THE ABCs OF STEM IN PRESCHOOL TELEVISION PROGRAMMING: A CASE-STUDY ANALYSIS OF THE BEST METHODS TO INTRODUCE SCIENTIFIC SUBJECT MATTER INTO PRESCHOOL-AGED TELEVISION PROGRAMMING

by

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ABSTRACT

A child's natural inclination to explore the world around him/her has been a fundamental part of child development theory. From 2- to 5-years-old, or preschool-aged, children are "tiny scientists" who are capable of understanding basic concepts of science, technology, engineering, and math (STEM). Through the examination of child development studies and children's educational programming history with an analysis of three renowned educational television programs for the preschool audience, this paper creates a framework for developing preschool television programming with STEM content. A concluding discussion details how the Framework is then implemented in the creation of a film *Discovery Camp*: "Busy Bees Make Honey."

INTRODUCTION

"Take chances, make mistakes…and get messy!" -Miss Frizzle, *The Magic Schoolbus*

"Oh, I'm just a bill, yes I'm only a bill." – Bill, *School House Rock*

For over half a century, many children have often learned the fundamentals of education from television. Whether it is numbers with Count Dracula on *Sesame Street (1969)* or the value of family and friendship with Barney the dinosaur through *Barney & Friends (1992),* educational and informational programming has in the past and continues today to enhance the interpersonal and academic skills of young viewers (Guernsey and Seal-Wanner 2007). While many prosocial values are frequently instilled in the youngest preschool audience of 2- to 5-years old, however, children's television programs rarely address basic science concepts in the fields of science, technology, engineering, and mathematics (STEM). Presently, it is a missed opportunity to establish a foundation of scientific understanding in youth through a medium they spend about 3 hours per day watching (A.D.A.M. Medical Encyclopedia 2021). The introduction of early STEM concepts at a young age sets children up for success in their academic and professional careers and strengthens their critical reasoning and logic skills (National Research Council 2012).

In this paper, I provide evidence that 2- to 5-year-old children do have the capacity to learn and use a simplified form of scientific inquiry. With this evidence, I will propose that to further enhance their early childhood development of scientific reasoning and discovery, preschool television programs should introduce early STEM concepts into their narratives. This inclusion will be accomplished through the examination of the history of children's television programming, a discussion of current childhood development research findings, an analysis of

the successes and failures of three preschool educational television programs, and, finally, a practical application of the research and findings into a short preschool film of my own.

History of Children's Television Programming Content

Television programming has long influenced child development. Research has shown that children who view programming with overt educational messages including academic lessons and prosocial teachings are more altruistic and compassionate and are more prepared for and perform better in school (Linebarger et. al 2001 and other studies). With the passage of the Children's Television Act (CTA) of 1990 by the United States Congress, the U.S. government recognized the importance of quality social-emotional and academic messaging in media aimed at youth by setting standards for television content. The Federal Communications Commission defined educational and informational programming (E/I) as content that "furthers the positive development of the child in any respect, including the child's cognitive/intellectual or social-emotional needs" (Federal Communications Commission [FCC] 1991).

Traditionally, children's E/I formats were differentiated by two distinct formats: story versus magazine (Calvert and Kotler 2003). Story formatted programming usually relayed social-emotional, also referenced as prosocial, values and messages (i.e. kindness, helping others, caring, sharing, etc.) through a fictional narrative structure with events occurring over space and time (Calvert and Kotler 2003). Modern-day examples of this format include Disney Junior's *Mickey Mouse Funhouse (2021),* where Mickey and the Fab Five (Mickey, Minnie, Daisy, Donald and Goofy) introduce children to the importance of sharing with one another and being kind to everyone and Nick Jr.'s *Paw Patrol (2013)*, with a crew of super-cool puppies who embrace teamwork to save the day.

Magazine formatted series tended to relay academic messaging (i.e., STEM, history, and literacy). This was accomplished through a series of short independent story segments, or vignettes, that together composed a single episode intended to teach a unifying subject or theme like counting or chemistry (Calvert and Kotler 2003). *Sesame Street (1969), Between the Lions (2000)* and *Bill Nye the Science Guy (1993)* were notable examples in this format.

There were some exceptions to this distinct storytelling format dichotomy for prosocial and academic subjects. A few breakthrough series like *The Magic Schoolbus (1994)* and *Cyberchase (2002)* found success using the story format to teach academic lessons. These academic programs usually targeted older audiences such as the "bridge" age group (the television industry's terminology for 4- to 8-year-old children) and the pre-teens (6- to 11-year–old children). The series with a story format featuring academic lessons excluded the youngest 2- to 5-year-old viewers (toddlers and early preschoolers) from higher level academic subject matter. This was due to a gross misunderstanding among the public about children's learning capacities due to inadequate scientific research.

In the late 20th Century, the modern scientific community had yet to discover that toddlers and preschoolers possessed a higher level of cognitive comprehension and information retention abilities than what early founders of childhood development surmised (Guernsey and Seal-Wanner 2007). Television programing, therefore, was not intended for them.

