dataset, looking closely at gender, race, and interactions with age. We also ran binomial tests to see how these data compare to U.S. population data. Then, to investigate whether there were differences by gender or race in who actively participated in STEM activities (RQ2), we used the Character Instances dataset to run chi-square tests, t-tests, and one-way analyses of variance (ANOVAs) to compare genders, races, and age groups on the STEM engagement variables. Finally, to answer the question of what types of STEM occupations were portrayed (RQ3), we used the Character Instances dataset to report frequencies of various STEM occupations and descriptive statistics by gender, race, and age. All analyses were run using SPSS Version 24.

Character Representation

Using the Unique Characters dataset, we considered the representation of race and gender across the STEM shows in our sample. Expected values used in the binomial tests were retrieved from 2015 U.S. Census data.

Gender. Of the 168 characters in the Unique Characters dataset, 57.1% were male, 37.5% were female, and 5.4% were coded as ‘other’. Excluding characters coded as other, a binomial test indicated that the proportion of female characters of .420 was lower than the expected .508, $p = .000$ (1-sided), suggesting that female characters were underrepresented compared to the U.S. population.

Considering only the 90 human characters in the Unique Characters dataset, 51.1% were male, 46.7% were female, and 2.2% were coded as ‘other’. A binomial test indicated no significant difference between the proportion of female human characters and the expected value in the U.S. population.

Gender by age. When looking only at the 67 child characters in the sample, representation of genders was actually quite balanced, with 50.7% being male and 49.3% being female (n.s.); however, the same was not true for adult characters. Among the 35 adult characters, 60.0% were male and 40.0% were female. A binomial test indicated that the proportion of adult female characters of .400 was lower than the expected value of .508, p = .016 (1-sided).

Race. Of the 90 human characters (race/ethnicity was not coded for non-human characters), 52.2% were White, 18.9% were Black, 16.7% were coded as 'unsure', 4.4% were Asian, 4.4% were Hispanic, 2.2% were coded as 'other', and 1.1% were of mixed race/ethnicity. No Native American or Middle Eastern characters appeared in our sample.

There were some significant differences compared to population estimates. We used binomial tests to compare White characters to characters that represent a race/ethnicity that is underrepresented in STEM fields (i.e., Black, Hispanic/Latino, Native American, and Mixed race), hereafter referred to as "minority characters." A binomial test indicated that the proportion of minority characters of .244 was lower than the expected .352, p = .019 (1-sided). Looking at each racial group that comprises the "minority characters" label separately, Hispanic/Latino seemed to be driving this difference. Binomial tests indicated that the proportion of Hispanic characters of .044 was lower than the expected .178, p = .000 (1-sided). Interestingly, White also seemed to be underrepresented. A binomial test indicated that the proportion of White characters of .522 was lower than the expected .613, though only with marginal significance, p = .075 (1-sided). This could be because of the high numbers of characters coded as 'unsure'.

Race by age. The underrepresentation of Hispanic/Latino characters held true for both child and adult characters. For the 54 child characters, a binomial test indicated that the proportion of Hispanic characters of .055 was lower than the expected .178, p = .008 (1-sided). The proportion of White children of .500 was also slightly lower than the expected .613, though only with marginal significance, p = .060 (1-sided). Amongst the 24 adults, no group was significantly lower than expected; however, a binomial test revealed that the proportion of

Hispanic/Latino characters was marginally lower than expected (observed = .041, expected = .178, p = .056. 1-sided).

Characters' On-Screen Actions

Using the Character Instances dataset, we examined the behaviors that characters modeled across the 90 episodes in our sample. Using t-tests, chi-squares, and ANOVAs we looked for differences by race, gender, and age in character role and STEM participation.

Character role. Before examining specific STEM behaviors, we looked for differences by race and age in how major or minor the characters are, i.e. their centrality to the narrative and educational content. Chi-square analyses of character role scores showed no significant differences between the different race groups in our sample. There was a marginally significant difference for gender; the trend suggests that male characters are more likely than female characters to be a protagonist (i.e., a character role score of 4), $\chi^2(1, N = 713) = 3.64$, p = .056. There was also a significant relationship between age and being a major character (i.e., a character role of 3 or 4), such that child characters are more likely to be major characters in shows than adult characters, $\chi^2(1, N = 447) = 68.67$, p = .000.

STEM participation. In order to look specifically at the characters' STEM-related behaviors, we first examined the characters' overall levels of active and passive learning of STEM content (episode-level codes), and then examined the specific STEM behaviors that the characters demonstrated, i.e., teaching, questioning, making observations, investigating, and problem solving. For those five specific STEM behaviors, a Principle Components Analysis in SPSS revealed two components; teaching loaded as one component, and the other 4 behaviors loaded together. Therefore, we summed questioning, making observations, investigating, and problem solving into a composite STEM Engagement variable. Below, we present analyses for both the composite variable and the individual items.

Active vs. Passive Learning. Child characters were significantly more active in their learning (M = 1.78, SD = 1.53) than adult characters were (M = .38, SD .97), t(424) = 11.76, p = .000. Comparisons across races and genders did not produce significant differences, except when considering only adults. White adults were significantly more active in their learning (M = .58, SD = 1.15) than minority adults were (M = .18, SD = .58), t(108) = 2.49, p = .014.

This supports the idea that while children of different races and genders exhibit similar levels of learning and engagement behaviors on-screen, the same may not be true of adults.

STEM engagement. Children displayed significantly higher STEM engagement (M = 2.61, SD = 1.97) than adults did (M = .88, SD = 1.29), t(430) = 11.161, p = .000. Here again, comparisons across races and genders did not produce significant differences, except when considering only adults. White adults displayed significantly higher STEM engagement (M = 1.08, SD = 1.63) than minority adults displayed (M = .53, SD = .78), t(109) = 2.40, p = .003.

Questioning. Children were found to ask significantly more questions (M = .54, SD = .67) than adults asked (M = .09, SD = .28), t(346) = 9.64, p = .000. As with the composite STEM engagement variable, comparisons across races and genders did not produce significant results except with comparisons amongst adults. White adults were found to ask significantly more STEM-relevant questions (M = .13, SD = .34) than minority adults did (M = .03, SD = .17), t(108) = 2.03, p = .044.

Making observations. Children were found to make significantly more STEM-relevant observations (M = .80, SD = .78) than adults made (M = .21, SD = .51), t(428) = 9.58, p = .000.

Comparisons across races and genders did not produce any significant results, and this was true for all age groups.

Investigating. Children were found to conduct significantly more investigations (M = .41, SD = .70) than adults did (M = .14, SD = .44), t(420) = 5.02, p = .000. Comparisons across races and genders did not produce any significant results; this was also true for all age groups.

Problem solving. Children were found to engage in significantly more problem-solving (M = .87, SD = .70) than adults did (M = .45, SD = .60), t(445) = 6.61, p = .000. No significant differences were found across races and genders. Although only marginally significant, trends suggest that white adults engaged in more problem solving (M = .48, SD = .66) than minority adults did (M = .26, SD = .51), t(80) = 1.89, p = .063.

Teaching. Adult characters were found to have significantly more teaching moments (M = .58, SD = .82) than child characters (M = .40, SD = .63), t(364) = 2.53, p = .012. No significant differences were found in comparisons across races and genders.

Further analyses of STEM participation by race. In the character representation section, minority characters were found to be significantly underrepresented when compared to the U.S. population. However, White characters were not overrepresented, and, in fact, they seemed to be marginally underrepresented. This was likely due to the large number of characters coded as ‘unsure’ for their race (16.7% of all human characters in the Unique Characters dataset). To investigate this further, we ran several one-way ANOVAs to compare races and examine how the ‘unsure’ group might be different from the easily identifiable races along our STEM behavior variables. Sure enough, characters coded as ‘unsure’ for race were more STEM engaged than at least one race group across two variables: active learning and questioning.

Excluding characters of 'unsure' race, there was close to no difference in performance of STEM behaviors between other races across all variables.

A one-way ANOVA showed that the effect of race was significant in active learning, $F(4, 367) = 3.95$, $p = .004$. A Tukey post-hoc test revealed that characters coded as 'unsure' were significantly more active in their learning ($M = 1.91$, $SD = 1.61$) than White characters ($M = 1.09$, $SD = 1.43$, $p = .005$) and Asian characters ($M = .63$, $SD = 1.01$, $p = .011$). Significant results showing the effect of race in active learning were also found amongst adults, $F(4, 118) = 2.87$, $p = .026$, and amongst children, $F(4, 194) = 4.98$, $p = .001$. With adults, a post-hoc Tukey test revealed that adults coded as 'unsure' were significantly more active in their learning ($M = 1.67$, $SD = 1.51$) than Hispanic adults ($M = .00$, $SD = .00$, $p = .038$) and Black adults ($M = .22$, $SD = .64$, $p = .022$). With children, a post-hoc Tukey test revealed Asian children were significantly less active in their learning ($M = .67$, $SD = 1.05$) than Black children ($M = 2.07$, $SD = 1.49$, $p = .012$) and children coded as 'unsure' ($M = 2.58$, $SD = 1.39$, $p = .000$). Children coded as 'unsure' were also significantly more active in their learning than White children ($M = 1.72$, $SD = 1.48$, $p = .035$).

A one-way ANOVA also found a significant effect of race on questioning, $F(4, 367) = 3.07$, $p = .016$. A Tukey post-hoc test revealed that characters coded as 'unsure' asked significantly more STEM-related questions ($M = .60$, $SD = .65$) than White characters ($M = .31$, $SD = .55$, $p = .016$). Race also had a significant effect on questioning among children, $F(4, 194) = 2.66$, $p = .034$. A Tukey post-hoc test showed only a marginally significant difference, with children coded as 'unsure' asking more questions ($M = .84$, $SD = .64$) than White children ($M = .48$, $SD = .65$, $p = .060$).

Portrayals of STEM Occupations

In the Character Instances dataset of 761 characters, only 217 (28.5%) characters were portrayed as having an occupation. Using a list of STEM occupations provided by the U.S. Bureau of Labor Statistics, we found that 30 of the 217 characters (13.8%) held STEM occupations. The STEM occupations that came up were animal expert, marine biologist, information technology officer, engineer, zoologist, astronomer, inventor, and scientist. Twenty-three characters held borderline-STEM occupations (i.e. occupations that require STEM skills and/or content knowledge, but were not explicitly included on the Bureau of Labor Statistics' list). These included doctors, nurses, mechanics, paleontologists, ophthalmologist, archaeologists, and inventors. The remaining 164 occupations were not related to STEM and ran the gamut, from racecar drivers and bakers to fictional or pretend occupations, such as superheroes and 'backyard explorers.'

STEM occupations by age, gender, and race. Of the 53 characters who held either a STEM or borderline-STEM occupation, the majority were adults (45.3%). The second largest age group was 'other' (32.1%), which reflects how it was often difficult to ascribe an age to a non-human character. Children made up 13.2% of occupations, and elderly adults made up 9.4%. There were no babies, or teenagers that held occupations.

Looking at gender, we found that the overwhelming majority of characters with STEM or borderline-STEM occupations were male (77.4%). Females made up 20.8% of characters with these occupations and characters coded as 'other' made up 1.9%.

The breakdown of STEM and borderline-STEM occupations by race was confounded by the inclusion of non-human characters, who had their race coded as 'irrelevant'; they made up 39.6% of characters with STEM-related occupations. If they are excluded we find that 81.2% of characters were White. The remaining 18.8% of occupations were held by three Black characters (5.7%), two characters coded as 'unsure' (3.8%), and one Hispanic character (1.9%).

Discussion

Summary and Interpretation of Results

This study investigated the landscape of character portrayals on STEM-focused educational television programs for young children. We identified a sample of 30 STEM television shows that are available to children in the U.S. today via broadcast, cable, or streaming and randomly selected three episodes from the most recent season of each. From these 90 episodes, 1,086 characters were identified and coded for their character attributes and STEM participation across the episodes. From that full dataset of 1,086 characters, the 761 individual speaking characters were analyzed for their demographic representation and their modeling of STEM behaviors.

Our first research question focused on the representation of gender and race in these STEM television programs, and how that compares to the U.S. population. Overall, female characters were significantly underrepresented in our sample. This is a classic industry shortcoming that has been documented in many content analyses across decades of television studies (e.g., Jeffries-Fox & Signorielli, 1978; Long et al., 2001; Signorielli, 1990). Somewhat encouragingly, the story improved when we looked at child characters. While adult female characters were underrepresented on screen, child female characters were represented in relatively equal numbers to their male child counterparts. Interestingly, the underrepresentation of females also disappeared when we limited the sample to only human characters. Together, these two caveats are quite encouraging because literature on identification and perceived similarity suggests that children are most likely to be influenced by characters whom they perceive to be like them (Hoffner & Buchanan, 2005); it seems likely that human children characters would be perceived as more similar to viewers than adults or non-human characters.

Representation of race/ethnicity presented a somewhat complicated story. White characters were not overrepresented compared to the makeup of the U.S. population. However, minority characters were significantly underrepresented. This was driven mostly by a lack of Hispanic/Latino characters in the sample. One might wonder how it could be that minority characters are underrepresented but white characters are not overrepresented. The answer seems to lie in the large percentage of racially ambiguous characters, which, in this study, were coded as “unsure.” This may be an industry shortcoming, but might also reflect how producers of these shows are attempting to address issues of diversity – by including many ambiguous characters, characters with non-human skin tones, and many non-human characters. While this does reflect improvements in diversity as far as including more non-white characters, it is yet unclear whether this is an effective way of addressing the need for representation and the fact that children of all races should be able to see characters on screen who actually look like them. It may be that children of different races see a racially ambiguous character and project their own race onto that character (as it seems producers are hoping is the case). However, it may be that, for the majority of children, these racially ambiguous characters still look like an “other” and do not in fact provide on-screen role models that children can see themselves in. More work is needed on children’s perceptions of character race to disentangle these possibilities.

