Preschoolers' Recall of Science Content
From Educational Videos Presented With and Without Songs

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Abstract

This experimental investigation evaluated the impact of educational songs on a child's ability to recall scientific content from an educational television program. Preschoolers' comprehension of the educational content was examined by measuring children's ability to recall the featured science content (the function of a pulley and its parts) and their use of the precise scientific terms presented in the episode. A total of 91 preschoolers were included (3-5 years old). Clusters of children were randomly assigned to a control group or one of three video groups: (a) Dialogue Only, which did not include a song; (b) Dialogue Plus Lyrics, which included a song; or (c) Lyrics Only, which consisted of a song, played twice. Results from interviews suggested that children from all video groups (lyrics and/or dialogue) were able to explain the form and function of a pulley better than the control group. The data suggested that children from the Lyrics Only group understood the science content because of the visual imagery, not through the information provided in the lyrics. In terms of precise vocabulary terms, significantly more children in the Dialogue Only group recalled at least one precise term from the program compared to the Lyrics Only group. Looking at the interview as a whole, the children's responses suggested different levels of scientific understanding. Children would require additional teacher-led instruction to deepen their scientific understanding and to clarify any misconceptions. This paper discusses implications of these findings for teachers using multi-media tools in the science classroom and producers creating new educational programming for television and other platforms.

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Chapter 1 – Introduction

Half of the most critically acclaimed educational preschool television shows feature songs (Common Sense Media & Rideout, 2011). An educational song on these shows often "undergirds or outwardly carries the messages and morals of the videos" (Campbell, 2002, p.60). Empirical research, however, provides mixed evidence regarding the effectiveness of using songs to teach educational messages in television programs (Calvert, 2001; Pezdek & Hartmann, 1983; Wolfe & Jellison, 1995). Researchers suggest that when children are simultaneously presented with music, rhyming lyrics, and visuals, a complex level of cognitive processing is needed to internalize the meaning of the sung words (Calvert, 2001; Wallace, 1994). Preschoolers also do not have the same capacity as adults to understand the meaning behind a song's lyrics (Wolfe & Jellison, 1995), thereby making songs ineffective tools for teaching specific content on television.

These research findings contradict adults' intuitions about music's ability to engage and teach children – particularly since many adults remember educational songs from their childhoods (Calvert, 2001; Calvert & Tart, 1993; Wallace, 1994). In studies that critiqued children's ability to understand song lyrics, the songs were presented to children in isolation, without supporting dialogue or the context of a storyline (Calvert & Billingsley, 1998; Wolfe & Jellison, 1995). On the contrary, summative evaluations of PBS and Nickelodeon programming that features music find that children can recall academic

information from full episodes (Bachrach, Houseman, Goodman, & Tran, 2009; Linebarger, Kosanic, Greenwood, & Doku, 2004; Linebarger, Piotrowski, 2009). There is a clear disconnect between findings from the lab research on educational songs on television, the summative program evaluations, and children's home experiences.

Studies on songs or related audio-visual material suggest that children demonstrate better understanding of content when information is spoken instead of sung (Calvert & Billingsley, 1998; Hayes, 1999; Hayes, Chemelski, & Palmer, 1982). Research on music and cognition suggests that adults' perception of lyrics and melody is an integrative process (Racette & Peretz, 2007; Sammler, Baird, Valabregue, Clement, Dupont, Belin, & Samson, 2010). The conditions surrounding the presentation of the material (e.g., melody, tempo, pitch) can hamper the recall of lyrics (Wallace, 1994) and the processing of the semantic meaning of the words (Craik & Lockhart, 1972). Adding complexity to the issue, children also have a limited working memory capacity when watching television (Fisch, 2000). If children do not understand their lyrics, what do songs contribute to educational television?

One key variable in considering the effectiveness of songs to teach children is how writers incorporate them into an episode or storyline. Songs could be featured as part of a magazine format program, a series of skits and songs that are tied together with an overarching theme, or a long-form narrative program. Although there is no consensus regarding which format, magazine or long-form narrative, is best for teaching young children, evidence suggests that breaks

during a story can disrupt a child's attention and impair their comprehension (Davis, 2008). In both cases, writers often use the melodies of traditional folk songs or popular rock songs, fitting new lyrics into the song's existing structure. For example, a pre-literacy program called *Between the Lions* (Berger, Cerf, Frith, Mullen, Rath, & Stiles, 2000) uses a magazine format and characters sing full musical numbers either to each other or directly to the audience. Usually visual effects including letters and words appear on the screen as the puppets sing. Researchers have shown that *Between the Lions* successfully teaches children pre-literacy skills (Linebarger, 2000; Linebarger et al., 2004). In their articles, however, the authors do not even mention that the program has songs, never mind the impact of the songs. Alternatively, songs can be blended into the story, similar to a Broadway musical. In those cases, the songs are typically short and help transition characters from one location or scene to the next with characters suddenly "breaking out into song" without much explanation. These songs often contribute to the ritual aspects of a television program, being consistent from episode to episode, and providing support during transitions between scenes. These programs may also include a longer educational song which could stand on its own without the context of the full episode.

This research study examines the question, does the presence of a song in a short video impact a preschooler's ability to learn the academic content presented in that video. Furthermore, does a child recall more information from the video (with or without the song) than from the song alone? When preschool shows weave songs into the storyline of the program, the songs' content is

typically repeated in the dialogue throughout the episode. When songs live online, however, the support from the complete episode is absent. The act of integrating songs into a story, even a short story, could increase their effectiveness to teach because the dialogue clarifies and elaborates on the information from the song lyrics.

This study uses *Sid the Science Kid* (Plourde, 2008), a preschool television program that incorporates songs throughout a narrative. The main educational song, usually sung by Sid's teacher, takes the viewer out of the immediate reality of Sid's world and provides visual representations to explain science content and terms that are unique to each episode. The information presented through the lyrics relates to dialogue in the surrounding scenes. One goal of the program is to encourage children to think, talk, and work as scientists. This study focuses on the selected episode's impact on children's ability to talk about specific science content: the pulley system. In this paper, learning from the video or understanding the video specifically relates to children's "talk" about the recalled content, and comprehension addresses children's ability to recall what happened in the story.

Sid the Science Kid's use of an educational song provides the unique opportunity of measuring and comparing children's learning from three different presentations – a video **with** an educational song (Dialogue Plus Lyrics), a video **without** an educational song (Dialogue Only), and a video with **only** an educational song, played twice (Lyrics Only). By experimenting with spoken and sung information within an experimental group, this method differs from previous

research on songs from *School House Rock* (McCall, 1973) and *Sesame Street* (Sesame Workshop, 1969) that studied the songs in isolation (studies in Calvert, 2001; Wolfe & Jellison, 1995). This study also includes a control group that did not watch a video.

With three video groups, the current study allows for examining the song's unique contribution to a young viewer's recall of the story and the educational messages by exploring the following general questions:

- Does the presence of a song affect a child's ability to recall the storyline of a television show and the educational content it is presenting?
- Does a child recall educational content better from song lyrics when a song is part of a story compared to when it is viewed in isolation?
- Do children pay closer attention to the television screen during a song compared to scenes with only dialogue?

Answering these questions will provide additional insight about what children are able to recall from song lyrics and the accompanying visuals. With this information, writers and producers could adjust the presentation and use of songs in television programs and other multi-media platforms to more effectively teach children new academic content and vocabulary.

Children's media use in 2011.

As the types of media platforms have increased over the past decade, so has children's access to forms of digital media besides television. A recent study

titled *Zero to Eight: Children's Media Use in America* (Common Sense Media & Rideout, 2011) provides detailed information about the typical preschooler's media diet. Preschoolers had an average total media time of 3:16, which included watching TV, DVDs, or videos, reading, listening to music, playing media games, and other activities on computers or handheld devices. Common Sense Media and Rideout found that over half of all children have access to mobile media, including smart phones, iPods (with video), and tablets, and as much as a quarter of their screen time was spent with these devices. In addition, the study reports that among 5- to 8-year-olds, 68% used a computer and 53% played video games at least once a week. Still, television "continues to dominate children's media use" with 74% of the media diet from television (Common Sense Media & Rideout, 2011, p. 11) and could play a large role in children's lives.

There is very little federal regulation regarding the content, quantity, and quality of television that is intended for children. In the Children's Television Act of 1990 (revised in 1996) the Federal Communications Commission (FCC) requires networks to schedule a minimum of three hours of "educational and informational" (E/I) programming per week for children under 16 years old between the hours of 6:00 a.m. and 11:00 p.m. (Children Now, 2008). Most of this programming was (and still is) broadcast on Saturday mornings between 8:00 a.m. and noon. With the wealth of children's media content available online, families can supplement network television to provide evidence-based educational television programming to children. Although in 2006 the FCC's decided on rules

related to children's programming websites, the regulations only addressed advertising on the sites and not the quality of the content.

The FCC definition of "educational" has not changed much over the years. Their website currently states E/I as "programming specifically designed to serve the educational and informational needs of children ages 16 and under" (FCC, 2010). This vague regulation gives broadcasters complete discretion in designating their programs as E/I. Over the years, scholars analyzing the programming frequently disagree with the networks' E/I designations (Jordan & Woodard, 1997). Essentially, it is the public's responsibility to hold networks accountable for their labeling decisions. Organizations such as Common Sense Media and Campaign for a Commercial Free Childhood are children's media watchdogs that help keep networks from taking the label too far. As articulated in Common Sense Media & Rideout (2011), children's media exposure is more than just television and websites, and the FCC should revisit the language in the regulations to address the current media landscape.

Networks' marketing departments use the term "educational" to describe applications for websites, smart phones and other mobile platforms even though there is little or no evidence regarding its effectiveness. Children's media producers place songs both on television and in other media platforms (e.g., websites, apps for mobile devices, music video DVDs) with and without scenes from the full episode. They assume that the edited video still teaches children the educational material. The research on these products' efficacy in teaching children is in its infancy. Preschool children can navigate websites, explore apps,

and watch videos without adult supervision. Since songs broadcasted on television today are mostly viewed in the context of an episode, it is necessary to examine the impact of video songs on children's learning. This study examines three different presentations of educational material during songs and scenes to quantify the level of effectiveness for each variation. Results could provide producers with information about how to increase the effectiveness of online video clips and full television episodes.

Professional Significance of the Study

This study fills a gap in the literature regarding how songs affect children's recall of educational content when the songs are integrated into preschool television programs. Unlike this study, previous research focused on video songs alone without the context or additional explanation about the songs' educational messages that dialogue could provide. In those studies, children were presented with information that was either spoken or sung, but not both (see Calvert, 2001 for a review). In addition, children had difficulty comprehending songs with abstract concepts (Calvert & Billingsley, 1998) and with implicit or inferred messages (Wolfe & Jellison, 1995). There is an increasing need to answer these questions due to the pervasiveness of song use in preschool television. This is the first study to date that both (a) uses songs to present perceivable information in an age-appropriate way and (b) includes an experimental manipulation of the educational content by including or excluding sung presentations (song segment) and spoken presentations (dialogue segments) of the material.

Children's cognitive abilities and previous experiences also impact their learning outcomes. For example, children's working memories are not developed enough to simultaneously process all the different layers of audio-visual stimuli involved. Therefore, without repeated viewing, songs may not contribute at all to children's learning. Calvert, Fisch, Wolfe, and Jellison have all made recommendations about how songs should be used to improve comprehension, but they have not used stimuli to study the effectiveness of their suggestions. The television program used in this study, *Sid the Science Kid,* incorporates numerous suggested techniques. They include aligning the storyline with the educational content, repeating the educational content in dialogue throughout the program in multiple contexts, and using clear language with concrete examples.

In addition to learning science content, producers of *Sid the Science Kid* may that music may increase children's interest in science or instill a more positive perception of science. Research on children's science programming suggests that they enjoy learning about academic content when science questions and answers are presented in a story (Mares, Cantor, Steinback, 1999). In the past few years, television producers have been responding to the public need to increase children's interest in science by creating more science-based television programming for younger children. In September 2012, for example, Sesame Workshop announced that the last segment of the 43rd season of *Sesame Street* will focus on science, technology, engineering, and math and be presented as a musical, "Elmo the Musical" (Jenson, 2012). *Sesame Street* has over 30 years of published research that speaks to its ability to teach children school readiness and

prosocial skills (Fisch & Truglio, 2000). The current study could inform *Sesame Street* writers on how to create more effective video songs about science within a musical format program.

Research Design and Research Questions

This experimental study examines children's recall of specific science content, a pulley system, which was presented in a video with or without an educational song or a story. The study's stimuli videos comes from *Sid the Science Kid,* a program that follows many recommendations made by Fisch (2000; 2004) and Calvert (2001) to reduce the cognitive demand of television and enhance children's ability to recall educational content. In this paper, the video groups that include a song are identified with the term Lyrics and the video groups that include a story are identified with the term Dialogue.

Research design.

Three groups of children watched an edited episode of *Sid the Science Kid* that included only lyrics, only dialogue, or both. When presented together, the dialogue before and after the song lyrics introduced and elaborated on the educational content for the viewer, thereby reducing the song's cognitive demand on the preschooler's working memory. Numerous aspects of children's comprehension were compared across video groups. In all videos, the dialogue and lyrics were accompanied by animated visual imagery. See Table 1 for descriptions of the edited videos presented to the groups.

Table 1. *Video Groups and Descriptions*

Group Name	Group Description
Dialogue Plus Lyrics	Students watched an episode of *Sid the Science Kid,* edited to remove all of the songs except for the educational song. Live action and other scenes that strayed from the main storyline were also removed.
Dialogue Only	Students watched the same episode as Dialogue Plus Lyrics, but the educational song was also removed.
Lyrics Only	Students watched the educational song without any scenes, and the song was presented twice without a break.

Because the study examined children's recall of precise vocabulary terms, a pre-test would have primed the children for the assessed content and affected post-test results. Therefore, instead of a pre-test, preschoolers in a control group that did not watch a video were asked questions to determine their knowledge of the featured content. The control group's responses provided information about what preschool children know about the science content from their regular daily life.

Research questions and hypotheses.

Research Question (RQ) 1: *How will preschoolers' demonstrated ability to talk about the featured science content differ based on whether or not they watched the videos?*

Hypothesis for RQ1: *On average, children from the video groups will articulate the featured science content more accurately than children from the control group.*

In this research question, responses from children in the video groups were compared to the responses from the control group to examine what they recalled about the pulley system from the video. This comparison will help determine

what information preschool children learned from this edited version of *Sid the Science Kid*. Program evaluations conducted on the first season of *Sid* used control groups to investigate what children learned from a selection of episodes (Bachrach et al., 2009; Bachrach, Grant, & Goodman, 2012; Penuel, Bates, Pasnik, Townsend, Gallagher, & Llorente, 2009). Bachrach et al. (2009) found that "when presented with similar materials to those they had watched on [*Sid*], compared to non-viewers, children replicated activities and used terminology they heard on the show and that reflected scientific investigation and observation" (p. ii). In the current study, children watched a video that was shortened from its broadcast length; therefore the differences in content knowledge between the video groups and control group provide evidence to whether or not the edited video effectively presented the educational material, regardless of the song.

Research Question 2: *How will preschoolers' recall of the featured science content differ based on whether they watched the video with scenes and a song (Dialogue Plus Lyrics) or just scenes (Dialogue Only)?*

Hypothesis for RQ2: *On average, Dialogue Plus Lyrics will recall more of the content than Dialogue Only.*

In answering RQ2, two groups of children were presented with videos that included a complete eight-minute storyline with educational material that aligned with the plot. The storyline was presented using dialogue, spoken by multiple characters in the show. Dialogue Plus Lyrics included a song two-thirds of the way through the story. Comparing the two groups of children's descriptions of the science content helps quantify the song's educational value, considering both the lyrics and its accompanying visual imagery.

Within the context of a storyline, it was hypothesized that the song would enhance children's recall of the scientific content presented in *Sid the Science Kid* videos. In general, animation presented during a song may not match the rest of the episode in terms of visual style, characters, or setting. Therefore, the song provides writers with the artistic freedom to present the viewer with numerous examples and explanations of the science content. For example, the song in the selected episode shows a family that lives in a tree house and how they bring everything into their house, from the fridge to their pet bull, up to the house by using a pulley. There are approximately a dozen examples of items going up and down in the pulley throughout the song. Repetition and providing varying examples are techniques that have been found as critical in the explicit instruction method for effective teaching in reading (Archer & Hughes, 2011). Furthermore, the song lyrics in this study repeated the scientific terms that were presented through the dialogue. Because of the additional visuals and repetition of terms provided during the song, children hearing the song and viewing the additional imagery should have had the best chance of learning and recalling the featured material.

Research Question 3: *How will preschoolers' ability to recall of the storyline differ based on whether they watched the video with scenes and a song (Dialogue Plus Lyrics) or just scenes (Dialogue Only)?*

Hypothesis for RQ3: *On average, there will be no differences between the groups in terms of their recall of the storyline.*

The third research question asks whether the song could impair children's comprehension and recall of the storyline if it acts as a separation between the

beginning and end of a story, similar to a commercial (Collins, 1973). If the song places an excessive cognitive load on children's processing capacity, their ability to recall and integrate information that occurred before and after that song could be impaired. If children do not successfully process the lyrics, then the song could prevent them from comprehending the episode's educational messages. It is hypothesized that if a song is well aligned with the educational content, as it is in this study, the song will not negatively affect children's comprehension of the story.

Research Question 4: *How will preschoolers' recall of the featured science content differ based on whether they watched the video that had dialogue (Dialogue Plus Lyrics and Dialogue Only) or not (Lyrics Only)?*

Hypothesis for RQ4: *On average, children in Dialogue Plus Lyrics and Dialogue Only will recall more of the content than children in Lyrics Only.*

This research question addresses the extent to which the song itself, without the context of a storyline, supports children's ability to describe the parts of a system and demonstrate awareness of the system's purpose and how it functions. In the longer videos, the dialogue is introduced and explains the scientific information with a conversational tone by familiar characters. Spoken text is easier for children to understand and process than sung lyrics (Calvert, 2008; Calvert & Tart, 1993), so without dialogue children with only lyrics would be at a disadvantage. Additional challenges for children's comprehension of the lyrics could come from distortion due to pitch, rhythm, or the singer's diction. The visuals that accompany the song could provide educational information to children. This study aims to determine the extent to which the visuals supported

children in understanding the scientific content, especially if children fail to comprehend the lyrics themselves. If any of the above possibilities came to fruition, children would recall the material better from the videos with dialogue, compared to the video with only lyrics.

Research Question 5: *How will preschoolers' visual attention to the screen differ based on whether or not the segments included dialogue or lyrics?*

Hypotheses for RQ5: *On average, children who viewed lyrics segment will pay closer attention to the video than children who viewed dialogue segments*.

Out of all the research about music and children's television, researchers overwhelmingly agree that music and sound effects influence children's visual attention (Alwitt, Anderson, Lorch, & Levin, 1980; Calvert, Houston, Watkins, & Wright, 1982; Calvert & Gersh, 1987). If viewers are more attracted to videos with songs, their increased attention may influence their comprehension of the material. It could be especially beneficial if the songs had accompanying visuals that presented the educational material using concrete examples. When children watch a program for the first time, children will look away if the story is too confusing and they do not understand it (Crawley, Anderson, Wilder, Williams, & Santomero, 1999). Including songs in new programming or episodes that present novel content could influence children's attention and comprehension.

The next chapter will review the literature on the theoretical constructs that are most related to this study's research questions: (a) children's cognitive processing and capability to understand what they see and hear on television and (b) child- and program-centric variables that affect children's comprehension and

recall of educational material presented in video songs. The chapter will also discuss considerations regarding using songs within a television episode and the ability of television to teach science. Throughout the chapter, empirical research will be used to demonstrate how these theoretical constructs relate to previous studies.

Chapter 2 – Literature Review

Cognitively Processing Educational Songs on Television

Songs that present educational content in preschool television programs are often intertwined with the episode's storyline. The current study examines whether inserting a song into a story impacts children's comprehension of the video's featured educational content. This question is investigated by manipulating the presence of a song in one of three videos: **Dialogue Only**, which consists of scenes with dialogue; **Lyrics Only**, which consists of the song, presented twice; and **Dialogue Plus Lyrics**, which includes both types of segments. In all three video groups, children viewed the accompanying animation with the dialogue and/or lyrics.

In order to identify learning differences caused by elements of these three videos, this paper will next explore the constructs involved. The first is children's cognitive ability to process and recall the educational messages in television programs. Craik and Lockhart's (1972) level of processing model provides a framework for discussing children's ability to remember and recall information from sung lyrics or spoken dialogue. The second theoretical construct relates to how the song fits into the episode's storyline and educational material. Fisch's capacity model (2000) provides the framework for how the presentation of the content within (and between) the lyrics and dialogue segments affects children's learning. This section of the literature review will present and examine these

frameworks, as well as provide empirical research that supports or contradicts elements of these theories.

Craik and Lockhart's level of processing model.

As children watch one of the three videos in this study, elements of the presentation may affect children's ability to recall the information from the video. Specifically, children's processing of educational messages would increase in complexity when presented through songs. Craik and Lockhart's (1972) levels of processing model provides a theoretical framework to understand how individuals remember information from stimuli. Craik and Lockhart contributed to memory research by suggesting that processing stimuli happens at different levels or depths. Individuals deeply process information when they have a connection with the meaning of presented material, which lends to better and longer-term recall of the information (Figure 1). Shallow processing limits the individual to the structural aspects of a word, phrase, or image. These levels are considered to be on a continuum, with acoustic processing in the middle. Acoustic processing includes the structural, phonemic, and prosodic aspects of language. Memorizing a sonnet by Shakespeare, for example, could include structural and acoustic processing without making a meaningful connection to the text. In the current study, if children do not deeply process the lyrics of the song, they may not understand (or recall) the educational content presented through those lyrics.