It wasn't until the early 21st Century that early educational science standards were revised. Young children were found to be "tiny scientists" who had a capacity to learn complex subjects by observing and interacting with the world around them. This discovery of a child's ability to critically think and process new information opened the door for children's television programming to introduce complex subject matter into its content.

CHAPTER ONE

NEW DISCOVERIES IN CHILD DEVELOPMENT RESEARCH: TINY SCIENTISTS

A child's natural inclination to explore the world around him/her has been a fundamental part of child development theory since scholars Piaget and Vygotsky laid the groundwork for child psychology in the 1960s and 1970s (Piaget & Inhelder 1969; Vygotsky 1978). While their understanding of children as curious information seekers who glean knowledge from their environment or social circle was valuable, it was limited. They did not perceive young children as critical thinkers. Their theories informed early childhood education curriculum which left harder, complicated academic STEM concepts out of the preschool and kindergarten education systems (Greenfield 2015).

In 2007, The National Academy of Sciences (NAS) published findings stating that "the capacity of young children—from all backgrounds and socioeconomic levels—to reason in sophisticated ways is much greater than has long been assumed" (NRC 2007). In support of this finding, further investigations into neurodevelopment warranted the NAS findings with their recent statistic that a child's brain is 90 percent formed before the age of 5-years old (Guernsey & Seal-Wanner 2007). Even more staggering, emerging research found that children begin asking questions to gather information about the world around them as early as 1 years old through vocalizations and gestures (Chouinard 2007). "Before they even enter school," the National Resource Council stated in their Framework for K-12 Science Education publication, "children have developed their own ideas about the physical, biological, and social worlds and how they work" (NRC 2012). Children are born as scientists, or as one author wrote, they are

"scientists in the crib" who use a simplified version of the scientific reasoning to question and explain the world around them (Gopnic et al 1999). With this discovery, a shift in education practices emerged: "Science teaching and learning in the U.S. K-12 education system" transitioned "from covering a large number of topics in fragmented, disconnected and shallow way to a focus on a small number of core or big ideas" (Greenfield 2015). By 2012, the Next Generation Science Standards, or NGSS, were developed based on this Framework which brought complex STEM subjects into kindergarten curriculum. From understanding the difference between weather and climate to analyzing forces and motion, kindergartners are taught the fundamentals of STEM education (National Research Council 2012). Preschool, however, was omitted from the NGSS.

As of 2022, there is still a deficit in the educational system in educating all capable young minds. Since research has found that children possess an inherent nature of exploration and curiosity from infancy, there is a clear need to introduce STEM subjects to children before they enter kindergarten to further develop their knack for scientific inquiry. It has been documented in peer-reviewed scientific journals that those children who are not taught a science curriculum in their early formative years later test poorly in science readiness as they enter kindergarten (Greenfield et al 2009). The modern child is not, in many cases, achieving his or her cognitive developmental potential.

While no formal science education preschool standards currently exist, the National Resource Council is in the process of developing a plan to address them. Head Start, a program of the U.S. Department of Health and Human Services, produced an "Early Learning Outcomes Framework: Ages Birth to Five" that "designates 'scientific reasoning' as one of its central domains" (Greenfield 2015). With a future set of standards, hopefully the classroom setting will

facilitate the cognitive advancement of the youngest members of society. Despite the vast amount of work and research in progress to facilitate learning in a preschool setting, however, many children will still fall behind in the sciences upon entering kindergarten. According to the most recent 2019 U.S. Census, only 47.4% of 3- and 4-year-olds in the United States are enrolled in a private or public preschool. Even with science curriculum standards, more than half of the country's preschool-aged children will continue to not have access to science education through a preschool classroom. Most preschools also do not enroll 2-year-old children who are also at a critical developmental stage to learn scientific concepts.

I believe, therefore, that it is in the best interest of society to find alternative methods to classroom instruction to introduce STEM concepts to kids in their everyday lives. I suggest that the easiest and most powerful way to educate children 5 years old and younger is through television programming delivered through traditional means or internet platforms.

A significant amount of time in a child's day is spent in front of screens. Public survey data and research has found that as of 2020, the average child between 0- to 8-years old averages 2.5 hours of screen time daily and sometimes up to 5 to 7 hours daily. That statistic averages to children spending 912.5 hours annually staring at screens (A.D.A.M. Medical Encyclopedia 2021 and other studies). Since 2006, it has been documented by researchers such as Thakkar, Garrison, and Christakis that children over 3-years old could "learn educational content from television" and that "certain shows can positively influence aspects of cognitive development" (Thakkar, Garrison & Christakis 2006 and other studies).

Based on these significant findings, I propose E/I preschool television programming move beyond the focus on prosocial values in their storytelling and incorporate more complex

science topics into their narratives to develop preschoolers' scientific knowledge base and understanding.

To do so, it is critical to understand what facets of educational and informational programs are successful and which ones have failed in preschool engagement and comprehension. This understanding will then lead to knowledge about how to implement the successes in future programming moving forward.

