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RESEARCH ARTICLE

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Water woes: The effects of children's science media on conservation knowledge, self-efficacy, and environmental worry in the United States of America

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ABSTRACT

Encouraging individuals, especially children, to decrease their use of natural resources is critical to creating sustainable communities. We thus investigated whether children could learn conservation strategies from an educational TV show. We measured 4- and-5-year-olds' ($N = 110$) knowledge, self-efficacy, and environmental worry before and after showing them an episode of the PBS show *Nature Cat* that either did or did not teach about water conservation. Children who watched the episode about water conservation demonstrated improved only marginally in their understanding of water conservation strategies compared to the control group, but they did become significantly more worried about the environment. These findings suggest that exposure to nature-related educational media has the potential to improve children's understanding of environmentalism and increase children's concern for the environment. Based on these findings, we suggest ways to increase the impact of environmental educational media.

IMPACT SUMMARY

Prior State of Knowledge: Television media is a widely available educational resource and has the potential to teach children about important and timely topics, like the importance of conserving environmental resources. Prior research shows that children can learn some science topics from educational media.

Novel Contributions: The current study is the first that we know of that experimentally investigates whether watching television media can improve children's knowledge about resource conservation or affect their attitudes about the environment.

Practical Implications: This research has significant implications for the design of future educational media, education strategies, and policy, especially regarding children's knowledge about environmental conservation.

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> Unless someone like you cares a whole awful lot, nothing is going to get better, it's not.
> Dr. Seuss, *The Lorax*

Environmental sustainability is a crucial topic given the ways in which climate change is dramatically affecting our planet (IPCC, 2023). Since today's children will live longer than all previous generations, they will also have to deal with the repercussions of climate change for the longest amount of time (Dong et al., 2016). Therefore, it is vital that they are equipped with the knowledge necessary to protect the environment. One efficient way to disseminate this knowledge is through the use of educational media, since children engage with books, television shows, and other sorts of media on a daily basis (Pew Research Center, 2020). Although past work has found that educational media can be beneficial for children's science learning and attitudes towards science (e.g., Anderson et al., 2001; Fortner, 1985; Gunter et al., 1997; M. L. Mares et al., 1999), it is unknown whether children can learn specifically about environmental conservation. The current study thus utilizes an experimental approach to study the utility of a narrative educational television show (*Nature Cat*, distributed by PBS Kids) in improving children's understanding of one aspect of living sustainably: water conservation. By increasing our understanding of whether and what children are learning from media about conservation, this study can contribute to crucial efforts to help children maintain environmental well-being.

Children's learning from media

Children engage with all kinds of media on a daily basis, including storybooks, video games, and television (e.g., Ganea et al., 2011; Hopkins & Weisberg, 2021; Leech et al., 2020; M. L. Mares et al., 1999; Marino et al., 2011). The currently focuses on television media, given that children engage with it more often than any other kind of media (Bonus & Mares, 2019).

Past work has found that watching educational television generally improves children's educational outcomes (see review in Hopkins & Weisberg, 2017). For example, watching *Sesame Street* at 5 years is positively correlated with high school science grades, even after controlling for parent education level, geographic location, and family structure (Anderson et al., 2001). Further, in regions of the world where early educational opportunities (e.g., preschool) are not easily accessible, like Bangladesh, shows such as *Sesame Street* can provide educational stimulation to children (M.-L. Mares & Pan, 2013).

Exposure to educational media may also help children to learn specifically about science. For example, television media can positively influence elementary-aged children's attitudes towards science (M. L. Mares et al., 1999) and can teach 8- and 15-years-old about scientific topics (Fortner, 1985; Gunter et al., 1997). Additionally, storybook interventions have been used to teach preschoolers and early elementary schoolers about complex scientific topics such as evolution by natural selection (e.g., Brown et al., 2020; Kelemen et al., 2014). Other work has found that preschool-aged children can learn scientific content, such as how the day/night cycle works, from educational television (e.g., Bonus & Mares, 2019). Thus, television media has the potential to be an extremely effective resource for young children to learn science

However, children sometimes struggle to learn effectively from educational media. The vast majority of such media include fantastical elements, such as anthropomorphic animals (Chlebuch et al., 2023; Goldstein & Alperson, 2020; Taggart et al., 2019), which means that children may have difficulty understanding that the educational content contained in these stories is relevant to the real world (e.g., Ganea et al., 2014; Larsen et al., 2018; Walker et al., 2015). By using a television show with anthropomorphic characters, the current study also contributes to our understanding of how such characters may help or hinder children's learning from media.

Improving children's knowledge about environmental sustainability

Earth's biodiversity and natural resources have decreased drastically (Groves et al., 2002). This decrease is due to the over-consumption of natural resources, predominantly in industrialized regions of the world (Sulston et al., 2013). Even though many people are interested in preserving these resources, many lack knowledge about how to do so (Bennett et al., 2017). Today's children will have to deal with not only the environmental problems that come up as they get older, but also the repercussions of the problems caused by all who came before them. It is therefore vital that they are prepared to do so.