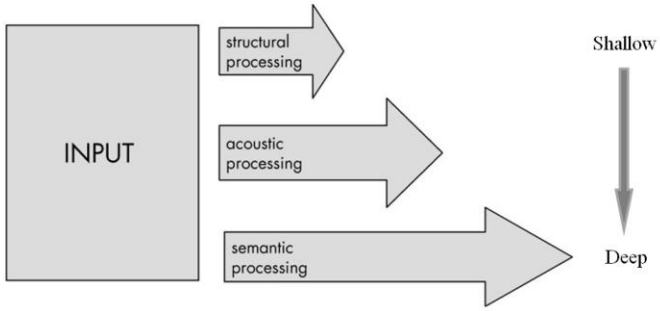


Figure 1. Levels of Processing, by Psychology Press, 2008, retrieved from http://www.psypress.com/groome/figures

Craik and Lockhart (1972) provide numerous examples of studies that use the free recall paradigm to illustrate the difference between shallow and deep processing. In a few cases, participants were asked to do different tasks with words or phrases, without knowing that they would be asked to recall the words after the task. In one study (Tresselt & Mayzner, 1960), the tasks included crossing out vowels in words, copying the words, and judging whether or not words fit the category of "economics." After reviewing numerous similar studies, Craik and Lockhart recognized that tasks that required participants to consider the *meaning* of the words resulted in the highest recall. In these studies, participants were not explicitly told to remember the words; therefore, the framework may not work as well in situations where participants are informed about the nature of the testing. In the current study, children were told that they would be answering questions about the video afterwards. These instructions may put children more of a "learning" state of mind, which could support deeper processing, compared to

an "entertainment" state of mind, which could lead to shallower processing (e.g., Salomon, 1981).

Some aspects of a video, like the animation, may be easier for children to remember despite the viewing context. In discussing their model, Craik and Lockhart (1972) recognize that meaningful visual imagery can be deeply processed and stored in long-term memory. This study examines children's ability to recall educational content (sung and spoken) that is accompanied by visual representations of the content. In conditions where students do not recall the terms used in the program, but do recall the visual imagery, lyrics were processed as a shallow level while the images were processed at a deeper level.

The strength of the visual images may be a better predictor for children's learning than the lyrics or dialogue. In their article, "Preschoolers' retention of televised events: Is a picture worth a thousand words?" Hayes and Birnbaum (1980) argue that preschoolers tend to ignore large parts of the audio portions of certain television programs and pay greater attention to the visual aspects of those presentations. During the video songs, it would be strategic to present the concepts visually, thereby reducing the importance of the lyrics. Perhaps, Calvert's research findings in the experiments with *School House Rock* was better evidence that their visual images were ineffective, not the lyrics.

Processing of dialogue and lyrics.

When children listen to a song, there are multiple layers of auditory stimuli that children must perceive simultaneously. In Craik and Lockhart's (1972) model, they recognize a flexible central processor that is involved at all levels; however, it can only handle a limited amount at one time. Craik and Lockhart do not specifically address the elements of songs that would compete with language in the processing battle to long-term memory. In songs, musical elements such as pitch, tempo, dynamics, and rhythm increase the cognitive demand on children (Wallace, 1994). To even approach a deep processing level, children need to purposefully ignore all of the non-linguistic stimuli to focus on the actual words in the song. In practice, children have no reason to make this substantial effort. In the case of a television program that uses an educational song, understanding the meaning of the lyrics would require elaboration by a teacher or a different aspect of the video.

Certain qualities of songs lend themselves toward shallower processing during the first exposure (e.g., phrasing, rhyming scheme, rhythm, melody). The first phrase of "The Alphabet Song" (A-P) provides an example for how musical elements can prevent deep processing for young children. See Figure 2 for the four measures of the first phrase. The rhyming scheme of "G" from Part 2 and "P" from Part 4 is fairly easy for children to learn and remember. This rhyming element is both structural and acoustic. The rhythm, though, is much more difficult. Parts 1 and 3 both have four letters and four syllables that are on the

beat, which is simpler to recall and mimic. Parts 2 and 4, however, do not match. Part 2 includes 3 letters over four beats, while part four squeezes five letters/syllables in the same space. For children, this imbalance leads to mispronouncing "l-m-n-o" and often losing the rhythm of the phrase. Semantically, children may believe that the sounds for "l-m-n-o-p" equate to only one or two letters of the alphabet, rather than five because of the structure from Part 2. As children repeat the song, and teachers elaborate on its meaning, they can process the lyrics more deeply (know the names of each letter) and the purpose of the song (the order of the letters in the alphabet).Young children may sing this song for months, or even years, before this very deep processing occurs. Only once the song is completely internalized, with semantic processing, can it be used accurately and successfully.

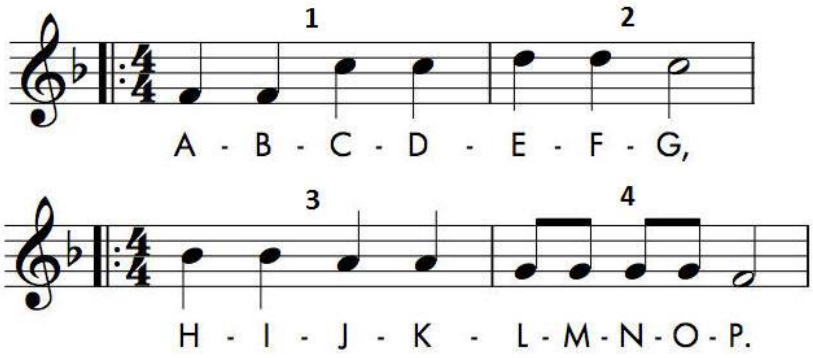


Figure 2. The first phrase of "The Alphabet Song" (retrieved from kiddles.com)

Craik and Lockhart's (1972) theory suggests that it would be easier to understand the meaning of words when they are spoken, compared to when they are sung. In terms of increasing children's comprehension, viewing a video with spoken lyrics would be considered most helpful. In their study of *School House*

Rock, Calvert and Tart (1993) used the levels of processing model to explain their findings. The episode's topic was The Preamble to the U.S. Constitution, which presents its content with accompanying animation. Researchers assigned college students into two treatment groups; one group watched the video song with the lyrics sung and the other with the lyrics spoken (without music). After repeated exposures to the video, students who heard sung lyrics had recall that was more accurate than students who heard spoken lyrics. Researchers noticed, however, that students who heard the lyrics sung were more likely to substitute words in their rendition of The Preamble that changed the original meaning of the text; students replaced one or both of the words in the rhyming phrases without taking into consideration the meanings of the words. Calvert (2008) shared this example, "one person in the singing condition wrote '…to ensure the blessings of liberty to ourselves and our *prosperity*…' rather than '…to ensure the blessings of liberty to ourselves and our *posterity*…'" (p. 326-327). Calvert suggested that the song failed to teach the preamble because students did not properly recall the word "posterity," a low-frequency word, rare in conservational English. Arguably, it would be appropriate for students to substitute "posterity" for a phonetically similar word that is more familiar.

Researchers must consider the educational goals of the video song when evaluating outcomes. In the case of *School House Rock*'s "The Preamble," perhaps the purpose of the song was to instill pride in American children about their heritage. In that case, Calvert's instruments were not aligned with the goals of the program. Memorizing The Preamble perfectly ("posterity" and all) would

not be the appropriate evidence towards measuring children's pride. If the video song's purpose were to explain the content outlined in The Preamble, clearly additional instruction and elaboration would be required for deeper, meaningful understanding of the historical document.

Most of the time, a video song's learning goal would require children to understand the meaning of the messages presented by the lyrics. Even if listeners memorized most of the words to a song, in Craik and Lockhart's (1972) model they still may have no idea what the song actually means. Calvert repeated the 1993 study with children using a different *School House Rock* song. The video, "I'm Just a Bill," describes the process of how a bill becomes a law. Calvert exposed third graders to the video in its original soundtrack either once or four times. (The song featured both sung lyrics and some spoken dialogue with background music.) She examined students' verbatim recall and their comprehension of the content. Although children who viewed the video four times recalled more of the lyrics than the single exposure condition, they did not gain a deeper understanding of what those lyrics meant. "When asked what a bill was, one child told us that a bill was 'something that you pay'" (Calvert, 2008, p.327). The current study uses visual imagery that more clearly represents the educational content compared to the animation that accompanied "I'm Just a Bill." That clarity may help children gain understanding of the educational content without requiring deep processing of the lyrics.

With *School House Rock* videos, Calvert found it problematic to use "singing to teach information that went deeper than superficial memorization of

the lyrics" (Calvert, 2008, p.327). Unlike the program used in the current study, *School House Rock* did not present the sung information in a larger narrative context. A storyline that provided an incentive for students to understand the lyrics – a problem that need to be solved or a character that needed to meet a goal – could have supported children's learning. Within the storyline, content from the lyrics could be repeated with spoken dialogue and characters could have created a direct connection between the educational content and the child's life. One video created for this study provides support for processing lyrics by including similar information with dialogue before and after the song, which was missing from Calvert's studies.

One of the reasons why songs are difficult for children to process deeply is because the rhyming lyrics may attract children's attention, resulting in processing that occurs at the acoustic (or phonemic) level rather than the semantic level. In their research on nursery rhymes, Hayes et al. (1982) found that preschool children preferred rhymed chants, even though their comprehension and retention of story elements was higher when the story was told in prose. In a later study, Hayes (1999) further experimented with the rhythmic element of nursery rhymes by including three conditions: rhymed chants, prose, and a non-rhyming chant. He explained that children who heard the non-rhyming chant scored on comprehension directly in between the children from the prose and rhyming conditions, without being significantly different from either group. The current study combines aspects of Hayes' research by presenting the educational content in both rhyming lyrics and non-rhyming dialogue.

Elements of television programs that are familiar to children, like the characters or the setting, could potentially support deeper processing and better recall of content. Craik and Lockhart's (1972) model considers that "highly familiar, meaningful stimuli are more compatible by definition with existing cognitive structures … [and would be] processed to a deep level more rapidly than less meaningful stimuli and [would] be well-retained" (p. 676). This observation fits in well with other theories of learning that encourage systematic instruction that includes using scaffolds to build on a student's previous knowledge (e.g., Archer & Hughes, 2012).

Typically, producers do not intend for educational songs on preschool television to be simply memorized. Songwriters' intend to reinforce a message (e.g., be kind to others) or to introduce a new concept (e.g., how plants decay). If children need more support to process lyrics beyond rote memorization, how much more support can be provided within a single viewing experience? This study takes the first step in answering this question.

Fisch's capacity model.

Fisch's (2000) capacity model for children's comprehension of educational television provides a framework to understand how children's working memory capacity and television's programmatic features both influence learning. He suggests that because children's working memory needs to simultaneously process the narrative of the story and the educational content featured in the episode, preschoolers' processing system becomes overwhelmed

and only the narrative transitions to long-term memory. Figure 3 presents aspects of viewers' previous experiences and the program's characteristics that affect how demanding the processing task is for children. The narrative includes the sequence of events, goals set and achieved by the characters, and other plot related information. The educational content refers to the information or messages that the program intends for the children to learn. Although Fisch's capacity model does not directly address the impact of songs, it can be applied to current study in terms of the narrative in the video, viewer characteristics, and the extent to which songs contribute to program characteristics that affect processing.

Fisch developed this model after conducting a summative evaluation of *Cro*, a television program about technology (Fisch, Goodman, McCann, Rylander, & Ross, 1995). When examining the results, Fisch and colleagues noticed that not all episodes equally contributed to increasing children's understanding of the technological principles presented in the program. Fisch et al. realized that significant differences between the video group and the control were only present for episodes where the educational content was closely tied to the narrative. When the educational content was only tangentially related to the narrative, there were no significant differences in science knowledge between viewers and non-viewers. Fisch noticed that other research found positive educational outcomes when episodes had close alignment between the narrative and educational content (e.g., Square One TV Research, 1988).

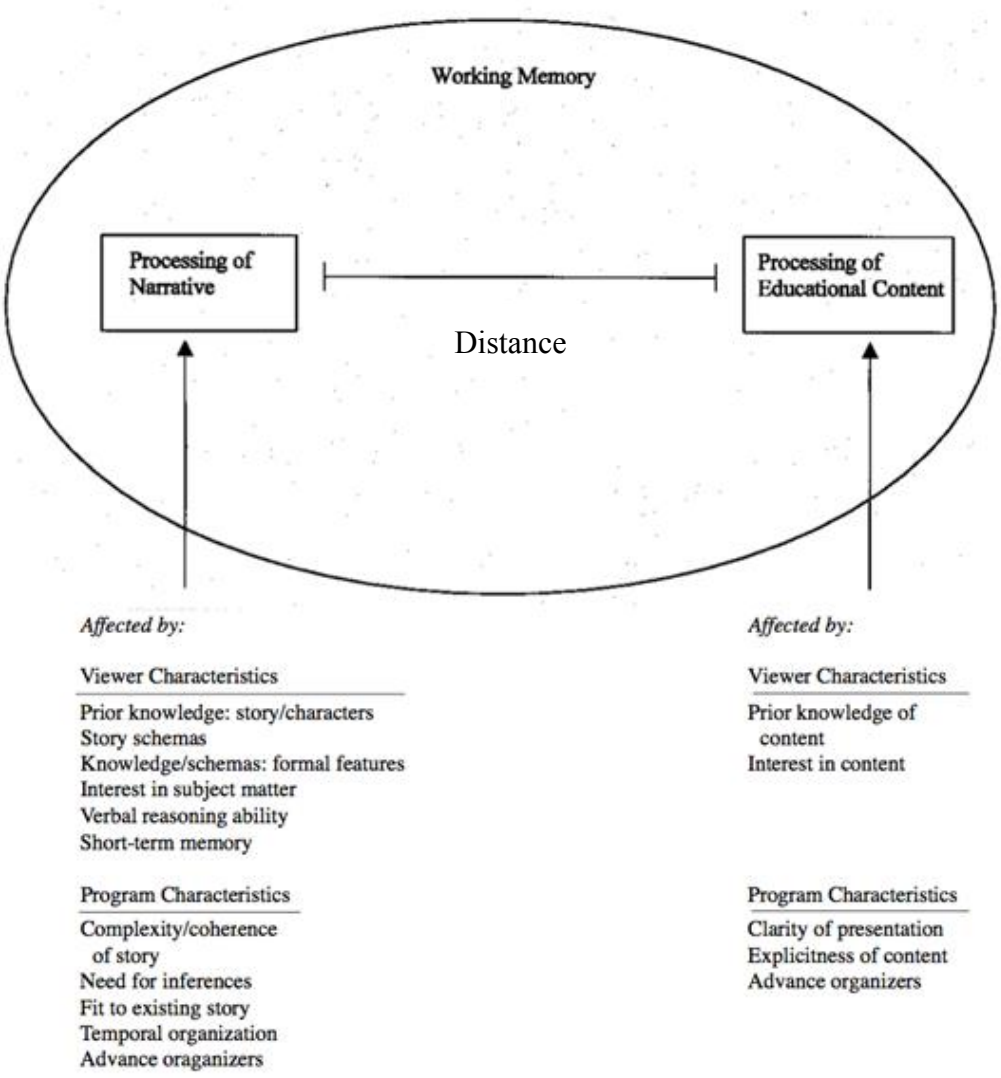


Figure 3. Theoretical construct described by the capacity model, with factors that determine the resource demands for comprehending narrative and educational content (Fisch, 2000, p.69).

Fisch (2000) provides suggestions on how to create television programs that reduce the demand on children's processing system and increase children's comprehension of the educational material. Table 2 presents these suggestions in the left column and how these ideas were implemented in the program used in the current study in the right column.

Table 2. *Five Ways to Increase Comprehension of Educational Content*

Suggestions by Fisch (2000, p.82)	Examples from current study's program
1. Increase total amount of working memory resources to understanding program as a whole (e.g., Salomon's, 1981, theory of AIME)	During the research session, children were told that they will be asked questions about the video when it is over. They sat on chairs facing the screen, with minimal distractions in the room.
2. Reduce the demands of processing the narrative	The story structure is familiar to preschoolers; Sid goes to school, is in class, and then comes home.
3. Reduce the demands of processing educational content	The content is presented in a very explicit manner. It is repeated throughout the video with multiple examples, presented with visual imagery.
4. Minimize the distance between narrative and educational content	The educational content is closely aligned with the narrative. In fact, the entire plot supports the presentation of the educational material.
5. Increase viewers' voluntary allocation of working memory	Children were engaged with the story, characters, and science content.

In children's television, the narrative aspects of an educational song may not align with the narrative aspects of the rest of the episode. From his observations, Fisch (2000) explains that when "educational content is tangential to the central narrative of a television program, the two parallel processes of comprehension compete for limited resources in working memory" (p.66). Alternatively, when the "educational content is woven tightly through the narrative, then the two parallel processes become complementary rather than competitive, and comprehension is strengthened" (p. 66). The addition of a song would bring additional layers of complexity to this delicate balance.

Other considerations for alignment of narrative and content

Songs often align with either the educational content or the narrative in children's television programming. The episode for this study was chosen, in part, because the song has educational and narrative similarities to the rest of the video. It was the only one out of the four episodes on simple machines in which this was the case. For example, in the episode preceding the one selected for this study, Sid wants to lift a large stuffed animal onto his bed, but cannot hoist it up. Teacher Susie sings a song about levers that takes place in a three-ring circus in which a lever system helps dozens of clowns make a human pyramid. In this case, the song is not aligned with the episode's storyline. Fisch does not consider how a song like this would affect this aspect of his model. Furthermore, if children do not understand the meaning of songs, would placing a song in the middle of a story impact the relationship between the narrative and the educational content? This study will contribute to answering that question.

While Fisch was developing his model, repurposing television programming for the Internet or mobile devices was not as widespread as it is today. Fisch (2000) suggests that producers need to consider both the child's abilities and the program's design when creating an effective program. Now, producers place segments from television programs on the web and into apps without evaluating their effectiveness to teach children when they are on their own. Changes in any aspect of a media presentation in the transfer of content from one platform to another could impair the qualities that made the programming educational on television. Fisch does not address, however, the

impact of re-purposing segments of the video on children's comprehension. The current study used edited versions of *Sid the Science Kid* with just the three-minute educational song (Lyrics Only) to provide some insight on this question.

Another element of viewing educational programming online or in an app is that children may consider watching television as "educational" but the non-television platforms as "fun." In Fisch's first suggestion from Table 2, he cites Salomon's theory regarding the amount of invested mental effort (AIME) children bring to a viewing experience. Salomon (1981) found that when the socio-cultural context for watching television centered on learning, children recalled more academic information from a video compared to when the context was undefined. When children approach a PBS Kids app as an entertainment experience, they may recall less academic information from the same material compared to when they approach it as a learning experience.

An additional consideration is how songs impact the processing of the narrative and/or the educational content. In some cases, a song may help increase the clarity of educational content, especially for concepts that are more abstract. For example teaching how plants grow could be presented using time-lapse photography during a song. This topic is not possible to accurately demonstrate within the narrative of a single-day story. In other cases, a song may provide a story that is independent from the episode's narrative. If the song were presented in the middle of an episode, however, disrupting the temporal ordering in the narrative could impair children's comprehension of the educational concepts (Fisch, 2000).

Clarity of educational messages

In 2009, Fisch added to his model by emphasizing the importance of using "concrete" educational content. He found that concrete, or perceivable, messages that are presented visually support comprehension when auditory processing fails. Consider the differences between the songs "C is for Cookie" and "Bein' Green," both written by Joe Raposo for *Sesame Street.* In the first, Cookie Monster introduces the letter "c" by repeating the phrase "'C' is for Cookie, that's good enough for me" at least 10 times per song. It is obviously repetitive, but the song also uses clear language and a simple rhythm to present an explicit and concrete message. In a recent survey conducted by this paper's author, "C is for Cookie" was one of the best-remembered songs from the series (i.e., adults remembered that the song was in the show and they remembered the words from the chorus).

Alternatively, "Bein' Green" does not have explicit messages and children have difficulty understanding it. Below are three verses from the song:

> *It's not easy being green / It seems you blend in with so many other ordinary things*
> *And people tend to pass you over / 'Cause you're not standing out*
> *Like flashy sparkles in the water / Or stars in the sky*
>
> *But green's the color of spring / And green can be cool and friendly-like*
> *And green can be big like a mountain / Or important like a river*
> *Or tall like a tree*
>
> *When green is all there is to be / It could make you wonder why*
> *But why wonder why wonder / I am green, and it'll do fine*
> *It's beautiful, and I think it's what I want to be*

Wolfe & Jellison (1995) interviewed adults about the educational messages in "Bein' Green" and they indicated that the song was mostly about self-acceptance,

while it also provided examples of the color green. In contrast, preschool children did not recall the all of the messages identified by the adults. While children were able to remember that Kermit was green, they were not able to verbalize the lessons from the song about "accepting who you are" or "learning to accept others who are different" (p. 282). If "Bein' Green" was presented in the context of a larger story about why Kermit was experiencing those feelings, or if the video presented the messages better visually, children may have had more success articulating its messages.