Three case studies will be analyzed for their strengths and failures in conveying STEM concepts to a preschool audience and the formulaic methods by which they do so. The three series chosen span the last five decades of children's E/I programming and have been lauded as gold standards in preschool educational media: *Sesame Street (1969), Dora the Explorer (2000)* and *Ada Twist, Scientist (2021).* Episodes with a STEM focus were selected for evaluation. A Framework for best practices in developing new STEM-based E/I series for a preschool audience will be used as a metric of success in teaching preschoolers scientific concepts through television. Then, the conclusion will be a discussion of how the best practices identified in the case studies were implemented in a film of my own, *Camp Discovery*: "Busy Bees Make Honey."

CHAPTER TWO

CASE STUDIES IN E/I PROGRAMMING

Channels of Inquiry

To evaluate the success of a preschool show beyond its viewership numbers and profit, it is necessary to develop a metric to measure how well the series incorporates elements into the narrative that enhance scientific understanding in the audience.

In her watershed book, *Screen Time: How Electronic Media from Baby Videos to Educational Software Affects Your Young Child,* Guernsey and co-author Seal-Wanner denounced the misinformation of screen time as being harmful to child development and introduced the three key elements that influence a child actually increasing their knowledge from media (Guernsey and Seal-Wanner 2007 and other studies). Guernsey called these "channels of inquiry" that influence a child's development the 3 C's: child, content, and context.

C-1: Child

The preschool child audience member differs drastically from an older child and adult television viewer. With each year after birth comes significant milestones that are summarized in *Appendix A: Developmental Milestones: Speech and Language*.

Despite their rapid development, their cognitive skills are simplistic and limited to a finite learning capacity. Television programs that are successful are aware of the needs of children and incorporate their developmental stage of learning into the narrative.

Complexity. Children learn best when they can draw on preexisting knowledge or experiences. Salomon found that the "Amount of Mental Effort" required to understand media is directly related to how well a child learns. It must be "not too easy, not too hard" and based in their fundamental understanding of the world (Salomon 1983 and other studies). Toddlers under three years old struggle to distinguish reality from fantasy. Concepts introduced in the series should be simple and grounded in real life. According to Guernsey and Seal-Wanner, "moderately novel and complex content is considered ideal to support learning" which, although it can prove a moderate challenge for comprehending in young viewers, is within their learning capacity and keeps them engaged throughout the duration of the episode.

The language, action, and context must be relatable and understandable to children (Guernesy and Seal-Wanner 2007). For example, at this age, they are just learning to question "why" and know the answers or distinguish opposites. They are still learning numbers and letters (See Appendix A).

C-2: Content

The ability of a child to comprehend the educational lessons within an episode are determined by two key content factors: narrative structure and cues.

Narrative structure. At around 2 ½ years of age, children grasp narrative arcs, or stories (Guernsey and Seal-Wanner 2007). Prior to this age, they do not understand story structure (beginning, middle, and end) and thus may not learn from a television program (See Appendix A). The narrative arc must be linear, thematic, and slow paced to ensure the greatest comprehension (2007).

For preschoolers, ages 2- to 5- years old, the format of the episode is critical for comprehension especially content cues guiding them through the episode (Anderson et al 1981, Tiwari 2020).

Cues. Content cues are production or narrative techniques that guide the viewer toward a desired outcome or lesson. Kirkorian et al. found that by utilizing cinematography and editing tricks such as zooming in and transitions, the child's attention can be drawn to the intended *educational content* rather than any *incidental content* (2008). Utilizing visual and verbal cues can be an effective manner for making the content relatable to the real world and facilitating understanding. This technique must be used with caution, however. Traditional cinematic filmmaking styles do not belong in a children's programming. Simplicity, linear storytelling and predictability yield the best engagement and value/lesson retention. Quick scene cuts or flashbacks cannot be tracked by a child. Puns, inference, and subtext do not belong in the dialogue (Mares and Acosta 2010). The viewers take what is on screen as literal and will be confused if it does not align with their world view or learning capacity (Fisch 2000).

Music. Music was not included in C-2 of the Channels of Inquiry. After conducting extensive research on the recurring elements in children's programming, however, I found this important component not included in the 3Cs. Music and the repetition of lyrics has shown to facilitate learning and comprehension (Diaz et al 2022). Therefore, music has been included in the Framework and is a fundamental part of most preschool programming.

C-3: Context

Repetition. Imitation is based on repetition. Georgetown University psychologist Rachel Barr found through her experiments that children between 12 and 36 months are able to learn from media on screens and imitate an action or word only if they see the action or word multiple times due to a "video deficit" in which children require seeing an action or word over and over in a video to imitate or comprehend it where they would grasp it quicker in a real-life example (Guernsey and Seal-Wanner 2007). She also found that "after 12 months of age, it appears more likely that a child will be able to recall what he sees on video and perform it himself—if the video is designed like the ones in these laboratory experiments, with slow, simple actions, lots of repetition and words uttered precisely to coincide with what appears on screen" (2007). Until age 3, many children struggle with "video deficit," so to counteract this, series aimed at audiences under 3-years old should avoid film cuts in a story line sequence and repeat actions and words often. The "video deficit" disappears with repetition.

Repetition, however, does not always equate with imitability or comprehension. If an action is not paired with linear visual storytelling or the dialogue, children will not be able to understand what is happening on screen and will not learn the subject matter.