Although media could be an effective way to education children about environmental sustainability, the science topics that television shows and other media aim to teach are typically those that are required by school curricula (e.g., the Next Generation Science Standards), which means that they rarely include information about environmental sustainability. Indeed, a recent content analysis of the subjects taught in educational books and television shows indicates that only 4.4% of media focus on conservation, and only 0.4% of media focus on ecosystems or habitats (Chlebuch et al., 2023). There is thus a need to produce more media that focus on sustainability and to understand whether such media can successfully teach young children about conservation. The current study asks whether watching a television episode about environmental conservation influences preschool children's views on how to engage in environmental action, their environmental self-efficacy, and their degree of worry about the environment.

Past work has found that children unfortunately have limited knowledge about environmental sustainability (Malandrakis, 2008; Palmer et al., 2003). While they know that certain actions like littering can be damaging to the environment, they report many misconceptions about how waste is processed, like that waste is taken by waste management workers to their own homes (Palmer et al., 2003). However, children can improve their environmental behaviors through intervention programs. A case study with 3- to-4-year-olds enrolled in an environment-focused curriculum demonstrated that children learned about environmental strategies from this curriculum and applied them to their daily lives when they received encouragement from adults (Mackey, 2012). Many parents from this study were even willing to implement ideas that their children learned at school in their home, like switching from plastic food wrap to compostable food wrap and looking for litter on the road. Another study found that teaching 8- to-13-year-old children about marine litter increased their knowledge about the impact of marine litter on ocean life (Hartley et al., 2015). The children in this intervention study had the opportunity to interact with different kinds of litter that might be found in the ocean and learn about how different kinds of litter negatively impacts marine life. Learning about the negative

impact of litter positively influenced children to perform more environmental behaviors, such as being more conscious about proper waste disposal. This result illustrates the importance of understanding the broader environmental impacts of one's actions, beyond simply knowing which actions to take to prevent negative environmental consequences. This general knowledge is important because it can provide general principles on which children can base their decisions about future actions; merely memorizing which actions to take does not provide such flexibility.

While these studies demonstrate that children can be taught about how to address the outcomes of wasting resources, like litter, there is little work on interventions aiming to teach children about how to prevent such problems in the first place by conserving resources. The small amount of work on this topic is based on limited contexts. For example, some work has explored children's knowledge about conservation in the context of reducing food waste in a school setting. The food waste produced by children in schools is predominantly fruit and vegetable waste (Byker et al., 2014). However, children can be encouraged to eat more fruits and vegetables through small monetary incentives, therefore reducing the amount of plant waste that is created (Just & Price, 2013). Educating children on the impact of food waste and ways to reduce food waste may also be an effective strategy (Derqui et al., 2018). However, these strategies do not emphasize the effect that food waste has on the environment and also do not necessarily directly teach children about the importance of caring for the well-being of the planet or how they can do so by conserving resources.

These studies all demonstrate that intervention programs can help create positive change in children's environmental knowledge and behaviors. However, the accessibility of these programs can vary widely; not all individuals may live in geographical areas where such programs are offered, and such programs might be expensive or limited in their enrollment. Further, these studies have almost exclusively examined changes in children's knowledge or intended behaviors with respect to conservation, but it is also possible that such interventions could affect children's attitudes, especially their self-efficacy (i.e., how able they feel to engage in pro-environmental actions) and their worry (i.e., how concerned they are about these environmental issues) (e.g., Arcury et al., 2023; Liu & Green, 2024; Pullu & Gömleksiz, 2024)

To address these limitations, and allow children to feel empowered to conserve natural resources from early in life, the current study examines the impact of educational media on children's understanding of environmental sustainability, since media is a more widely accessible resource.

The current study

The current study asked whether preschool-aged children could learn about environmental sustainability, specifically water conservation, from a children's fictional educational television show, using a between-subjects pre-test/post-test design. We chose this age group for two main reasons. First, the television show that we chose (*Nature Cat*) is aimed at children of this age, hence it is important to test how much they are learning from it. Second, we expected preschoolers to know less about environmental conservation compared to older children, meaning that they could potentially learn more from viewing this television episode.

All children saw a 10-minute episode of *Nature Cat* (Lazar & MacDougall, 2018), distributed by PBS Kids. Children in the experimental condition saw an episode titled 'Water Woes', in which Nature Cat and his friends learn the importance of water conservation. While it is important for children to learn about conservation for a wide variety of natural resources, we focus specifically on water conservation because this was the topic of a pre-existing episode of a widely available television show, allowing for maximum ecological validity. As noted above, educational media rarely focus on any aspect of conservation are rare, which limited our choice of episode. Children in the control condition saw an episode titled 'Enter the Dragonfly', in which Nature Cat and his friends learn about the lifecycle of dragonflies. We hypothesized that, compared to children in the control condition, children in the experimental condition would experience a greater increase in their conservation knowledge. This should especially be the case for content that was directly related to the content of the *Nature Cat* episode they watched (near transfer). We also hypothesized that children in the experimental condition would report feeling more capable of helping the environment (ie., experience an increase in self-efficacy) and less worried about the environment than children in the control condition. All hypotheses and analyses were pre-registered; see https://osf.io/9hrc4.

Method

Participants

A total of 118 children participated in our study. Eight of these participants were tested but excluded from the final sample: 7 children did not finish the Conservation Choice Task and 1 appeared to have difficulties understanding the question. Our final sample thus included 110 children (57 girls; mean age = 4.97 years [59.61 months], range = 3.92–6.83 years [47–82 months]). Children were randomly assigned to either the experimental condition ($n = 55$; 29 girls; mean age = 59.36 months) or to the control condition ($n = 55$; 28 girls; mean age = 59.85 months). Mean age did not differ significantly across conditions ($p = 0.74$).