These songs from *Sesame Street* illustrate two extremes in terms of using clear language and explicit messaging. In the current study, the song and its accompanying visuals portray concrete examples of the scientific content with explicit language. Ideally, hearing dialogue that clearly articulates the program's educational messages before and after the song would mediate any comprehension difficulties that result from not understanding messages in the lyrics. By comparing results from the different video groups, this study will add to scholars' understanding of what children can learn from songs with concrete messages.

Key Advantages of Using Songs in Educational Television

Incorporating music in educational television is a natural choice for the preschool audience. During these early years, parents and teachers often incorporate songs into a child's daily routine to make activities special, to create and maintain traditions, to teach academic and social skills, and to support

transitions between activities and while cleaning up (Custodero, 2006; Gillespie & Glider, 2008). Music can be helpful in storytelling because even children as young as five years old can listen to music and consistently decode its intended emotional messages (Terwogt & Van Grinsven, 1991). Young children are able to understand musical routines in storytelling, such as the opening theme song indicates that the show it about to start. For all of these reasons and more, television writers often integrate all types of songs into their programming.

Many producers purposefully use a variety of musical genres in their programming to expose children to a wide range of music. *The Wonder Pets!* by Josh Selig, for example, hires Broadway composers, uses a variety of musical genres, and records with live orchestras for the show's opera-styled episodes (Clarke, 2007). For preschoolers, musical learning is characterized by "musical enculturation, playful exploration of music, and informal encounters with music in the environment" (Campbell & Scott-Kassner, 2009, p.21). They are able to explore and experiment with melodies, rhythms, and words (Kratus, 1994). In the current children's media landscape, television and other digital video platforms are some of the main sources for children to be exposed to music.

The wide range of music on children's television can also engage parents. References to popular culture or hints at mature content in the lyrics keep adults' interest while they are watching the program with their children. Well-crafted songs encourage co-viewing, which has been shown to boost children's educational experiences while watching television (Dorr, Kovaric, & Doubleday,

1989). Producers can use songs or music to engaging adults in a program, thereby hopefully enhancing the educational benefits of that program for their children.

This study's stimuli program, *Sid the Science Kid*, incorporates songs into the program because of all of the reasons mentioned above (H. Stanford, personal communication, May 13, 2010). This study mainly examines two main purposes for including a song in a television program: to bring and sustain children's to the screen and to serve as a vehicle for exposing children to academic content. The remainder of this section presents research on how these constructs have been studied in educational television and they may influence children's recall of academic content.

Attention to the screen.

Children's attention to the screen is a substantial component of children's comprehension. In general, preschoolers have a limited attention span. When watching television, this age group typically looks at the screen less than 50% of the time (Anderson, Lorch, Field, Collins, & Nathan, 1986). Children's capability for sustained attention for television viewing increases with age, increasing to around 70% of the time for school-aged children (Anderson et al., 1986). Additionally, preschool "children have stable tendencies to focus and sustain attention in particular contexts but that their attention varies with the demands of the task and their ability or interest in meeting those demands" (Ruff, Capozzoli, & Weissberg, 1998, p.454). In their 1979 study, Lorch and Anderson were the first to suggest that children are purposefully selective about their attention to the

screen. One of their examples is that when children play with toys in front of the television, they purposefully monitor the program's sound track so they can attend to the screen upon hearing certain signal words (e.g., "cookie," "Big Bird," p.726). Since that first study, Anderson and his colleagues have examined the complex relationship between attention and comprehension (Calvert et al., 1982; Crawley, Anderson, Santomero, Wilder, Williams, Evans, & Bryant, 2002; Ruff et al., 1998). For example, children may look away from the screen when they do not understand what is happening in the story (Lorch & Anderson, 1979) or they may look away if they are already familiar with what is happening in the story (Crawley et al., 2002). If research has shown that children may not comprehend song lyrics, why do they keep watching the screen?

One consideration in answering this question is the visual imagery that accompanies a song. Often, this animation is more dynamic and contains more action than the images that accompanies dialogue. In an experiment with auditory and visual educational media, Pezdek and Hartmann (1983) experimented with videos that presented information primarily through sound versus visuals. The data suggested that children comprehend educational messages in both instances. Next, the researchers added distractions to each of the conditions, either auditory distractions or visual distractions. Pezdek and Hartmann found that children understood less of the auditory material when the auditory environment is compromised (e.g., by a record playing in the background), but they did understand the visual aspects even when their visual attention is impaired (e.g., by playing with a toy). In situations where information is presented with both

auditory and visual material, they suggest that children's comprehension slightly favors the content presented visually, but both forms of content can be processed and understood. The current study presented information in both ways and monitors children's visual attention to the screen during dialogue and lyrics segments to examine the impact of the modality on children's recall of the educational content.

Researchers agree that children need to watch the screen to comprehend educational messages that are primarily being presented visually (Anderson & Lorch, 1983; Pezdek & Hartman, 1983). Research conducted on programs with songs observed that preschool viewers pay attention to songs, often dancing or singing along with the characters (Campbell, 2002; Linebarger & Walker, 2005; Register, 2003). Because songs attract children's attention, writers should take that opportunity to present the educational content visually. Furthermore, if comprehension of the lyrics were challenging, action-filled visual content would help alleviate confusion. Most *Sid the Science Kid* songs have action sequences with visual representations of the featured science content. In the current study's videos, the song shows the pulley being used a multiple times. The dialogue scenes only show the pulley in use once. Analysis comparing the video groups' familiarity with science content presented in the episode illustrated whether or not the song's added exposures significantly contributed to children's understanding of what a pulley is and what it does.

Songs provide opportunities for content repetition.

Research on repeated viewing of television programming has mostly focused on repetition of the full episode. Crawley et al. (1999) were the first to emphasize episode repetition as an effective strategy for enhancing learning for preschoolers. To date, research studies have not focused on experimenting with the amount of content repetition within an episode. Even researchers who evaluate *Between the Lions*, a program that uses songs throughout the episode to repeat and emphasize literacy skills, do not mention the fact that the program has songs in the published studies of the series (Linebarger, 2000; Linebarger et al., 2004). The current study uniquely manipulates the inclusion of a song in the episode, thereby examining the effects of repetition within the viewing experience.

Songs may repeat educational content from dialogue segments, as well as repeat that information throughout the song. Unlike dialogue, the organization of verses and choruses provide multiple starting points for listeners to recall lyrics and messages presented throughout the song (Wallace, 1994). The chorus repeats and reinforces the key information about the content for the viewer. Furthermore, song verses can split up the ideas into manageable sections that scaffold information to support comprehension.

Repetition is an important part of effective instruction in the classroom. At its core, children's skills can increase when they repeat, or practice, the skill frequently and distribute it over longer periods of time (Archer & Hughes, 2011). For early readers, repetition is crucial for building automaticity, which is

positively correlated with fluency (Frey & Fisher, 2010). Automaticity also directly supports comprehension because it is thought to reduce the cognitive processing demand of reading the words on the page and allow more mental resources towards assigning meaning to the text (e.g., Bell & Perfetti, 1994). Repetition paired with extension or elaboration assists with children's acquisition of new information such as the meanings of words (Archer & Hughes, 2011). These benefits of repetition can be seen in children's television programming, with songs as the vehicle for repetition and extension.

In the television program *Dora the Explorer* (Gifford, Walsh-Valdes, & Weiner, 2000) writers use songs to guide the viewer through transitions and to repeat important story-related content. In Linebarger and Piotrowski's (2009) evaluation of *Dora*, researchers tested for story comprehension by asking where Dora and Boots travelled during the episode. The "Travel Song" is presented three times in each episode. Within the song, the lyrics repeat the names of the locations featured in that episode's journey. Children are invited to sing or chant along with Dora and Boots during each transition (Table 3). By the end of the episode, the children heard the three locations approximately a dozen times, and the final destination over two dozen times. Linebarger and Piotrowski found that children were highly successful at indicating the three locations. Although the researchers did not manipulate the song or isolate it in any way, it is puzzling that they seemingly ignored the extent to which the song may have contributed to children's ability to recall the locations.

Table 3. *Repetition in Dora the Explorer's "Travel Song"*

Description	Lyrics
Characters chant the three locations	"Tree, hill, Mystic Lake. Tree, hill, Mystic Lake."
Characters sing the chorus (same from episode to episode)	"Come on *vamanos*, everybody let's go! Come on let's get to it, we know that we can do it."
Characters sing and chant. Viewers are expected to chant the location.	Where are we going? Mystic Lake! Where are we going? Mystic Lake! Where are we going? Mystic Lake!"
The characters (and viewer) chant the destination again.	"Mystic Lake!"

In the current study, the song in *Sid the Science Kid* serves as a vehicle for content repetition. The song increases the vocabulary exposure by an additional 25-50% over the dialogue scenes. Within the song, the use of the science tool is also demonstrated multiple times (see Table 9 in Methods for details). One video group viewed only the dialogue segments, a second group will view the dialogue segments and the song, and a third group will view the song twice (no dialogue). This study will help producers understand how songs impact children's ability and interest to talk, walk, and think like scientists, which is the goal of the program.

Teaching Preschoolers Science using Television

There is an ever increasing need for scientists in this country. According to the U.S. Bureau of Labor Statistics, engineers and jobs related to computers were the two largest science-related occupations in May 2009 (Cover, Jones, & Watson, 2011). Science, technology, engineering, and math occupations make up 6% of all US employment, so it's crucial that students are trained to be qualified

for these jobs (Cover et al., 2011). Television can be a successful tool for presenting scientific content to children, providing that the programming is appealing and engaging for its targeted audience (Fisch, Yotive, Brown, Garner, & Chen, 1997). The producers at *Sid the Science Kid* take this challenge seriously, believing that "early positive experiences with science will encourage lifelong participation" (Kain, n.d.). In the current study, even children who were rated as only "a little" interested in science indicated that they enjoyed watching the science video.

PBS (often in partnership the National Science Foundation) has been developing television programs to meet specific science education goals. These goals include, but are not limited to: increasing children's interest in and positive attitudes towards science; broadening viewers' narrow stereotypes of science and scientists; and introducing or teaching specific scientific ideas and terms. Research has found that various programs have met different aspects of these goals. A sample of the research includes:

- *3-2-1 Contact* motivated elementary school children to participate in science-related activities (Chen, Ellis, & Hoelscher, 1988).
- *Fetch! With Ruff Ruffman* increased elementary school children's interest in science careers and challenged stereotypes about science and scientists (Paulsen, Bransfield, & Tan, 2007).
- *Design Squad* increased elementary school children's awareness of the engineering profession and improved students' attitude about their ability to engage in engineering design. (Hargrove-Leak, 2010).

Peep and the Big Wide World (PEEP) and *Sid the Science Kid* are two preschool science television programs that aim to encourage and model science inquiry

skills, including asking questions, making predictions, observing, and problem solving. The programs, however, differ in their pedagogical approach. In PEEP, animal characters are learner-explorers without explicit adult interactions. They try to make sense of natural phenomena in their environment using science inquiry skills and do not specifically highlight scientific terminology. In *Sid*, the teacher provides answers to Sid's questions, sharing specific scientific facts and terminology. The next section describes relevant frameworks in science education and presents research on PEEP and *Sid the Science Kid*. The methods and findings of the two programs' summative evaluations informed the methods and research questions of this study.

Instructional frameworks considered in the development of preschool science television programming

The current framework for science education in the elementary grades, which is also used in the television show PEEP, takes inspiration from David Hawkins' 1965 essay "Messing About in Science." Hawkins describes science education as an experience that consists of creative probing and exploring, in which the teacher as a facilitator or guide whose leadership is rooted in a student-centered approach. He actually "warns" the reader not to present terms as "the base of rote or merely verbal learning" (Hawkins, 1974, p.5). He emphasizes the importance of improvising with the available materials, and merely making suggestions to further students' own explorations and not to replace them with the teacher's own ideas. This student-centered teaching approach is embraced by

PEEP's advisor Karen Worth and is clear in each episode's storyline.

One of the challenges with Hawkins' framework is that children may not leave the experience with a set of facts or terms that they could then share with others who were not in that same learning environment. In a preschool setting, teachers focus on developing a child's knowledge base on a variety of scientific topics to prepare them for kindergarten. To balance the modern science education philosophy with the academic needs of preschoolers, *Sid the Science Kid* incorporates this more teacher-directed approach developed by Rochel Gelman and her colleagues *Preschool Pathways to Science: Facilitating Scientific Ways of Thinking, Talking, Doing, and Understanding.* Although scientific terms and labels are part of the curriculum, elements of Hawkins' philosophy around exploration and discovery are echoed. This curriculum and training program for early childhood educators provides guidance on how to introduce science in the preschool classroom.

Even though preschool children are naturally curious about the world around them, traditional science education has not paid much attention to the role of science training in early childhood education. Traditional stage theorist Piaget (1971) classified this age group as perception-bound with a dependence on the "here and now," and developmental theorist Vygotsky (1986) argued that preschool children explain "the names of objects by their attributes" and do not display evidence of scientific reasoning (p. 222). Another example of preschooler's cognitive limitations is their failure on the liquid conservation test. Gelman et al (2010) explains, "Even though they watch as the water in one of two

identical glasses of water is poured into a taller and thinner glass, they assert that the resulting amounts are no longer equal" (p. 2). Because these conceptions were accepted and widespread, most preschool teachers have not spent a lot of time teaching science (Saçkes, Trundle, Bell, & O'Connell, 2011).

Later research, however, brought evidence that preschoolers had some capacity for thinking and talking about many science-related topics (Gopnick & Schulz, 2007). Gelman et al. (2010) explains that children can and do develop concepts in within a domain, such as reasoning about cause and effect. In *Preschool Pathways to Science*, Gelman et al. (2010) explain that science is a process of studying objects and events in the world by asking and answering questions about phenomena. The authors explain that knowledge grows incrementally as a function of opportunity to associate data from the world into children's knowledge base. Their goal is to allow "children to explore big ideas in depth and to learn the practices and language of science" (Gelman et al., 2010, p.4).

When introducing children to new scientific information, Gelman et al. (2010) lists specific pedagogical techniques for teachers to keep in mind. Teachers need to organize the presentation of information in a way that supports children's ability to make predictions and inferences. In addition, content should be presented using different types of examples that exemplify the range and scope of the information. Furthermore, teachers should address the content repeatedly over a set period of time in multiple contexts. These guidelines from *Preschool Pathways* match instructional strategies that have been successful in teaching

vocabulary in a reading context.

When teaching vocabulary within an English language curriculum, Archer & Hughes (2011) explain that explicit instruction is a "structured, systematic, and effective methodology for teaching academic skills" (p.1). The method involves using an unambiguous and direct approach to teaching and is characterized by a series of supports where students are guided through the learning process in a very transparent way. Some of the elements of explicit instruction lend themselves to teaching science terms and vocabulary, particularly when presenting them on television. The most applicable strategies for preschool educational science television are: (a) focusing on critical content, (b) sequence skills logically, (c) provide step-by-step demonstrations, (d) use clear and concise language, and (e) provide an adequate range of examples and non-examples.

When introduced to a word for the first time, children speedily process information about this word and connect it to certain categorical properties, a practice called "fast mapping" (Carey, 1978, p.274). Carey (1978) explains that although children may gain some information about a new word, including the fact that it is a new word, the process of full mapping is a longer and more laborious process. It involves both adding the word into the child's lexicon and restructuring the conceptual domain related to the word. In Carey's study, after several months of weekly exposures to a new word only half of the participants achieved both of these developments.

When considering how children learn words, there is a difference between identifying a thing by name, producing the correct name for a thing, and

understanding multiple meanings of the name/word. For example, a preschooler's understanding of the word "love" would likely be different from an adult's definition. An individual's understanding of words and what they mean change over time and circumstance. Beck, McKeown, and Omanson (1987) suggest a continuum that starts with no knowledge of word, then general sense, then a narrow context-bound knowledge, then more knowledge, and finally rich decontextualized knowledge. Someone may also know a word, like physic's "force," and have a sense of what it means, but not be able to explain it.

During the preschool years, considerable evidence suggests that storybook reading fosters vocabulary growth (for a review, see Dickinson & Smith, 1994). Stories can introduce new ideas and provide explicit information of domain specific properties of objects or "things." As children become more familiar with single objects, they can "[pull] together properties that tie the objects together … to develop generalizations and beginning concepts" (Neuman, Newman, & Dwyer, 2010, p.6). By telling stories, television programming can introduce new vocabulary, but cannot tailor its presentation to meet each child's individual needs. The following section provides more details about how *Sid the Science Kid* introduces new ideas and terms to its viewers.

Presentations of science in *Sid the Science Kid*

The *Sid the Science Kid* curriculum used in the current study leans closer towards Archer & Hughes' explicit instruction technique than Hawkins' child-centered approach. The science material featured in the video fits in to the

Preschool Pathways to Science central concept of "form and function." In the dialogue and lyrics, numerous characters clearly define the function of a pulley in varied language, providing multiple examples of its use in different contexts throughout the show. The episode presents information in a logical and organized way. Although some of the more advanced aspects of the pulley are not explained (e.g., how the pulley affects force, tension, load), there are age-appropriate elements like the purpose of the pulley and its system of parts, which are presented in both the dialogue and lyrics segments of the video.

Sid the Science Kid songs typically include action sequences with visual representations of science content. Certain topics may be difficult to explain within the reality of Sid's world, particularly a phenomenon that is microscopic (germs) or has small changes over long periods of time (blooming flowers). Within the song, these ideas can be demonstrated clearly, explained in a concrete way, and repeated numerous times. The dialogue between Sid, his friends, his teacher, and his family throughout the episode matches the content portrayed in the song.

One challenge writers face when using animation to portray a scientific phenomenon in a humorous way is that they could confuse children regarding what is real and what is fantasy, particularly for 3-year-olds (Samuels & Taylor, 2011). For example, in one episode of *Sid the Science Kid* an animated anthropomorphic germ jumped and danced around the school building to show how germs spread from person to person. A child may understand that a germ is invisible, but still think that it is very large. In the current study, the animation

that accompanies the song includes a number of images that depict very heavy items being lifted by pulleys. While it is true that a pulley could help lift items to high places, the pulley itself does not alter the weight of the item so it can be lifted. In Figure 4, a young preschooler could assume that the mailman could lift a couch all by himself or that the pulley changes the weight of the couch. In this case, the songwriters' attempt at humor may mislead children about what the pulley can and cannot do. In the current study children's responses will be examined for evidence of this confusion.

Figure 4. Picture of mailman lifting a couch with a pulley in the song "The Tree House" in *Sid the Science Kid*

PEEP and *Sid the Science Kid* evaluations.

Researchers at Goodman Research Group conducted summative evaluations on the first seasons of *Peep and the Big Wide World* (PEEP) (Beck & Murack, 2004) and *Sid the Science Kid* (Bachrach et al., 2009). Both home-based studies included a control group and at least one treatment group, in which children watched a selection of episodes at least three times over a week's time. At the end of the week, a researcher visited each family and conducted an

informal play activity while observing and coding the child's behavior. One of general research questions for both studies addressed whether children exposed to the videos would approach the science explorations differently than children who had not watched the program. Researchers measured in the extent to which they demonstrated science inquiry skills by examining children's behavior and language during interactions with the materials.

During the play activities in both studies, children in the viewing conditions initiated in interactions with the materials more often (Bachrach et al., 2009) and/or with more intensity (as measured by the number of comments about predictions, observations, and/or solving problems) compared to children in the control groups (Beck & Murack, 2004). In both studies, more of the children in the viewing groups replicated what was modeled in the program compared to the control group. In Bachrach et al. (2009), strength of the finding depended on the target object in the play activity. For example, 89% of *Sid*'s viewers used a magnifying glass while only 25% used journals.

The two studies took different approaches in terms of coding children's verbal utterances during the play activity. Beck and Murack (2004) categorized children's comments to see if they showed evidence of the scientific inquiry process. Specifically, did the comments include predictions or observations and to what extent students were initiating and solving problems with the materials. In all cases, they found that video groups used language that matched the scientific inquiry process more than the control group. In Bachach et al. (2009), instead of

recoding children's language into categories, researchers noticed that children from the viewing groups used the exact terms and descriptions of the science objects from the video. For example, nearly half of the children in the video groups "used the term 'magnify' as they worked, and three quarters or more used the term 'look bigger'" compared to very few of the children in the control group (Bachrach et al., 2009, p. 17).

While PEEP's goal is to "encourage, facilitate, and guide a child's own thinking rather than deliver the facts" (Worth, n.d.), a goal of *Sid the Science Kid* is to encourage children to "think, talk, and work as scientists" (Kain, n.d.). Children's language in the two studies was analyzed in a way that aligned with the programs' respective goals. One could argue that although children who watch PEEP may think like a scientist, they might not describe the activity as "science." Without putting a name to it, there are limitations on the possibility of changing a child's attitude or interest in "science." Evidence from Bachrach et al.'s study suggests that the program did influence children's "talk" and that children were fully aware that what they were doing was "science" and that Sid and his friends were "scientists." That self-awareness could make the difference in a child choosing to become a "scientist."

In both studies, however, researchers did not explicitly ask children to describe the objects or explain what they do. It's possible that some children may have been able to articulate more information about the science tools, if they were asked directly. The current study contributes to this literature by directly asking children to answer questions about the featured science object/tool in the program.