Social Partner. In addition to repetition, research has demonstrated that for toddlers to grasp the educational lesson and story, they need to view the program as a "social partner" (Troseth, Saylor and Archer 2006). Richert, Robb and Smith expanded upon this study to conclude that "the likelihood that children will learn from screen media is influenced by their developing social relationships with on-screen characters" (2011). Popular child programming

such as *Blue's Clues (1996)* and *Daniel Tiger's Neighborhood (1992)* can attribute their success in part due to their adoption of a "social partner" as a technique in the storytelling by breaking the fourth wall between the audience and the characters (Ryan 2010). Children can directly engage with the video, much like they do with a parent or teacher. Most notably, *Blue's Clues (1996)* took an additional step in making the video on screen a social partner by introducing "the pause" (Gladwell 2000). It was a tipping point in educational media that was realized in subsequent series such as *Mickey Mouse Clubhouse (2006)* and *Dora the Explorer (2000)*. Characters in early 2000s programing would directly engage with the audience by looking directly into the camera, known as "breaking the fourth wall," asking a question and then pausing for several seconds before acknowledging the viewer's answer and giving the correct response (i.e., *Dora the Explorer's* iconic "Swiper no swiping!").

Considering the comprehension levels of children under five years old, the ideal age for learning through a television narrative, then, is 2- to 5-years old, or preschool-aged. Using Guerney's 3Cs and my own experience as a Disney Junior network creative junior executive and National Geographic Kids editor, I have developed a Framework for Preschool STEM Television Series based on the research cited with the exact factors that should be incorporated into a series to ensure a successful STEM learning and retention outcome.

Table 1. Framework for Preschool STEM Television Series

Framework for Preschool STEM Television Series
Simple dialogue *Age-appropriate language, concepts and vocabulary*
Linear plot progression *Singular predictable fiction plot line ideally in story format versus magazine. Can be live action or 2D or 3D animation.*
Kid-friendly story devices or cues *References and themes related to concepts children can grasp (e.g.. adventure or cooking versus time and luck)*
Limited film production and post-production techniques *Avoid stylistic cinematography and scene cuts*
Repetition *Repeat lesson, words, actions, etc. multiple times for comprehension*
Music *Upbeat, catchy songs to engage viewers and support retention of material*
Relatable characters *Include cast composed of diverse, young individuals that viewers relate to or aspire to be*
Interactive elements *Introduce elements that require the viewer to engage with the action on screen.*
Tone *Lighthearted, sweet, silly. No dark, scary, or really sad elements.*

Case Study 1: *Sesame Street* "The Happy Scientists"

Sesame Street (1969) made history as the first children's television program dedicated to education (Kerney and Levine 2019). Prior examples of television series such as *Captain Kangaroo (1955)* and *Mr. Rogers' Neighborhood (1968)* set the stage for informative television programming that could be good rather than detrimental to a child's development.

Created by Joan Ganz Cooney and Lloyd Morrissett and featuring the masterful puppetry of Muppets creator Jim Henson, *Sesame Street* had two fundamental goals: "to reduce the educational deficits experienced by disadvantaged youth based on differences in their preschool environment" and "foster intellectual and cultural development in preschoolers" (Kerney and Levine 2019). Each hour-long episode was research and curriculum driven. As a magazine formatted show, the narrative was driven by a series of unrelated skits rather than progressive plot (Truglio 2019). It was met with huge success globally. By the end of the decade, researchers had found that the creators achieved their goal of educating preschool-aged children and readying them for school (Truglio 2019).

As technology evolved and televisions became more affordable, children's television networks saw a shift in the demographics of their viewers. In the late 1990s, there was a significant increase in 2- to 3-years old viewership. The popular *Sesame Street's* content had been developed to target the developmental cognition levels of 4-year-olds and for the first time saw a decline in ratings (Guersey and Seal-Wanner 2007). The producers realized that 2-to 3-year-old attention spans were shorter than 4- and 5-year-old children. The content that was once lauded by research was labeled "frenetic" while simpler, straightforward story formatted series like *Barney & Friends* were praised (Guersey and Seal-Wanner 2007).

In response, *Sesame Street* producers reduced the episode duration from one hour to 45 minutes. They also wanted to stay true to their tried-and-true magazine format but knew that presented a challenge to their viewers' comprehension of the lessons due to the lack of continuity between skits. Their solution was to give the segments a unifying theme and make every episode "predictable and routine like preschool" with interactive game segments and a "full uninterrupted story line" (2007). By 2001, *Sesame Street's* new format not only engaged more viewers and for a longer duration but also appealed to their levels of cognitive development and prepared preschoolers for kindergarten. With this new direction came greater success. According to Wright et al, preschoolers who watched *Sesame Street* at ages 2 and 3 had higher testing scores in reading, vocabulary, school readiness, and math (2001). Over the next two decades, *Sesame Street* evolved to address issues beyond the academic curriculum to include current events, careers, socio-emotional values, and health and wellness (Truglio 2019).