For our second research question, we wanted to know whether the STEM behaviors modeled by characters would differ based on their race or gender. Prior content analyses have shown that not only are there differences by race and gender in quantity of characters, but that characters of different genders and races tend to exhibit different types of behaviors on screen, with female and minority characters often being portrayed in very stereotypical ways (Aubrey & Harrison, 2004; Baker & Raney, 2007; Klein & Shiffman, 2006; Ward, 2004). Aubrey and Harrison (2004) explain that television can contribute to both stereotypical and non-stereotypical attitude formation depending on the behaviors modeled by on-screen characters. Therefore, we chose to focus on the positive STEM behaviors that characters might model in these programs.

There were very few differences in character role or STEM behaviors by gender. This finding maps well onto Long, Boiarsky, and Thayer's (2001) analysis of counter-stereotypes in science education television. They found that although male characters largely outnumbered female characters, males and females were equally likely to be portrayed as scientists. Similarly, in the present study, we found that although female characters were underrepresented, they were equally as likely as their male counterparts to be portrayed exhibiting STEM behaviors like making observations and problem solving. Our findings, however, depart from Long, Boiarsky, & Thayer's findings when it comes to race. In their study, minority characters were much less likely to be labeled as scientists and were given much less time on screen. In the present study, we did not find many differences in character role or STEM behaviors by race. This may reflect some improvement in portrayals of race in STEM TV over the last 15 years, but it could also be due to the fact that our sample was much larger than theirs (30 STEM shows in the present study versus only 4 in the 2001 study).

Though not a primary focus in our research questions, age ended up being an important variable to consider in our analyses. Unsurprisingly given that our sample consisted solely of children's television programs, there were significantly more characters depicted as children than as adults. What was surprising, however, was that child characters were treated significantly more equally in terms of race and gender than adult characters. This is likely due to the fact that adults in our sample were more auxiliary characters and less directly involved in the STEM narrative.

Finally, we wanted to know what types of STEM occupations were being portrayed in children's STEM TV. Because educational television can serve as an initial point of exposure to new topics and ideas for young children, there is great opportunity for children to learn about various types of STEM careers and occupations through STEM television. For example, a child growing up in a family with limited economic resources might have very little opportunity to meet a computer scientist in real life, especially a female computer scientist given that they are so few in number. But a television show that portrays a female computer scientist as a character would be an easy way to introduce that child to the concept and let them know that such a career is possible. Unfortunately, it doesn't seem that these shows are taking much advantage of this opportunity. We found that only 28% of the characters in our sample were portrayed as having any type of occupation at all, or even pretending to have an occupation. Only 4% were shown to have a STEM occupation, and these were quite limited in scope; only eight unique STEM occupations were portrayed. While this does not necessarily present a problem in the industry, it does seem like a missed opportunity that media producers might want to capitalize on.

Limitations

Though quite comprehensive compared to similar content analyses, this study is not without its limitations. First, looking at the sample, the criteria for inclusion in the sample were quite loose; programs needed only to self-identify as aiming to teach STEM. After completing the coding process, it was clear to the coders that some of these programs included drastically more educational content than others. Future work might investigate quality of STEM content in addition to character portrayals in order to see if there is any relationship between the educational quality programs and how well they represent diverse characters. Additionally, although inter-rater reliability was quite high for most of the variables in this study (Cohen's Kappa for most variables ranged between .81 and .97), our coding was certainly subject to human interpretation. Future studies might seek to include more objective variables such as time on screen for each character. And finally, content analyses represent a first step in understanding media effects by identifying patterns and trends that might lead to effects. Future studies should extend this line of research to experimentally investigate the impact of these portrayals on children's learning of and/or attitudes towards STEM.

Implications and Conclusions

Despite these limitations, this study has important implications for researchers and media producers alike. There is evidence that studies such as this one can in fact have tangible effects within the media industry. The Geena Davis Institute on Gender and Media conducted a survey of all TV and film executive content creators who had attended their research presentations and symposia. Over two-thirds of respondents reported that they had utilized information they learned from the research in two or more projects. When asked what they had changed about the projects, over a quarter of respondents reported having changed the "aspirations or occupations of female characters" (Smith, 2012).

In terms of research implications, there have been surprisingly few content analyses of children's television that have focused on representations of gender and race. This is especially true when you look at educational television. Many of the existing character analyses have focused, for example, on Disney films or cartoons in general (Leaper et al., 2002; Pila, 2016; Thompson & Zerbinos, 1995). Educational television, however, is a particularly popular genre for children who have yet to enter formal schooling, which is also, developmentally, an opportune time to begin to expose them to early STEM topics (Brenneman et al., 2009; Callanan & Oakes, 1992).

Overall, our findings suggest that today's STEM television landscape has many strengths in terms of character representation, but also a few weaknesses. If producers of children's STEM television can continue to make strides by featuring more female characters and moving towards a goal of true racial representation rather than some ambiguous idea of diversity, we may soon find that this genre can have a wide-reaching impact on all children's interest in STEM and beliefs about who participates in STEM.

III. STUDY 2. The Impact of Exposure to a Counter-Stereotypical STEM Show on Children's Attitudes Towards STEM Learning and STEM Careers

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 (President's Council of Advisors on Science and Technology, 2009; Unfried, Faber, Stanhope, & Wiebe, 2015). Unfortunately, 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 (President's Council of Advisors on Science and Technology, 2009; Stoet & Geary, 2018). In order to address this 'STEM gap', it is essential that we better understand how children's early attitudes towards STEM are formed and what factors might influence them in a positive way. Media is one environmental factor shown to shape children's attitudes and beliefs (Jordan, 2004). Educational television, especially, has been found to boost children's positive attitudes towards learning and specific school subjects. Fisch (2004) 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. In this chapter, I present an experimental study that investigates the ability of a STEM-focused educational television show to shape children's attitudes towards STEM. More specifically, I explore several factors that might influence the relationship between television exposure and attitude change, namely the inclusion of diverse characters, children's relationships with those characters, and children's perceptions about various aspects of the show.

The Development of Children's STEM Attitudes

In order to investigate the potential for educational television to have a positive impact on children's attitudes towards STEM, it is first necessary to understand how those attitudes form and develop over time, both in regards to STEM-related school subjects and to STEM-related occupations.

Attitudes towards STEM subjects. Student attitudes toward an academic subject can be broken down into self-efficacy and expectancy-value beliefs, two important subcomponents of achievement motivation (Eccles & Wigfield, 2002). Self-efficacy is the belief in one's ability to complete tasks or influence events that have an impact on one's life (Bandura, 1986a). Research has shown that students are more likely to pursue postsecondary schooling in STEM fields if they have high self-efficacy in math (Wang, 2013) or science (Scott & Mallinckrodt, 2005). Expectancy-value beliefs have to do with an individual's perceived likelihood of attaining specific goals and appraisal of the value gained or lost from such attainment (Eccles & Wigfield, 2002). Having high expectancy-value beliefs has been found to be associated with a student's persistence in taking advanced science and math courses (Fan, 2011; Simpkins, Davis-Kean, & Eccles, 2006). Unfried and colleagues (2015) combined these two types of beliefs, self-efficacy and expectancy-value, to create a measure of attitudes towards STEM validated with children as young as eight years old. Indeed, the authors found that these early attitudes towards STEM are positively related to various other measures of interest in STEM careers (Unfried et al., 2015).

Attitudes towards STEM careers. Historically, the association between career interests and participation in STEM career pathways has been studied most rigorously in the context of postsecondary education (Chen, Gully, Whiteman, & Kilcullen, 2000). Recently, however, researchers have begun to examine the career interests of younger students in relation to STEM careers. Maltese and Tai (2011) 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 (2012) found that students' career interests when entering high school were the strongest predictors of their career interests when leaving high school.

A few studies have begun to investigate career aspirations in even younger children. In a study of first-, third-, and fifth-graders, Auger, Blackhurst, and Wahl (2005) found that first-graders' self-reported career aspirations were just as specific and realistic as those of the fifth graders. Selkow (1984) 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 (Curran & Kellogg, 2016; Morgan et al., 2016), provide strong reason to continue to investigate career aspirations in very young children, especially as they pertain to STEM careers.

The Need for Diverse STEM Portrayals

Not only are American children's attitudes towards STEM concerningly low (Master, Cheryan, & Meltzoff, 2017; Stoet & Geary, 2018), their ideas about who participates in STEM are also extremely narrow. A recent meta-analysis by Miller and colleagues (2018) 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. Though disappointing, these impressions are not inaccurate. Women and people of color are largely underrepresented in STEM fields in the United States (National Science Board, 2010; President's Council of

Advisors on Science and Technology, 2009). Blickenstaff (2005) writes that there is no singular reason why this is the case, but that it is a complex and multi-faceted problem. As discussed in Chapter 2, the underrepresentation of female characters and racially diverse characters in STEM television shows is likely one contributing factor.

Importantly, 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 (Burke & Mattis, 2007; Sadler et al., 2012). In other words, it is not that they don't 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., Bond, 2016; Marra, Rodgers, Shen, & Bogue, 2009; Post-Kammer & Smith, 1986), or racial minority students' self-efficacy in STEM (e.g., Hurtado, Newman, Tran, & Chang, 2010; MacPhee, Farro, & Canetto, 2013), but I argue that in addition to boosting self-efficacy for minority groups, we must also work to broaden all children's ideas about who participates in STEM. Accordingly, this study seeks to investigate whether exposure to a STEM television show that features girls and racially diverse characters can impact children's attitudes towards STEM and ideas about who holds STEM careers.

Television Viewing and Attitude Change

Theoretical frameworks. The relationship between television exposure and attitude change (often referred to as persuasion or entertainment education) has long been explored by communication researchers. Significant effects have been shown across many domains, from political views to attitudes towards healthy behaviors, and everything in between (see Shrum, 2012; Wilson & Sherrell, 1993, for reviews). For children specifically, researchers have found effects of television exposure on social attitudes (Castelli, De Dea, & Nesdale, 2008), racial attitudes (Vittrup & Holden, 2011), sex role attitudes (Signorielli & Lears, 1992), and attitudes towards learning (Fisch, 2009). As discussed in Chapter 1, cultivation theory (Gerbner et al., 1986) and social cognitive theory (Bandura, 1986b) 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 (Gerbner et al., 1986). 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 (Bandura, 1971). 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.

Single vs. repeated exposure. Specifically looking at exposure to a science show and children's reported interest in science, Mares, Cantor, and Steinbach (1999) 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, in a recent study, Bond (2016) 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 actually influence children in a positive way.

Based on the theoretical frameworks presented above and the limited extant literature in this area, I hypothesize that repeated exposure to counter-stereotypical STEM portrayals might in fact positively influence young children's attitudes towards STEM. Specifically, I propose the following:

H1: Repeated exposure to a counter-stereotypical STEM program will be related to a positive change in attitudes towards STEM subjects.

H2: Repeated exposure to a counter-stereotypical STEM program will be related to a positive change in attitudes towards STEM careers.

H3: Repeated exposure to a counter-stereotypical STEM program will be positively related to self-identification as someone who can participate in STEM activities.

Beyond Exposure – Individual Differences Matter

Although the potential for television exposure to facilitate attitude change has been well established, educational programs tend to vary greatly in their effectiveness, especially from viewer to viewer (Anderson, 1998; Thakkar, Garrison, & Christakis, 2006; Woodard, 1999). One key to understanding these varying effects is to have a better understanding of what the children themselves bring to the viewing experience. Valkenburg and Peter (2013b) argue that in order to gain a full understanding of the media experience, researchers must consider the users as individuals. Television viewers do not uniformly respond to the screen; they also bring their own perceptions and attributions to the viewing experience, which affects their individual experiences with the medium (Salomon, 1983). Therefore, in addition to looking at the effects of overall exposure, in this study, I also investigated various individual-level factors that might moderate the relationship between exposure and attitude change.

Familiarity. One viewer characteristic described in the capacity model of children's learning from educational television (Fisch, 2000, 2004) is the viewer's prior knowledge of subject matter related to the program. Familiarity with certain situations and settings can facilitate comprehension of new information that matches easily into that prior knowledge structure. In a study of televised narratives, Newcomb and Collins (1979) found that children's comprehension was enhanced when their ethnic and social class background matched that of the characters and situations portrayed in the program. They explain that "comprehension difficulties of young grade school children may reside partly in these children's lack of familiarity with the types of roles, characters, and settings, portrayed." Spilich, Vesonder, Chiesi, & Voss (1979) similarly reported that previously acquired knowledge affected the processing of new information within the same domain; in a study of textual narratives, they found that baseball fans were better able to recall central information from a story about a baseball game than non-fans. In a more recent study that specifically tested the viewer characteristics described in Fisch's capacity model, Aladé and Nathanson (2016) also found that prior knowledge related to both the narrative and the educational content were positively associated with comprehension in young children. The primary assumption in explaining these findings is that the processing of new information involves a matching procedure in which the new information is matched to the individual's existing knowledge structure (Spilich, Vesonder, Chiesi, & Voss, 1979). Following this line of thought, the more familiar a viewer is with the genre, setting, plot, and characters of a television program, the easier it will be for them to process and comprehend new information presented in the program, which, in turn, will better facilitate attitude change. Therefore, I hypothesize:

H4a: Familiarity with the genre of educational STEM television shows will be positively related to STEM attitude change.

H4b: Familiarity with the stimulus program will be positively related to STEM attitude change.

Appeal. In discussing how children are influenced by educational media, Fisch (2004) argues that if children do not enjoy a program, they simply will not turn it on, thus eliminating any potential benefit of the program. Other researchers have also pointed to the importance of program appeal as a prerequisite for learning (Linebarger & McMenamin, 2010; Linebarger & Piotrowski, 2006; Wakshlag, Reitz, & Zillmann, 1982). However, our understanding of what drives appeal and media preferences in young children is limited. Programs can be very appealing for some viewers and not at all appealing to others. This is an important individual-level factor to account for as it may support or inhibit any potential effects of exposure. Therefore, I hypothesize:

H5: Appeal of the stimulus program will be positively related to change in viewers' attitudes towards STEM.