Additionally, this study examines the effectiveness specific *Sid the Science Kid* segments and presented in three different configurations to learn more about how each segment type (dialogue or lyrics) affects children's verbal recall of the featured science object.

Literature Review Summary

Child-centric variables and program-centric variables influence children's ability to learn from educational television programs. Children may have varied levels of ability to process auditory input, motivation or interest, previous experiences and knowledge. Programs have various episode structures, different uses of music to target attention, and may vary in the distance between the narrative and educational content in an episode. When television programs use song to present educational material, a deep level of processing is required for children to internalize the meaning of the lyrics. Additionally, a song's alignment with the storyline and its placement within an episode may either impair or support children's comprehension of the educational content. For science-based educational television, songs can help present perceivable examples for science topics and serve as vehicles for content repetition.

The current study adds to the literature by manipulating the use of dialogue and lyrics segments in a science video. The chosen episode's song has a narrative that aligns with the episode's narrative, and presents similar educational content as the dialogue. The design allows for examination of what children can learn from video songs, both the lyrics and the visual imagery. Results provide

information regarding how the presence of songs influences children's interest in watching the program again. The study also contributes to researchers' understanding of the relationship between songs, attention, and comprehension – of both educational and narrative content. The following chapters detail the study that was conducted, describe the results, and present its implications for television writers or producers and teachers using media in the classroom.

Chapter 3 – Method

Participants

The sample consisted of 91 children, including 58% females and 42% males. The average age of the children was 4.68 (SD = .659) with no significant differences in age by gender (F (1, 84) = 1.406, p = .47; Mean $_{\text{males}}$ = 4.69, SD = .72; Mean $_{\text{females}}$ = 4.59, SD = .57). Because not all parents returned the questionnaires, additional demographic information is available for up to 82 children. To indicate the child's ethnicity, parents were provided with a list of choices and asked to check all that applied. See Table 4 for the distribution in the sample.

Table 4. *Ethnicity Distribution in Sample*

Ethnicity	Number of Children	Percent of Sample
Asian/Asian-American	6	7%
Black/African-American	3	3%
Latino/a	2	2%
White/European-American	58	64%
Multi-ethnic	10	11%
Other	1	1%
Unknown	11	12%

Slightly over 13% of responding parents reported having attended high school, earned a high school diploma or attended some college. Approximately 27% reported holding a Bachelor's degree and 8% reported attending some graduate school, while 32% completed a Masters and 9% finished a Doctoral Degree. Ten parents (11%) did not provide this information. Research on children's interest in science has been related to having a parent who is a scientist

(Breakwell & Beardsell, 1992) and parents who expose children to science-related experiences outside of school (Farenga & Joyce, 1997). One-third of parents indicated that there was a science professional in their home.

Recruitment.

A large recruitment effort was conducted because of typically low response rates from parents in school settings (15-25%) and an expectation that some children may have already seen the chosen episode of *Sid the Science Kid,* therefore being ineligible to participate. Children were recruited from four childcare centers in the Boston area. In accordance with the Institutional Review Board at Tufts University, parents were required to provide written consent for their children to participate and be recorded (recruitment letters and consent forms in Appendix A). Families were thanked for their participation with either a $5 donation to the child's school or the receipt of a *Sid the Science Kid* book ($5 value), depending on the school's preference.

School directors provided recommendations on how to best communicate to the parents in their schools and recruitment letters with consent documents were modified, including adding a link to complete consent forms online. The IRB approved all changes. Recruitment letters went to parents in English-speaking classrooms with a return deadline of two to three weeks. The dates of the viewing sessions were determined ahead of time and included in the letters. Parents submitted completed forms to the office or their teacher. Researchers sent over 300 recruitment letters to four preschools and 152 consent forms were

returned or submitted online (48% response rate).

Selecting the final sample.

There were a variety of reasons why children were either not eligible to participate or could not be included in the analysis. Information to determine inclusion came from parent questionnaires (in Appendix B) that were submitted with the consent forms. Some children were excluded due to circumstances that occurred during testing. The table below details the number of children and the reason why they were excluded.

Table 5. *Number of Excluded Children and the Reason for Exclusion*

Reason For Exclusion	**Number of Children**	**Running Total (152 start)**
Already saw the episode of *Sid the Science Kid* used in study	32	120
English not primary language	5	115
Parent indicated child had an Individualized Education Program for special needs*	10	105
Children were absent during the dates for data collection	8	97
Children could not follow basic directions or did not speak at all during the interview	4	93
Child withdrew during the study	1	92
Child watched less than 50% of the video during the video session (outlier)	1	91

*Children with an Individualized Education Program for special needs were not included because it was unclear if children were on the IEP because of problems related to language or attention.

Procedures

After obtaining approval from the Institutional Review Board at Tufts University, a small pilot study was conducted at the Tufts Educational Daycare Center with 26 children. The goal of the pilot was to evaluate study procedures, see if children understood the edited versions of the episodes, and determine whether or not their viewing behavior would lend to coding the children's engagement with the program or attention to the screen. Researchers conducted one 30-minute research session for each video group and the control group over two mornings. To assign children in groups, the eligible children were organized into clusters by age and put into alphabetical order by last name. Using a random sequence generator, researchers assigned children of the same age to each of the conditions, to be sure that children of different ages were in each of the groups for the pilot. Then, the groups were randomly assigned to a timeslot to determine the order of the groups. Groups included between four and six children.

The results of the pilot study revealed that the procedures were feasible, children were able to answer the questions about the storyline and science content, and researchers concluded that measuring children's attention would be more reliable than children's engagement. (The video was not designed to be interactive, so most children watched the program quietly, without behavior that lent to coding a continuum of engagement with the video.) Researchers adjusted the random assignment procedure so children were grouped into clusters based on their classroom, rather than their age. This process enabled a more organized collection and return of the children to their classrooms before and after the

research sessions. Researchers also determined that the assessment lengths were appropriate because the time between when the children watched the video and the interview would be less than 10 minutes. Interview scripts were adjusted so research assistants could easily take notes about children's responses. Study procedures and instruments were finalized and approved by the IRB before recruitment began.

Researchers collaborated with school directors/principals to create a schedule and inform teachers of data collection plans. After all of the submitted forms were completed from each school, eligible children were identified for study participation. Just about half of the children came from a large preschool (N = 47), while the other three smaller preschools each had 11, 14, and 19 children included in the study (see Table 6). Eligible children from each class were randomly assigned to groups.

Table 6. *Number of Children per Group by School*

School	**Video Groups**			**Control Group**	**Total**
	Dialogue Only	**Dialogue Plus Lyrics**	**Lyrics Only**		
University Educational Daycare Center	6	5	5	3	19
Jamaica Plain Preschool	3	4	0	4	11
Lincoln Preschool	4	4	3	3	14
Somerville Preschool	11	12	12	12	47
All Schools	24	25	20	22	91

Because of school scheduling changes and absences, some children needed to be re-assigned to a different group or moved to a different research day. Despite last minute adjustments, the children's assignments resulted in similar group sizes (see Table 6). Neither gender, χ^2 (1, N = 91) = 6.033, p = .11, nor age, F(3, 91) = .797, p = .50, were significantly different across the four conditions. There were no significant differences between the groups in terms of children's gender, age, ethnicity, parent education, or having a science professional in the home. See Appendix C for detailed information about the demographics of each group.

Research sessions.

Each day of data collection consisted of up to four 30-minute research session timeslots between 9:00am and 12:00pm. Researchers scheduled time in between each research session for clean up and set-up, as well as transitioning the children from their class to the research room. Each group of children was assigned to one research session. At least one group from each condition was scheduled for each morning, to keep the sample size of each group relatively even. Somerville Preschool had four days of data collection, Lincoln Preschool and Tufts Educational Daycare Center had two days, and Jamaica Plain Preschool had one day.

Room setup.

The research session took place in rooms that were large enough for six children to comfortably sit and watch the television. In three locations, children

sat on two rows of mats on the floor, while in the fourth location, children needed to sit on chairs because the television was placed in a high shelving unit. In each location, the sessions took place in a room at the school that contained various items on the wall near and around the television (e.g., a school library with bookshelves, an afterschool room with child art on the walls). Researchers placed children's seating close to the television and all items that could be removed from the area were placed behind the children to reduce distractions. Cameras were placed immediately next to the television (and behind it when possible) and pointed towards the children. Researchers set up separate tables and chairs in far corners of the room for the interviews. The distance between the interview area and the waiting area aimed to reduce the amount of distraction during the interviews and to prevent children who were waiting for their turn to hear the questions and other children's answers.

Introductions and assent process.

Three researchers attended research sessions when groups contained six children, while two researchers attended on the other days. A researcher greeted the children once they arrived in the classroom and instructed them to sit on a mat or in a chair. While a researcher turned on the video camera, children introduced themselves and heard the Introduction Script (in Appendix A). The researcher explained what was going to happen during the session, including that children were going to watch a science video and then were going to be asked questions about it (the control group was told they were going to be asked questions about science). Children were informed that everyone was going to get a turn, but they

could tell researchers if they wanted to stop at any time. After children's questions were answered, they were asked if they were ready to start. Once children responded that they were ready, the video or interviews began.

Video viewing sessions.

Children watched one of the three versions of the *Sid the Science Kid* episode on a television set. The chosen episode, "The Tree House," was edited down to less than 10 minutes. The video was played, uninterrupted. Even though the researchers were sitting behind or to the side of the seating area, sometimes children looked at the researchers during the video. Researchers were told to watch the video and not look back at the children, to prevent interactions and minimize distractions by the researchers. Because children's attention to the screen was being coded, researchers were also instructed not to explicitly tell (or gesture to) the children to watch the video. For the most part, children sat and watched the videos with minimal talking or interactions. In most cases where children were not looking at the screen, they were looking at the walls of the classroom or at their own bodies and clothing.

Video interviews.

When the video ended, one researcher turned off the television and explained to the children that they would be chosen, one at a time, to be interviewed. While they were waiting for their turn, another researcher would lead them in some quiet stretching exercises. In the locations where children sat on mats, the children stayed on their mats while stretching. For the location where

children sat on chairs, the group was moved to a large carpeted area for the stretching and waiting period.

The researchers aimed to interview all the children as quickly as possible after the show ended, to minimize period of time between when children watched the video and they were asked questions about it. On most days, two researchers were available to interview one child each, simultaneously. Researchers read from an Interview Record Sheet (in Appendix B), which allowed them to indicate children's responses during the interview. The interviews for the videos typically lasted two and a half minutes per child, so the beginning of the interview for most children was within five minutes of the end of the video (e.g., if they were the first, second, or third child, out of six, to be interviewed). When a third researcher was not available, one researcher interviewed one child at a time. In those cases, the time between the end of the video and the start of the interview for the last (fourth) child could last up to 10 minutes. To examine differences between groups on this waiting period, each child was assigned a number based on the order of which they were interviewed. Chi-square tests showed no significant differences between groups in terms of the number of children at each position, $\chi^2(12, N = 85) = 9.093$, $p = .695$. (Due to equipment malfunction, six children's positions were not recorded.) Once all children completed their interviews, the lead researcher thanked them for their participation and children were returned to their classrooms.

Control group interviews.

Children in the control group followed a modified procedure, because these children did not view a video. One or two researchers interviewed one child at a time while another researcher led the remaining children in stretching exercises. Once all children completed their interviews, the lead researcher thanked them for their participation and children were returned to their classroom. When it was not possible to interview the children in the control condition as a group (e.g., if there were only one or two children in the group), they were interviewed individually using a modified Introduction Script. Four children were interviewed individually in a quiet space separate from their classroom, such as the corner of a lobby or a hallway.

Documentation of the viewing sessions and interviews.

Researchers used various strategies to keep track of each child's Interview Record Sheet and recordings. First, Interview Record Sheets were prepared with children's ID numbers and removable post-its with the children's names so the material could be prepared ahead of time, yet still allow for last minute changes. Children's names were also said out loud once children were seated, their names recorded on a seating chart (in Appendix B). The viewing rooms were set up similarly for each video group and at each school, so the seating chart remained the same across locations. The video was turned on while the children were sitting down to minimize drawing children's attention to the camera and to also record children's names on the videotape. Additionally, each child's interview was recorded in a separate digital file using iPods or iPhones. Files were labeled with

children's ID number and saved to an online password-protected storage site after each study session.

Experimental stimuli.

The episode selected for this study had to meet several requirements. First, it had to have a typical story structure with a beginning, middle, and end. Second, to match the recommendations from the capacity model (Fisch, 2000), the episode needed to have educational material well aligned with the storyline. Third, the program needed to contain an educational song that addressed the episode's main educational message. Fourth, when all other songs were deleted from the episode, the story needed to remain intact. Finally, the program needed to be age-appropriate and engaging for a preschool audience, yet have educational material that children most likely did not already learn in school or at home.

Sid the Science Kid, an educational preschool television program produced by Jim Henson Productions, met all of the requirements mentioned above. The program uses a type of animation called Henson Digital Puppetry Studio, which creates 3-D computer-generated characters based on a puppeteer's live performance. *Sid*'s curriculum is based on the *Preschool Pathways for Science* (Gelman et al., 2010). The program focuses on exposing children to a wide variety of science topics within biology, chemistry, engineering and more, through scientific inquiry.

The program's basic storyline is very simple and focuses on the main character, Sid, and his life as a preschool child. Every story starts with Sid's

morning and his "big question," which he shares with the audience. Afterwards, he briefly discusses his question with his parents who send him off to school to ask his friends and teacher for their ideas on how to answer his question. Teacher Susie is always prepared with a possible solution and an activity for the children to explore the question and answer it themselves. After school, he discusses everything with his grandmother and parents. The show usually ends with a momentous finale where Sid returns to the place where he first asked his question (in his bedroom or backyard) and he explicitly explains what he learned at school and how it solves his problem.

As mentioned in the literature review, three studies conducted on *Sid the Science Kid* have found that the program effectively teaches children scientific ideas and terms (Bachrach et al., 2009, 2012; Penuel et al., 2010). The characters explicitly use the term "science" while presenting science information on particular themes in each episode. Producers aspire to bring age-appropriate scientific inquiry and fun explorations from Sid's classroom into children's lives. Specifically, the program's website encourages teachers to integrate science activities from the show into the classroom and parents to extend the show's science concepts into the home.

Episode chosen for study.

The chosen *Sid the Science Kid* episode, "The Tree House," introduces viewers to the pulley system. In *Preschool Pathways*, Gelman et al. (2010) present "form and function" as a central concept and "tools and their uses" as a

way to explore that concept. This episode is one in a four-part series about simple machines. In "The Tree House," Sid wants to know how he can get his heavy toy box up into his new tree house. At school, Sid learns about pulleys and how they can help lift heavy things to high places. Back at home, his father builds a pulley system for Sid's tree house and uses it to lift the toy box for Sid.

The full episode of "The Tree House" was edited to remove scenes that did not directly follow the storyline and all non-educational songs. It features a song about pulleys two-thirds of the way through the program. Table 7 presents the songs and scenes in "The Tree House" episode. Rows that are highlighted grey were cut from the program for this study. Still pictures with narration and background music helped transition the viewer between the remaining scenes. (A transcript is included Appendix B.)

Table 7. *Scene Descriptions in the Edited "The Tree House" Video*

Scene Descriptions in Program	**Included in Edited Video**
Opening Theme Song	No
Sid's Big Question – Sid speaks to the audience, wondering about how to get his toy box up into his tree house.	Yes
Breakfast Time – Sid asks his parents about how to get his toy box up into the tree house.	No: Narration transitions viewer from Sid's home to his school. It ends with Teacher Susie calling in children for rug time.
Ride to School with Mom – song	
Looking for my Friends – song	
Sid Survey – Sid asks his friends about how he should get his toy box into the tree house.	
Rug Time – Sid asks Teacher Susie about how to lift the toy box and she introduces the pulley to the class	Yes
Super Fab Lab – Susie presents the students with a challenge involving the pulley.	Yes

Scene Descriptions in Program	Included in Edited Video
You Try It – live action sequence with children trying the challenge	No: Narration explains that the children used the pulley to successfully lift a bucket of tennis balls.
Super Fab Lab Summary - Sid concludes that the pulley could help him lift his toys.	Yes
Good Laughter-noon – students make jokes about pulleys	No: Narration transitions viewer to the song.
Playground – children play a game of "tree house" in the playground	
Teacher Susie's Song – a song about a family that lives in a tree house	Song*
Car Ride Home with Grandma	No: Narration transitions viewer from Sid's school to Sid's home.
Sid's House – Sid's father lifts toy box into tree house with the pulley.	Yes
Sid's Closing Monologue	No: Narration concludes the story.

* This song was the lyrics segment in the video that was manipulated. It was in the Dialogue Plus Lyrics video and missing from the Dialogue Only video. The song was presented twice in the Lyrics Only video.

Educational messages chosen episode and song.

The main message of the "The Tree House" was that a pulley is a simple machine that makes it easier to lift up heavy things. The scientific terms related to this message were presented using dialogue and song lyrics. The animation also presented examples of pulleys visually throughout the entire video. The next few paragraphs describe the messages in the dialogue and what is included or added with the song.

Teacher Susie introduced Sid and the audience to the pulley during "Rug Time." She defined it immediately, by explaining that it "makes it easier to lift up heavy things." While showing the children a picture of a pulley, she described its parts. She said, "Every pulley has a wheel, see? The rope goes through here. And

the top of the pulley has a hook." The terms related to the pulley and its parts were mentioned numerous times throughout the episode by different characters. The children, Teacher Susie, and Sid's parents discussed it during "Rug Time," the "Super Fab Lab," and at Sid's house. Pulley was defined nine times in the dialogue during the scenes before and after the song (Table 8).

Table 8. *Explanations of the Pulley's Function as Presented in the Dialogue*

Sequence in Episode	**Line from the Script**
1	"The pulley makes it easier to lift up heavy things."
2	"So, pulleys help lift things up, and pull things sideways?"
3	"Maybe a pulley would make it easier to lift up Sid's toys."
4	"They find that using a pulley is the easiest way to lift the bucket."
5	"If we use the pulley, we could lift the bucket straight up."
6	"Here we are using the pulley to lift up the bucket. Then I had an idea. I can use a pulley to lift the box of toys all the way up to my tree house!"
7	"Pulleys can be used to lift up all kinds of heavy things."
8	"So, I told my dad about what we found out in school today, about lifting stuff and how much easier it is if you use a pulley."
9	"Sid, using a pulley to lift up your toys is a great idea!"

In addition to the dialogue, lyrics in the song defined a pulley's form and function. Throughout the song, the lyrics and animation provided numerous examples of a family that lives in a tree house and uses a pulley to send down messages and to bring up things that they need. Compared to the dialogue in the rest of the video, the song presented more examples of people using a pulley to carry items over long distances and lift heavy things. Additionally, the term "pulley" was used five times and the parts of a pulley are explicitly described in the lyrics: "A pulley is a simple machine with a wheel on an axle with a rope." As

shown in Table 9, the Dialogue Plus Lyrics group received the highest level of exposure to the precise scientific terms associated with a pulley.

Table 9. *Occurrence of Precise Terms in Text for Dialogue and Lyrics*

Term	Dialogue	Lyrics*	Dialogue Plus Lyrics
Pulley	21	5	26
Rope	2	1	3
Wheel	1	1	2
Axle	0	1	1
Hook	1	0	1
Total Instances of Terms	25	8	33

*The Lyrics Only video group heard the lyrics twice.

Instruments

This study used three instruments: a child interview, an observation protocol, and a parent questionnaire. Instruments are included in Appendix B. Children in all groups were interviewed, but only children in the video groups were videotaped and coded for attention with an observation protocol. Parents completed the questionnaire during the consent process.

Child interview.

Researchers interviewed children individually to obtain measures for six dependent variables: (a) *Story* main idea – that Sid used a pulley to lift his toys into his tree house; (b) *Function* of pulley; (c) *Description* of its parts; (d) recall of *Precise Terms*; (e) *Recognition* of pulley; and (f) *Motivation* to watch again. Variables *Function, Description, Precise Terms*, and *Recognition* all fall under the umbrella of "science content knowledge," addressed in the research questions

of this study. The exact set of interview questions for each group is available in Appendix B. Table 10 presents the items in the interview that were used to obtain measurements for these variables. Please note that the Lyrics Only group did not view the scenes that told Sid's story and the control group did not watch the video, so these children were told a short story to obtain responses to items 1 and 2.

Table 10. *Items from Interview Used for Each Dependent Variable*

Item	**Dialogue Only & Dialogue Plus Lyrics**	**Lyrics Only**	**Control Group**	**Dependent Variables**
1	In the beginning of the video, do you remember what Sid's question was?	I have a friend who has a tree house. He really wants to bring his toy box up into his tree house, but it's too heavy and he can't lift it.		*Story*
2	Do you remember how Sid got his toys up into his tree house?	Can you think of a simple machine that could he use to get the toy box up into the tree house?		*Story* Science content knowledge
Item	**All Groups**			**Dependent Variables**
3	Can you tell me what a pulley does? Anything else?			Science content knowledge
4	Can you tell me, what are the different parts of a pulley? Anything else?			
5	Look at these three pictures. Can you guess which picture shows a pulley?			
Item	**Dialogue Only, Dialogue Plus Lyrics, & Lyrics Only**		**Control Group**	**Dependent Variables**
7*	Look at these faces. Point to the face that shows how you feel about the video.		n/a	*Motivation*
8	Would you want to watch that video again? Yes, no or maybe?		n/a	
9	Would you want to watch a different episode of this show? Yes, no or maybe?		n/a	

*Item 6 was not used in these analyses.