To calculate our target sample size, we conducted a power analysis for a one-sided, paired samples *t*-test with an effect size of $d = 0.50$, assumed power of 80%, and significance level of 0.05, as found in prior work on children's learning of scientific topics from storybooks (Hopkins & Weisberg, 2021). This analysis revealed that we would need 108 participants, so the current sample of 110 participants is sufficient to detect a minimum effect size of 0.5.

Children's race and ethnicity were tracked via parent report. In the full sample, 61% ($n = 67$) identified as White, 1.8% ($n = 2$) identified as Black or African American, 13.6% ($n = 15$) identified as Asian, 1.8 ($n=2$) identified as Native American, 10.0% ($n = 11$) identified with more than one race, and 10.9% ($n = 12$) did not provide race and ethnicity.

This study was conducted online via Zoom during the COVID-19 pandemic ($n = 72$) and later at preschools and a children's museum ($n = 38$) in a large city in the Northeastern United States. There were no differences in performance on any measures for participants who completed the study online versus in-person (all p's > 0.05). Online participants were recruited from around the United States using Facebook advertisements, from the Children Helping Science website, and by advertising through our lab's museum and library partners.

Materials

Nature Cat episodes

Children watched one 10-minute *Nature Cat* episode, either 'Water Woes' (experimental condition) or 'Enter the Dragonfly' (control condition) on a tablet (in-person participants) or their own desktop or laptop computer (online participants).

In 'Water Woes', Nature Cat and his friends learn about water conservation. The episode is divided into four phases. In the first phase, Nature Cat and his friends discover that Daisy the Bunny's tomato plants are wilted because they have not been watered. They then discover that this is because Daisy's water tank has no more water in it, and the nearby lake is also all out of water Figure 1(a). Then, Nature Cat and friends try various methods to make rain, such as writing letters to the sky Figure 1(b). After none of these solutions work, Nature Cat and his friends realize that instead of trying to generate more rain, they should figure out how to make the rainwater last longer Figure 1(c). As a result,

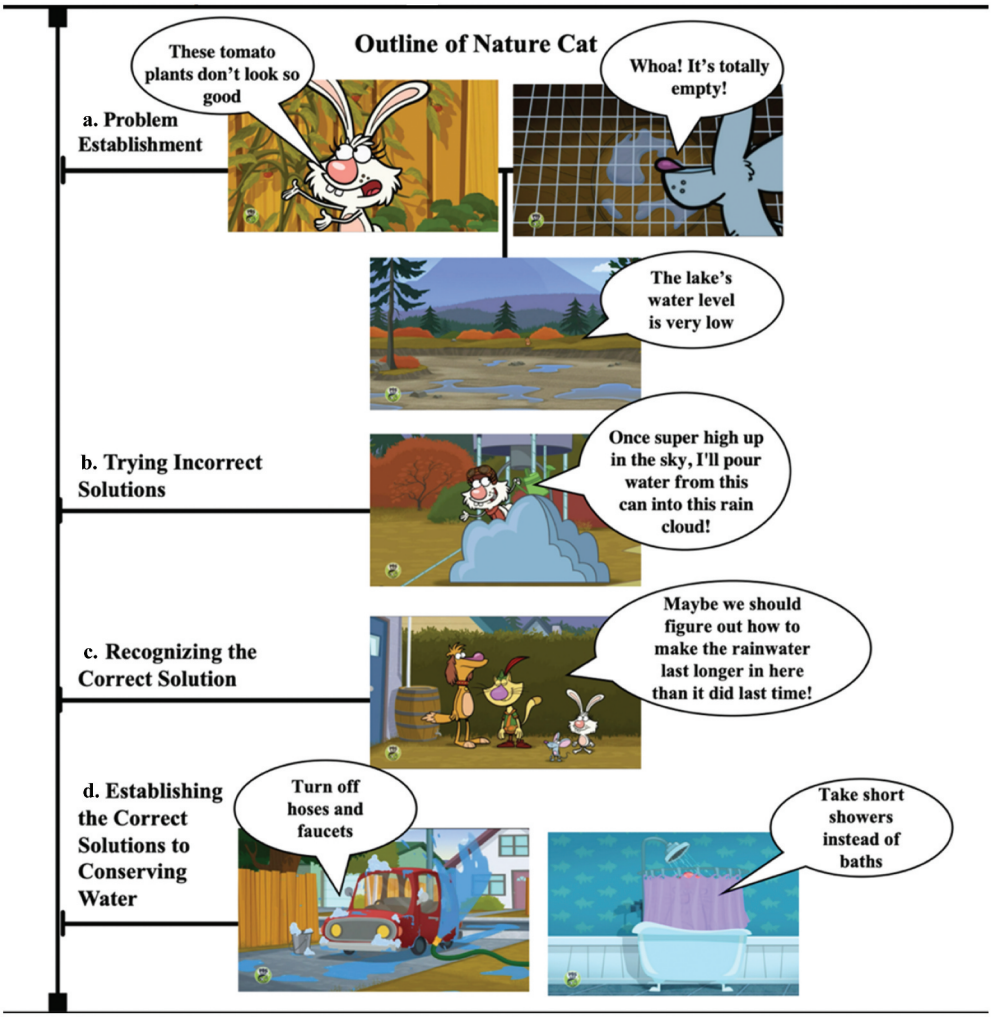

Figure 1. Breakdown of *Nature Cat* episode 'Water Woes'.

towards the end of the episode, the narrator suggests several strategies for conserving water, such as by turning off hoses and faucets when they are not in use and taking short showers instead of baths Figure 1(d).