Perceptions of educational intent. In the literature on television exposure and attitude change, one factor that often comes up is the explicitness of the persuasive message. Researchers in the fields of persuasion and entertainment-education have argued programs are most effective at changing attitudes when viewers are unaware of the persuasive intent of the program (Moyer-Gusé, 2008; Moyer-Gusé & Nabi, 2010; Slater, 2002; Slater & Rouner, 2002). Moyer-Gusé (2008) explains that the goal of these entertainment-education programs is to embed the persuasive message so deeply into an entertaining narrative that viewers do not notice the persuasive intent. In some cases, this has been found to lead to less reactance and less counterarguing. In other cases, however, researchers have found that the inclusion of an explicit persuasive appeal can actually lead to greater attitude change (Moyer-Gusé, Jain, & Chung, 2012). Similarly, Fisch (2000, 2004) argues that explicitness of the educational content is an important factor in facilitating children's processing of educational material. While explicitness of the content and/or of the appeal is usually thought of as a program characteristic, I argue that, like appeal, perceived explicitness of the message might vary greatly from one viewer to another. Since the evidence in this area is limited and somewhat contradictory, I pose the following as a research question:

RQ1: Will recognition of the educational intent of the stimulus program be positively or negatively related to STEM attitudes?

The Role of Characters in the Relationship between Exposure and Attitude Change

Engagement with characters. Several studies have identified engagement with characters as a key component to the persuasive effects of narrative television (de Graaf, Hoeken, Sanders, & Beentjes, 2012; Klimmt, Hefner, Vorderer, Roth, & Blake, 2010; Moyer-Gusé, Chung, & Jain, 2011). This is sometimes referred to as identification. Cohen (2001), who most famously conceptualized the term, describes identification as "a mechanism through which audience members experience reception and interpretation of the text from the inside, as if the events were happening to them" (p. 2450). He goes on to argue that identification is a central mechanism for explaining the effects that media has on its audiences. Identification has also been conceptualized as a temporary shift in self-perception, in which the viewer takes on the perspective of the character (Klimmt et al., 2010). Important for the context of the current study, Moyer-Gusé et al. (2011) found that identification led not only to attitude change, but also to an increased sense of self-efficacy, which in turn was associated with behavior change.

Engagement with characters has been conceptualized and operationalized in a multitude of ways. There are three specific relevant constructs that have been successfully measured and investigated with young children: perceived similarity, wishful identification, and parasocial relationships.

Perceived Similarity. Perceived similarity refers to the degree to which a viewer feels that he or she is similar to a character (Moyer-Gusé, 2008). This similarity can be rooted in shared physical attributes, personality traits, group membership, or shared attitudes and beliefs (Hoffner & Cantor, 1991). Perceived similarity is often thought to be a prerequisite for identification, but Moyer-Gusé (2008) argues that it is a quite distinct concept – whereas traditional identification requires cognitive perspective taking with a character (which might be too advanced for the target age group of this study), perceived similarity often relies on more superficial, easily detectable likenesses. Like wishful identification, perceived similarity has successfully been measured in very young children (de Droog & Buijzen, 2014).

Wishful Identification. Wishful identification is defined as the desire to be like or act like a character (Hoffner & Buchanan, 2005). Unlike identification, which requires a certain level of cognitive sophistication that is not likely to be explicitly present in young children, wishful identification has been successfully measured in children as young as four years old (de Droog & Buijzen, 2014). Prior research (Hoffner et al., 2006) has shown that wishful identification can have an effect on occupational aspirations, which makes it an especially important concept to include in the present study.

Parasocial Relationships. Engagement with characters is also often discussed in terms of viewers' parasocial interaction and parasocial relationships with characters. The idea of parasocial interaction (or PSI) was first introduced by Horton & Wohl (1956), who conceptualized the term as referring to the simulated contact between a viewer and a performer. Conceived just as television was becoming an integral part of the average American home, parasocial interaction theorists originally aimed to explain the relationship forged between viewers and television personalities with whom they suddenly had "face to face" contact. Since then, many researchers have applied PSI to a variety of formats, including television news (Rubin, Perse, & Powell, 1985), soap operas (Babrow, 1987), children's cartoons (Rosaen & Dibble, 2008), and even satellite radio (Lin, 2006). Researchers have found that parasocial interaction often leads to long-lasting relationships between viewers and television characters (J. R. Turner, 1993). These parasocial relationships are often likened to real-life interpersonal relationships, in which viewers feel that they know a television character as well as they might know a neighbor or a friend (Rubin et al., 1985). In recent years, Calvert and colleagues have conducted several studies investigating the parasocial relationships that young children have with media characters. In childhood, where the boundaries between reality and fantasy are less defined (Harris, Brown, Marriott, Whittall, & Harmer, 1991; Sharon & Woolley, 2004; Woolley & E Ghossainy, 2013) and media characters travel from the screen to the toy chest (Calvert & Richards, 2014), these parasocial relationships can be even more intense than in adulthood. Children's parasocial relationships with characters have been clearly linked to learning outcomes (Gola, Richards, Lauricella, & Calvert, 2013; Lauricella, Gola, & Calvert, 2011), and Calvert (2014) argues that these parasocial relationships are also likely the underlying mechanism through which other studies have found effects of media exposure on children.

Based on these three distinct, yet complementary, bodies of literature, I hypothesize that all three forms of engagement with characters would positively influence children's attitudes towards STEM. Specifically:

H6a: Perceived similarity with stimulus characters will be positively related to STEM attitude change.

H6b: Wishful identification with stimulus characters will be positively related to STEM attitude change.

H6c: Parasocial relationships with stimulus characters will be positively related to STEM attitude change.

Implicit and Explicit Occupational Attitudes

Looking specifically at attitudes towards social groups (i.e., gender- and race-based attitudes), it is important to note the difference between implicit, or subconsciously engrained, attitudes and explicit, or consciously expressed, attitudes. Research on implicit attitudes has found that there is a motivation to respond without prejudice that causes people to explicitly report attitudes that are sometimes very different from their implicitly measured attitudes (Eno & Ewoldsen, 2010). Little is known about the developmental trajectory of motivation to respond without prejudice or the point at which children's implicit attitudes begin to diverge from their explicit attitudes. Baron and Banaji (2006) were the first to reveal the emergence of implicit attitudes towards social groups in young children. In order to accomplish this, they developed a child-friendly modification of the Implicit Association Test (IAT) originally developed by Greenwald, McGhee, and Schwartz (1998). The researchers measured implicit and explicit racial attitudes of 6-year-olds, 10-year-olds, and adults. Their goals were to investigate whether or not implicit racial attitudes were formed and detectable in very young children and to compare the trajectory of the youngest children's explicit and implicit attitude formation with that of older children and adults. The 6-year-old participants showed clearly detectable implicit pro-White/anti-Black attitudes. Importantly, mean levels of implicit pro-White/anti-Black attitudes were the same across all ages. This suggests that once implicit racial attitudes are formed, they remain relatively constant through adulthood. Conversely, explicit attitudes were detected at an equal strength as implicit attitudes in the 6-year-olds, but this explicit preference for White over Black diminished across age groups. The 10-year-olds explicitly reported a preference for White over Black that was still present but significantly less pronounced than that of the 6-year-olds, and for the adult participants, no explicit attitudes were detected.

Very relevant to the current study, Steffens, Jelenec, and Noack (2010) measured nine-year-old children's implicit and explicit gender-based stereotypes about math in relation to their academic self-efficacy, academic achievement, and course enrollment preferences. They found that implicit attitudes about math and gender were even more predictive of self-efficacy and achievement than their explicit attitudes. However, it is unclear whether this would hold true for younger children given the findings of Baron and Banaji (2006). There are very few other studies that measure both implicit and explicit attitudes in young children, and especially not in the context of STEM. Therefore, I pose the following as an exploratory research question:

> RQ2: How do children's implicit attitudes towards STEM occupations compare to their explicit attitudes?

Method

Study Design

To investigate the effect of exposure to STEM shows that feature diverse characters on children's attitudes towards STEM, I conducted a pre/post experimental study that took the shape of a media intervention using the science and math-based show Cyberchase. The study was conducted in before- and after-school child care centers in a northern suburb of Chicago. Over the course of eight weeks, participants in the treatment group regularly viewed episodes of Cyberchase, a STEM show identified in Study 1 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.

Study Sites and Recruitment

After approval of the study by the Institutional Review Board, local child care programs were contacted and informed about the study. These child care centers provide before- and 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. Three centers agreed to take part in the study. Center directors sent consent forms home to parents of all kindergarten and first graders at their centers. Centers were randomly assigned to either the treatment or control condition.

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 ($M = 6.57$, $SD = .52$). Participants represented a fairly diverse sample in terms of both race/ethnicity and socioeconomic status. There were no significant differences between treatment and control groups on any demographic variables. Table 3 presents demographic information of the treatment and control groups.

Table 3. 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				
$60,000-$84,999		21.3		18.2
$85,000-$99,999		9.0		0.0
>$100,000		69.7		81.8
Parental Education				
Bachelor's Degree		43.5		36.4
Master's Degree		29.1		36.4
Professional or 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

Procedure

Pre- and posttest. Participants were tested in a quiet space in their child care classroom. Each one-on-one testing session lasted approximately 15-20 minutes. The following assessments were administered: Me/Not Me, Program and Genre Familiarity, Attitudes towards STEM, Occupational Attitudes, Program Appeal, and Character Engagement (Wishful Identification, Perceived Similarity, and Parasocial Relationship). See Measures section for details. Testing sessions were audio recorded for later transcription. It took approximately two weeks to complete pretesting for all participants across the three centers. After exposure, posttesting took an additional two weeks.

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 saw 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 weren’t in viewing sessions, such as coloring, reading books, making jewelry, playing board games, etc.

Posttest. After the eight weeks of exposure, researchers conducted posttest interviews with each participant that were very similar to the pretest interviews, but also included some Cyberchase-specific assessments. Like the pretest, posttest interviews were conducted one-on-one in a quiet location at the study site. Posttest assessments were: Me/Not Me, Cyberchase Familiarity, Attitudes towards STEM, Occupational Attitudes, Cyberchase Appeal, and Perceptions of their Favorite Cyberchase Character (Wishful Identification, Perceived Similarity, and Parasocial Relationship). See Measures section for details.

Parent survey. Parents of all participants were also asked to complete an online survey about their child’s media habits, science and math activities at home, and their own attitudes towards science and math, as well as demographic information about the family.

Stimulus

The stimulus program for this study was chosen using data from Study 1. 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. (See Appendix C for a detailed explanation of the formula and the full ranking of shows.)

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/). From tackling fractions in ancient Greece to using decimals to repair train tracks, the diverse team of female and male protagonists learn that math is everywhere and a useful tool for solving problems. 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. 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.

Measures

"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 Metzloff (2017). 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. Most of these labels had been used in prior research (Marks, Szalacha, Lamarre, Boyd, & Coll, 2007; Rogers & Meltzoff, 2017; K. L. Turner & Brown, 2007). Brother and Sister were added as additional "warm-up" type questions. Scientist, problem solver, and investigator, were added for this study to measure participants' identification with STEM-related roles and behaviors. Artist was added to provide some additional contrast to the STEM labels. Each word was printed on a laminated 4x5-inch card and presented to the child one at a time in the order listed above. Following the procedure used by Rogers and Metzloff (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 were coded as 1. Codes for the three STEM labels were summed to create a STEM self-identification score that could range from 0-3, $\alpha = .54$.

Attitudes towards STEM. In order to measure attitudes towards STEM at pre- and posttest, twelve items were selected from Unfried et al.’s (2015) validated measure of Student Attitudes Toward Science, Technology, Engineering, and Math (S-STEM). The full measure consists of 37 items across four distinct attitudinal constructs: mathematics attitudes, science attitudes, engineering/technology attitudes, and 21st century skills attitudes. S-STEM was validated with 4th-6th grade students. Studies involving younger children, however, tend to focus on the science and math constructs only. This is likely because technology and engineering tend not to be introduced in school until later grades. Following prior research with 6-9 year olds (Bond, 2016), we selected items from only the science and math sub-sections of S-STEM. For math, participants were asked the following five questions: “Do you like learning about math?”, “Do you think math is fun?”, “Do you think math is hard to do?” (reverse coded), “Do you think you are good at doing math?”, and “When you grow up, do you think it will be important for you to know math?” Response options were “not at all,” “a little,” “a lot,” and “a whole lot” with corresponding smiley face pictures that children could point to. The same five questions were asked for science (e.g., “Do you like learning about science?”), resulting in a 10-item measure with a possible range of 0-15, $\alpha = .89$.

Occupational attitudes. The occupational attitudes measure, used at pre- and posttest, was created specifically for this study and was informed by previous research (Beuf, 1974; Bigler et al., 2003; Liben et al., 2001). Due to time and space constraints of data collection, we did not use a traditional 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 Bigler et al., 2003; Liben et al., 2001), and then asked them to verbally elaborate on their response in order to capture their explicit attitudes (adapted from Beuf, 1974).

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 so as to allow for a very clean manipulation of only the race or gender while keeping everything else about the picture constant. See Appendix D for the drawings used in this measure.

To create a quantitative measure of implicit attitudes, forced choice responses from the 12 items were summed to create a scale that measured participants overall adherence to traditional stereotypes about STEM occupations. In other words, to what extent does the participant think of STEM occupations as belonging to white males, which we know is generally true from prior research (see Miller et al., 2018 for a review). 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 scale of 0-12 represented greater adherence to stereotypes. Inter-item reliability for this scale was quite low; $\alpha = .25$. (We also checked to see whether the measure should be separated into two separate scales, one for gender and one for race, but inter-item reliability for the separated scales was even lower; $\alpha = .17$ and .05, respectively.)

Coding of open-ended responses. To capture participants' explicit occupational attitudes, we conducted a qualitative analysis of their responses to the open-ended 'why' component of the measure. Their responses were transcribed from audio recordings and researcher notes and were typically one or two sentences long. Two coders read through the responses and devised separate preliminary coding schemes for the data. These coding schemes were compared and reconciled to form a more refined coding scheme. The coders then double coded a sample of the data, yielding a Cohen's κ of .740, $p < .001$. The coding scheme was refined one more time and another sample was double coded. The subsequent results showed strong agreement between the two coders' judgments (Cohen's $\kappa = .938$, $p < .001$).

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"). 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.