The lead researcher and a second researcher read the interview questions and answer choices from the Record Sheet. Interviewers abbreviated children's answers and wrote them on the Record Sheet during the interview as a backup for the recording and for when children did not verbalize their answers. Specific questions and scoring criteria for each dependent variable are described in the sub-sections below. As shown in Table 10, items 2 and 4 were included for more than one variable, using different coding schemes.

Dependent variable: Story main idea (Story).

Comprehension of the episode's main idea was assessed for the two video groups: Dialogue Only and Dialogue Plus Lyrics. The main idea of the story was that Sid used a pulley to lift his toys up into his tree house. To assess children's understanding of the main idea, children were asked two questions: (item 1) what was Sid's question, and (item 2) how did Sid get the toys into his tree house. For item 1, children received a score of 1 if they explained that Sid was trying to lift his toy box into his tree house. If they could not remember Sid's question, children were given a score of zero and were told that Sid wanted to get his toys into his tree house. For item 2, children received a score of one if they recalled that he used a pulley or if they explained that he "lifted" or "pulled" up the toy box. Responses without the correct explanation received a score of zero. These scores were combined as the variable *Story* for a maximum score of two.

Dependent variables for science content knowledge: Function, description, precise terms, recognition.

Children's recall of the science content featured in the video was examined for all four groups. Items 2 – 5 were used to examine different aspects of understanding a pulley's form and function. The three variables include the *Function* of a pulley, *Description* of a pulley's parts, the terms related to a pulley and its parts (*Precise Terms*), and recognizing a picture of a pulley (*Recognition*).

Function.

The interview provided children with two opportunities to get full credit for knowing the pulley's function. If children remembered that Sid used a pulley or knew that pulleys could lift items into tree houses (interview item 2), children received a score of one for *Function*. If children did not know or remember the term pulley, they were told that Sid or "my friend" used a pulley to lift the toy box. Then, when interviewers asked children to explain what a pulley does in item 3, children received a score of one if they explained that a pulley helped lift or pull things up. If children also mentioned that pulleys could bring things down and/or move things sideways, children received a score of two. Children who did not provide a correct answer for either item received a score of zero.

Description.

Knowing the different pieces of the pulley system was an important part of exploring the idea of "tools and their uses." Item 4 assessed this science content by asking children to name the pulley's parts. Correct answers included: wheel, rope, hook, and axle. Children could use the vocabulary introduced by the

program and/or describe the parts using their own words. For example, children called the rope a "string," the axle a "little metal thing in the wheel," and the wheel a "circle." Children received one point for every part they correctly named or described, for a maximum of four points.

Precise term.

One of the program's goals was to teach children science vocabulary, typically low frequency words for preschoolers. Item 4 was used to assess each video's effectiveness in teaching the episode's featured vocabulary terms. Children's responses were examined to quantify how many precise terms they used from the video (wheel, rope, axle, and hook). For this variable, only the responses from item 4 were used, because terms that described the parts of the pulley were given more equal exposure across the three video groups compared to the term "pulley" itself. Children who used at least one of the precise terms (wheel, rope, axle, or hook) were given a score of one, while all other children were given a score of zero.

Recognition.

A recognition task was also conducted to examine children's knowledge about the pulley's form (item 5). Children were shown three pictures (Figure 5) and were asked to identify the pulley. The two foils were a wrench and a protractor, which did not appear in the video. These science tools were chosen in part because, like a pulley, are low frequency words and may be unfamiliar to preschool children. Children received a score of one for *Recognition* if they correctly chose the picture with the pulley and a score of zero if they did not.

Figure 5. Pictures used in recognition task

Qualitative data analysis.

Children had multiple opportunities during the interview to explain what they knew about the form and function of a pulley. The lead researcher identified themes by examining all of children's responses as a whole using pattern analysis (Miles & Huberman, 1994). Themes are listed and explained in the results chapter of this paper.

Dependent variable: Motivation.

For the three video groups, motivation to watch the video was assessed using three questions (items 7-9). First, children were asked to point to a picture with the face that best described how they felt about the video (Figure 6). Second, children were asked if they would be interested in watching this video again. Third, the children were asked if they would be interested in watching a different episode of this show. For the last two questions children were given answer choices of yes (score of two), maybe (score of one), or no (score of zero). A composite score that sums these three questions was created such that higher scores reflect higher enjoyment and motivation to watch the video again (maximum *Motivation* score was six).

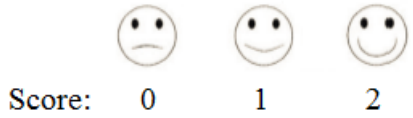


Figure 6. Picture of faces

Observation protocol.

Research suggests that children's visual attention is directly correlated with their comprehension of educational material (Anderson & Kirkorian, 2006; Anderson & Lorch, 1983). To examine attention, children in the video groups were recorded while watching the episode and their visual attention was analyzed from the recordings. Using the video's time code, the lead researcher counted the number of seconds when children were not looking at the television screen. Total seconds for each scene/song and the entire video were recorded on the Observation Protocol Sheet (Appendix B).

To determine the reliability of coding for visual attention across students, the lead researcher coded approximately 20% of the children a second time. A stratified random sample of students was selected for re-coding to ensure that the scores would be representative of the range of scores found in the sample. Six students were selected from each group. A correlation was conducted with both rounds of coding for the dialogue and lyrics scenes (for the Lyrics Only group only the first exposure to the song was used). Correlations and Kappa values confirmed a substantial agreement in scores (Table 11).

Table 11. *Correlations for Intra-Reliability Testing*

Type of Scenes	N	Kappa Value	Pearson's *r*	*p* Value
Dialogue Scenes	12	.770	.984	<.001
Lyrics Scene	12	.842	.965	<.001

Dependent variable: Attention.

Attention to the screen was examined by comparing children's time looking away from the screen during dialogue and lyrics segments of the video. *Attention* was compared for the same parts of the video for the two relevant groups (e.g., dialogue sections for Dialogue Only and Dialogue Plus Lyrics groups). *Attention* was also examined by determining the percent of time children spend looking at the screen during each segment with dialogue and each segment with lyrics (Figure 7). An average for each relevant segment was calculated for each child.

$$\frac{\text{(Seconds in segment – seconds looking away)}}{\text{Seconds in segment}} = \text{Percent of time looking at TV during segment}$$

Figure 7. Formula for calculating percent of time looking at screen

Parent questionnaire.

Parent questionnaires provided information about each child's previous exposure to pulleys and to *Sid the Science Kid*. The questionnaire also included questions about children's demographic information (as described in the participants section) and their home experiences with science and music (see

Appendix B for the exact questions and answer choices). There were three items about how much children enjoy science experiments, how interested they are in science, and how often children engage with media that involves science. There were also three items that addressed children's interest in music, how often the family listened to music, and the amount of videos children watched that included music.

Researchers checked with the schools to be sure that lessons about simple machines, including the pulley, had not been taught to the groups of children invited to participate in the study. Two questions on the parent questionnaire asked parents about home experiences with using a pulley or a wheel to lift items.

Data entry procedures.

Two researchers entered all data using online survey software. In the validation procedure, the lead researcher compared online entries to the hardcopy of the Interview Record Sheets or parent questionnaire to ensure no data entry errors. If errors were found, the lead researcher corrected the entry error and saved the updated value in the dataset. After all data entry and validation was completed, data were coded and composite variables were created. All analyses were conducted with IBM SPSS v.20 and Microsoft Excel 2007.

Chapter 4 – Results

The data from interviews and recordings of 91 children was analyzed to answer this study's research questions. The findings suggest that children in each the video groups had equal recall of information regarding the function and form of a pulley, notwithstanding the presence of dialogue and/or lyrics segments. In terms of precise vocabulary recall, children who only watched dialogue segments were more likely to recall terms from the video compared to children who only watched lyrics segments. This result suggests that even though lyrics combined with visual imagery can be used as a vehicle for introducing science concepts, dialogue is required to teach precise science terms. Although attention to the screen was high for both types of segments (over 90%), children in the Dialogue Plus Lyrics group watched the lyrics segment for a higher percent of the time compared to the dialogue segments (94% vs. 98%). Themes identified by looking at all of children's responses during the interview suggest that although children remembered what a pulley was and part of how it works, the stability and utility of that information was rather weak. Children would require additional teacher-led instruction to deepen their scientific knowledge (i.e., mechanical reasoning) and understand the pulley's limitations.

Characteristics of Children in Groups

Before discussing the results of analyses conducted with the dependent variables, the section below presents findings from questionnaire items that

address characteristics of children in the groups. Table 12 displays the descriptive statistics from these items by group.

Children's previous experience with science and music.

Parents were asked if their children had experiences related to a pulley system. Positive responses were 21% for Dialogue Only, 17% for Dialogue Plus Lyrics, 16% for Lyrics Only, and 24% for Control. Chi-square tests showed no significant differences between groups (see Table 12 for results). The questionnaire also included questions about children's interest and experience with science/experiments and music/songs. Composite scores were created for both sets of questions (see p.75 in Methods**)** so that higher scores indicated that children had greater interest and more experiences. An analysis of variance (ANOVA) showed no significant differences between groups in terms of their music interest and experiences, $F(3, 78) = 1.191$, $p = .319$, or science interests and experiences, $F(3, 78) = .313$, $p = .816$.

Children's previous experiences with *Sid the Science Kid*.

Asking parents about children's prior exposure to the television program was crucial because previous research suggests that familiarity with a program can support children's comprehension of educational material (Crawley et al., 2002). Two-thirds of children had previously seen *Sid the Science Kid*. Although no significant differences were found among the video groups, there was a significant difference between the video groups and the control group. While 80-90% of each video group had seen the program before, only 50% of the control

group had seen it. Table 13 presents results of six chi-square tests comparing two groups at a time.

Table 12. *Previous Exposure to the Pulley, and Interest/Experience in Science and Music By Group*

Variable	Dialogue Only	Dialogue Plus Lyrics	Lyrics Only	Control
Home Exposure to Pulley System				
Yes	5	5	3	5
No	17	15	16	12
Interest/Experience in Science (mean)	2.93	2.79	2.94	3.06
Interest/Experience in Music (mean)	3.35	3.62	3.57	3.50
Previous Exposure to *Sid the Science Kid*				
Yes	18	17	18	8
No	3	4	2	8
I don't know	2	0	0	2

Table 13. *Chi-Square Results Comparing Home Experience with Pulley System and Previous Experience with Sid the Science Kid by Group*

	Dialogue Only	Dialogue Plus Lyrics	Lyrics Only
Home Experience with Pulley System			
Dialogue Plus Lyrics	$\chi^2(1, N = 42) = .030$, $p = .863$	-	-
Lyrics Only	$\chi^2(1, N = 41) = .312$, $p = .576$	$\chi^2(1, N = 41) = .030$, $p = .863$	-
Control Group	$\chi^2(1, N = 39) = .225$, $p = .635$	$\chi^2(1, N = 37) = .091$, $p = .763$	$\chi^2(1, N = 36) = .963$, $p = .326$
Previous Exposure to *Sid the Science Kid*			
Dialogue Plus Lyrics	$\chi^2(1, N = 42) = .171$, $p = .679$	-	-
Lyrics Only	$\chi^2(1, N = 41) = .176$, $p = .675$	$\chi^2(1, N = 41) = .671$, $p = .413$	-
Control Group	$\chi^2(1, N = 37) = 5.54$, $p = .019$	$\chi^2(1, N = 37) = 3.970$, $p = .046$	$\chi^2(1, N = 36) = 7.089$, $p = .008$

Given the significant differences between the control group and each video group, all analyses in which there were significant differences on dependent measures between a video group and the control group were re-run using only the control participants who had previous exposure to *Sid the Science Kid*.

Group Effects with Dependent Variables

Dependent variable: Story main idea.

For the Dialogue Only and Dialogue Plus Lyrics groups, children's comprehension of the storyline was captured through two questions in the *Story* variable. This variable was limited to these groups because only these two saw the dialogue scenes that contained the original episode's story. Scores were obtained by combining children's responses from the first two items on the interview (maximum score of two). The main idea of the story was that Sid used a pulley to lift his toys up into his tree house. A t-test was conducted to examine the differences between the mean *Story* scores for the Dialogue Only ($M = 1.54$, $SD = .658$) and the Dialogue Plus Lyrics ($M = 1.40$, $SD = .817$). The means did not significantly differ, $t(47) = .667$, $p = 0.508$. Most children from both groups successfully recalled of the main idea of the story.

Dependent variables for science content knowledge: Function, description, precise terms, and recognition.

Function.

To examine if there was any impact of the videos on children's knowledge of what a pulley does, an analysis of variance (ANOVA) was conducted for the

variable *Function*. As described in the Method section (p.71), responses on two items (worth a maximum of 2 points) were used to demonstrate children's knowledge of the function of a pulley. Children received 1 point if they knew it pulled or lifted items up, and they received a second point if they also mentioned it can bring things down and/or sideways. The ANOVA showed a main group effect on *Function*, $F(3, 87) = 12.671$, $p < .001$ (see Table 14 for means and standard deviations for each group). Although it appeared that the video groups had higher mean scores than the control group, a post-hoc analysis was required to determine which groups were significantly contributing to the main effect.

The type of post-hoc test to use depends on the variability of scores in each group. As presented in the table, the four groups showed different degrees of variability in scores – the Lyrics Only and control groups showed higher variability than the Dialogue Only and Dialogue Plus Lyrics groups (see means and standard deviations in Table 14). The Levene's Test for Homogeneity of Variances was examined to see if this variability was statistically significant. The results indicated that the variances were significantly different, $F = 2.898$, $p = .040$. Specifically, the Lyrics Only group showed greater variability than the other video groups and the control group showed the lowest variability. Due to this result, the Games-Howell post-hoc tests ($p < .05$) were used to examine which groups contributed to the significant main effect (Morgan, Leech, Gloeckner, & Barrett, 2011).

Children in the video groups were better able to describe the function of a pulley compared to the control group. There were no significant differences on *Function* between the video groups. These findings remained consistent when the video groups were compared to the subset of children from the control group who had previous experience with *Sid the Science Kid*.

Table 14. *Means and Standard Deviations for Function by Group*

Group	N	Mean	SD
Dialogue Only	24	1.17	.482
Dialogue Plus Lyrics	25	1.04	.455
Lyrics Only	20	.90	.718
Control Group	22	.27	.273

Description.

To examine each video's impact on children's recall of the form or structure of a pulley, an ANOVA was conducted for the variable *Description*. This variable was obtained using item 4 from the interview in which children described the parts of the pulley (see Method p.71). Responses received one point for each part correctly named or described. The ANOVA showed a main group effect for *Description*, $F(3,87) = 6.519$, $p < .001$. The Levene's Test was significant, with the video groups having higher variability than the control group, $F = 8.04$, $p < .001$ (see Table 15 for means and standard deviations). The Games-Howell post-hoc tests ($p < .05$) determined that children in the video groups had significantly higher *Description* scores than children in the control group. There were no differences on *Description* between the video groups. These findings

remained consistent when the video groups were compared to children from the control group who had previous experience with *Sid the Science Kid*.

Table 15. *Means and Standard Deviation for Description by Group*

Group	N	Mean	SD
Dialogue Only	24	1.54	1.02
Dialogue Plus Lyrics	25	1.60	1.15
Lyrics Only	20	1.40	1.43
Control Group	22	.32	.84

Precise term.

In addition to *Description*, children's recollection of the parts of the pulley was coded to create a dichotomous variable to represent whether or not children used at least one *Precise Term* from the video (see Method p.72). Figure 8 presents the percent of children from each group who recalled at least one precise term and the percent that did not. Table 16 presents the results from a series of chi-square tests that showed significant differences between the Dialogue Only and the control group, and the Dialogue Plus Lyrics and the control group. The test also showed a marginally significant difference ($p = .069$) between the Dialogue Plus Lyrics and the Lyrics Only group. The Lyrics Only group was not significantly different from the control group. These findings remained consistent when the video groups were compared only to children from the control group who had previous experience with *Sid the Science Kid*.

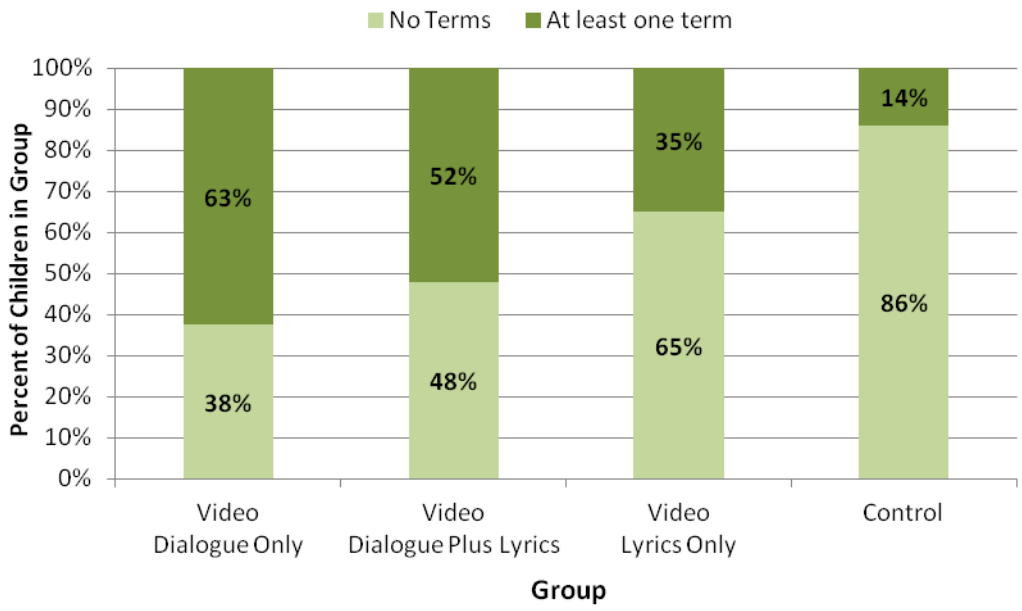


Figure 8. Percentage of children who recalled no precise terms versus at least one precise term

Table 16. *Chi-Square Results Comparing the Recall of No Precise Terms Versus at Least One Precise Term by Group*

	Dialogue Only	**Dialogue Plus Lyrics**	**Lyrics Only**
Dialogue Plus Lyrics	$\chi^2(1, N = 49) = .551$, $p = .458$	-	-
Lyrics Only	$\chi^2(1, N = 44) = 3.300$, $p = .069$	$\chi^2(1, N = 45) = 1.301$, $p = .254$	-
Control Group	$\chi^2(1, N = 46) = 11.506$, $p = .001$	$\chi^2(1, N = 47) = 7.670$, $p = .006$	$\chi^2(1, N = 42) = 2.636$, $p = .104$

Recognition.

Children were presented with three pictures and asked to identify the pulley (Method p.72). Figure 9 shows the percent of children in each group who responded correctly and incorrectly to the recognition item. Table 17 presents the results from a series of chi-square tests that showed significant differences

between Dialogue Only and the control group, and Dialogue Plus Lyrics and the control group. The Lyrics Only group was not significantly different from the control group. The video groups were not significantly different from each other. This finding remained consistent when the video groups were compared only to children from the control group who had previous experience with *Sid the Science Kid*. Compared to the other dependent variables, the control group was quite successful with identifying the picture of the pulley.

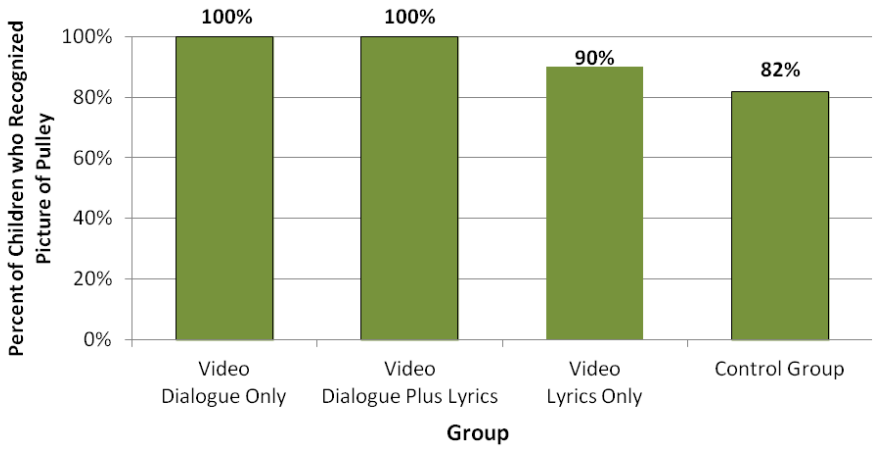


Figure 9. Percent of children who recognized picture of pulley by group

Table 17. *Chi-Square Results Comparing Recognition of Pulley Picture by Group*

	Dialogue Only	**Dialogue Plus Lyrics**	**Lyrics Only**
Dialogue Plus Lyrics	All students in both groups recognized pulley.	-	-
Lyrics Only	$\chi^2(1, N = 44) = 2.514$, $p = .113$	$\chi^2(1, N = 45) = 2.616$, $p = .106$	-
Control Group	$\chi^2(1, N = 46) = 4.779$, $p = .029$	$\chi^2(1, N = 47) = 4.968$, $p = .026$	$\chi^2(1, N = 42) = .573$, $p = .449$

Qualitative analysis of children's responses.