The series is by far the leader in children's television programming for promoting diversity, representation, and inclusion. From colorful shapes, sizes, personalities, and abilities of the Muppets to the child and adult cast's racial, socioeconomic, physical, and gender differences, no child viewer will feel unrepresented in the show. There is a character that is relatable to nearly every viewer in some manner—a fact that is evidenced by viewership in over 130 countries with co-productions based on the original series in many of them (Mares and Pan 2013).

Today, *Sesame Street* continues to rank high in approval by parents and preschoolers. The episode length in recent years returned to a run-time of nearly an hour, around 52 minutes. This may be due to the distribution platform change from PBS to HBO where children can watch the episode in one complete sitting without commercial breaks or interstitials. While educational in nature, *Sesame Street* episodes always include at least three early educational concepts: letters,

numbers, and words. It does not, however, always include STEM or science-based concepts. For this paper, the episode "Happy Scientists" was chosen based on the content matter.

Due to the magazine format, the amount of STEM content in the episode only makes up less than a quarter of the entire episode. In "Happy Scientists," Elmo, Telly, and Rosita ask science teacher, Gordon, if kids can be scientists. His response is an enthusiastic, "yes!" and that the only qualification to be a scientist is the ability to ask questions and investigate. While most of the content in the episode is simple and age-appropriate (i.e., number and letter of the day), the script here is very complex for preschoolers featuring vocabulary words like "hypothesis" and "investigate."

The science segment fails in educating children due to the wrong choice of repetition. As Guernsey explains, repetition does not equal comprehension without the proper clues (Guernsey and Seal-Wanner 2007). This is evidenced by the silly "Happy Scientist" songs that do define the terms "investigate" and "hypothesis," but do not provide enough visual cues to aid viewers in comprehending them. In creating my film, I made sure that all songs had a visual component if they addressed a new subject or word (i.e., in the song "Head, Thorax, Wings and Sting", I included a bee graphic with arrows pointing to each body part. The cast also performs a dance pointing to the position of the head, thorax, wings, and sting on their own bodies as they sing along.)

The remainder of the episode does not teach STEM subjects. While *Sesame Street* does not excel at translating STEM concepts to a preschool audience, their ability to teach fundamental learning subjects is where they outperform other series. They convey basic educational topics in an engaging and age-appropriate manner. From counting to the "number of the day" to singing a song about feelings, the music, repetition of words and numbers, and visual

cues aid in a child's understanding of these early concepts. The Muppets also invite the viewer into the narrative by talking directly into the camera.

The camerawork, in particular, is distinguishable from most other children's programs. *Sesame Street* is a live action series. The camera does not have many movements. In fact, outside of a few handheld shots, the scenes are mostly mid to wide shots. There are no zooms or pans. The only cuts come between scenes or skit segments. Unlike animated children television series counterparts, *Sesame Street's* live action scenes play out on screen as if the cast is on a stage. The action unfolds as it would in reality. This method blurs the line of fantasy and reality but enhances a child's understanding that what they see before them on screen is, in fact, real. Most preschool live action series adopt this technique from *Barney and Friends (1992)* to *Blippi (2014)*. This is a method I chose to adopt when creating my own live action film to be discussed in depth in the next chapter. There are few editing techniques employed. The camera rarely zooms or pans. Instead, the child cast enter and exit the frame and stand in the center as they might on a theatrical stage.

Case Study 2: *Dora the Explorer* "School Science Fair"

On August 14, 2000, a 7-year-old Latina girl revolutionized animated preschool television (Diaz-Wionczeck et al 2009). Her name was Dora and she would soon become a household name around the world.

Dora the Explorer (2000) ranks as one of the most-watched preschool shows in the United States (Diaz-Wionczeck et al 2009). At its zenith, the series saw viewership of 21 million adults and children monthly. It was broadcast in 74 countries in 15 languages (Carter 2008). The

series featured a rare combination of traits in the protagonist: female, Latina, and bilingual (Ryan 2010). The creators purposefully made Dora and the show unique. Co-creator and co-executive producer Chris Gifford intended "to create a show that teaches little kids problem-solving skills…strategies like stopping to think, asking for help, and using what you know" (Diaz-Wionczek et al 2009). In essence, the series' intention was to empower preschoolers. This exploring child was the first example of what a "tiny scientist" could look like in television.

The series was curriculum driven. In production, the writers incorporated seven different learning methods from Howard Gardner's Theory of Multiple Intelligences in which academic subject matter can be taught in multiple ways by embracing different forms of intelligence: spatial-visual, verbal-linguistic, logical-mathematical, musical-auditory, naturalist, interpersonal and intrapersonal skills (Gardner 2013). In a single episode, a viewer would learn early concepts such as "counting, colors, shapes" along with new vocabulary words in both English and Spanish through music and repetition (Carter 2008). In fact, in 2005, Linebarger and Walker conducted a study to see how television impacted young audiences Their findings revealed that "*Dora the Explorer* and *Blue's* Clues resulted in the most significant increase in vocabulary words at thirty-months, well above that of nonviewers" (Linebarger and Walker 2005). Carter also argues that the show was even able to instill the fundamentals of cartography in young viewers (2008).