Familiarity. Because program and genre familiarity can play a role in how children experience a program (Fisch, 2004), participants completed brief familiarity assessments at pretest and posttest. At pretest, the assessment gauged overall familiarity with STEM-focused educational television programs. At posttest, the assessment gauged specific familiarity with Cyberchase.

STEM TV Familiarity. The pretest familiarity assessment was designed to gain an understanding of participants' general exposure to shows that are in the same genre as the stimulus program, Cyberchase. It consisted of 15 images of characters from STEM shows that had been identified in Study 1, such as Sid the Science Kid, Team Umizoomi, Peg + Cat, and The Magic School Bus. For each image, children were asked to name the character shown. Correct answers received two points, answers where the child was able to name the show but not the character received one point, and incorrect answers or no answer received zero points, resulting in a possible score of 0-30, $\alpha = .76$.

Cyberchase Familiarity. At posttest, the familiarity measure served as a measure of recall to check on how well the participants attended to the stimulus program. Participants were shown images of the five main characters in Cyberchase and asked if they knew the name of the character. Correct answers received two points, answers that were very close but not exactly correct (e.g., "Max" instead of "Matt") received one point, and incorrect answers or no answer received zero points, resulting in a possible score of 0-10, $\alpha = .85$.

Appeal. Past research has shown that appeal of an educational television program can play an important role in children's learning from that program. Therefore, at posttest, we assessed participants enjoyment of Cyberchase. Participants were asked how much they liked the show Cyberchase, how much they'd like to watch more episodes of Cyberchase, and how much they'd like to watch other shows that are like Cyberchase. Response options were "not at all," "a little," "a lot," or "a whole lot." Scores for each of the three items could range from 0-3 and were summed to create an overall appeal measure ranging from 0-9, $\alpha = .81$.

Perceptions of educational intent. Participants were asked whether the Cybersquad "used any school subjects, like reading, science, math or social studies, to solve problems and defeat Hacker" and "if so, which ones?" This was a dichotomous measure, with participants who mentioned any STEM subject, such as science or math, receiving a score of 1. Participants who said no, or mentioned only non-STEM subjects such as reading, received a score of 0. Participants were also asked whether or not they thought they learned anything from watching Cyberchase. Again, this item was turned into a dichotomous variable, with students who said yes receiving a score of 1 and students who said no receiving a score of 0.

Character Engagement. For each of the following, participants were asked to select their favorite character from Cyberchase (with picture prompts) and asked the following questions in relation to the character they identified.

Perceived similarity. To measure how much the participant felt that the character was like them, we adapted Hoffner and Buchanan's (2005) perceived similarity scale. The scale included the following three items: "Do you think [character] is like you?," "Do you think [character] looks like you?," and "Do you think [character] acts like you?" The language of each item was slightly simplified from the original scale in order to be easily understood by 5- and 6-year olds (e.g., "behaves like you" replaced with "acts like you"). Likewise, responses were originally measured on a 7-point semantic differential scale, but that was determined to be too complicated for this age group. Instead, we utilized the same 4-point scale that was used in other pre- and post-test measures, with response options being "not at all," "a little," "a lot," or "a whole lot." Scores on each item were summed to create an overall perceived similarity score that could range from 0 to 9, $\alpha = .74$.

Wishful identification. In order to measure how much the participants wanted to be like their favorite character, we adapted Hoffner's (1996) wishful identification scale. The measure included three items: "Would you like to do the kinds of things [character] does on the show?" "Is [character] the kind of person you want to be like?" and "Do you wish you could be more like [character]?" As with our perceived similarity scale, we simplified the response options from Hoffner's (1996) original 5-point Likert-type scale, to the same 4-point smiley face scale used throughout this study, with responses ranging from "not at all" to "a whole lot." Scores on each item were summed to create an overall perceived similarity score that could range from 0 to 9, $\alpha = .78$.

Parasocial relationships. To measure the extent to which children had developed parasocial relationships with their favorite character from Cyberchase, we utilized three items from Richards and Calvert's (2016) measure of child-reported parasocial relationships. One item was selected from each of the three factors that were identified by Richards and Calvert as central to children's parasocial relationships: humanlike needs ("Do you feel sad when [character] makes a mistake?"), attachment and friendship ("Is [character] your friend?"), and social realism ("Is [character] real?"). Responses were measured on the same 4-point smiley face scale used throughout this study, with responses ranging from "not at all" to "a whole lot," which was adopted from the Richards and Calvert (2016) study. Scores on each item were summed to create an overall parasocial relationship score that could range from 0 to 9, $\alpha = .77$.

Results

All analyses were completed using SPSS version 24. Prior to hypothesis testing, we checked for differences in all outcome variables by classroom, by treatment group, and by researcher who conducted the interview; this was especially important given that participants were assigned to condition at the classroom level rather than at the individual level. No significant differences were found. Table 4 presents means and standard deviations of each outcome variable for the treatment and control groups.

Between-Group Effects

To test the first three 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). The primary purpose of a mixed ANOVA is to understand if there is an interaction between these two factors on the dependent variable (Laerd Statistics, 2013). In other words, 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.

Table 4. Means, Standard Deviations, and Frequencies for Each Variable by Treatment Group

Variable	Control			Treatment		
	Mean	SD	Percent Yes	Mean	SD	Percent Yes
Change in STEM attitudes	-1.91	4.48		-0.24	5.18	
Change in occupational attitudes	-0.09	2.02		0.48	1.56	
Change in STEM self-identification	0.22	1.62		0.67	1.43	
Scientist self-identification			56.50			76.00
Problem-solver self-identification			82.60			84.00
Investigator self-identification			56.50			80.00
Genre familiarity	5.48	3.40		7.24	4.55	
Cyberchase character familiarity				5.68	3.05	
Program appeal				4.28	1.99	
Recognition of STEM						80.00
Recognition of learning						56.00
Wishful identification				4.08	3.50	
Perceived similarity				2.32	2.21	
Parasocial relationships				2.44	2.14	

A 2x2 mixed ANOVA was used to test H1, which hypothesized that participants in the treatment group would have a more positive change in STEM attitudes from pretest to posttest than participants in the control group. There was no main effect of time (pre and post) ($F(1,45) = 2.28$, $p = .138$), no main effect of condition (treatment and control) ($F(1,45) = .297$, $p = .588$), and no interaction between time and condition ($F(1,45) = 1.38$, $p = .247$). Children who watched Cyberchase did not have a significantly different change in their attitudes towards STEM than those who did not.

A 2x2 mixed ANOVA was used to test H2, which hypothesized that participants in the treatment group would have a more positive change in their occupational attitudes from pretest to posttest than participants in the control group. There was no main effect of time ($F(1,46) = .575$, $p = .452$), no main effect of condition ($F(1,46) = 1.32$, $p = .257$), and no interaction between time and condition ($F(1,46) = 1.20$, $p = .280$). Children who watched Cyberchase did not have significantly different occupational attitudes than those who did not.

A 2x2 mixed ANOVA was used to test H3, which hypothesized that participants in the treatment group would have a more positive change in their STEM self-identification from pretest to posttest than participants in the control group. The analysis revealed a marginally significant main effect of time ($F(1,45) = 3.925$, $p = .054$), no main effect of condition ($F(1,45) = 1.19$, $p = .281$) and no interaction between time and condition ($F(1,45) = 1.01$, $p = .319$). On average, children who watched Cyberchase did not have significantly more positive change in STEM self-identification more than those who did not. However, looking at the graphed results of the mixed ANOVA, there does appear to be a trend in the hypothesized direction. (See Figure 1.)

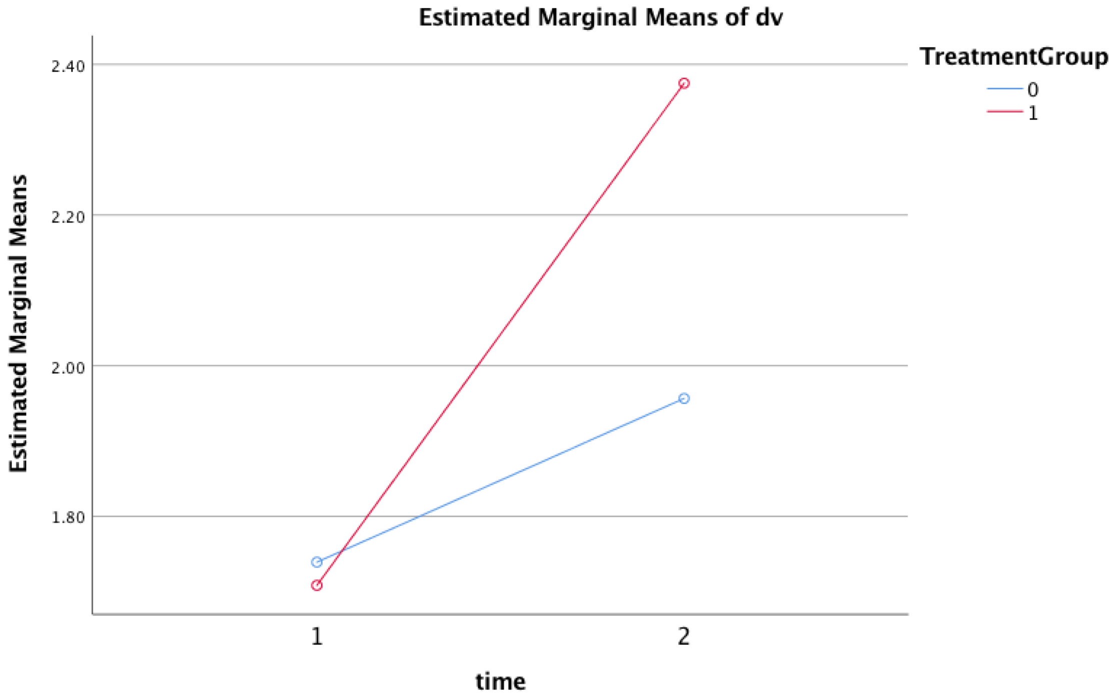

Figure 1. Change in STEM self-identification from pretest to posttest for treatment group (red) and control group (blue).

To probe this further, we looked separately at each item that comprised the STEM self-identification scale, to see if, for example, there might be differences at posttest between treatment and control in self-identification as a scientist, but not as a problem solver or investigator. Chi-square tests of independence examining differences at posttest between treatment and control in self-identification as a scientist or problem solver did not find significant relationships. However, there was a marginally significant difference between treatment and control at posttest in self-identification as an investigator. Eighty percent of participants in the treatment group self-identified as an investigator at posttest, compared to only 56% of the control group, X^2 (1, N = 48) = 3.074, p = .080.

Within-Group Effects

In addition to looking for differences between treatment and control groups, we also used general linear regression to look for individual-level predictors of STEM attitude change within the treatment group. Prior to hypothesis testing, we looked at Pearson correlations between all demographic and outcome variable to find any potential covariates. Age was found to be a significant predictor of change in STEM attitudes, with older children experiencing significantly more positive change than younger children ($F(1, 23) = 8.312$, $p = .008$, $R^2 = .265$). Thus, age was included as a covariate in the following analyses. Table 5 presents results of the within-group analyses.

To test H4a, which hypothesized that familiarity with the STEM television genre would positively predict attitude change, we ran a regression with change in STEM attitudes predicted by genre familiarity. The overall model was significant, with 37% of variance explained ($F(2, 22) = 6.50$, $p = .006$). There was a marginally significant effect of genre familiarity, but in the opposite direction of what was hypothesized. Controlling for age, participants who scored higher in STEM television familiarity had slightly less positive change in attitudes towards STEM from pretest to posttest, ($B = -.37$, $\beta = -.33$, $p = .067$).

To test H4b, which hypothesized that familiarity with Cyberchase at posttest would positively predict attitude change, we ran a regression with change in STEM attitudes predicted by Cyberchase familiarity. Controlling for age, there was no significant effect of Cyberchase familiarity on STEM attitude change, ($B = -.10$, $\beta = -.06$, $p = .749$).

H5 hypothesized that program appeal would be positively related to STEM attitude change. A linear regression controlling for age revealed no significant effect of appeal, ($B = .24$, $\beta = .09$, $p = .624$).

RQ1 dealt with the viewers' perceptions of the educational intent of Cyberchase. Two separate analyses were run to answer this question. First, we grouped participants in the treatment group into those who recognized that the Cybersquad used science and math to solve problems and those who did not. An independent-samples t-test revealed a marginally significant difference, such that participants who recognized and reported STEM subjects in Cyberchase had higher STEM attitude scores ($M = 22.0$, $SD = 5.15$) compared to those who did not ($M = 15.8$, $SD = 9.09$); $t(23) = -2.06$, $p = .051$. We then grouped participants in the treatment group into those who reported believing that they learned something from watching Cyberchase and those who did not. An independent-samples t-test revealed a significant difference, such that participants who reported that they learned something from watching Cyberchase had higher STEM attitude scores ($M = 23.5$, $SD = 3.67$) compared to those who did not feel they learned anything from watching ($M = 17.3$, $SD = 7.58$); $t(23) = -2.71$, $p = .013$.

To test H6, we ran three separate regressions with perceived similarity, wishful identification, and parasocial relationship with child's favorite Cyberchase character, each predicting change in STEM attitudes. Due to high levels of multicollinearity between these three variables, they could not be entered into the same regression model. Controlling for age, there was no effect of either perceived similarity or wishful identification on change in STEM attitudes. However, strength of the participant's parasocial relationship with their favorite character from Cyberchase was a significant predictor of their change in STEM attitudes. Children with higher PSR scores had a greater increase in their attitudes towards STEM from pretest to posttest. The addition of PSR resulted in a significant 15% percent increase in variance explained, ($F(2, 22) = 7.82$, $p = .003$). Controlling for age, participants who had stronger parasocial relationships with their favorite Cyberchase character had significantly more positive change in attitudes towards STEM from pretest to posttest, ($B = 3.10$, $\beta = .43$, $p = .027$).