In 'Enter the Dragonfly', Nature Cat and his friends go on a quest to find dragonflies. They use a series of clues to find dragonflies by the nearby pond, where they learn about the lifecycle of dragonflies. The episode ends with the characters singing a song about dragonflies.

Environmental sustainability knowledge questions

This measure asked two open-ended questions: 'What does it mean to help nature?' and 'How can you help nature?' The order of these questions was fixed across participants.

At pre-test only, we additionally asked 'What is nature?' as a warm-up question and as a way to provide our own definition for children to use in the study: 'Nature is us and the other plants and animals and the world around us'.

Conservation Choice Task (CCT)

This task introduced a character named Sam or Alex (names counterbalanced between pre- and post-test; gender-matched to child's gender). The experimenter told children that Sam/Alex is trying to help nature: 'S/he is trying to make some choices, and s/he needs your help! I'm going to tell you some of the things s/he's deciding between, and I need you to tell me what s/he should do'. Then, children were asked to help Sam/Alex decide between making a choice that is conservational versus a choice that is not. There were 15 items in this task, divided into three subscales, which were based on how directly children could apply information about conservation from the episode to the question (i.e., distance of transfer) (Aladé et al., 2016; Kirkorian, 2018; see also Hopkins & Weisberg, 2021). Subscale 1 (near transfer) included five choices that were explicitly listed by the narrator in 'Water Woes' about conserving water (e.g., turning off the faucet when you aren't using it vs. leaving the water on). Subscale 2 (far transfer) included five choices that were related to conserving water but were not presented as solutions in 'Water Woes' (e.g., washing one's car infrequently vs. frequently). Subscale 3 (furthest transfer) included five choices that were related to conserving other resources (e.g., turning off the lights when you leave a room vs. leaving them on). While asking children about each choice, the experimenter showed children a picture of the two options (see Figure 2). For each choice, we counterbalanced whether children heard first about the conservational option or the non-conservational option. Scoring information for this task is provided below, in the Coding and Scoring section.

Environmental self-efficacy and environmental worry

Children were asked to provide ratings on a 5-point scale (Prabhakar et al., 2018). This 5-point scale consisted of 5 numbered blue circles of varying sizes, starting with circle 1 on the left (see Figure 3).

Using this visual aid, the experimenter presented two practice questions (at pre-test only) to ensure participants understood how to use the scale. Both practice questions asked children how much they would want to eat something: either cookies (which we expected most children to respond positively to) or worms (which we expected most children to respond negatively to). Once the child selected a circle to indicate how much

Figure 2. Example visuals for conservation choice task (CCT). Note. a: One of the characters, Alex; b: Choice related to water conservation solutions presented in 'Water Woes'; c: Choice related to water conservation solutions not presented in 'Water Woes'; d: Choice not related to water conservation and not presented in Water Woes.

they wanted to eat the cookies or worms, the experimenter explained the scale in more detail: 'The way this scale works is that this side (indicating circle 1 and circle 2) means that you would want the cookies/worms *a little*, this circle (indicating 3) means that you would want the cookies/worms *a medium amount*, and this side (indicating circle 4 and circle 5) means that you would want the cookies/worms *a lot*. You picked [the number the child picked], which means that you want the cookies/worms [wording to describe chosen circle]. Is that right?' If the child demonstrated trouble understanding the scale (e.g., did not respond to the first prompt, said 'I want 5 cookies!'), the experimenter would explain the scale again, and then re-prompt the child to pick a circle. All children were able to use the scale accurately after the two training trials.

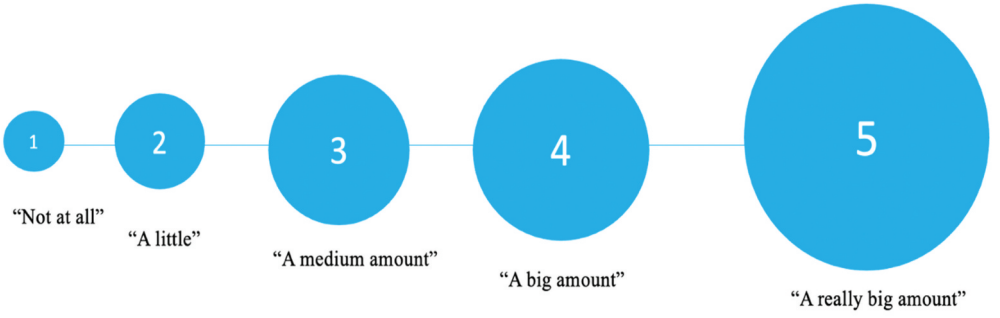

Figure 3. 5-point scale for self-efficacy and environmental worry measures.

Then, the experimenter then asked children, 'How much can you help nature?' (i.e., self-efficacy) and 'How worried are you about nature?' (i.e., environmental worry). The order of these two questions was fixed across participants. We chose to use only a single question to address each of these concepts to keep the pre- and post-test relatively short and easy for our young participants to complete.