A series purely dedicated to education, however, would not succeed. The creators wanted a balance of education and entertainment in which there was a "linear narrative shaped around a high-stakes adventure in which viewers help Dora overcome a series of structured challenges to reach their ultimate goal" (Diaz-Wionczek et al 2009)

Dora the Explorer (2000) met preschoolers where they were at in their developmental stages both physically and mentally. Young viewers were quite literally invited into the story to

become participants of the plot. A hallmark of the series was the interactivity between the viewer and Dora. Dora broke the fourth wall to address her audience by asking them questions and pausing to await their answers. This direct address both through Dora's visual gaze and verbal dialogue "communicates respect for her audience and creates an emotional bond between the character and child audiences" (Ryan 2010). She empowers preschoolers to make decisions and be in control of their own learning in a world that usually does not ask them to solve problems (Carter 2008 and other studies). Dora teaches them that their actions and what they do and say is important. It makes a difference. From preventing a bully from stealing by saying, "Swiper no swiping" to being the sole keeper of the map directions to reach their destination, a child becomes Dora's social partner who is necessary to overcome the episode's conflict (Diaz-Wionczek et al 2009). Most importantly, this empowerment did not end with Dora's sign off "Adios." After successfully navigating the televised narrative, both Anderson and Catling found in their individual studies that children realized their influence and learned by imitating the television (2000; 2006). They were equipped to use their knowledge and problem-solving skills in the real world.

A simple analysis of the formulaic episodes reveals just how this incredibly successful educational series was able to accomplish such a feat. For the sake of demonstrating *Dora the Explorer's* ability to contribute to scientific learning in children, season 7's "School Science Fair" episode will be discussed.

The themes of each story-formatted episode of *Dora the Explorer (2000)* range. In "School Science Fair" Dora and fellow Latina friend, Emma, introduce the subject of renewable energy sources. From the first shot, preschoolers see two strong female leads in lab goggles. They have what is yet to be revealed as a geothermal diorama with a volcano in front of them.

Immediately, the audience is welcomed in by the young characters in both Spanish and English. The global audience finds themselves relating to the two characters either due to the breached language barrier, racial diversity, and age and gender inclusivity.

The two-dimensional, hand-drawn animation style is simple with bold colors that are also inviting. The tone is upbeat as they explain their "energy project" and count down with the audience to make the volcano go "kaboom!"

The script and animation are perfectly suited for the preschool audience. No text appears on screen for this non-reading demographic. Instead, when describing a novel and complex concept like where "energy" can come from, the camera slowly pans from the sun for "solar," to the trees blowing in the wind for "wind," down to a nearby stream for "water" and over to a patch of dirt and grass for "earth". These visual and verbal cues facilitate learning which only after their introduction can be applied to the diorama where Dora pours hot water into the volcano and the surrounding homes light up from the "green power." Within the first five minutes of the episode, the producers have adeptly engaged the audience and taught them a high-level scientific subject through a progression of cues.

The episode runs shorter than typical children's magazine series at 23 minutes, but longer than other story format series. Much of that time, however, is allotted to repetition and music.

Dora and Emma need to reach the school science fair. The only way they can is with the help of the audience's ability to retain and recall information. The character of Map empowers viewers to learn the three places Dora must travel: bridge, rescue center, school. From icons of the locations that illuminate to colored paths towards the locations, kids actively participate in the plot progression by repeating where they need to go both as a chant and song.

Unlike other network series found on Disney Junior, *Dora the Explorer* incorporates multiple songs throughout the episode. These catchy tunes serve a purpose: to solidify the lesson they learned ("Carnivores and Herbivores"), teach new material ("Science Fair"), or celebrate and uplift the viewer for completing a task ("We Did It").

It is no wonder upon analysis that the series became a huge success. As Guernsey concluded, a successful preschool series is aware of the needs of its viewers and incorporates their developmental stage of learning into the narrative. *Dora* does this with every episode and gives viewers the ability to participate in the program. It is the model of best practices in developing and producing an educational preschool television series.

Case Study 3: *Ada Twist, Scientist* "Bird's Eye View"

Ada Twist, Scientist (2021) premiered on Netflix in 2021. Based on the titular book series and developed by acclaimed creator of *Doc McStuffins*, Chris Nee, the goal was to introduce science to a preschool audience. The series features six episodes in Season 1. Each individual animated story-formatted episode has a run time no longer than 11 minutes with a live-action, nonfiction interstitial afterwards. The episodes are a combination of 2D and 3D animation. While studies have yet to be conducted on the efficacy of *Ada Twist, Scientist* to set children up for success in the sciences, it is the most recent model of early science concepts in the preschool media space and valuable to be evaluated. The episode that will be examined is episode 104 "Bird's Eye View".

"Bird's Eye View" scores moderately on the complexity scale. The episode is set in a familiar backyard location with characters Ada, Iggy, and Peck representing limited gender and racial diversity (one black girl, one white girl, one white boy). Their dialogue is higher level than

preschool but does define many unfamiliar terms including the birds they discover as “hatchling” and “fledgling” through explicit dialogue and visual animation. Scientific jargon and references, however, are introduced without explanation and seem to appeal more to the parent co-viewers such as “Engineering 101” or “architects.” Unlike *Sesame Street*, there is a lack of repetition of words and phrases to help kids grasp basic science vocabulary like “theory” and “observe.” The lack of repetition throughout will hinder their understanding and the complexity of the language will prove challenging to keep the target audience engaged.