Table 5. Results of Regression Analyses

Dependent Variable: Change in STEM Attitudes				
Control Variable	B	SE	β	R^2 change
Age	5.56	1.93	0.52	0.27*
Independent Variables (entered separately)				
Genre familiarity	-0.37	0.19	-0.33	$0.11^{\dagger}$
Cyberchase character familiarity	-0.10	0.31	-0.06	0.00
Program appeal	0.24	0.48	0.09	0.01
Perceived similarity	0.66	0.46	0.28	0.06
Wishful identification	0.35	0.27	0.24	0.05
Parasocial relationship	3.10	1.31	0.43	0.15*
Dependent Variable: STEM Attitudes at Posttest				
Independent Variables (entered separately)				
Recognition of STEM subjects	6.20	3.01	0.39	$0.16^{\dagger}$
Recognition of learning	6.23	2.30	0.49	0.24*

*$p < .05$, $^{\dagger}p < .08$

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 didn't 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 22.6% and skills responses made up 12.3% of the total 438 responses. Only 1.8% (n = 8) of responses expressed a belief about equality. 7.5% of responses did not fit into any other category and were coded as other. See Table 6 for the breakdown of frequencies of each code.

For items that manipulated race, responses that cited visual characteristics were also most common, making up 32.9% 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 equipment. 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 8.8% of responses did not fit into any other category and were coded as other. See Table 7 for the breakdown of frequencies of each code.

Table 6. 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	33	7.5
Gender-stereotypical	31	7.1
Exposure	15	3.4
Gender-counter-stereotypical	12	2.7
Equality	8	1.8
Total	441	100.5

Note: Percentages do not sum to 100 because combined codes were counted as exposure and race codes (e.g. a race-stereotypical-exposure response counts under both race-stereotypical and exposure)

Table 7. Qualitative Codes for Race-Based Occupational Attitude Responses

Code	Frequency	Percent
Visual characteristics	135	32.9
Non-committal	121	29.5
Skills	59	14.4
Other	36	8.8
Race-stereotypical	29	7.1
Equality	12	2.9
Exposure	11	2.7
Race-counter-stereotypical	6	1.5
Gender-stereotypical	3	0.7
Gender-counter-stereotypical	1	0.2
Total	413	100.7

Note: Percentages do not sum to 100 because combined codes were counted as exposure and race codes (e.g. a race-stereotypical-exposure response counts under both race-stereotypical and exposure)

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.

Discussion

Summary and Interpretation of Results

To investigate the effect of repeated exposure to a counter-stereotypical STEM show on children's attitudes towards STEM, I 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 STEM show 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.

My first three hypotheses about the effects of repeated exposure on STEM attitudes were not supported. Analyses revealed no significant differences between treatment and control groups in their change in attitudes towards STEM, attitudes towards STEM occupations, or self-identification with STEM as a result of repeated exposure to Cyberchase. 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.

Although there were no observed differences between treatment and control, there were some interesting findings in regards to individual differences. Familiarity was a significant predictor of change in STEM attitudes, but in the opposite direction as hypothesized. Children who were more familiar with educational STEM shows in general had less positive attitude change than their peers who were less familiar with STEM shows. Participants' experience with Cyberchase in particular seemed not to matter; neither familiarity with the show nor appeal of the show were significantly related to STEM attitudes.

Children's perceptions of the educational intent of the show also affected their attitudes towards STEM. Participants who reported that the Cyberchase characters use math and/or science to solve problems were marginally more likely to have positive STEM attitudes at posttest, and participants who reported that they felt they had learned something from watching Cyberchase had significantly more positive STEM attitudes than their peers who did not report learning anything.

In terms of character engagement, I hypothesized that children who had deeper engagement with their favorite Cyberchase characters would experience more positive change in STEM attitudes. This hypothesis was supported, but only with one measure of character engagement. Perceived similarity to and wishful identification with their favorite character were not related to attitude change. However, strength of parasocial relationship with a favorite character from Cyberchase was strongly positively related to STEM attitude change. Children who developed strong parasocial relationships with their favorite character from Cyberchase experienced significantly more positive attitude change from pretest to posttest than those who had not developed strong parasocial relationships with their favorite character.

Finally, we conducted some exploratory qualitative analyses of children's open-ended responses to the occupational attitudes measure in order to compare their explicit and implicit attitudes. 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 choice. 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 off of 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 data on explicit attitudes presented a very different picture than the more implicit response data. Unlike with the implicit responses, which did not show any clear patterns, explicit race and gender stereotypes were quite prevalent, 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 implicit 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.

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 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. Though pilot data demonstrated face validity for the measure, the observed internal reliability statistics were quite low. 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. Lastly, it is important to note that the individual difference results of this study are correlational, and therefore cannot be used to determine the direction of causality.

Theoretical Contributions

Despite these limitations, the results of this study provide valuable contributions to several areas of media effects theory. 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 (1988), 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 (Calvert, Kotler, Zehnder, & Shockey, 2003; Farnall & Smith, 1999; Graves, 1999; O'Keeffe & Clarke-Pearson, 2011). 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 (2016) 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 (Calvert et al., 2003; O'Keeffe & Clarke-Pearson, 2011), or self-reported familiarity and comfort with an outgroup (Farnall & Smith, 1999; Graves, 1999). This study, like Bond's (2016), 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 (Hurwitz, 2018; Mares et al., 1999). However, cultivation theory does suggest that it is cumulative exposure over years that affects the way people view the world. 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.

This study also provides an important extension of the research on individual differences. Valkenberg and Peter (2013a, 2013b) made a call to action for researchers to begin to focus on individual differences, rather than simply controlling for them, an idea that has since been gaining traction in the communication field. The negative effect of genre familiarity found in this study was quite surprising. Fisch's capacity model, one of the few existing theoretical models of children's learning from educational television, states that prior knowledge related to a program is an important facilitator of children's processing of the content (2000, 2004). Likewise, other studies have found prior knowledge to be a significant predictor of comprehension and learning (Aladé & Nathanson, 2016; Piotrowski, 2014). In this case, however, greater familiarity with the genre would also mean greater familiarity with the stereotypical portrayals that are prevalent in the genre (see Study 1). In line with cultivation theory and the drip hypothesis, this heavy inflow of stereotypical portrayals likely mitigated any positive effect of exposure to the counter-stereotypical stimulus.

Interestingly, when participants recognized that Cyberchase contained STEM material, and especially when they felt they had learned something from watching Cyberchase, they were more likely to experience positive effects of exposure. Though this runs counter to the major tenets of entertainment-education research (Moyer-Gusé, 2008), it does align with a tenet of the capacity model, which states that explicitness of the educational content supports processing and comprehension (Fisch, 2000, 2004). The direction of these results likely has to do with the developmental stage of the participants. While adolescents and adults may be resistant to the idea of being persuaded by a television program, young children may have not yet developed this sort of reactance to persuasion. The intersection of developmental theory and entertainment-education theory is an important point to explore further.

Results of this study also help to disentangle the literature on engagement with characters. It seems, for this age group at least, that the strength of parasocial relationships with characters is a more important moderator of the effects of television exposure on attitude change than wishful identification or perceived similarity with the characters. Indeed, other researchers have also recently found strong effects of parasocial relationships (PSR) on various outcome measures related to television exposure (Gola et al., 2013; Putnam, Cotto, & Calvert, 2018; Schlesinger, Flynn, & Richert, 2016; Schlesinger & Richert, 2017). Cumulatively, these studies provide strong support for a PSR scale as the primary way to measure character engagement in young children.

Finally, the quantitative and qualitative analyses of children's implicit and explicit gender- and race-based occupational attitudes provide interesting insights. The quantitative measure of implicit attitudes did not reveal any patterns or trends, which may have been due to measurement error (see limitations section) or 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 (Bigler et al., 2003; Liben et al., 2001), 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. Future research should continue to investigate this relationship between children's exposure to STEM careers, their attitudes towards STEM careers, and ways to measure those attitudes.

Practical Implications and Conclusions

Taking all of these findings into account, there are a few key pieces of practical advice that I would put forth for parents, educators, and media producers. First and foremost, we need more counter-stereotypical portrayals of STEM involvement in children's television. Having one or two examples is not enough. We need to turn the steady drip of stereotypes into a steady drip of examples of equality and efficacy for all children. For producers specifically, making the educational value of a show explicit to viewers seems to be critical. Unlike with shows for adolescents or adult viewers, for young children, there seems to be no need to bury the educational content under the narrative. When children believe they are learning, they may in fact be more persuaded by the material. Finally, characters are key. This is certainly no secret within the industry; but parents and educators can capitalize on the power of characters by encouraging and fostering young children's relationships with media characters, particularly ones that can serve as strong role models for engagement in STEM. More work is needed to fully demonstrate the causal effects of exposure to counter-stereotypical STEM portrayals, but this study provides valuable insights for understanding individual differences that can lead to more positive STEM attitudes.

IV. General Discussion and Areas for Future Research

In order for the U.S. to cultivate an equitable society in an increasingly technological world, it is critical that everyone in our culture sees women and minorities as people who belong in STEM. One way to help accomplish that goal is to increase the quantity and quality of diverse STEM portrayals in the media. Furthermore, because attitudes towards science and math and towards various social groups are formed at a young age, these diverse portrayals must be present in the media that young children consume. In this dissertation, I have presented two studies that contribute to our understanding of the media's impact on children's beliefs about who does STEM work: (1) a content analysis of the character portrayals in STEM-focused educational television shows for young children and (2) an experimental study that looked at the effects of exposure to a counter-stereotypical STEM show and the individual differences that contributed to those effects.

In the first study, I analyzed the characters present in 30 STEM-focused television shows for young children and asked: (1) what genders and races were represented in the shows and in what proportions, (2) were there differences by gender or race in the quality of STEM engagement, and (3) what STEM occupations were portrayed on screen. Across the 90 episodes that were coded and analyzed, female characters and non-white characters were significantly underrepresented on screen compared to the U.S. population. Interestingly, white characters were not overrepresented. This was due to a large inclusion of characters who were racially ambiguous and/or animated in non-human colors and skin tones. More work is needed to determine whether these racially ambiguous characters are indeed achieving the promise of diversity. Is it enough for children to see vaguely non-white characters engaging in STEM, or does there need to be more representation of a broad range of ethnicities, including darker skin tones, in order for children to believe that all kinds of people participate in STEM?

Encouragingly, when female and minority characters were present on screen, they were treated relatively equally to their male and white counterparts in terms of their STEM engagement and prominence in the show. Compared to content analyses of years past, this does seem to represent a general trend in the direction of egalitarianism. This trend is in line with recent findings by Miller and colleagues (2018), who conducted a meta-analysis of fifty years of "draw-a-scientist" studies and found that children's drawings in recent years show many more women and diverse people than drawings of scientists in past decades. However, the majority of depictions of scientists were still of white males wearing lab coats, demonstrating that we still need to make progress in expanding children's ideas about what science entails and who does it.

In terms of the portrayal of STEM occupations, the programs in our sample did not seem to be capitalizing on the opportunity to expose children to STEM careers. Only 28% of characters in the sample were shown in any type of occupation, and only 4% were shown to have a STEM or STEM-related occupation. Considering that all of these shows claim to be teaching children some aspect of STEM or early STEM skills, and that media play a key role in the socialization of children towards various careers (Berry & Asamen, 1993; Greenberg, 1982; Stroman, 1991), this seems like a missed opportunity.

In Study 2, I conducted an experimental investigation of the effect of exposure to a counter-stereotypical STEM show on children's attitudes towards STEM and STEM careers, as well as the individual differences that contribute to that attitude change. Research on the positive effects of educational television has traditionally focused on learning outcomes (e.g., Fisch & Truglio, 2001; Kirkorian, Wartella, & Anderson, 2008) and prosocial behavior (e.g., Friedrich &

Aletha Huston, 1973; Mares & Woodard, 2005). However, in addition to supporting concrete knowledge and skill acquisition, educational media can also have positive effects on children's attitudes towards learning and interest in exploring new topics (Chew & Palmer, 1994; Fisch, 2004; Johnston & Ettema, 1982; Mares et al., 1999; Vittrup & Holden, 2011). The kindergarten and first grade children in this study clearly had already developed gendered and racially-motivated beliefs about who holds STEM careers, as indicated by their open-ended responses to an occupational STEM attitudes measure. However, exposure to Cyberchase, a STEM show that features a female-dominant cast of racially diverse characters, did not move the needle on their attitudes towards STEM in any measurable way. Importantly, this exposure occurred two to three times per week over the course of eight weeks, which has been shown to be a sufficient exposure period for similar media interventions that looked at concrete learning outcomes (Hurwitz, 2018). Thus, the biggest, practical takeaway from this study was that in order for educational media to contribute to the development of positive, egalitarian attitudes through the use of counter-stereotypical portrayals, we need to move towards a point where counter-stereotypes are not only present once in a while, but actually saturate the children's media environment.

Children's open-ended responses in Study 2 also demonstrated the importance of exposure to different STEM careers. When children expressed counter-stereotypical beliefs, they were often discussed in terms of either personal exposure, such as one child who mentioned her grandmother was an engineer, or mediated exposure, such as a child who recalled watching a movie about women who were scientists. This point ties back to Study 1, which showed that portrayals of STEM occupations in children's STEM shows were lacking. Not every child has the opportunity to encounter a female engineer in real life, but all children could be exposed to a female engineer if one were portrayed in a popular and accessible children's television program.

Considering Study 1 and Study 2 together, there is strong support here for the inclusion of more portrayals of STEM occupations, especially ones held by diverse characters, in children's television and film. This type of increased exposure might support the development of positive occupational gender and race schema in children's minds, which would allow new counter-stereotypical examples to be processed and remembered more easily.

Directions for Future Research

There are several ways in which this research could be expanded upon to further our understanding of the potential positive impacts of educational television. For one thing, it is essential that we continue to quantitatively measure the state of diversity in children's television and disseminate that information to industry partners. The Geena Davis Institute has been the leading research center for these types of large-scale content analyses of gender representation in children's media, and, encouragingly, they have seen positive action taken by industry leaders as a result of their research. In one survey of television and film executives who had attended their research presentations and symposia, they found that over two-thirds of respondents reported that they had utilized information they learned from the research to inform their program creation (Smith et al., 2012). Unfortunately, there is no equivalent of the Geena Davis Institute that is focused on racial diversity. And further, there are other types of diversity beyond gender and racial diversity that could be taken into account. For example, are differently-abled children seeing themselves represented in STEM? Are children raised in low socioeconomic contexts learning from the media that they too can pursue STEM careers? These questions would be fruitful starting points for future content analyses to explore.