Children had multiple opportunities during the interview to explain what they knew about the form and function of a pulley. All of the children's responses were examined using pattern analysis (Miles & Huberman, 1994) and themes related to the children's level of science knowledge were identified. They were labeled: *System*, *Tool*, *Heavy*, and *Tree House*. *System* qualified children's responses to determine whether or not they described the pulley as a system of parts. Although five parts of the pulley were mentioned in the video, two could be considered the most crucial – the wheel and the rope. Children did not need to use those terms, but they needed to at least describe a wheel and a rope (see Table 18 for examples). The *Tool* theme examined whether or not children indicated that a person powered the pulley, rather than a pulley moving items on its own. As shown in Table 18 words like "you" and "help" were often included in responses that provided evidence for the presence of this theme. Two other qualities of a pulley that were evident in the responses included children's specificity that a pulley was used to lift "heavy" things and that pulleys are used to lift things into "tree houses."

Table 18. *Examples of System and Tool Themes*

Theme	**Included**	**Examples from Children's Responses**
System	Yes	"A rope, a round pulley, a little circle inside the pulley" "Spin thing to spin the rope, so can put the stuff up - rope, hole" "A rope, the little round thing that's metal in it, and the circle"
	No	"All of them, I don't know" "Rope" "Basket on a rope"

Theme	Included	Examples from Children's Responses
Tool	Yes	"His dad pulled the rope." "When you pull on the rope it makes you go up" "You pull the rope and it makes the thing on the flat part go up"
	No	"It brings up things to tree houses" "It lifts up heavy things" "It pulls stuff all the way into the tree house"
Heavy	Yes	"It lifts heavy things up"
	No	"It pulls up stuff that you need"
Tree House	Yes	"If you get lots of stuff and there's too much to carry up into your tree house, then you can use a pulley."
	No	"It pulls stuff up"

Approximately half of the children in the video groups had responses that exemplified the themes *System* and *Tool* (see Table 19). Viewing a video that included dialogue segments seemed related to describing the pulley as a *System*. Alternatively, viewing a video that included a lyrics segment seemed related to describing the pulley as a *Tool*. Evidence also suggests that dialogue segments indicated a relationship with children's description that pulleys lift heavy things. A relatively small, but comparable, group of children from each video group indicated that pulleys lift things into tree houses. The Dialogue Only and Dialogue Plus Lyrics group also heard that pulleys are clotheslines, are part of cranes, and can be used on a playground.

Table 19. Nu*mber of Children per Group that Included Evidence of Science Knowledge Theme in Their Responses*

Group	N	System	Tool	Heavy	Tree House
Dialogue Only	24	11	12	12	3
Dialogue Plus Lyrics	25	12	9	8	5
Lyrics Only	20	9	8	2	3
Total	69	32	29	22	11

Attention.

Overall, children paid close attention to the videos, with all children looking at the screen between 73% and 100% of the time. While this amount is considered above average for preschoolers watching television in the home environment (Anderson et al., 1986), it is probably typical for a research session in a classroom. Children's visual attention to the screen was coded by recording the number of seconds children looked away from the screen (see full description in Method p.74).

The mean number of seconds all children looked away from the screen during dialogue segments was compared between the two Dialogue groups (Table 20). Although the Dialogue Plus Lyrics group had a higher mean than the Dialogue Only group, a t-test showed the difference was not significant due to the large amount of within group variability, $t(43) = 1.008$, $p = .319$. For example, six children in the Dialogue Plus Lyrics group look away for over 50 seconds, whereas 11 children in the same group looked away for less than 20 seconds.

Similarly, three children in the Dialogue Only group look away for over 40 seconds, whereas 11 children in the same group looked away for less than 10 seconds.

Table 20. *Means and Standard Deviation for Seconds Looking Away During Dialogue Segments by Group*

Group	N	Mean	SD
Dialogue Only	20	21.40	34.807
Dialogue Plus Lyrics	25	31.36	31.377

The mean number of seconds children looked away from the screen during lyrics segments was compared between the two Lyrics groups (Table 21). A t-test showed that children from Lyrics Only and Dialogue Plus Lyrics groups had no significant differences in terms of attention, $t(43) = -1.230$, $p = .225$. The song was only about 90 seconds long and within group variability contributed to the mean difference not being significant. In this case, 15 children from the Dialogue Plus Lyrics group did not look away from the screen at all, whereas three children looked away for at least five seconds. Similarly, in the Lyrics Only group, seven children did not look away at all, whereas three children looked away for more than 11 seconds.

Table 21. *Means and Standard Deviation for Seconds Looking Away During Lyrics Segment by Group*

Group	N	Mean	SD
Lyrics Only	20	3.95	6.091
Dialogue Plus Lyrics	25	2.00	4.545

The final analysis regarding children's attention to the screen entailed examining the percent of time children looked at the screen during the dialogue segments compared to the lyrics segments. On average, children paid close attention to both the dialogue segments (95% of the time) and the lyrics segments (97% of the time). Because some of the children in these groups overlap, it is not practical to compare them statistically. For children in the Dialogue Plus Lyrics group who were exposed to both segments (Table 22), they paid significantly closer attention to the lyrics segment (98%) compared to the dialogue segments (94%), $t(24) = -3.078$, $p = .005$. In practice, though, the difference of less than five percentage points for a 90 second song is not very substantial.

Table 22. *Dialogue Plus Lyrics: Means and Standard Deviation for Percent of Time Looking at Screen by Segment Type*

Group	**N**	**Mean**	**SD**
Dialogue Segments	25	.94	.060
Lyrics Segments	25	.98	.051

Motivation.

As described in the Method section (p.73), children were asked three questions to assess their enjoyment of the video and their motivation to watch it again. An ANOVA was conducted with the three video groups. The results did not find a significant main effect between groups, $F(2, 68) = .491$, $p = .614$. Almost all of the children, in all three video groups, indicated that the video made

them happy and that they would watch this or another video again (see Figure 10; maximum score of six).

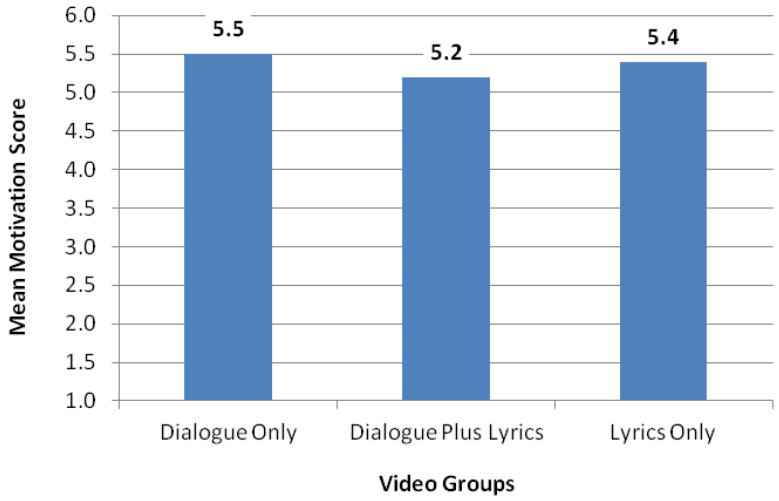


Figure 10. Mean motivation scores by video group

A second analysis was conducted to examine if differences in children's science interest score (from parent questionnaire) affected children's motivation scores. Children's science interest composite score was recoded into a dichotomous variable, so scores lower than three were coded as zero and scores three and higher were coded as one. An independent sample t-test revealed that there were no significant differences in motivation scores between students with lower interest/experience in science ($M = 5.23$, $SD = 1.178$) and students with higher interest/interest experience in science ($M = 5.39$, $SD = 1.054$), $t(62) = -0.583$, $p = .562$.

Chapter 5 – Discussion

Preschool television programs are filled with songs designed to teach specific academic content. Although the programs as a whole are evaluated, little is known about how songs affect children's learning. Previous research that examined video songs suggests that they are poor tools for teaching preschoolers certain messages (Calvert, 2001; Wolfe & Jellison, 1995). Studies about children's attention to television, though, have consistently supported the idea that sound effects and music attract children's attention to the screen (Alwitt et al., 1980; Anderson & Lorch, 1983). How do songs influence preschoolers' ability to learn from television programs, besides bringing their attention to the screen?

The goal of this study was to examine the educational and motivational value of including a song to teach scientific content during a television program. To do this, the preschool program *Sid the Science Kid* was edited to include three combinations of lyrics and/or dialogue that presented similar educational content: Dialogue Only, Dialogue Plus Lyrics, and Lyrics Only. Children's demonstrated understanding of the science content, recall of vocabulary terms from the videos, and attention to the screen were measured using interviews and observations. Children's motivation to watch the program again was also examined. The first section of the discussion will review the study's research questions and address each hypothesis considering the study's results. The second section will address the implications of these findings for different audiences. The third and final

section will address the limitations of this study and suggest avenues for future research.

Research Questions, Hypotheses, and Results

Songs and storyline.

Research Question (RQ) 3: *How will preschoolers' ability to recall of the storyline differ based on whether they watched the video with scenes and a song (Dialogue Plus Lyrics) or just scenes (Dialogue Only)?*

Hypothesis (H) 3: *On average, there will be no differences between the groups in terms of their recall of the storyline.*

In this study, the expectation was that the cognitive demands from the song would not impair children's ability to understand the story because the song was aligned to both the storyline and to the educational content. Results from the *Story* variable suggested that this expectation was realized and the lyrics did not impair or enhance children's ability to recall the main idea of the story. Children from both video groups with dialogue were able to recall the main idea of the story and H3 was not rejected.

In his capacity model, Fisch (2000) explains that television writers can reduce the cognitive demands of educational television by aligning the educational content with the episode's storyline. As mentioned in the literature review, children have a limited working memory capacity and educational television programs depend on children simultaneously processing both the narrative and educational content. Fisch (2000) suggests that when the educational content is central to the plot, rather than tangential, the dual

processing of the narrative and content complement each other and can share resources. When resources are working in parallel rather than competing against each other, children's comprehension of both the story and the educational material is improved. This study uses an episode in which the story and the content were aligned not only during the scenes with dialogue but also during the scene with lyrics. Results suggest that the alignment supported children's comprehension, supporting the capacity model's framework. Future research may consider examining a song that is not aligned with the narrative to see if it would impair comprehension.

Science content knowledge: Function, description, precise terms, and recognition.

RQ1: *How will preschoolers' demonstrated ability to talk about the featured science content differ based on whether or not they watched the videos?*

H1: *On average, children from the video groups will articulate the featured science content more accurately than children from the control group.*

Like in the two summative evaluations of *Sid the Science Kid*, Bachrach et al. (2009; 2012), data suggested that children's language about the science topic significantly differed between the video groups and the control group. Many children who viewed edited video of *Sid the Science Kid's* "The Tree House" episode successfully recalled what a pulley does and described what a pulley was, what it did, and its parts, as suggested by significant differences in *Function* and *Description*. Most children in the control group knew very little or nothing about pulley systems. The hypothesis for RQ#1 was not rejected.

Children who viewed the dialogue segments most successfully recalled specific vocabulary terms from the videos. Significant differences in *Precise Terms* between Dialogue Only and Dialogue Plus Lyrics groups and the control group, and no significant difference between Lyrics Only and the control, suggested that dialogue was a critical component of recalling the vocabulary terms. Children in the groups who saw the dialogue segments were the only two groups to recognize the pulley 100% of the time. There was a picture of a pulley presented during the "Rug Time" scene (during a dialogue segment) that was very similar to the picture used in the interview, which may have given these children an advantage.

RQ2: *How will preschoolers' recall of the featured science content differ based on whether they watched the video with scenes and a song (Dialogue Plus Lyrics) or just scenes (Dialogue Only)?*

H2: *On average, Dialogue Plus Lyrics will recall more of the content than Dialogue Only.*

Video groups did not differ between each other in terms of children recalling and describing the pulley's function and its parts. The dialogue clearly and explicitly explained how a pulley worked, providing specific examples and using the vocabulary throughout the story. The song started about two-thirds of the way through the video. It also presented numerous examples, clearly described three of its parts to the viewer, but showed more close-ups of the pulley working. This finding dismissed the fear that the presence of song partway through an episode would impair children's comprehension of the educational material, the way that Collins (1973) found with commercials. Almost all of the

children who watched the videos with dialogue successfully explained that a pulley lifts or pulls items up into high places. They also specified that pulleys lift heavy items, which were most often presented in the dialogue examples.

On television, many programs include songs as part of a complete episode. This research question addresses the added value or negative impact that a song could have on children's ability to recall academic content from an episode. RQ3 addresses children's recall of the storyline aspect of Fisch's (2000) capacity model, this question relates to recalling the educational content. Placing a song within the context of a complete story and presenting the same educational content further reduces the demands of the program on children's cognitive resources. However, if the song were presented different educational content, the story elements could have competed with the educational elements for children's limited resources. This competition often favors the narrative (Fisch, 2000) and would result in a loss for children's ability to learn the educational content.

Producers and writers of *Sid the Science Kid* followed many of Fisch's suggestions to help improve children's abilities to process educational content. The stimuli used in this study follow the guidelines by: keeping the storyline simple, using clear and explicit language to explain simple educational messages, and aligning the story with the educational content so they complement each other instead of compete. Additionally, dialogue repeated the educational content throughout the story, thereby increasing the number of opportunities to expose children to the educational messages. The fact that the song in "The Tree House"

episode aligned with the video's storyline may have contributed towards the non-significant differences on the science content variables (F*unction, Description, Precise Terms*, and *Recognition*) between the video groups. The song did not impair or enhance children's ability to recall the science content presented in the dialogue. The hypothesis for RQ#2 was rejected.

RQ4: *How will preschoolers' recall of the featured science content differ based on whether they watched the video that had dialogue (Dialogue Plus Lyrics and Dialogue Only) or not (Lyrics Only)?*

H4: *On average, children in Dialogue Plus Lyrics and Dialogue Only recall more of the science content than children in Lyrics Only.*

In examining RQ4, no significant differences were found between the three video groups on *Function* or *Description*. Because of Calvert's work and Craik & Lockhart's model, it was surprising that the Lyrics Only scores were not statistically different from the other video groups. It was expected that the spoken information from the Dialogue groups would have more positively impacted the science knowledge scores. The means trended towards being smaller for the Lyrics Only group compared to the Dialogue groups, but the differences were not statistically significant.

Significant differences between groups on the variable *Precise Terms* suggest that the song was not an effective tool for introducing exact science terms. Lyrics Only was not significantly different from the control group and it was marginally significant with the Dialogue Only group. In previous research on children's comprehension of song lyrics, findings suggest that children have

difficulty recalling lyrics, and understanding their meaning, after only one exposure (Calvert, 2008; Hayes et al., 1982). The song chosen for this study had an up-tempo, calypso feel. A slower tempo would reduce the number of lyrics in the song and could make it easier for children to understand the singer.

Despite the fact that many children in the Lyrics Only group could not remember the precise terms (pulley, wheel, rope, hook, or axle), children successfully described the pulley as a system of parts. Children used their own words to describe what they saw in the video, telling researchers the colors, shapes, and textures for the parts that they could not label. For example, children called the wheel a "wooden round thing" and the axle a "little grey metal thing." Hayes & Birnbaum (1980) suggest that preschoolers rely heavily on the visual aspects of video presentations, and recall visual information better than auditory information. By comparing results on *Precise Term* and *Description*/*Function*, the data suggested that children may not have understood the lyrics, but they were able to use the visual imagery that accompanied the song to introduce the pulley.

Almost all children correctly identified the picture of the pulley. The lack of variation in scores by the Dialogue Only and Lyrics Only group (all children recognized the pulley) contributed to statistically significant differences between those groups and the control group. It was surprising that so many of the children in the control group successfully identified the picture of the pulley. An examination of the characteristics the control group children revealed no significant relationships between recognizing the pulley and having a parent who

was a scientist or had a high level of education. High scores on *Recognition* may have resulted from the fact that the item was towards the end of the interview, after the function of the pulley had been discussed. Additionally, children from both the control group and the Lyrics Only group were unfamiliar with the noun pulley. The picture of the pulley included a hand pulling the rope, a clue as to which was the correct picture.

Although children recalled specific academic content from the video, the qualitative analysis results suggested that the information presented to the children during the song mislead children regarding the pulley's abilities. During the song (lyrics segment), images of pulleys lifting refrigerators and cars into tree houses possibly relayed a false impression that a pulley actually makes these items lighter, so that they can be lifted. Children this age often confuse fantasy and reality (Samuels & Taylor, 2011) and *Sid the Science Kid* writers may not have accounted enough for this developmental challenge. Ironically, children in the Lyrics Only group were the least likely of the video groups to say that pulleys lift heavy things, an essential part of the definition of the pulley in the dialogue segments. Perhaps this was because the lyrics segment also showed characters sending letters (not heavy) with the pulley, while the dialogue segments only used heavy items in the examples.

The images from the video often excluded an important part of the pulley system – the person doing the lifting by pulling the rope. Across the groups, fewer than half of the children mentioned that a person pulls the rope to lift items.

Children in the Dialogue Only group were the least likely to include the presence of a person pulling the rope in their explanations. Perhaps that difference resulted from viewing the fewest examples of a pulley working "in action." The lyrics segment of the video provided over a dozen examples of items going up and down in pulleys, often with people pulling the rope, which the Dialogue Only group would not have seen.

Overall, the videos provided opportunities for children to hear about pulleys, see a pulley in action, and start thinking about what pulleys can do and how people use them. Children were willing to talk about what they learned, even when they did not know the accurate labels or terms. The children's recall of the information provides evidence that their knowledge about pulleys seems limited to some understanding of function and basic terminology (especially for children who saw dialogue segments). The program, however, did not engage the viewer in scientific inquiry in a way that would have allowed for deeper exploration of the topic.

Attention to the screen and motivation.

RQ5: *How will preschoolers' visual attention to the screen differ based on whether or not the videos they watch contain a song?*

H5: *On average, children in the Dialogue Plus Lyrics group will pay attention to a greater percentage of the video compared to Dialogue Only group.*

There were no significant differences in children's attention to the screen during the dialogue sections of the video based on whether they were in Dialogue Only or Dialogue Plus Lyrics. Similarly, there were no significant differences in

children's attention to the screen during the song based on whether they were in Lyrics Only or Dialogue Plus Lyrics. The study was not set up to include distractions or competing stimuli that would bring children's attention away from the screen. Whether or not children looked at the screen did not seem to be related to whether or not the video had a song, and there was a significant amount of within group variability for each group. H5 was rejected.

Almost all children from the three video groups enjoyed the video. The video groups did not vary based on children's motivation to watch this video again or watch another episode of the show. Although the video's high ratings could have been related to children's desire to please the researchers, the overall high attention scores suggested that children did enjoy watching the video. With or without the song, the videos were equally entertaining and engaging for the children. Interestingly, children who were labeled by their parents as not being very interested in science were just as likely to say they would watch the video again as children labeled less interested in science. This finding supported Sid's producers' goal of increasing children's interest in science.

Implications of Previous Research on Educational Songs on Television

The educational success of the song in "The Tree House" contradicted the findings of studies conducted by Calvert and her colleagues (review in Calvert, 2001) and Wolfe and Jellison (1995). In those studies, songs were presented in isolation and did not necessarily present the educational content in an explicit way – through the lyrics or the visuals. The educational content chosen for this study

was the form and function of pulley, which was simply defined in the lyrics and visually demonstrated in the animation (a family who used a pulley to bring things up and down from their tree house). Perhaps those studies would have had different results if they used television programs that included songs that were more concrete or visually demonstrable in the song, like the one used in *Sid's* "The Tree House." In the case of *School House Rock*, a child who did not understand the lyrics could not understand what the song was about. Calvert asked a child "what is a bill" and child answered that it was something you got after eating dinner in a restaurant. Although the child was not wrong, that was not the definition that the video was trying to teach. In this study of *Sid the Science Kid*, children were able to understand the meaning of the lyrics using the visual information.

This study's finding that children were able to describe the form and function of the pulley from only the song challenges Calvert's previous research findings. Her studies often focused the recall of precise terms and used stimuli that were not age-appropriate. The current study expanded on Calvert's work by using a program that was created for preschoolers and by considering the children's ability to describe the pulley and its parts using their own words when they could not recall the precise term from the program. Additionally, this study included a treatment group with both lyrics and dialogue, not just one or the other. When comparing the two groups with lyrics, children who also had dialogue were

better able to recall the precise terms (different from control group) compared to those without the dialogue (not different from control group).

Comments Regarding Validity

As with any quantitative study, it is important to address issues regarding the study's validity. Internal validity relates to the soundness of the investigation, while external validity refers to the extent to which the results of an investigation can be generalized to other groups or circumstances. In terms of internal validity, this study's experimental design incorporated a control group and randomly assigned participants to groups, both methods that strengthen a study's internal validity. Additionally, procedures were closely followed across groups and locations, with few differences between research sessions. The study's method design and implementation reduced the influence of external factors on the dependent variables.

Another consideration regarding the internal validity of the study is whether or not the interview responses accurately reflected children's knowledge. Although it was a non-standardized measure, the child interview included multiple opportunities for children to demonstrate their understanding of the form and function of a pulley. Researchers were trained to ask children "anything else" after each child's response to encourage verbalization of their ideas. This prompt often resulted in children sharing additional information, even information beyond the scope of the original question. Only once the children said "no" or indicated they had nothing else to say did the researcher move onto the next question.