One element of complexity that *Ada Twist* does well is guiding the viewer from reality to fantasy sequences. While this age group certainly struggles to see anything as “pretend,” the show uses a cue through a transition to 2D, hand-drawn animation that supports the brainstorm sequence. Children know the birdhouses in the sequence have not been made yet. They are simply tests to see what will work to give a baby bird a home.

The narrative is poorly written for this audience. The intended theme is “trial and error,” as demonstrated by the multiple iterations of a constructed bird house, and to “never give up,” which was the theme of the song performed halfway through the episode. Two themes are two too many. For preschoolers, the episode cannot have broad or abstract concepts. It is about a single problem and how to solve it from start to finish; or getting from Point A to Point B.

The singular song in the episode, “I Give Up,” is catchy, but underutilized for educational purposes. The lyrics center around a purely prosocial theme of perseverance rather than teaching children a simplified, kid-friendly version of the traditional trial-and-error methodology of scientific inquiry. It was a missed opportunity to introduce the very basics of the scientific method.

The episode concludes with a live action "Meet a Scientist" segment that uses language and introduces concepts that are far too complex for any child under the age of 4 years old to comprehend. The interactivity, however, is stellar. The scientist breaks the fourth wall and speaks directly to the audience, making them relatable and personable. The viewer feels a connection to the subject and thus to the material presented, even if it is over their heads. The bright colors and lively acting will keep kids engaged, but not necessarily educate them.

While this series will struggle reaching the intended preschool audience with the scientific concepts, the visual narrative will be impactful and engage children. *Ada Twist, Scientist* should be a model for kid-friendly story devices or cues and limited film production and post-production techniques.

The story devices and film production techniques used are intentional. The dialogue matches the onscreen action. For example, when Ada remarks, "It's the momma bird feeding her baby," the audience sees a bird in the distance. The camera then takes the audience into Ada's binocular lenses to reveal a zoomed in image on the mama bird feeding the baby a worm. There are no jump cuts to confuse children or disorient them. Scene transitions are gradual. For passage of time, we see the sky turn from a sun with a bright background to a moon with a nighttime backdrop and then back to a sun. It is one single take with clear cues and easy for kids to track. For those scenes with difficult action sequences, the cast narrates the action to guide viewers and aid in comprehension.

Overall, the story formatted narrative of *Ada Twist, Scientist* had the potential to introduce the preschool audience to the basics of scientific inquiry and methodology and failed. The dialogue and themes were too high-level for the intended age group. It did well with the

scene pacing, camerawork and editing for this age group. These elements served as a model as I created my own film.

CHAPTER THREE

THESIS FILM- *DISCOVERY CAMP*: "BUSY BEES MAKE HONEY"

In developing my own preschool program, *Discovery Camp*, I utilized the Framework for Preschool STEM Television Series as well as the best practices from the three case studies to create an accessible and engaging 11-minute episode, "Busy Bees Make Honey."

As early child development scientists and theorists have found, preschool-aged children are little scientists, seeking to explore and learn more about their world by asking questions and getting hands-on in their surroundings. Their view of the world is limited, however, to the places their guardians take them. *Discovery Camp* was created to reflect a child's own experience in the world and aid them in discovering the incredible science flourishing in their own backyards.

The series is intended to be kid-driven and relatable. In developing the script, I chose to follow the story format when crafting the narrative. As evidenced by *Dora the Explorer, Ada Twist, Scientist,* and many other STEM preschool series like *Doc McStuffins (2012),* Dinosaur Train (2009) and *Blue's Clues (1996)*, the story format is much easier for kids to track the subject matter and they feel invested in the outcome of the story and its characters. Yet, there is value in the magazine format, especially for a live action series. I have interspersed a few segments within the film to feel like the magazine structure and highlight an element I really want kids to learn (i.e., "Head, Thorax, Wings and Sting" song). Based on the research conducted, animated series typically find more success with preschool audiences. My budget was limited, however. A quality animated episode requires a budget of hundreds of thousands of dollars, a crew of directors, artists, animators, editors, and writers, and an animation studio.

Instead, I chose to isolate specific scenes that I felt animation would enhance and provide a better visual cue for learning (e.g., flower parts).

A formulaic plotline for every episode is also crucial for child comprehension. Preschool-aged kids come to expect the same plot patterns to emerge in the episodes. This eliminates a child's need to process new and novel story structure or subplots. They can simply focus on the new educational content being introduced.

For each episode of *Discovery Camp,* three preschool to early elementary-aged children work together to discover a STEM topic that is present in their natural environment. Their "camp" is a playhouse. The playhouse is a blanket fort where they share their observations of the natural world through a who/what/where/when/why question.