Furthermore, as a basis for this dissertation research, I argued that early childhood was an important time in children's development to study the formation of gender- and race-based occupational attitudes. Though early childhood is an important time to study these effects, there may also be other points in a child's development where the media could have a meaningful impact on attitudes towards STEM and/or their attitudes towards other genders and races. Future research should continue to explore STEM attitudes and occupational attitudes at various points in the developmental trajectory to discover whether there is a critical period in the formation of these attitudes where interventions would be most effective.

It would also be worthwhile to look at portrayals of STEM-related activities and occupations in television for older children. Television programs available for children beyond the preschool and early elementary years tend to be less educational and more focused on entertainment and drama (Levin, 2007; Romano, 2004). Though learning and attitude change may not be the primary goals of tween dramas and sitcoms, that does not mean there are not socialization opportunities present in these programs. The narrative nature of the programs might even provide greater opportunity for occupational portrayals.

Future research should also examine the effects of parental mediation in the realm of counter-stereotypical STEM portrayals. Active parental mediation has been found to have strong effects on children's responses to several types of media content, both for mitigating the effects of negative content and for bolstering the effects of positive content (Nathanson, 2010; Nathanson, Wilson, McGee, & Sebastian, 2002; Nathanson & Yang, 2003; Seon-Kyoung & Doohwang, 2010). In line with prior research, it is possible that having a trusted adult to point out the attributes of the counter-stereotypical portrayals would make the examples more salient and more meaningful in children's minds.

Lastly, an important direction that I plan to pursue in my own research trajectory is to continue to explore the relationships between attitudes, comprehension, and learning in young children. Each of these constructs is often tested as an outcome measure, and, certainly, all are important components of the positive effects media can have on children. While these outcomes seem highly related to one another, the direction of their relationships is unclear; does comprehension beget learning which begets attitude change? Or do positive attitudes foster comprehension and learning? Disentangling these relationships would be an important step in theorizing about the positive effects of media on children – an area of media effects scholarship that has surprisingly little theory development.

Conclusion

In arguing for the importance of media studies as a discipline, Kellner (1995) wrote, "Radio, television, film, and other products of media culture provide materials out of which we forge our identities, our sense of class, of ethnicity and race, of nationality, of sexuality, of us and them" (p. 10). Given that media can have such power, and given the fact that children today are spending more time than ever using screens and digital media (Rideout, 2013, 2014, 2017), it is imperative that researchers continue to investigate the ways in which this influence can be used to achieve positive societal effects.

Drawing from theory and research in the fields of social psychology, cognitive development, and media effects, this dissertation took an important step towards demonstrating the positive impact that educational television can have on young children by exposing them to new areas of learning and presenting counter-stereotypical portrayals of STEM engagement. Critically, it makes the case for the importance of exposure to diverse STEM portrayals not just for girls or minority children, but for all children. This intersection of gender, race, and STEM had received very little empirical attention in prior work. Though some questions remain open, this dissertation provides strong practical and theoretical contributions toward understanding where we are today in the landscape of diversity in children's STEM-focused media.

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Appendices

Appendix A – Full Sample

Program	Episode	Program Availability
Annedroids	S3 E8 “Robomutt” S3 E4 “The Escape Artist” S3 E3 “Paling Around”	Amazon Video
Blaze and the Monster Machines	S1 E10 “Caketastrophy” S1 E9 “The Team Truck Challenge” S1 E6 “Stuntmania!”	Nickelodeon, Nick Jr., Channel 5, YouTube, Amazon Video, iTunes, Vudu, Google Play
Blue’s Clues	S6 E3 “Wishes” S6 E5 “Playdates” S6 E9 “Bluestock”	Nick Jr., YouTube, Amazon Video, Vudu, Google Play, iTunes
Boj and Buddies	S5 E9 “Doctor Denzil” E5 E11 “Adventure Camp” E5 E1 “Fun and Games”	Universal Kids, Netflix, iTunes
Bubble Guppies	S3 E14 “The Bubble Bee-athalon!” S3 E04 “The Super Ballet Bowl!” S3 E17 “Swimtastic Check-Up!”	Nickelodeon, Nick Jr., YouTube, Amazon Video, iTunes, Vudu, Google Play
Cosmic Quantum Ray	S1 E1 “Allison Attacks!” S1 E6 “Olga’s Dish of Doom” S1 E9 “Me, Robot”	Kika, Discovery Family, Amazon Video, iTunes
Curious George	S8 E9a “Curious George Goes for 100” S8 E1a “Toy Monkey” S8 E3a “George’s Backwards Flight Plan”	PBS Kids, PBS, YouTube, Amazon Video, iTunes, Google Play, Vudu, Hulu
Cyberchase	S9 E1 “An Urchin Matter” S9 E3 “Trash Creep” S9 E2 “Going Solar”	PBS, PBS Kids, PBS Kids Go!, Qubo, YouTube, Amazon Video, iTunes, Google Play
Dino Dan	S2 E13a “Officer Trek” S2 E4a “Team Dino” S2 E23a “Cowboys vs. Dinosaurs”	Nick Jr., Noggin, Amazon Video
Dinosaur Train	S2 E19 “Tiny and the Crocodile” S2 E95 “The Lost Bird” S1 E2 “The Call of the Wild Corythosaurus”	PBS, PBS Kids, YouTube, Amazon Video, iTunes, Vudu, Google Play

Doki	S1 E19 “Deep Freeze Doki” S1 E26 “Stuck on Carnival” S1 E21 “Robot Rampage”	Discovery Kids, Qubo, Netflix, YouTube, Amazon Video, Google Play
Dora the Explorer	S7 E1 “Dora's Easter Adventure” S7 E2 “Feliz Dia de Los Padres” S7 E16 “Book Explorers”	Nickelodeon, Nick Jr., CBS, Google Play, Amazon Video, YouTube, Vudu, iTunes
Earth to Luna!	S2 E10 “Reaching the Rainbow” S1 E22 “Flying Lights” S2 E13 “Spinning Webs”	Netflix, Amazon Video
Go, Diego, Go!	S4 E8 “Koala's Birthday Hug” S3 E16 “Freddie the Fruit Bat Saves Halloween!” S3 E17 “Egyptian Camel Adventure”	Nick Jr., Amazon Video, Vudu, iTunes
Mickey Mouse Clubhouse	S5 E4 “Minnie-rella” S4 E8 “Minnie’s Pet Salon” S4 E11 “Donald Jr.”	Disney Junior, Disney Channel, PlayHouse Disney, Google Play, YouTube, Amazon Video, iTunes
Monster Math Squad	S2 E12 “Special Delivery” S2 E9 “Delivery Monster Doesn’t Deliver” S2 E19 “Number Line Monster’s New Game”	CBC Television, Discovery Kids, Google Play, YouTube, Amazon Video
Nature Cat	S3 E4 “Woodpecker Picks a Place” S1 E19 “The Great Grasshopper Race” S1 E15 “Earth Day Today”	PBS, Treehouse TV, Amazon Video, Google Play, YouTube, iTunes, Vudu
Octonauts	S2 E1 “Colossal Squid” S2 E6 “Octonauts and the Bowhead Whales” S2 E19 “Octonauts and the Manatees”	CBeebies, Disney Junior, iTunes, Amazon Video
Odd Squad	S1 E8 “Crime at Shapely Manor” S1 E5 “Reindeer Games” S1 E11 “How to Interrogate a Unicorn”	PBS Kids, TVOntario, Ici Radio-Canada Télé, Google Play, YouTube, Amazon Video, iTunes, Vudu
Peep and the Big Wide World	S2 E7 “Count Them Out” S2 E9 “Chirp Sorts it Out (Sort Of)” S2 E5 “Snow Daze”	PBS Kids, Discovery Kids, TLC, Discovery Family, Tiny Pop,

		Knowledge Network, Amazon Video
Peg + Cat	S1 E15a “The Mega Mall Problem” S1 E9a “The Honey Problem” S1 E14a “The Blockette Problem”	PBS, PBS Kids, Amazon Video, Vudu, YouTube, Google Play, iTunes
Ready Jet Go!	S1 E17 “Asteroids, Meteors, and Meteorites” S1 E14 “A Visit From Uncle Zucchini” S1 E24 “Which Moon is Best?”	PBS Kids, Vudu, YouTube, Amazon Video, iTunes, Google Play
Sesame Street	S45 E14 “Oscar's Trash Saving Plan” S45 E9 “If Me Had That Wand” S45 E7 “A Bicycle Built For Two”	HBO, PBS Kids, YouTube, Sprout, Sesame Studios, Sesame Amigos, Hulu
Sid the Science Kid	S2 E7 “Clean Air” S2 E10 “Let There Be Light” S2 E24 “The Big Cheese!”	PBS, PBS Kids, iTunes, YouTube, Amazon Video, Google Video, Hulu
Team Umizoomi	S4 E9 “Umi Grand Prix” S4 E12 “Umi Ninjas” S4 E2 “City of Lost Penguins”	Nickelodeon, Nick Jr., Vudu, YouTube, Amazon Video, iTunes, Google Play
The Cat in the Hat Knows A Lot About That!	S2 E15 “Rumbly Tumbly” S2 E33 “Take a Walk” S2 E27 “Paper Chase”	PBS Kids, CITV, Treehouse TV, Amazon Video, iTunes, Netflix, YouTube, Google Play
The Magic School Bus	S4 E2 “Goes to Mussel Beach” S4 E13 “Gets Programmed” S4 E7 “Sees Stars”	Netflix, Amazon Video, iTunes, Google Play, YouTube, Vudu
Thomas Edison’s Secret Lab	S2 E5a “Futile Attraction” S2 E10a “Great Bouncing Eyeballs!” S2 E12a “All Heavy Lifting”	Netflix, Amazon Video, YouTube, iTunes, Google Play
Tumble Leaf	S2 E11a “Clam-tastic Voyage” S2 E13a “The Windy Hop” S2 E2a “Snowflake Dance”	Amazon Video
Wild Kratts	S2 E13 “Aqua Frog” S2 E15 “Tortuga Tune Up” S2 E19 “Rattlesnake Crystal”	PBS, PBS Kids, Vudu, YouTube, Amazon Video, iTunes, Google Play

Appendix B – Coding Manual for Study 1

Character-Level Codes

1. <charspeak>: Does this character speak or have any animal utterances/reactions?
0 = no
1 = yes

2. <chargend>: What is the character's gender?
m = male
f = female
o = other/unsure
g = group (use this for a group of individuals coded together, such as a chorus, when both males and females are part of the group)

3. <charage>: What is the character's age? (should be clear visually and/or from context clues such as voice/speech)
b = baby (0-2)
c = child (3-12)
t = teen (13-19)
a = adult (20-59)
e = elderly adult (60+)
o = other/unsure (animals that don't have clear context clues should be coded as other)
g = group (use this for a group that has several different ages)

4. <charanimorlive>: Is the character animated or live?
l = live
p = live puppet
a = cartoon animated
o = other/unsure
g = group of many characters (with mix of animated, live, puppet, etc.)

5. <chartype>: What is the character's type?
h = human/humanoid (i.e. human-like creature like a leprechaun)
a = animal/dinosaur (including fictional animals like unicorns, dragons, etc.)
t = robot or tech device (smartphone, computer, etc.)
n = non-animal nature object (tree, flower, sun, etc.)
c = car, truck, or other transportation vehicle
m = monster (muppets, goblins, monsters inc, unclear monster-type characters, etc.)
o = all other inanimate object (explain in note section)
u = unsure (explain in note section)
g = group of many people (with mix of character type)

6. <charethn>: What is the character's ethnicity/race? (Judge by appearance and/or dialogue, other context clues; if unsure, explain in notes)

w = White
b = Black or African American
a = Asian, Southeast Asian, or Pacific Islander
h = Hispanic, Latino, or Spanish origin
n = American Indian or Alaska Native
e = Middle Eastern
m = Mixed-race/multi-racial
u = unsure/ambiguous
i = irrelevant because not a human/humanoid character
g = group of many people (with mix of ethnicities)

7. <charhair>: What is the character's hair color?
bk = black or dark brown
br = light brown
bd = blonde
gr = grey or white
r = red or auburn
o = other
u = unsure (i.e. head is covered or character is too far away to tell)
i = irrelevant because not a human/humanoid character
g = group of many people (use only for a group with different hair colors represented)

8. <chareye>:
bk = black
br = dark brown or brown
h = hazel or light brown
bl = blue
s = silver or grey
gr = green
o = other
u = unsure (i.e. eyes cannot be seen because of angle of camera or because character is too far away)
i = irrelevant because not a human/humanoid character
g = group of many people (use only for a group with different eye colors represented)

9. <charrole>: What role category does this character fall into?
0 = walk-on character that does not contribute to the storyline OR regular character that makes a very brief and non-significant appearance
1 = walk-on character with role that is critical to the plot (this character is a guest character and only present in the episode to fill a specific role)
2 = minor/supporting character (this character can be reoccurring, but does not directly contribute to the plot or storyline)
3 = major character (this character is central to the plot and plays a large role in the story line)
4 = protagonist (this character is the most critical to the plotline, most highlighted in the story; can be multiple characters)

10. <activelearning>: Does this character participate in active learning of STEM content? I.e., did the character learn new information as a result of some action (e.g., asking a question or making an observation that is immediately addressed or answered) Guiding audience through a thought process counts as active learning.
0 = character is not involved in any active learning
1 = character occasionally participates in active learning but mostly participates in passive learning
2 = character often actively learns STEM material but also often participates in passive learning (eg. half passive learning, half active learning)
3 = mostly actively learns
4 = character only participates in active learning, and no passive learning

11. <passivelearning>: Does this character passively learn STEM content? (If a character did not actively pursue new information relating to STEM, but was present when new STEM material was taught, this counts as an instance of passive learning.)
0 = character is not involved in any passive learning
1 = character occasionally participates in passive learning but mostly participates in active learning
2 = character often passively learns STEM material but also often participates in active learning and investigations (eg. half passive learning, half active learning)
3 = mostly passively learns
4 = character only participates in passive learning, and no active learning

12. <teaching>: Does the character teach STEM facts or explain information relating to STEM content? Teaching implies that the character is an expert on some topic imparting information to non-experts. (A chunk of new information counts as a "moment"; there can be multiple teaching moments within the same scene.)
0 = character is not involved in any teaching
1 = character has one or two teaching moments during the episode
2 = character is involved in many teaching moments throughout the episode

13. <practquestion>: Does this character ask questions to find out STEM information in the episode?
0 = no
1 = asks one or two questions
2 = asks many questions throughout the episode

14. <practobserve>: Does this character make observations that lead them to find out STEM information?
0 = no
1 = makes one or two observations
2 = makes observations throughout the episode

15. <practinvestigate>: Does this character plan or conduct an investigation, collect data, and/or analyze it as a practice of scientific inquiry?
0 = no
1 = plans/conducts an investigation that is a minor part of the episode
2 = plans/conducts an investigation that is a large focus of the episode

16. <practproblemsolving>: Does this character design, test, compare, or communicate a solution to a problem?
0 = no
1 = designs/tests/compares/communicates a solution **once or twice** in the episode
2 = designs/tests/compares/communicates a solution **multiple times** in the episode

17. <occupation>: Does this character have a particular job or occupation?
If so, write in the occupation as an open-ended code. (If you have an idea of what the occupation is, you may use background info (wikipedia, show's website, etc.) to find the correct title for that occupation.)
If not, write "na"

18. <pretendoccupation>: Does this character pretend to have a particular job or occupation?
If so, write in the occupation as an open-ended code. (If you have an idea of what the occupation is, you may use background info (wikipedia, show's website, etc.) to find the correct title for that occupation.)
If not, write "na"

<u>Episode-level codes</u>
Does the episode demonstrate an intent of creating a culturally diverse cast through color, species, age, gender, speech, or ethnicity?