Children who were completely non-verbal during the interview were excluded from the analysis.

In terms of external validity, the demographics of the study's sample differed slightly from the general makeup of the U.S. child population (U.S. Census Bureau, 2011). Specifically, the children's parents were more highly educated and the group was less ethnically diverse. Each of the groups in the study did not differ from one another, which suggests that the findings were unrelated to these child-centric variables. In terms of the study's ecological validity, it may be challenging to generalize these findings to non-classroom settings where children could potentially be more distracted while watching television. Children in this study were told that they would be asked questions once the video ended, which typically would not happen at home. This social context could have improved their academic outcomes by increasing the amount of invested mental effort children put towards watching the video (Salomon, 1981).

Implications of Findings for Different Audiences

Policy makers.

As described in the introduction, there is very little federal regulation regarding the content, quality, and quantity of educational television. The Children's Television Act of 1990 developed by the Federal Communication Commission (FCC) only requires the main networks to broadcast three hours a week of educational television for children ages 2-16. The definition of

educational is vague and the rules do not address video that is presented on non-television platforms. For example, a PBS show could be shown as educational through summative evaluations, but would a 30 second clip from the show also be considered "educational?" This is a distinction that should be made clearer. With the increased availability and flexibility of media directed at television, the FCC should require more precise and clear labeling of high quality educational programming both on television and on the web (websites, apps, YouTube, etc.) to support parents who want to make these choices for their children.

Despite the quantity of media online, most children in low-income families still watch most of their programming on television. Certainly, educational programs on PBS are intended to augment these children's exposure to academic content with the goal of increased school readings. This study, in addition to other research on repeated viewing of television programming, suggests that one exposure to a television episode is not enough to effectively teach children academic vocabulary terms. For example, research on repeated viewing (Crawley et al., 2002) led Nickelodeon to broadcast *Blue's Clues* (Johnson, Kessler, & Santomero, 1996) and *Dora the Explorer* episodes five times a week. This study's findings suggest that watching *Sid the Science Kid* once is not enough to recall all of the presented vocabulary in the episode. During interviews, almost all children indicated that they would want to watch the video a second time. To broadcast more episodes of *Sid the Science Kid* on a regular basis on network television, regulations for increased time dedicated for educational

programming would need to be implemented. If policy makers want television programming to capitalize on its teaching potential, viewing only 6 shows (one episode each) on Saturday mornings would not be enough to get preschoolers ready for kindergarten.

In 2009, there was a call for comment about the Children's Television Act, recognizing that the policy was outdated. At the time of writing this paper, however, there has been no formal change to the legislation to reflect children's actual media use or what the research community has learned about using television as a teaching tool. Over the past 23 years, there have been hundreds of studies on how children best learn from educational programming presented on television that could now be incorporated into a stricter FCC definition of "educational." Additionally, new research is coming out every year about how non-television educational media is most effective in teaching academic content. A revision of the policy could not only better address the children's media landscape, but also could enhance that landscape by assuring the quality of the content that is broadcasted or available online.

Television producers and writers.

Songs bring energy into television programs and help engage audience members of all ages. Preschoolers, however, approach music in a developmentally different way than older children and adults. Campbell & Scott-Kassner (2009) describe their musical learning as "musical enculturation, playful exploration of music, and informal encounters with music in the environment

(p.21). These qualities correspond nicely with specific purposes of songs that have been used by television writers, such as to open a television program (theme song), to transition children between scenes in an episode, to ritualize events, or to simply entertain.

When it comes to using songs to teach specific academic content, preschoolers present writers with certain challenges. To start, preschoolers have limited working memory capacity, resulting in their limited ability to process and recall song lyrics. Findings from this study suggest that it may be helpful to present vocabulary terms in dialogue before and after a song to enhance children's recall of academic vocabulary. This extra exposure will offer the information in a spoken context (reduction in cognitive demand from sung context) and also will prime children for terms that may be in the lyrics.

Fortunately, educational content presented through the song lyrics are typically presented visually as well. Findings from this study suggest that children easily recall these images. Writers must be careful, though, that the images accurately reflect the meaning of the academic content. If a song's imagery incorporates a lot of fantastical elements, preschoolers may become confused about what is "real" and what is not. Perhaps writers should watch the animation without the lyrics or even conduct some pilot testing of the visuals alone, to see if the images accurately portray the intended messages.

Writers may be tempted to use a song to escape the episode's setting or storyline. In this study, the song's theme was well aligned with the overall

episode storyline. If a song's theme or sub-story is not aligned with an episode storyline, however, the effects of the song on children's learning may be different. Changing the setting and theme of the episode during the songs may increase the cognitive demand of the video, potentially harming a preschooler's ability to successfully recall the educational content presented in the video.

Children's enjoyment of the program and motivation to see it again was not influenced by the presence of the song. Therefore, writers should be strategic about using songs to attract children's attention and provide concrete examples of the educational content. Songs can repeat the content, but preschool children may not understand lyrics. Goals relating to exposing children to new words would be aided by presenting those terms in the episode's dialogue in addition to the song. Table 23 summarizes the main recommendations for television producers on how to best integrate educational songs in television programs or non-television applications, such as online video players or Smartphone apps.

Table 23. *Integrating Educational Songs on Television Programs or Non-Television Applications*

Recommendations	
Within a program	Align the song's theme or story with the episode's narrative
	Align the song's educational material with the episode's educational content
Within a program or alone	Introduce and define vocabulary terms using spoken non-rhyming dialogue
	Repeat vocabulary terms and definitions throughout the song's chorus and verses
	Explicitly present multiple examples of educational content in different contexts
	Accompany songs with concrete and accurate visual representations of the content

Songs are also being sold on CDs and mp3s that do not have video. A qualitative examination of students' responses from the Lyrics Only group suggests that the visual representations that accompanied the song highly contributed to what children recalled about pulleys. In conjunction with previous research on the processing of song lyrics, the data indicate that just an audio version of a song may not have the same learning outcomes as a video. A spoken introduction of the material could be added to the beginning of each song's track to prime the children about the song's educational content, and therefore increase their ability to learn from the song.

The findings suggest that presenting songs by themselves online or on a DVD (without the context of an episode) can be helpful for introducing new academic content during a science lesson. To teach vocabulary, though, the data suggest that additional explanations of the target vocabulary would be helpful. Repeating the song may also help with the recall and retention of educational material.

Producers for shows like *Sid the Science Kid* are also putting scenes online without the context of the episode, presumably to have short video clips for children to watch. The results of this study suggests that producers could cut the shows in half to offer 10 minute versions of the episodes for online viewing and children could still learn new information from the educational content. This could be an alternative to only watching one scene (which may not be an effective

learning tool at all) or watching the whole episode (which may not be preferable due to time constraints or bandwidth limitations).

Teachers.

The U.S. education system recently pushed down standards to demand more academic learning from preschoolers. Despite this change, preschool educators are some of the least prepared teachers for science education. A 2011 examination of the Early Childhood Longitudinal Study – Kindergarten cohort (ECLS-K) dataset found that kindergarten teachers only taught science once or twice a week for less than 30 minutes, and this was not enough to impact third grade science achievement (Saçkes et al., 2011). Notably, most teachers indicated that they only used scientific equipment once or twice a month. Although ECLS-K did not include data about why teachers did not teach science more often or for longer periods of time, Saçkes et al. (2011) comment that teachers lacked pedagogical content knowledge for teaching science and the tools to devise inquiry-based science activities. Perhaps programs such as *Sid the Science Kid*, with its engaging videos and free teacher resources from the PBS, teachers could model Teacher Susie's strategies for teaching science and download ready-made lesson plans.

Furthermore, this study's findings suggest that preschool teachers could present just the 90-second song to successfully introduce science content and pique children's interest to learn more. As indicated in the results section, there were no significant differences between the Lyrics Only and Dialogue Plus Lyrics

group on children's content knowledge. This lack of distinction suggests that precious classroom time that would be consumed by the full 22-minute episode could be given back to the teacher if they instead showed the 90-second educational song and spent the other 20 minutes facilitating an interactive hands-on science activity. Table 24 lists strategies for including video songs in a science lesson.

Table 24. *Video Songs from PBS that Complement Preschool Lessons*

Strategies
• Identify a video that best aligns with the science content being explored.
• Briefly and clearly describe the topic of exploration to children before playing the video.
• If needed, provide children with information regarding the song's narrative context.
• Provide children with key terms and definitions of those terms before playing the video and review them after the video ends.
• After reviewing the terms and examples from the video, transition children to a hands-on exploration of the concept.

In Bachrach et al. (2012) *Sid the Science Kid* was shown in classrooms along with teacher-guided class activities. The study found that children did not pick up the terms "observe, contrast, or investigation," even though the terms were used in all four episodes shown during the study. Presenting these terms only once in each episode was not enough to actually teach children those words or what they meant. Teachers would need to supplement the information from the videos with explicit instruction of those terms and activities. Another part of scientific inquiry that is addressed in *Sid the Science Kid* is the use of science journals to record data. Even though characters in the show write in their journals

in each episode, teachers in Bachrach et al. (2012) reported that children did not fully understand how to use the journal by the end of the week. Teachers felt a more explicit teacher-led lesson would be required for children to more fully understand the concept of recording data into a science journal as part of the scientific process.

While preschool children are competent at describing what they see, science education requires students to move beyond description and explain or explore why things happen the way they do. As addressed in the literature review, Hawkins (1974) emphasizes the importance of students' exploring and improvising with materials to understand why things happen. The first of three steps in science learning is allowing children to "construct, test, probe, and experiment without superimposed questions or instructions" (p.1-2). He would argue that simply teaching (or telling) children the names of tools and why they are used is not effective science instruction. In this study, when children could not recall the name of a part of the pulley, children were able to describe them using color, texture, and shape. In contrast, children did not provide additional evidence that they understood how the pulley worked. The main mechanical aspect of the pulley is the fact that when the rope is pulled, instead of the item coming toward us (Figure 11, left side), the item actually moves in the opposite direction (Figure 11, right side).

This cause-effect process is caused by the fact that the rope is being manipulated by the wheel to behave differently. This concept may be somewhat advanced for a preschooler, but it could be appropriate to explore during a hands-on, teacher-led activity.

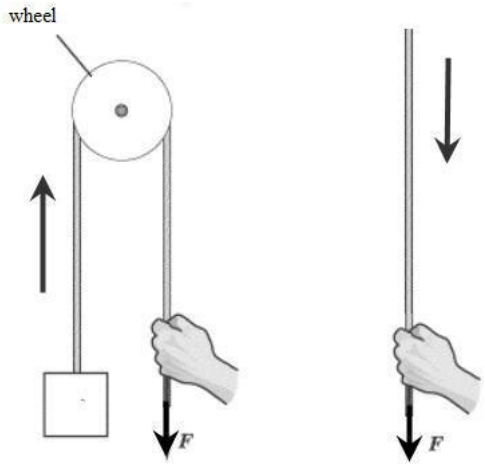


Figure 11. Movement of rope in response to force with and without a wheel

Hawkins (1978) describes science teachers as facilitators, guiding and scaffolding information for students as they ask questions and explore phenomena. Certainly, a television program cannot substitute for teachers in this role. In this study, the videos did not really engage the students on any substantive levels with the scientific ideas involved with a pulley system. (e.g., force, tension, load etc). Because *Sid the Science Kid* cannot follow Hawkins' exploration-based and student-centered pedagogical approach, producers depend on the parent or teacher to extend the children's learning. Perhaps, only with adult intervention could children gain deeper scientific understanding.

The limitations found in this study for children's mechanical reasoning is likely not the medium of television, but *Sid the Science Kid*'s rigid storytelling rubric. The preschool science program, *Peep and the Big Wide World (PEEP),* does follow Hawkins' approach and research indicates that children learn scientific inquiry skills. Although the programs have not been explicitly compared in any known research, PEEP may be more effective than *Sid* in supporting the growth in children's scientific reasoning skills. Upon additional examinations of the children's interview responses, there was a lack of evidence that children understood the mechanism behind the pulley. In fact, children seemed to describe the pulley as a magical autonomous machine that it lifted or pulled up heavy things by itself, rather than a tool propelled by human force. Perhaps these children were too young to be able to understand this abstract idea. Or maybe children misunderstood because the process of using a pulley was segmented during the video – rarely was a person shown pulling the rope to lift an object all in the same clip. In fact, at the end of the video when Sid's father pulls the rope to lift Sid's toy box, the scene ends with the toy box hanging in mid-air just next to the tree house.

The program successfully taught the "what" about a pulley (its parts and function) and "when" a pulley would be used; however, *Sid the Science Kid* was unsuccessful in teaching children "why" and "how" a pulley works. Some experts in science education would argue that the why and how are the most important aspects of science learning (Russ, Scherr, Hammer, & Mikeska, 2008). Knowing

science terms does not translate to knowing how to design a pulley or being interested in creating new scientific tools. Alternatively, in *Preschool Pathways* Gelman et al. (2010) argues that learning the "what" can be a good stepping stool for future instruction. The data from this study suggest that students of all levels of interest in science in general (based on parent surveys) enjoyed watching the program and would be interested in watching it (or another video like it) again. This finding supports that television programs can serve as a vehicle to increase children's interest and/or motivation to learn more about scientific ideas. In music, for example, knowing musical terms does not translate to knowing how to play a piece or being passionate about music making. Knowing the terms is crucial, however, when musicians want to play, create, or share their music (on paper) with other musicians.

In all, the data suggest that children recalled information about the pulley from each of the different segments of the video. The program was most effective when information was presented in multiple modes, with spoken language and visual imagery. The song successfully held children's attention and introduced the topic through concrete visual examples. To support children's learning of the pulley's form and function, the vocabulary associated with it, and an introduction to its purpose, teachers could use video with or without songs as tools in conjunction with direct instruction and hands-on activities.

Limitations and Future Directions

As with all empirical studies, these findings come with several limitations. This study included a small number of children per group, many of which had parents that were highly educated. Half of parents in this study had post-college education, while nationally that number is only16% (U.S. Census Bureau, 2011). Although parents were asked to report on specific exposure to the featured topic in the questionnaire, children with parents who had a higher education could have been more exposed to the scientific method or other elements of inquiry-based learning that was presented in the program. Children with more educated parents may also have better expressive language and vocabulary (Hart & Risley, 1995), which could have impacted results due to children being more prepared or ready to learn the language-based material in the videos.

The interview required children to express their understanding of the science content verbally, which was challenging for some of the children. This study did not include a baseline vocabulary test or other oral language fluency assessment to control for any expressive language differences between children. It is possible that using a hands-on task could have provided the opportunity for children to demonstrate the function of the pulley without needing to speak. Additionally, such a task would have provided children with an additional opportunity to express their understanding of the mechanics of the pulley.

The interview itself provided children with some of the scientific information. For example, if the children did not recall the term “pulley” at first,

they were told as part of the interview. It's possible that the act of sharing the term could have affected their processing or recall of information for the subsequent questions. The interview questions also asked children to indicate how they felt about the video and if they would want to watch it, or one like it, again. It is possible that positive responses to these items were due to social desirability effects, where children responded positively because that is what they thought the researchers wanted to hear.

Although efforts were made to keep testing procedures similar between locations, viewing and testing equipment and locations were not standardized across all children/locations (e.g., furniture, room size and décor, size and location of TV set). It is unlikely, though, that these differences impacted the findings of this study. The testing environment was different from most children's normal television viewing experiences. Specifically, children watched in a group rather than individually like they would at home. This restricts the generalizability of the findings to more typical home settings (Anderson et al., 1986). Despite the limitations, the work presented here offers contributions to the literature in both theory and practice.

This study also leads to new research questions. In terms of the role of music, does the musical style affect children's learning? Children's ability to understand lyrics may depend on the musical elements including rhythm, pitch, and rhyme, as well as the level of distortion in the singer's voice. Musical styles would vary in each of these musical elements (e.g., slower vs. faster; background

orchestration vs. minimal accompaniment; male vs. female singers). In this study, videos used an up-tempo song, with a full-sounding band, and a female singer. A future study could experiment with the song's musical style, keeping visuals and lyrics the same to see if comprehension of the lyrics could be enhanced. The song used in this study had a calypso feel, which may not be equally appealing to all adults. Researchers should consider conducting a study to examine whether or not producers' musical choices in children's programming influences parents' interest or willingness to co-view (e.g., top-40 songs vs. classic rock).

In this study there was quite a lot of repetition within and surrounding the song. There is more to examine regarding how much repetition is needed within, before, and/or after songs to support children's learning. Would the information in the song need to repeat the content from the dialogue-based scenes exactly, or could the song bring in new information? The number of exposures to the song itself could also be manipulated to see how many exposures best support comprehension of lyrics. Furthermore, does the format of the episode influence how songs affect learning? Is the musical "Broadway" type of episode more effective than a magazine format in children's recall of educational content?

Songs are being used to present all types of academic content and prosocial messages. This study used science content, but would this same research design have the same results if the program taught other educational messages, such as emotional regulation? In this study, the song's theme was well aligned with the overall episode storyline. If a song's theme or sub-story is not aligned with an episode storyline, however, the effects of the song on children's learning

may be different. The placement of the song within the story could also be adjusted, to see if having the song earlier or later impacts children's recall.

Long-term memory for songs and educational messages is a natural extension from research that looks at shorter-term recall. Children's retention of the information in the videos was not part of the research design in this study. Previous research done by Calvert (2001) and Wallace (1994) suggest that songs can stay in a person's memory for a very long time. A future study could investigate whether children who viewed a lyrics segment have better retention of the content and/or vocabulary over time than children who only heard dialogue?

Sid the Science Kid chose to present the song as a non-stop 90 second segment. Other programs, such as *Wonder Pets!,* integrate some spoken language into the songs to help emphasize information or portray important story details in a clear way. Future research could consider how could songs be more effective for both long- and short-term recall? For example, writers could include more spoken language during the song, blending the line between song and dialogue rather than more abrupt scene changes. If a small amount of the key lyrics were sung in a way that was more suggestive of speech, would children recall more of the language?

One last set of questions relate to the science education aspects of this study. The literature review of this paper compared the pedagogical approaches of both *Sid the Science Kid* and *Peep and the Big Wide World*. In schools, the student-centered approach endorsed by *PEEP* is considered more appropriate. On television, though, what are the best ways of conveying scientific information to

children? How does the *Sid the Science Kid* approach compare to the *PEEP* approach in terms of various science outcomes, ranging from children's interest in science or attitude towards science to children's demonstrated levels of mechanical reasoning? Does the top-down approach used by *Sid* provide enough depth in terms of exploration of the science concepts? Alternatively, does the student-centered approach used by PEEP provide children with enough information for them to discuss the academic content with others who have not seen the program?

It is clear that children enjoy music and songs, and that it holds their attention. This study suggests, however, that songs embedded in television shows may not be an effective educational vehicle when presented on their own. TV producers can take steps to support preschoolers' comprehension and recall of the educational content by a) incorporating spoken language before, during, and/or after sung lyrics and b) using clear and accurate representations of the content in the visual accompaniment to the song. Teachers and parents can support children's ability to learn from songs (segments of full episodes) by pre-teaching, repeating, and elaborating on the educational messages.

Appendices

IRB # : 1106015

Study Title: Video Songs Pilot Study

Principal Researcher: Rachel Schechter

Dear Families,

Thank you for taking the time to read these documents.

My name is Rachel Schechter and I'm a Doctoral candidate at Tufts University. With funding from the Fred Rogers Memorial Scholarship, I am conducting the Preschool Science TV Study to better understand how to teach preschool children about scientific concepts using a television show. Eligible participants will be interviewed or watch a short video and answer a few questions about it. Please read the attached consent forms regarding your child's participation.

To help us understand what children learn from the television show they view, we need to learn about how you integrate video, music, and science into your family life at home. If you choose to include your child in the study, please answer the questions in the attached questionnaire. We will use this information to help determine which children are eligible to participate. Children who have already seen the featured episode or learned the science concepts will not be eligible.

Your survey responses will be confidential. A donation of educational materials will be made to your child's school for every eligible child that participates in the study.

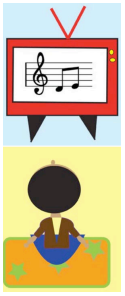
We are happy to answer your questions. Please contact the Principal Investigator Rachel Schechter at (617) 694-7434 or Rachel.Schechter@Tufts.edu or the Research Manager Jordan Jacobs at (917) 921-1198 or Jordan.Jacobs@Tufts.edu. For access to information about our study and the researchers, please visit our website at http://sciencetvstudy.wordpress.com.

Sincerely,

Rachel Schechter

Tufts

IRB # :1106015
Study Title: Preschool Science TV Study
Principal Researcher: Rachel Schechter



PARENTAL PERMISSION FORM

Dear Families,

Your child's school is participating in the Preschool Science TV Study. Television can be an effective tool to introduce preschoolers to scientific concepts and get them excited about science learning.

The goal of this study is to investigate what children can learn about science from *Sid the Science Kid,* a show that uses stories and songs to teach. Please complete this packet to include your child in this fun and educational experience. If you would like to read and complete this packet online, please go to http://app.fluidsurveys.com/surveys/sciencetvstudy/consent.

Here's the most important information for you to consider.
(The next page has more detailed information if you wish to read it.)

What exactly will the children be doing in the study?

- There will be two groups of children. The first group will be asked several age-appropriate science questions. The second group will first watch a short 10-minute video and then answer the same questions.
- Children will be videotaped while they are watching the videos and audio taped during the interviews. Tapes will be used for coding purposes and will be completely confidential. *(Recordings and transcripts of the recordings will not be available for parents or non-research personnel to view, hear, or read.)*

Where and when will the study take place?