Memory check

During post-test only, we asked children 8 open-ended questions related to the events of their assigned episode (e.g., What kind of plants were Nature Cat and his friends trying to grow?). None of the memory questions for either condition asked about resource conservation.[1]

Parent environmental knowledge survey

For participants in our online sample only, caregivers were also asked to complete an online survey on their environmental views (see Appendix 1); we have completed surveys for 54 participants. Parents answered a series of questions about their environmental knowledge (e.g., 'What does it mean to be environmentally friendly?') and attitudes, and about how they talk about environmental sustainability with their children. We report the pre-registered analyses involving this survey in our Supplementary Materials.

Procedure

Two experimenters ran the study: Experimenter 1 (E1) conducted the pre-test measures and viewed the episode with the child, while Experimenter 2 (E2) conducted the post-test measures. E2 was blind to condition, which was accomplished by having them sign on to the Zoom session after the episode had played (online participants) or leave the room during the pre-test and episode viewing phase of the study (in-person participants). With parent permission, testing sessions were video- or audio-recorded.

The study was divided into three phases: pre-test, media, and post-test. At the pre-test, E1 administered the environmental knowledge questions, the Conservation Choice Task (CCT), the self-efficacy rating question, and the environmental worry rating question. The order of these measures was fixed across participants. Next, children watched their assigned episode of *Nature Cat*. Then, at post-test, E2 repeated the environmental

knowledge questions, the CCT, and the two scale measures. E2 also asked, 'Did you learn any new strategies from Nature Cat that you can use to help nature?' This question was used to capture whether children could explicitly report what they had learned from the show. Then, E2 administered the memory check. Participants were also asked if they'd ever seen this episode of *Nature Cat* before.[2]

Coding and scoring

Environmental sustainability knowledge questions. Children's responses to the questions 'What does it mean to help nature?' and 'How can you help nature?' were coded as 'conservation' if the responses involved helping nature by reducing resource use of some kind (e.g., 'Don't waste paper because paper is made from trees and don't waste water, make sure not to cut down trees') and as 'not conservation' if the responses did not involve reducing resource use (e.g., 'By picking up garbage'). To analyze these responses, we counted the total number of conservation strategies children provided as part of their answers to these two questions.

Conservation choice task. Children received 1 point every time they endorsed a conservational choice, and 0 points every time they endorsed a non-conservational choice. For example, in response to the statement, 'After washing their hands, should Sam/Alex leave the water on OR turn it off?', a child would receive 0 points for choosing that Sam/Alex should leave the faucet on and 1 point for choosing that Sam/Alex turn it off. Because there are 15 questions on that task, children can receive a maximum of 15 points, 5 in each sub-scale (see Table 1).

Memory check. Children were given 1 point for each question answered correctly, 0.5 points for each question answered partially correctly, and 0 points for no response or an incorrect response. Appendix 2 lists the correct answers for each question. Reliability was not assessed for this measure.

Results

We first explored Pearson correlations between all of our primary measures and demographic variables, including the method by which each child participated in our study (in-person or via Zoom; see Table 2). For these correlations, we dummy-coded our categorical variables (condition, method of participation, race, and gender). We found no significant correlations between condition and any other measure, and no significant correlation between the child's method of participation and other measures, suggesting that these

Table 1. Children's mean scores on conservation choice task subscales by condition (standard deviation in parentheses).

	Experimental Group				Control Group			
	Subscale 1	Subscale 2	Subscale 3	Total Score	Subscale 1	Subscale 2	Subscale 3	Total Score
Pre-test	3.73 (0.97)	1.89 (1.07)	4.07 (0.94)	9.69 (1.61)	3.60 (1.15)	1.82 (1.23)	4.00 (0.92)	9.42 (2.02)
Post-test	4.09 (1.13)	2.18 (1.06)	3.95 (1.13)	10.22 (2.11)	3.73 (1.04)	1.95 (1.21)	4.05 (1.08)	9.73 (2.22)
Difference	0.36	0.29	0.12	0.53	0.13	0.13	0.05	0.31

Table 2. Pearson's correlations of all main measures and key demographic variables.

	Location	Age (Years)	Gender	Race	Pre-test CCT	Post-test CCT	Pre-test Conservation Strategies	Post-test Conservation Strategies	Pre-test Self-Efficacy	Post-test Self-Efficacy	Pre-test Worry	Post-test Worry	Memory Score
Location	1.00												
Age (Years)	−0.02	1.00											
Gender	0.10	−0.10	1.00										
Race	**−0.27****	−0.02	**−0.25****	1.00									
Pre-test CCT	0.02	**0.26****	0.08	−0.03	1.00								
Post-test CCT	0.06	**0.41*****	0.00	0.03	**0.65*****	1.00							
Pre-test Conservation Strategies	0.12	0.10	0.05	−0.09	**0.20***	0.18	1.00						
Post-test Conservation Strategies	−0.10	**0.32*****	−0.16	−0.05	**0.24***	**0.36*****	**0.32*****	1.00					
Pre-test Self-Efficacy	−0.11	0.14	−0.10	0.18	−0.03	0.08	−0.05	0.08	1.00				
Post-test Self-Efficacy	−0.12	−0.06	−0.02	0.11	−0.08	−0.07	−0.04	0.07	**0.55*****	1.00			
Pre-test Environmental Worry	−0.03	0.09	−0.18	−0.05	0.11	0.14	**0.27****	**0.20***	0.01	0.07	1.00		
Post-test Environmental Worry	−0.01	−0.01	−0.17	−0.03	0.04	0.08	0.17	0.18	−0.06	0.01	**0.69*****	1.00	
Memory Score	−0.04	**0.51*****	0.08	0.13	**0.21***	**0.30****	−0.02	0.09	**0.25****	0.00	−0.10	−0.17	1.00