19. <divcolor>: Are the non-human **characters** intentionally painted different colors?
0 = no
1 = there is one example of a different colored character
2 = yes, many examples of differently colored characters
na = there are no non-human characters

20. <divspecies>: Are the non-human **characters** of different species/types in order to demonstrate diversity?
0 = no
1 = there is one example of species diversity
2 = yes, many examples of species diversity
na = there are no non-human characters

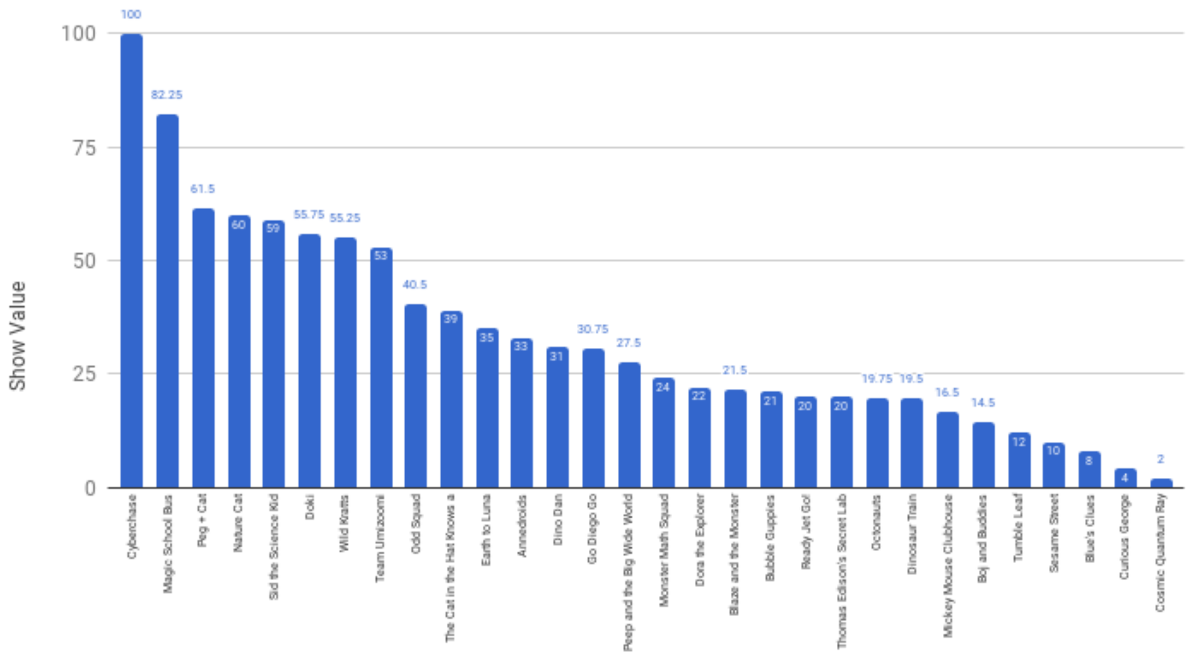
21. <divrace>: Are the human characters of different races/ethnicities? Or if the race/ethnicity of humans is unclear, are the characters purposefully depicted with different colors?
0 = no, or the only human character is a white male
1 = there is one character of a different race, or the only human represents a minority group

2 = there are several characters of different races and/or different races depicted throughout episode
na = there are no humans

22. <divspeech>: Is there diversity in vernacular or accents among the speaking characters? (As a sense of threshold for what counts as a diverse speech pattern, if you were to watch/listen with your eyes closed, you should be able to guess that the character is of a different race and/or ethnicity)
0 = no
1 = one character has a different accent or speech pattern
2 = yes, many examples of linguistic diversity in the episode

23. <divexplicit>: Is there any explicit or overt discussion of diversity as part of the plot or storyline?
0 = no
1 = diversity is mentioned once, or as a very minor point
2 = yes diversity is mentioned throughout, or as a major point of the plot

Appendix C – Program ranking and formula used to select Study 2 stimulus



The creation of these formulas began by outlining the most important elements that we wanted to see in the shows we picked. These were minority representation, gender representation, and high STEM engagement exhibited by characters in general. With the guiding motivations established, the formulas were conceived.

Formula 1. Combined Character Value Formula

$$\text{Show value} = \Sigma\text{charvalue}$$

$$\text{charvalue} = (\text{stemengagement})(\text{isfemaleSC} + 1)(\text{isminoritySC} + 1)(\text{charrolemult})$$

- stemengagement = practquestion + practobserve + practinvestigate + practproblemsolving
- charrolemult =
    - 2 if charrole = 4

- 1.5 if charrole = 3
- 1.25 if charrole = 2
- 1 if charrole = 1 or 0

Since the main unit of analysis in coding was the individual character, the value of a show in all of our formulas was posited to be the sum of the value of each individual character within that show. Each character's value is calculated differently depending on the formula. Episode-level/global codes were excluded from the formula as much of the information they capture would be represented in the summation of each character's value.

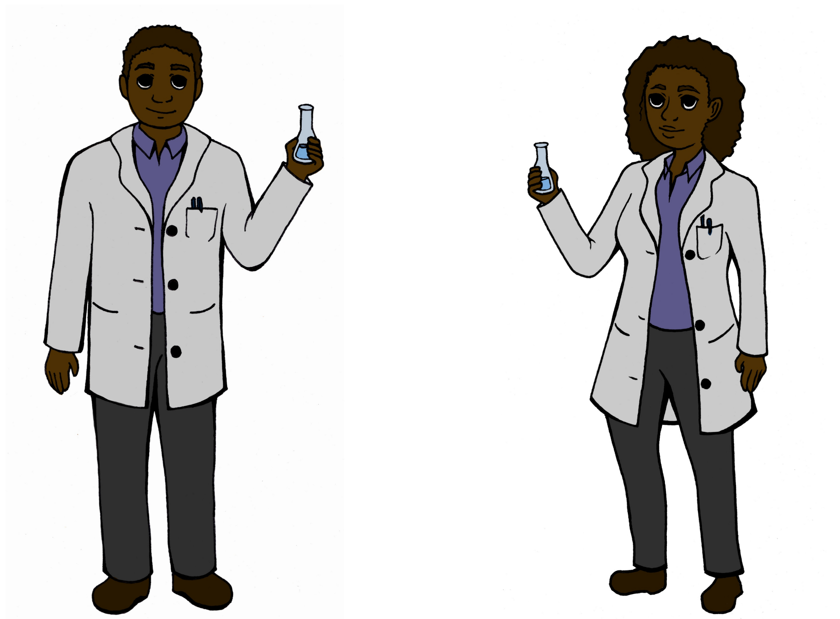
With the Combined Character Value Formula (CCV, Formula 1.) we sought to credit characters that met all of our aforementioned guiding motivations. Since we valued STEM engagement exhibited by characters in general, all characters that exhibited some STEM engagement would have value.

Seeing that we were looking for shows that presented highly STEM engaged female and minority characters, we wanted female and minority characters that displayed STEM engagement to be valued more highly than their white or male counterparts. This was accomplished by adding two terms to the formula to weight female and minority characters more heavily, "(isfemaleSC+1)(isminoritySC+1)." These served as x2 multipliers so that female and minority characters would get their base STEM engagement score multiplied by 2 if they were either female or a minority or by 4 if they were both. Since the <isfemaleSC> and <isminoritySC> codes were coded as binary 1's and 0's, the "+1" was added to make the term a x2 multiplier and to ensure that no characters were multiplying their STEM engagement score by 0.

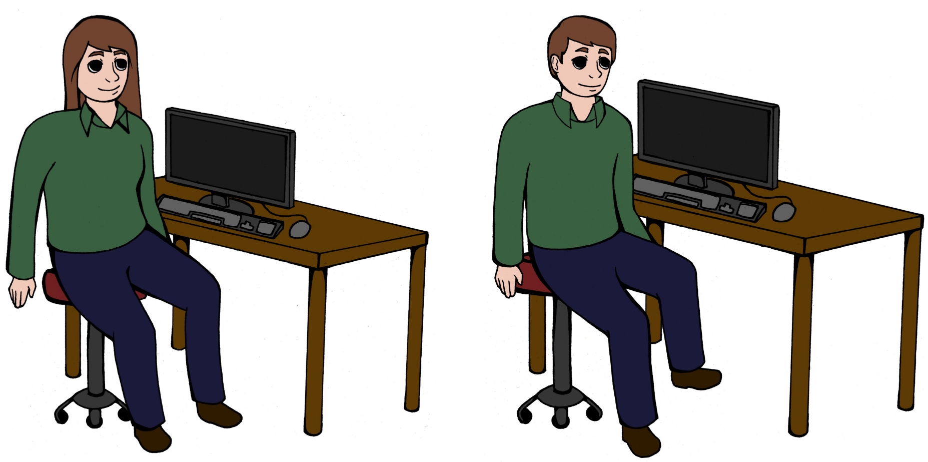
The final term in the CCV formula, "(charrolemult)," was added to weight characters based on their role in the show. For our purposes of selecting shows with standout main characters, we wanted STEM engagement demonstrated by the protagonist(s) of a show to be valued higher than STEM engagement exhibited by minor or walk-on characters. The role of each character in the show was captured by the <charrole> code, which was coded on a scale from 0 to 4, with 4 being a clear protagonist of a show and 0 being an insignificant walk-on character. Since our other two weights worked as x2 multipliers, we wanted the <charrolemult> to work the same way. The <charrolemult> therefore transformed the 0 to 4 scale of the <charrole> code to a 1 to 2 scale. The interval between a major character (<charrolemult>=1.5) and a protagonist character (<charrolemult>=2) is larger than other intervals because protagonist characters were far less frequent than other categories (they made up only 15.4% of individual speaking characters).

Together, these weights would have the combinatory effect to rank and distinguish shows based on the overall STEM engagement of a show, as well as whether they featured STEM engaged minority and/or female characters.

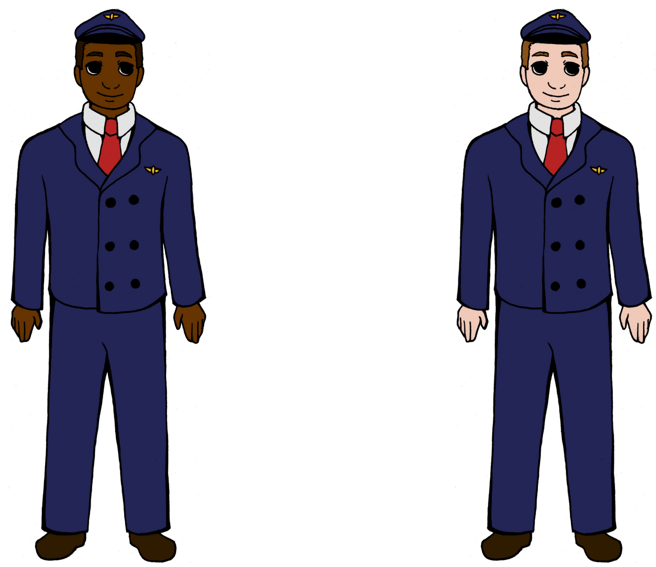
Appendix D – Drawings used for Occupational Attitudes Measure



5



6



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Curriculum Vitae

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AREAS OF INTEREST

Children and media, educational technology, cognitive development, comprehension models

EDUCATION

Present — **Northwestern University,** Evanston, IL
Doctor of Philosophy, Media, Technology, & Society Program, School of Communication (June, 2018)
Dissertation: *Character Portrayals in STEM-focused Educational Television Shows and their Impact on Children's Attitudes Towards STEM*
Committee: Drs. Ellen Wartella and Alexis Lauricella (Co-chairs), Kevin Clark, Heather Kirkorian

2013 — **The Ohio State University**, Columbus, OH
Master of Arts, School of Communication
Thesis: *What preschoolers bring to the show: The effects of viewer characteristics on children's learning from educational television.*
Committee: Drs. Amy Nathanson (Chair), Emily Moyer-Gusé, David Ewoldsen

2011 — **University of Pennsylvania**, Philadelphia, PA
Bachelor of Arts in Communication, Magna Cum Laude, College of Arts and Sciences, with Honors from the Annenberg School for Communication
Honors thesis: *To sing or not to sing: The use of musical interstitials in educational television for preschoolers*. Advisor: Dr. Jessica Taylor Piotrowski

AWARDS & HONORS

Student Engagement Award (2017) from The Graduate School, Northwestern University, in recognition of outstanding contributions to the graduate community at Northwestern.