- The study will take place at your child's school at a convenient time arranged by the teachers and administrators.
- Each session will last no more than 30 minutes, and each child will participate in one session.

If you have any questions about the study please visit our website at www.sciencetvstudy.wordpress.com or email us at sciencetvstudy@gmail.com. If you have questions about your rights as a research participant, you may contact the Tufts Institutional Review Board at SBER@tufts.edu or (617) 627-3417.

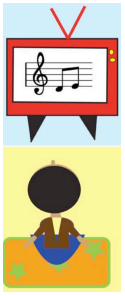
Please sign one copy of the attached consent form and complete the Child Questionnaire and return it to school with your child to his/her teacher.

Thank you,

Rachel Schechter
617-694-7434

Tufts

IRB # :1106015
Study Title: Preschool Science TV Study
Principal Researcher: Rachel Schechter



Please read this page if you wish to know more details about the study procedures. Otherwise, continue to the next page.

Do we have to participate?

Participation is voluntary and you may withdraw your child from the study at any time. If you choose not to participate, your child will experience his/her regular day in the classroom. Any completed questionnaires will not be used in the analysis or reporting of results. If you choose to have your child leave the study, it will not affect your child's care.

How will my information be kept confidential?

We will store research files in locked cabinets or secure computer files. Instead of using names on research data, each child will be assigned a study ID number. One master list will link a person's name to a study number. If results of this research are published, we would not use information that identifies you or your child.

What are the benefits of my family participating?

Your child might learn new concepts or improve his/her scientific knowledge. In addition, you will have the satisfaction of knowing that you contributed to the understanding of how young children learn. The study's findings may also improve the quality and effectiveness of preschool educational television in years to come. As a thank you for your participation, a book will be sent home as a gift for every eligible child that participates.

Are there any risks to participating?

There are no specific risks associated with participating in this study. Steps to keep your confidentiality will be taken (described above). Some students may feel stress or anxiety when being interviewed. Researchers will use age appropriate language to reassure students that there are no right or wrong answers and to help them feel at ease.

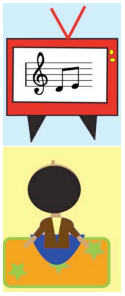
Who is eligible to participate?

This study is targeted at 4- and 5-year-olds who speak English as a primary language. If a child has already seen the selected episode of *Sid the Science Kid* or has learned about the featured science content at school or home, they will not be included in the study sample.

Please turn to the next page.

Tufts

IRB # :1106015
Study Title: Preschool Science TV Study
Principal Researcher: Rachel Schechter



Your signature on this form would mean:

- The research study was explained to you.
- You had a chance to ask all the questions you have at this time and your questions have been answered in a way that is clear.
- You agree for your child to take part in the research study.
- You understand that your child's participation in this research is voluntary.

_____Please initial for consent to videotape your child

_____Please initial for consent to audiotape your child

_____
Printed Name of Adult Caregiver

_____
Printed Name of Child

_____ _____
Signature of Adult Caregiver Date

Video Groups Introduction Script

1) Today we are going to watch a video about science.
2) When the video is over, Jordan and I will be asking you a few questions about the video. Everyone will get a turn, so wait on your mat and we will tap you on the shoulder when it is your turn.
3) Researchers will be in the back of the room doing some paperwork while the video is playing.
4) If you don't want to watch the video or answer the questions, you don't have to. If you want to go back to the classroom at any time, just let us know.
5) (*For video groups with dialogue only)* The video has not been finished yet, so there will be some parts of the show where there will be pictures and a voice that will explain what is happening in the story. When the video is over, Jen will stop the video.
6) Does anyone have any questions about what we are going to do? [Answer any questions.]
7) Okay, time to start the video.
8) [After the video ends] Jordan and I are going to choose children to answer some questions. Jen is going to lead you in some stretches while you wait your turn.

Control Group Introduction Script

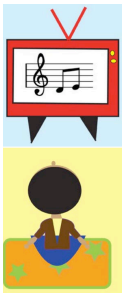
1) Today we are going to ask you a few questions about science. Everyone will get a turn, so wait on your mat until Jordan or I tap you on the shoulder when it is your turn.
2) If you do not want to answer the questions, you don't have to. If you want to go back to the classroom at any time, just let us know.
3) Does anyone have any questions about what we are going to do? [Answer any questions.]
4) Okay, Jordan and I are going to choose children to answer some questions. Jen is going to lead you in some stretches while you wait your turn.

Control Group Modified Introduction Script

1) Hi, child's name, thank you so much for helping me today. I'm going to ask you a few questions about science. Are you ready to answer a few questions?
2) [Continue with interview.]
3) Thank you so much for your help today. Are you ready to go back to the classroom?

Once all children complete their interview, researchers will thank them for their participation and return the children to their classroom.

Tufts



SCIENCE TV QUESTIONAIRRE

ABOUT YOUR CHILD

What is your child's birthday? _____

Is the child who is participating in this study a: ❒ girl or ❒ boy?

Is English the primary language spoken by your child? ❑ Yes ❑ No

Which class is your child in (or Teacher Name)?_____

Does your child show an interest in science?
❒ None
❒ A little
❒ Somewhat
❒ A great deal
❒ I don't know

Does your child enjoy participating in scientific experiments?
❒ None
❒ A little
❒ Somewhat
❒ A great deal
❒ I don't know

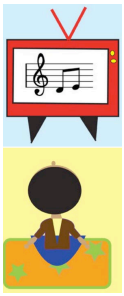
How often does your child engage with media (books, television, radio, materials) that involves science?
❒ Never
❒ Rarely
❒ Sometimes
❒ Frequently
❒ I don't know

How often does your child watch videos or television shows that include music?
❒ Never
❒ Rarely
❒ Sometimes
❒ Frequently
❒ I don't know

Does your child show an interest in music?
❒ Never
❒ Rarely
❒ Sometimes
❒ Frequently
❒ I don't know

How often does your family listen to music together?
❒ Never
❒ Rarely
❒ Sometimes
❒ Frequently
❒ I don't know

Please turn over to complete the other side.



Has your child ever engaged with any of the following activities at home?

	Yes	No	I don't know
Using a wheel and rope to pull or carry a bucket, like getting water from a well.	❒	❒	❒
Use a pulley system to lift heavy objects.	❒	❒	❒
These activities are addressed in this study, so please try to refrain from doing either of these activities over the next few weeks.			

Has your child seen *Sid the Science Kid* on PBS or online at pbs.org?

❑ Yes ❑ No ❑ I don't know

If yes, do you know if they have seen part or all of the episode that introduces children to using a pulley to lift heavy objects?

❑ Yes ❑ No ❑ I don't know

A FEW MORE QUESTIONS ABOUT YOUR CHILD:
(These responses are optional and will be used for statistical purposes only.)

Does anyone in your child's household work in a science-related field? ❑ Yes ❑ No

Does your child have an Individualized Education Program (IEP)? ❑ Yes ❑ No

What is your child's race/ethnicity: (Check all that apply)

❑ American Indian or Alaska Native
❑ Asian
❑ Black or African American
❑ Other (please specify) _____
❑ Native Hawaiian or Other Pacific Islander
❑ Hispanic or Latino
❑ White/Caucasian

What is the highest level of education you have completed? (Check one.)

❑ Some high school
❑ High school diploma or GED
❑ Some College
❑ College
❑ Some graduate courses
❑ Master's degree
❑ Doctorate
❑ Other (describe) _____

Thank you for your participation!

Interview Question Sheet – Video With Song or Video No Song

Instructions for Interviewer: Please check the most appropriate box. Use the back of the form for notes if necessary.

Student ID: _____ **Date**: _____
Group #: _____ **Researcher Initials:** _____

Hi (child's name), Thanks so much for helping us today. Are you ready to answer some questions about the show?

Content Knowledge Questions

1. In the beginning of the video, do you remember what Sid's question was?

❒ no answer or incorrect

Let me remind you, what Sid wanted to know how to lift his heavy toy box up into his tree house.

❒ how to get toys up to tree house or similar

2. Do you remember how Sid got his toys up into his tree house?

❒ no or I don't know

Sid used a pulley to lift his toy box.

❒ used the word "pulley" as a noun

2b. Can you tell me what a pulley does?

❒ no or I don't know

❒ pull things up, down or sideways

3. Is there anything else you can do with a pulley?

4. Can you tell me, what are the different parts of a pulley? Anything else?

❒ wheel ❒ rope ❒ axle ❒ hook ❒ bar ❒ Other _____

5. Look at these three pictures. Can you point to the picture that shows a pulley? *(circle child's choice)*

wrench protractor pulley

Turn Over Sheet

Turn Over Sheet

6. Which part of the video was your favorite?

6a. What did you like about it?

7. Look at these faces. Point to the face that shows how you feel about the video.

8. Would you want to watch that video again? Yes, no or maybe?

❒ no ❒ maybe or I don't know ❒ yes

9. Would you want to watch a different episode of this show?

❒ no ❒ maybe or I don't know ❒ yes

10. Have you learned about pulleys before today? ❒ yes ❒ no ❒ I don't know

***If yes,* where did you learn about pulleys? _____**

Thank you for sharing your ideas!

Please write any additional notes from the interview below. Indicate if the note responds to a particular question.

Notes:

Interview Question Sheet – Control Group

Instructions for Interviewer: This activity record should be filled out as thoroughly as possible during the visit. Use the back of the form for notes if necessary.

Student ID: _____ **Date**: _____

Group #: _____ **Researcher Initials: _____**

Hi (child's name), Thanks so much for helping us today. Are you ready to answer some questions?

1. I have friend who has a tree house. He really wants to bring his toy box up into his tree house, but it's too heavy and he can't lift it. Can you think of a simple machine that could he use to get the toy box up into the tree house?

If child says "pulley," ask: **Where did you learn about pulleys?**

2. My friend used a pulley to get his toys up into his tree house. Can you tell me what a pulley does?

❒ no or I don't know (*Skip to pictures*.)
❒ pull things up, down or sideways

2a. Is there anything else you can do with a pulley?

2b. Can you tell me, what are the different parts of a pulley? Anything else?

❒ wheel ❒ rope ❒ axle ❒ hook ❒ bar ❒ Other _____

3. Look at these three pictures. Can you guess which picture shows a pulley? *(circle child's choice)*

wrench protractor pulley

If wrong, *say*: **That was a good guess. That's a _____ and this is a pulley. A pulley is a simple machine that has a wheel and a rope that makes it easier to lift up heavy things.**

Thank you for sharing your ideas!

Interview Question Sheet – Video Songs Only

Instructions for Interviewer: This activity record should be filled out as thoroughly as possible during the visit. Use the back of the form for notes if necessary.

Student ID: _____ **Date**: _____

Group #: _____ **Researcher Initials:** _____

Hi (child's name), Thanks so much for helping us today. Are you ready to answer some questions?

1. I have friend who has a tree house. He really wants to bring his toy box up into his tree house, but it's too heavy and he can't lift it. Can you think of a simple machine that could he use to get the toy box up into the tree house?

2. My friend used a pulley to get his toys up into his tree house. Can you tell me what a pulley does?

❒ no or I don't know (*Skip to pictures*.)
❒ pull things up, down or sideways

2a. Is there anything else you can do with a pulley?

2b. Can you tell me, what are the different parts of a pulley? Anything else?

❒ wheel ❒ rope ❒ axle ❒ hook ❒ bar ❒ Other _____

3. Look at these three pictures. Can you guess which picture shows a pulley? *(Circle child's choice.)*

wrench protractor pulley

If wrong, *say*: **That was a good guess. That's a _____ and this is a pulley. A pulley is a simple machine that has a wheel and a rope that makes it easier to lift up heavy things.**

4. Look at these faces. Point to the face that shows how you feel about the video. *(Circle child's choice.)*

Turn Over Sheet

Turn Over Sheet

5. Would you want to watch that video again? Yes, no or maybe?

❒ no ❒ maybe or I don't know ❒ yes

6. Would you want to watch a different episode of this show?

❒ no ❒ maybe or I don't know ❒ yes

7. Have you learned about pulleys before today? ❒ yes ❒ no ❒ I don't know

***If yes,* where did you learn about pulleys? _____**

Thank you for sharing your ideas!

Please write any additional notes from the interview below. Indicate if the note responds to a particular question.

Notes:

Observation Protocol Sheet

Student ID: _____ **Date**: _____

Group #: _____ **Seat #:**_____

Researcher Name: _____

Indicate in each box the number of seconds the child looked away from the screen for each occasion during the length of the scene.
Mark the box with ∅ if children's attention did not leave the screen
In the total row, count the number of second for each column.

	Without Song	**With Song**
Sid in Backyard		
After breakfast with his family…Teacher Susie calls the children into the classroom for rug time		
Rug Time		
let's have a special Super Fab Lab on the playground! Yay!		
Super Fab Lab		
Susie's Song		*After using their new ideas…a family who lives in a tree house*
New that school is over…use his new ideas in his tree house		
At Home		
That night…his next big idea. (Stop coding when researchers start moving towards the children.)		
Totals		

Data Collection Seating Chart Filled in by _____
Group #_____ Location_____
Date_____ Time _____

1	2	3
4	5	6

Data Collection Seating Chart Filled in by _____
Group #_____ Location_____
Date_____ Time _____

1	2	3
4	5	6

Sid the Science Kid "The Tree House" Transcript

Sid: welcome to my backyard, it's been pretty exciting around here lately, thanks to my dad, who built me a--da da--tree house. Ha ha! Yeah, let's give it up for dad! [Applause] hoo hoo! But I have a problem. You see, I put my toys in this box and I want to take them up now, I can push this big box, but, uh, it's way too heavy to lift all the so that how do people get heavy stuff from down on the ground to way up high on and how am I gonna lift this big box when I now, what i really need to know is, how am I gonna get my toys into the tree house.

Mom: Sid, breakfast time.

Narrator: After breakfast with his family Sid's mom drives him to school. He can't wait to tell his friends about his big question. When Sid arrives at school, he waves goodbye to his mom and waves hello to Teacher Susie. Then Sid says hello to his friends, May, Gerald, and Gabriella. Then Teachers Susie calls the children into the classroom for rug time.

Teacher: So, what's on my young scientists' minds today?

May: Oh, we were talking about bringing our things up to a tree house.

Teacher: Sounds like fun.

Sid: Yeah, my dad built me the coolest tree house ever, and I'd love for everybody to come over and see it sometime.

Kids: Okay. Cool!

Sid: But I can't figure out how to get all my toys up into the tree house.

Teacher: Sid, you have a very interesting problem. You know, there is a simple machine that can really help you out.

Gerald: A machine? Well, like a washing machine?

Gabriella: Or a crane?

May: Or a bulldozer?

Teacher: Actually, I'm talking about a much simpler machine. Let's see here, ah, this is called a pulley.

Kids: Oh.

Teacher: Every pulley has a wheel. The rope goes through here and the top of the pulley has a hook, and here's a pulley being used to lift up a big steel beam. The pulley makes it easier to lift up heavy things. And we know what this is, right?

Kids: A clothesline.

Teacher: Yeah.

May: Oh, my grandma uses a clothesline to pull clothes like this [creek, creek]. So pulleys help lift things up and pull things sideways?

Teacher: Exactly, May, very good.

May: Thank you.

Gabriella: Hey, maybe a pulley would make it easier to lift up Sid's toys.

Teacher: Well, that's a great idea, Gabriella. Where can we investigate more about pulleys?

Kids: In the super fab-lab.

Teacher: Grab your journals and let's have a special super fab-lab on the playground.

Kids: Yay! [cheering]

Sid: All: It's the super fab-lab.

Kids: Outside! Yay! Investigate! Explore! Discover!

Teacher: Ok, my scientists, I have attached that bar so I could hang the pulley and you can use it if you want to because today your job is to find the easiest way to lift up this big bucket of balls way up there where Gerald is.

Gerald: Hi!

May: Maybe the easiest way is just to pick up the bucket.

Gabriella: Oh, good idea, May! Then we can climb up the ladder with it.

Teacher: Oh, I like those suggestions. You should try them.

Sid: Or we could just try to push the bucket up the slide, 'cause the slide is another simple machine, right?

Teacher: You're right, Sid, and that's a great idea. But, what do you think might happen to the balls?

Sid: well, if I pushed the bucket up the slide, oh, the bucket might lean back and the balls would fall all over the place.

Sid the Science Kid "The Tree House" Transcript

Gerald: Hey, hey, if we used the pulley, then we could lift the bucket straight up, and then the balls wouldn't fall out.

Teacher: Oh, I'm hearing great ideas so go for it. Try out those ideas.

Narrator: The children tried all of their ideas. They find that the pulley is the easiest way to lift the bucket.

Teacher: Ok, scientists, I can't wait to see what kinds of observations you've made. Gerald, may we look at your journal?

Gerald: Um, so we all tried to lift this bucket up, but the bucket was heavy, and so we couldn't do it without all the .. ♪♪ Da da da da ♪♪ we used a pulley, and that made it much easier.

Teacher: Nice observations, Gerald.

Gerald: Thank you.

Teacher: Scientist can do lots of things when they work together ok, Sid, may we look at your journal, too?

Sid: Oh sure. Here we are using the pulley to lift up the bucket, and then I had an idea. I can use a pulley to lift my box of toys all the way up to my tree house.

Teacher: Oh, that's a great idea, Sid. Pulleys can be used to lift up all kinds of heavy things. Wow, I'm impressed with all my pulley experts. You know so much about pulleys! Okay, I think it's time to play with all your new ideas.

Kids: Yay!

Narrator: After using their new ideas in the playground, Teacher Susie sings the children a song about a family who lives in a tree house.

Teacher Susie [song]:

We're the Pullman family, we live in the trees,
In a high rise jungle with a view and a breeze.
We love the life up here. Please understand me fully,
We get all we need by using a pulley.

When we want some salad or some cocoa in a cup,
We send a message down that says send it up.
They sent our mail and our clothes up to where we are.
Last week we got a freezer, a couch and a car.
Mary had a little lamb, its fleece was white and woolly.
They came by to visit, sent up by a pulley.

Sid the Science Kid "The Tree House" Transcript

When we need a tractor or a brand new mirror,
We send a message down, send it right up here.
A pulley is a simple machine, a wheel on an axle with a rope.

On the next tree down there is a beautiful branch,
The Johnsons moved up there and built themselves a little ranch.
They have a bull for a pet. That bull is not a bully.
The pet store sent him up with, what else, a pulley.

We love the life up here, we're as happy as can be.
Whatever we want, the pulley sends it up the tree.
We're the Pullman family, we live in the trees,
In a high rise jungle with a view and a breeze.

Narrator: Now that school is over, Sid arrives at home. He can't wait to use his new ideas in his tree house.

Sid: Ta da! Here I am in my tree house. So I told my dad about what we learned in school today, about lifting stuff and how much easier it is if you use a pulley, and you know what dad said?

Dad: I'm on it.

All: Ha ha!

Mom: Sid, using a pulley to lift up your toys is a great idea.

Sid: Aw, thanks, mom. Thanks, Ikki.

Dad: Okay, the rope is on there I think we're ready for operation: lift the toys up with a pulley!

All: Yay!

Dad: Okay, everybody count to three.

All: One, two, three!

Dad: Okay, come on, boy, it's coming.

Sid: Cool. hey, dad, it's working. Keep pulling.

Dad: Okay.

Mom: Super dad! he's doing it! It's going up!

Sid: Go, dad, go! go, dad, go! Go, dad, go!

Sid the Science Kid "The Tree House" Transcript

Dad: Almost there!

Sid: Little further and we did it!

Dad: Whammo, the pulley worked!

Sid: Ha ha!

Mom: Hey, Sid?

Sid: Yeah, mom?

Mom: You know what might be fun?

Sid: What?

Mom: I could get you and dad your sleeping bags and you could sleep in the tree house tonight.

Sid: Yeah, that's a great idea!

Dad: All right! Campout in the tree house!

Sid: Yay, this is gonna be so much fun! My mom and dad are awesome!

Narrator: That night, Sid and his dad have a sleepover in his tree house. But Sid can hardly sleep, because he's busy thinking of his next big idea.

Demographic Information by Group

Variable		Dialogue Only	Dialogue Plus Lyrics	Lyrics Only	Control	Total or Mean
Child Gender						
	Male	6	9	11	12	38
	Female	18	16	9	10	53
Child Age		4.62	4.84	4.70	4.55	4.68
Child Race						
	Asian	1	1	1	3	6
	Black	1	3	0	1	5
	Native American	0	0	0	0	0
	Native Hawaiian	0	0	0	0	0
	White	20	12	17	13	62
	Multiple Races	0	3	1	0	4
	Other	1	0	0	0	1
	Not Reported	1	5	0	5	11
Child Ethnicity						
	Not Reported as Hispanic	22	23	17	21	83
	Hispanic	2	2	3	1	8
Parent Education						
	Some high school	0	1	0	0	1
	High school or GED	1	1	0	0	2
	Some College	2	5	2	0	9
	College	7	5	8	5	25
	Some grad school	0	3	2	2	7
	Master's Degree	10	4	6	9	29
	Doctorate	3	1	2	2	8
	Not Reported	1	5	0	4	10
Science Professional in Home						
	Yes	10	5	9	6	30
	No	13	16	11	12	52
	Not Reported	1	4	0	4	9

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