We dummy coded condition as −0.5 for the control condition, 0.5 for the experimental condition
We dummy coded method as 'In Person' = −0.5, 'Over Zoom' = 0.5
We dummy coded gender as 'male' = −0.5, 'female' = 0.5
We dummy coded race as White = 0.5, and anything other than White as −0.5
*denotes $p < 0.05$.
** denotes $p < 0.01$.
***denotes $p < 0.001$.

factors did not significantly influence our results. We did find significant correlations between method of participation and race, suggesting that participants who completed the study via Zoom were less likely to be White, further suggesting online recruitment and testing may help researchers to access more diverse subject populations.

Pre-registered analyses: Primary analyses (section 7.1)

All analyses reported in this section were pre-registered (https://osf.io/9hrc4).[3] We have presented results here based on the analyses we pre-registered. However, upon realizing that our data was not always normally distributed via the Shapiro-Wilks test, we have included additional linear regression analyses in the Supplementary Materials. The findings of these regression tests were equivalent to the results found through our ANCOVAs, with one minor difference which we discuss below. All primary analyses were completed in SPSS, while our exploratory and supplementary analyses were completed using R.

Changes to children's environmental knowledge (pre-registration sections 7.1.1 and 7.1.2)

We pre-registered an ANCOVA to be used to check for differences between conditions in children's post-test performance on the Conservation Choice Task. Due to the skewed nature of our data, we additionally obtained robust standard errors and bootstrapped confidence intervals.

To investigate whether watching 'Water Woes' as opposed to 'Enter the Dragonfly' led to gains in overall knowledge about resource conservation, we used an ANCOVA predicting children's post-test Conservation Choice Task scores using condition assignment as the independent variable and pre-test scores, age, and children's memory scores as the co-variates.[4] At pre-test, children in the experimental condition scored an average of 9.69 out of 15

($SD = 1.61$) and at post-test they scored an average 10.22 out of 15 ($SD = 2.11$). At pre-test, children in the control condition scored an average of 9.42 out of 15 ($SD = 2.02$), at post-test they scored an average 9.73 out of 15 ($SD = 2.22$) (see Table 1). There was no difference in pre-test scores between conditions ($p = 0.43$). The overall model was significant $F(4, 109) = 25.10$, $p < 0.001$. However, contrary to our predictions, condition did not have a significant effect on participants' post-test scores $F(1, 109) = 1.37$, $p = 0.25$ (See Table 3).

Table 3. ANCOVA Model of participants' performance on conservation choice task.

Source	Partial Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Square
Corrected Model	251.69	4	62.92	25.10	<0.001	0.49
Intercept	0.52	1	0.52	0.21	0.65	0.00
Age (years)	18.98	1	18.98	7.57	0.01	0.07
Total Memory Score	1.86	1	1.86	0.74	0.39	0.01
Pre-test Score	151.88	1	151.88	60.58	<0.001	0.37
Condition	3.40	1	3.40	1.37	0.25	0.01
Error	263.23	105	2.51			
Total	11455.00	110				
Corrected Total	514.92	109				

a. R Squared = 0.49 (Adjusted R Squared = 0.47)

We also investigated children's scores on the three subscales of the CCT: Water conservation strategies they saw in Water Woes (near transfer, Subscale 1), water conservation strategies they did not see in Water Woes (far transfer, Subscale 2), and other kinds of water conservation strategies (furthest transfer, Subscale 3). We ran ANCOVAs for each of these subscales, again predicting post-test scores using condition assignment as a predictor variable and controlling for the effects of children's pre-test scores, age, and memory scores. There were no differences in pre-test scores between conditions for any of the subscales (all p's > 0.05). We found a marginally significant effect of condition on post-test scores for Subscale 1 ($b = 0.32$, $SE_{boot} = 0.16$, $t(109) = 1.94$, $p = 0.06$). The bootstrapped 95% confidence interval for this effect was

[−0.008, 0.64]. But there was no significant effect of condition on participants' post-test scores for Subscale 2 or Subscale 3 (both p's > 0.05). This marginal effect for Subscale 1 is statistically significant in the linear regression reported in the Supplementary Materials.

Changes to children's conservational strategies (pre-registration sections 7.1.3 and 7.1.4)

In addition to testing the effects of learning on the closed-ended CCT, we investigated whether children in the experimental condition would report more conservational strategies to our open-ended questions ('What does it mean to help nature?' and 'How can you help nature?') at post-test compared to children in the control condition. The answers to these questions were coded numerically, by counting the number of conservational strategies children generated. We ran an ANCOVA on the sum total conservational strategies children reported at post-test in response to both of these questions, using condition assignment as the independent variable and number of conservational strategies reported at pre-test and age as the co-variates. The overall model was significant, $F(3, 106) = 13.84$, $p < 0.001$. This analysis found that there was an effect on the number of conservational strategies that children reported at post-test, $F(1, 106) = 13.50$, $p < 0.001$, with children in the experimental group reporting more conservational strategies ($M = 0.64$, SD = 0.97) than children in the control condition ($M = 0.18$, SD = 0.58) (b = 0.50, $SE_{boot} = 0.16$, $t(109) = 3.59$, $p < 0.001$). The bootstrapped 95% confidence interval was [0.224, 0.775].