Honorable Mention for Top Student Paper (2016) from the Children, Adolescents, and the Media Division of the International Communication Association. Awarded for paper: *Measuring with Murray: Touchscreen Technology and Preschoolers' STEM Learning.*

Top Student Paper Award (2014) from the Children, Adolescents, and the Media Division of the International Communication Association. Awarded for paper: *What preschoolers bring to the show: The relation between viewer characteristics and children's learning from educational TV.*

Top Paper Award (2013) from the Children, Adolescents, and the Media Division of the International Communication Association. Awarded for paper: *The relation between television exposure and theory of mind among preschoolers*.

GRANTS & FELLOWSHIPS

Graduate Research Grant (2017) $3000 awarded by The Graduate School, Northwestern University.

Dissertation Research Grant (2017) $1500 awarded by the Communication Studies Department, Northwestern University.

Ignition Grant (2017) $2000 awarded by the School of Communication, Northwestern University.

Graduate Enrichment Fellowship (2011) from The Ohio State University Graduate School.

RESEARCH EXPERIENCE

2013-2018 **Graduate Student Researcher,** Center on Media and Human Development, Northwestern University, Evanston, IL
Research assistant on a five-year multi-site grant entitled "Collaborative Research: Using Educational DVDs to Enhance Young Children's STEM Education," National Science Foundation Reese Program, DRL-1252121 (PI: Wartella, 2013-2018).

2010-2011 **Research Assistant,** Annenberg Center for Advanced Studies of Communication, University of Pennsylvania**,** Philadelphia, PA

INDUSTRY EXPERIENCE

2018 **Freelance Qualitative Researcher,** *Sesame Street in Communities, Growing Up Great Initiative,* Sesame Workshop, R5 Research, Chicago, IL

2016 **Research Coordinator and Site Leader**, *Nature Cat* Outreach Experimental Study, WTTW Chicago, Kohl Children's Museum of Greater Chicago

2015-2016 **Educational Outreach Specialist**, *Nature Cat*, educational media property created by PBS KIDS, WTTW Chicago, and Spiffy Pictures

2015 **Content Team Assistant**, *UMIGO*, project funded by the US Department of Education's Ready to Learn Initiative

2011-Present **Freelance Researcher,** MediaKidz Research and Consulting, Teaneck, NJ

PUBLICATIONS

Refereed Journal Articles

Pila, S., **Aladé, F.**, Sheehan, K. J., Lauricella, A. R., & Wartella, E. (under review). Young Children Learning to Code via Tablet Applications

Anderegg, C. E., **Aladé, F.,** Ewoldsen, D. R., Wang, Z. J. (2017). Comprehension Models of Audiovisual Discourse Processing. *Human Communication Research, 43,* 344-362.

Aladé, F., Lauricella, A., Beaudoin-Ryan, L., & Wartella, E. (2016). Measuring with Murray: Touchscreen Technology and Preschoolers' STEM Learning. *Computers in Human Behavior, 62,* 433-441.

Fisch, S. M., Damashek, S., & **Aladé, F.** (2016). Designing media for cross-platform learning: Developing models for production and instructional design. *Journal of Children and Media, 10:2,* 238-247.

Aladé, F. & Nathanson, A. I. (2016). What preschoolers bring to the show: The relation between viewer characteristics and children's learning from educational television. *Media Psychology, 19:3,* 406-430.

Nathanson, A. I., **Aladé, F.**, Sharp, M., Rasmussen, E., Christy, K. (2014). The relation between television exposure and executive function among preschoolers. *Developmental Psychology, 50:5,* 1497-1506.

Nathanson, A. I., Sharp, M., **Aladé, F.**, Rasmussen, E., Christy, K. (2013). The relation between television exposure and theory of mind among preschoolers. *Journal of Communication, 63:6,* 1088-1108.

Fisch, S. M., Lemish, D., Spezia, E., Siegel, D., Fisch, S. R. D., **Aladé, F.**, & Kasdan, D. (2013). Shalom Sesame: Using media to promote Jewish education and identity. *Journal of Jewish Education, 79:3,* 297-314.

Chapters in Edited Works

Lauricella, A., **Aladé, F.,** & Wartella, E. (in prep.). Lessons Learned and Questions Revisited: A historical look at children and media research. In T. J. Socha & N. Punyanunt-Carter, N. (Eds.), *Children's Communication Sourcebook: Managing legacy and potential*.

Fisch, S. M., Damashek, S., & **Aladé, F.** (2017). Designing media for cross-platform learning: Developing models for production and instructional design. In D. Lemish, A. Jordan, & V. Rideout (Eds.), *Children, Adolescents, and Media: The future of research and action.* New York, NY: Routledge.

Technical Reports

Fisch, S. M. & **Aladé, F.** (2016). *Nature Cat* Outreach: Experimental Study. MediaKidz Research and Consulting: Teaneck, NJ.

Fisch, S. M. & **Aladé, F.** (2012). *Cyberchase: The Next Frontier – Analysis of Web Analytics.* MediaKidz Research and Consulting: Teaneck, NJ.

Fisch, S. M., Siegel, D. R., **Aladé, F.**, Fisch, S. R. D., & Kasdan, D. (2011). *Shalom Sesame: Use and value for Jewish families in the United States.* MediaKidz Research and Consulting: Teaneck, NJ.

CONFERENCE PRESENTATIONS

Aladé, F., Kumar, Y., Lauricella, A. R., Wartella, E., (2018, May). *Character Portrayals in Children's STEM-focused Educational Television.* Paper to be presented at the annual meeting of the International Communication Association, Prague, Czech Republic.

Pila, S., **Aladé, F.,** Sheehan, K. J., Atit, K., Lauricella, A. R., Gadzikowski, A., Wartella, E., & Uttal, D. (2017, November). *Learning to Code in the Classroom.* Poster presented at the annual conference of the National Association for the Education of Young Children, Atlanta, GA.

Aladé, F. (2017, May). *The Impact of Educational Television on Children's Attitudes Towards STEM and Interest in STEM Careers.* Paper presented at the annual meeting of the International Communication Association, San Diego, CA.

Pila, S., **Aladé, F.,** Atit, K., Lauricella, A. R., Gadzikowski, A., Wartella, E., Uttal, D. (2017, April). *Learning to Code in the Classroom.* Poster presented at the biannual meeting of the Society for Research in Child Development, Austin, TX.

Fisch, S. & **Aladé, F.** (2017, April). *"Onward and yonward!": Carrying informal science beyond the screen in cross-platform learning.* Poster presented at the biannual meeting of the Society for Research in Child Development, Austin, TX.

Aladé, F. (2016, October). *The Impact of Character Portrayals in Educational TV on Children's Interest in STEM and Attitudes Towards STEM Careers.* Poster presented as part of the Doctoral Consortium of the Special Topic Meeting of the Society for Research in Child Development, Irvine, CA.

Aladé, F., Lauricella, A., Beaudoin-Ryan, L., & Wartella, E. (2016, October). *Touchscreen Technology and Preschoolers' Learning of a Foundational STEM Skill.* Poster presented at the Special Topic Meeting of the Society for Research in Child Development, Irvine, CA.

Aladé, F. (2016, June). *Understanding the Web Use Behavior of Our Youngest Internet Audience.* Paper presented at the annual meeting of the International Communication Association, Fukuoka, Japan.

Aladé, F., Beaudoin-Ryan, L., Lauricella, A., & Wartella, E. (2016, June). *Measuring with Murray: Touchscreen Technology and Preschoolers' STEM Learning.* Paper presented at the annual meeting of the International Communication Association, Fukuoka, Japan.

Anderegg, C. E., **Aladé, F.,** & Ewoldsen, D. (2016, June). *An Application of the Dual Coding Landscape Model of Comprehension to Full-length Feature Films.* Paper presented at the annual meeting of the International Communication Association, Fukuoka, Japan.

Aladé, F. & Beaudoin-Ryan, L. (2015, May). *Interactivity and Preschoolers' STEM Learning.* Paper presented at the annual meeting of the International Communication Association, San Juan, Puerto Rico.

Aladé, F. & Anderegg, C. E. (2015, May). *The Construction of Situation Models for Comprehension of TV Dramas.* Paper presented at the annual meeting of the International Communication Association, San Juan, Puerto Rico.

Lauricella, A., **Aladé, F.**, & Wartella, E. (2015, May). *Media and the modern family: The influence of family structure on enjoyment and use of family media activities.* Paper presented at the annual meeting of the International Communication Association, San Juan, Puerto Rico.

Lauricella, A., **Aladé, F.**, & Wartella, E. (2015, March). *The influence of family structure on family media activities.* Poster presented at the biannual meeting of the Society for Research in Child Development, Philadelphia, PA.

Aladé, F. (2014, May). *What preschoolers bring to the show: The relation between viewer characteristics and children's learning from educational TV.* Paper presented at the annual meeting of the International Communication Association, Seattle, WA.

Anderegg, C. E., **Aladé, F.,** Ewoldsen, D. R., Wang, Z. J. (2014, May). *Comprehension Models of Audiovisual Discourse Processing.* Paper presented at the annual meeting of the International Communication Association, Seattle, WA.

Aladé, F. (2014, April). *Extending a model of children's learning from Educational TV.* Paper presented at the 16th annual research conference of the Northwestern University Black Graduate Student Association, Evanston, IL.

Nathanson, A. I., **Aladé, F.**, Sharp, M., Rasmussen, E., Christy, K. (2013, June). *The relation between television exposure and executive function among preschoolers.* Paper presented at the annual meeting of the International Communication Association, London, UK.

Nathanson, A. I., Sharp, M., **Aladé, F.**, Rasmussen, E., Christy, K. (2013, June). *The relation between television exposure and theory of mind among preschoolers.* Paper presented at the annual meeting of the International Communication Association, London, UK.

Aladé, F. (2012, May). *To sing or not to sing: The use of musical interstitials in educational television for preschoolers*. Paper presented at the annual meeting of the International Communication Association, Phoenix, AZ.

Gilmore, J. S., Jeong, M., **Aladé, F.,** Jordan, A. B., Kydd, & S. (2012, May). *Local news media framing of obesity before and during a public health media intervention.* Paper presented at the annual meeting of the International Communication Association, Phoenix, AZ.

TEACHING EXPERIENCE

Spring 2018	**Instructor**, Northwestern University, School of Professional Studies Course: Theories of Mediated Communication
Spring 2016, Fall 2017	**Instructor**, Northwestern University, Communication Studies Department Course: Research Seminar: Technopanic!
Winter 2015	**Guest Lecturer**, Northwestern University, Communication Studies Department Courses: Children's Culture, Theories of Mediated Communication
2014-2016	**Teaching Assistant**, Northwestern University, Communication Studies Department Courses: Theories of Persuasion, Persuasive Images: Rhetoric of Popular Culture, Theories of Mediated Communication
Spring 2013	**Instructor**, The Ohio State University, School of Communication Course: Theories of Persuasive Communication
Fall 2012	**Teaching Assistant**, The Ohio State University, School of Communication Courses: Social Implications of Communication Technology, Intercultural Communication, Information Technology and Organizational Communication

PROFESSIONAL DEVELOPMENT IN TEACHING & MENTORING

2018	**Competent Leadership Certification,** Toastmasters International
2017	**Peer Mentorship Training,** Northwestern University, The Graduate School
2015-2016	**Teaching Certificate Program**, Northwestern University, Searle Center for Advanced Teaching & Learning
2014	**TA Conference**, Northwestern University, Searle Center for Advanced Teaching & Learning
2011	**Teaching Summit,** The Ohio State University, University Center for the Advancement of Teaching

PROFESSIONAL DEVELOPMENT IN RESEARCH

2016	**Doctoral Consortium**, Society for Research in Child Development Special Topic Meeting on Technology and Media in Children's Development, Irvine, CA
2016	**Faculty Women of Color in the Academy National Conference**, University of Illinois at Urbana-Champagne, Office of Diversity, Equity, and Access

2012 **Future Faculty Retreat: Armed for the Academy**, The Ohio State University, Office of Diversity and Inclusion

SERVICE TO THE ACADEMY

2016-present **Assistant Editor,** *Social Policy Report*, Society for Research in Child Development

2014-2018 **Graduate Student and Early Career Representative**, Children, Adolescents and the Media Division, International Communication Association

Ad-hoc **Journal Reviewer**: *Computers in Human Behavior, Frontiers in Psychology, Journal of Children and Media, Journal of Experimental Child Psychology*

Ad-hoc **Conference Submission Reviewer**: International Communication Association, National Communication Association

SERVICE TO THE UNIVERSITY

2016-2018 **Mentor,** TGS Diversity Peer Mentorship Program

2016-2018 **Founding Member**, Graduate Student Steering Committee, Media, Technology, & Society Doctoral Program, Northwestern University

2016-2018 **Treasurer**, Keynotes Graduate Student A Cappella Group, Northwestern University

2016-2018 **Member**, Graduate Leadership and Advocacy Council, Northwestern University

2015-2018 **Assistant Chair**, Communications Residential College, Division of Student Affairs, Northwestern University

2016-2017 **President**, Graduate Student Association, Northwestern University

2015-2016 **Vice President of Membership**, Toastmasters, Northwestern University

2015-2016 **Communications Chair**, Graduate Student Association, Northwestern University

2014-2015 **Graduate Fellow,** Chapin Residential College, Northwestern University

2014-2015 **Student Task Force Member,** Innovations in Developmental Science, Northwestern University

2014-2015 **Conference Planning Committee Member**, Black Graduate Student Association, Northwestern University

2014-2015 **Social Co-Chair**, Graduate Student Association, Northwestern University

2014-2015 **Team Leader**, Inter-Cultural Explorers, Northwestern University

2012-2013 **Treasurer**, Colorful Women of the Academy, The Ohio State University

PROFESSIONAL AFFILIATIONS

International Communication Association (Children, Adolescents and the Media Division)

National Communication Association (Mass Communication and Communication and Social Cognition divisions)

Society for Research in Child Development

Toastmasters International