Changes to children's environmental self-efficacy (pre-registration section 7.1.5)

We investigated whether there were any effects of condition on children's environmental self-efficacy ratings. There was no difference in self-efficacy between conditions at pre-test ($p = 0.80$). We used an ANCOVA to predict children's post-test self-efficacy ratings, using condition assignment as the independent variable and pre-test self-efficacy ratings as the co-variate. On average, across the sample children rated their self-efficacy at 4.37 (SD = 1.15) at pre-test and 4.56 (SD = 0.91) at post-test. Our overall model was significant, $F(2, 107) = 23.30$, $p < 0.001$. However, there was no significant difference in post-test self-efficacy ratings between conditions, $t(109) = 0.40$, $p = 0.69$ (see Table 4).

Changes to children's environmental worry (pre-registration section 7.1.6)

We additionally investigated whether there were any effects of condition on children's environmental worries. There was no difference in worry ratings between conditions at pre-test ($p = 0.36$). On average, across the sample children rated their environmental

Table 4. Changes in Children's ratings for self-efficacy by condition.

	Experimental Group	Control Group
Pre-test	4.35 (1.19)	4.40 (1.12)
Post-test	4.58 (0.85)	4.55 (0.98)
Difference	0.23	0.15

Table 5. Changes in Children's ratings for environmental worry by condition.

	Experimental Group	Control Group
Pre-test	2.20 (1.34)	2.45 (1.56)
Post-test	2.82 (1.67)	2.40 (1.65)
Difference	0.62	−0.05

worry at 2.33 (SD = 1.45) at pre-test (Cronbach's alpha = 0.79) and 2.61(SD = 1.67) at post-test (Cronbach's alpha = 0.77). We used an ANCOVA to predict children's post-test worry ratings, using condition assignment as the independent variable and pre-test worry ratings as the co-variate. Our overall model was significant, $F(2, 107) = 54.51$, $p < 0.01$. Our analysis revealed that there was a significant difference in post-test worry ratings between conditions, b = 0.62, $SE_{boot} = 0.22$, $t(109) = 2.82$, $p = 0.006$). Children in the experimental condition had a significant increase in worry compared to children in the control condition (see Table 5).

Exploratory analyses

Changes to Children's conservation knowledge across entire sample

In addition to carrying out our pre-registered analyses, we also wanted to check whether there was any change in children's conservation knowledge across the whole sample. A paired-samples *t*-test revealed a significant difference between children's scores from pre-test to post-test, with children scoring significantly better at post-test ($t(109) = 2.56$, $p = 0.01$). However, this effect was small (Cohen's d = 0.21). We used a second *t*-test to specifically examine the experimental group for changes in children's scores from pre-test to post-test. This test was also significant, $t(54) = 2.35$, $p = 0.02$, with a small effect size (Cohen's d = 0.28). There was no significant change in score in the control condition ($p = 0.20$). Therefore, without controlling for pre-test scores, it seems that there was a general improvement in children's scores across both conditions, and this change was driven by the experimental condition.

Discussion

This study investigated whether a narrative television show would increase children's knowledge about conservation strategies and impact other aspects of their environmental views. Contrary to our predictions, our data suggests that children who watched an episode focusing on water conservation had some difficulty transferring their learning about this topic from this episode to real life. They did not perform any better on a task asking them to choose conservational actions compared with children who saw an

episode about an unrelated topic, although they were marginally more likely to do so for actions that were directly presented in the episode. This result is somewhat surprising, given that children's media is designed to be explicitly educational. Additionally, the episode that we used in this study was highly didactic, with a narrator directly telling viewers several strategies that they could use to save water, and past work indicates that narrative media can support children's learning (e.g., Jing & Kirkorian, 2020). Our results indicate that a single exposure to a television episode about water conservation is not sufficient to produce a significant impact on children's knowledge about actions that they can take to conserve water. However, this finding is in line with previous work demonstrating that preschool-aged children sometimes have difficulty transferring educational content from television and other media to real-life settings (e.g., Bonus & Mares, 2019; M.-L. Mares & Sivakumar, 2014). Why might this be the case?

First, the anthropomorphic nature of the media used in this study may serve as a barrier to learning in children. *Nature Cat* features anthropomorphic animals enacting conservational strategies instead of human characters, a common feature of children's media (Chlebuch et al., 2023; Nguyentran & Weisberg, 2024). This use of anthropomorphic creatures may have resulted in children's failing to realize that the strategies presented in *Nature Cat* were strategies that they themselves could use to help nature, because the characters did not resemble real people enough to encourage transfer of the educational material into real life. Prior work on the effect of anthropomorphic depictions sometimes finds that these depictions can interfere with children's learning (e.g., Bonus & Mares, 2019; Ganea et al., 2014; Larsen et al., 2018), although certain kinds of anthropomorphic depictions have also been found to be helpful to children's learning or to have no effect (e.g., Bonus & Mares, 2019; Geerdts et al., 2016). Future work should aim to compare children's responses to anthropomorphic and non-anthropomorphic characters in the area of conservation to determine whether this aspect of the TV show may have affected children's learning.

Another factor may be that the water conservation strategies presented in *Nature Cat* are commonplace enough that children knew about them before even watching the episode. Indeed, at pre-test, children responded correctly to 3.62 of the 5 strategies that were featured in the *Nature Cat* episode (subscale 1). Because of this, we checked children's pre-test and post-test scores for ceiling effects, and our analysis indicated that there was not a ceiling effect across the whole sample or within each condition. However, this does not change the fact that children knew much of the information that was taught to them through the episode. Further, many of the strategies presented in the episode – fixing leaky faucets, for example – are not actions that preschool children can do by themselves. Therefore, even if children recognized that these strategies would save water, perhaps they did not retain them effectively because these are not things they do not have control over in their households.

The timing of the post-test may also have obscured what children were learning. It may be that more time is needed for children to process the content and incorporate it into their general knowledge base (see Bonus, 2023; Rasmussen et al., 2016). Our post-test, which occurred immediately after viewing the episode, may have taken place too quickly to capture the episode's effects. Additionally, developmental research suggests that repeated exposure can be important for young children's learning (Horst et al., 2010; Zhan et al., 2018). Thus, it is possible that repeated exposure to a single episode or to an

entire season of children's conservation media could thus produce effects on children's knowledge or attitudes, even if a single episode did not. As a counterpoint, however, some research shows learning after a single exposure to a piece of media (e.g., Jing & Kirkorian, 2020), so it's possible that some of the other issues that we identified played a more central role in the weak learning observed in this study.

We also presented the TV show to children without providing any commentary on it. While this is indeed the way that many children consume screen media outside of the lab, it may not be the most helpful way for children to learn from these media. Having an adult provide context for a TV episode or discuss it afterward (i.e., active mediation) may help children to consolidate their knowledge more effectively than simply asking children to watch the episode on their own (M.-L. Mares & Acosta, 2008; Rasmussen et al., 2016). Because of this, it may also be the case that screen media are not as effective at teaching as print media, where an adult can more easily provide extra-textual commentary to scaffold children's learning (see Miller-Goldwater et al., 2023). It might also help to use interactive media (e.g., Ying et al., 2024), where children can respond directly to characters during the episode, helping them to learn more actively.

While we did not find our hypothesized effects on children's knowledge or on their self-efficacy, we did find that children who watched the episode about water conservation reported more conservational strategies as ways to 'help nature' in response to our open-ended questions. This suggests that this episode may have sparked their conservational thinking in general, even if these children struggled to learn specific strategies for water conservation. If children struggled to answer our open-ended questions, this could have also been due to children's limited verbal abilities during their preschool years; that is, it is possible that although children did know strategies to help nature at pre-test and did learn additional strategies from Nature Cat, they may have struggled to voice these strategies while answering our open-ended questions. Optimistically, then, media like this could help children to adopt a conservational mindset or to learn more general principles for protecting the environment, although our data suggest that they may struggle to apply such thinking to particular environmental actions.

Additionally, children who watched the episode about water conservation experienced a significant increase in worry about the environment. A single exposure to a TV show can thus shift children's attitudes, even if not their knowledge. We acknowledge that increasing children's worry about the environment could impact their mental health, a finding that is corroborated by other work on exposure to environmental health and children's mental health (e.g., Coley et al., 2015). Our hope would be that if children do grow more worried about the environment as a result of watching educational television on this topic, this increase in worry will also lead to an increase in children's motivation to take action to health nature, although current findings regarding the relationship between environmental worry and people's motivation to act are mixed (e.g., Bouman et al., 2021; Hickman et al., 2021; GoodesLéger-Goodes et al., 2022; Schwartz et al., 2022; von Gal et al., 2024). Thus, future work should investigate whether it is possible to channel children's worry about the environment into actions that will help the health of the environment.

Future work should also aim to uncover in more detail how engaging and age-appropriate television shows like *Nature Cat* can more effectively empower children to engage in pro-environmental action. The findings of the current study show that there is much work to be done if this goal is to be achieved, particularly with

respect to teaching children explicit strategies for engaging in conservation actions. Nevertheless, educational media has a crucial role to play in children's early education, as these media are widely available and have been shown to be educationally effective in a variety of domains (Hopkins & Weisberg, 2017). If we can make television shows more educationally effective on this topic, we will gain a powerful tool for educating future generations about the importance of conservation.

Notes

1. The memory check originally included a free recall portion as well, in which the second experimenter asked children, 'I didn't get to see what happened in that episode. Can you tell me what happened?' After running 39 participants through our study, this portion of the memory check was removed to reduce the duration of the study, as children grew tired towards the end of the study, and also because very few children could recall the events of the episode.
2. Initially, participants were asked this question at the very end of the procedure ($n = 45$), but we changed the procedure to ask this question immediately after viewing the episode and before any of the post-test measures for the remaining participants.
3. This study was part of the first author's master's thesis, and to complete the requirements of the master's thesis we conducted some of the planned analyses on all data collected before May 2021 ($N = 56$). Final analyses were conducted once all data collection was completed in December 2022.
4. Though we did not pre-register controlling for age as part of our analysis, because our exploratory correlation matrix showed age to be correlated with pre-test and post-test Conservation Choice Task scores, we chose to include age as a covariate in these analyses.

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