This setting was a deliberate choice. It is a familiar location for preschoolers: a blanket fort play space. In future episodes, the narrative will always begin at the play space where the children will come up with their next nature-themed question. (Future episodes will feature the moon and stars, seeds to plants, butterflies, frogs and metamorphosis, birds and migration, seasons, etc). Nature is an extremely popular subject with kids and their millennial and Gen-Z parents. It is an easy entry point into the natural and animal sciences. "Busy Bees Make Honey" is not the pilot episode. It will air mid-season once the plot sequence of events and characters have been established.

In "Busy Bees Make Honey," the audience meets the child cast during snack time in the play space, a very routine experience for preschool audiences. As the cast munches on a sticky, sweet snack of honey, the question arises: "Where does honey come from?" which opens the figurative door for the kids to learn about bees and honey. It also invites children to become social partners in the film. While there is no direct interaction with the camera like *Dora the*

Explorer, Millie, Audrey, and Cameron (the episode's characters) all serve as representatives for the audience. The viewers will answer along with them where they think honey comes from and to other questions that arise in later scenes.

The narrative through-line for the series is simple: children discover an element in the world around them. In this episode, children learn how bees make honey. It is accomplished through a blend of linear storytelling and magazine format sequences.

The episode's plot progression follows a traditional linear format until the transformation of the children into bees. This transformation sequence will happen in every episode and is marked by the same animation and little musical ditty: "It's transformation time! Imagination transformation time!"

While this transformation into bee costumes may seem confusing for an adult viewer at first, it is a critical developmental sequence for children. Preschool children explore their worlds through play acting (Fromberg 2015). Putting on a bee costume to reenact the world of bees is as natural to them as putting on mom's makeup or dad's robe and playing "house" or "work". At this developmental stage, preschoolers learn about their world through mimicry, and that is why it is necessary to reflect this behavior on screen.

After the bee transformation, the episode aligns with a more magazine formatted narrative. Songs and dances are interspersed among dialogue-heavy scenes introducing new vocabulary. Like *Dora* and *Sesame Street*, concepts are introduced through repetitive catchy lyrics with visual cues. In "Head, Thorax, Wings, and Sting" the kids point to each part of their bee bodies to help viewers understand the anatomy of a bee while singing and dancing along.

The script itself is more organic in nature than traditional preschool television programming narratives. The cast had a general outline of what information or terminology

needed to be presented in each scene, but much of the script was dictated by natural dialogue of the child cast. The language, then, was inherently "kid-friendly." I also stripped down the basics of bees and honey production to their simplest form by introducing only a handful of new words that children did not yet understand: hive, thorax, abdomen, wings, stinger, pollen, stamen, petal, stem, leaves, worker bee, queen bee, and waggle dance. This somewhat complex vocabulary was still within the comprehension level of the preschool audience. As emphasized in the 3-Cs, I ensured that the first usage of a word was always supplemented by a strong visual cue. For example, the adult figure in the story, the Beekeeper, introduces the flower parts (stem, leaves, stamen) in a back-and-forth interactive question-and-answer sequence by pointing to each part as the audience follows along.

The camera work and editing of the episode is nontraditional to live action filmmaking. It runs at a slower pace with fewer cuts and no dynamic cinematography. Scenes play out in their entirety before transitioning to the next scene. When the camera moves or zooms in, it is purely for emphasis and to help the viewer track the action as Guernsey recommends. Like other live action counterparts, like *Sesame Street,* the film work feels more theatrical rather than cinematic.

The strongest element of the episode is the music. Unlike most story formatted episodes that allot only one song per episode, the "Busy Bees Make Honey" episode includes three songs: "The Waggle Dance," "I'm Bringing Home Some Pollen for A Bee," and "Head, Thorax, Wings, and Sting." Catchy music and repetitive lyrics aid in comprehension and retention. The new vocabulary introduced in the dialogue is repeated in the lyrics of each song. Children will walk, or waggle, away from the screen recalling the waggle dance, anatomy of a bee, and what pollen and other bees do in the hive. As a testament to the effectiveness of this methodology, the cast of the show can still sing and explain what the waggle dance is six months after filming! Their

individual teachers asked them to recall the song and what the waggle dance means. To which they all sang the song and, as one teacher noted, discussed in depth the structure of a honeybee colony.

Should the episode be picked up by a network, another metric of comprehension success would be measured by showing the episode to independent focus groups of children who range in age from 2-5 years old, both boys and girls, and who from a variety of socioeconomic and racial backgrounds. A facilitator, such as a teacher or professional, would ask questions such as "what is a colony?" "How do bees tell other bees where the flowers are?" and other questions to see what information the children recall after viewing the episode. A follow-up study six months to a year later would be conducted with the same children to test long-term comprehension.

There were limitations to this film that, should it be picked up to be developed into a series, would need to be resolved. Due to the COVID-19 pandemic, the availability of child actors was limited to individuals living in the southern Indiana region in a pod (a self-contained group exposed to one another and limited in social interaction with other individuals). The child actors did not represent the ideal diversity of backgrounds to reflect the children watching the show. The kids and adult actors were also nonprofessionals who had never acted. Professional actors would be hired.

The graphics, set design, and audio capture were also limited by budgetary restrictions. Ideally, this episode would require a budget of at least $500,000. A full production and post-production crew would need to be hired to capture each child's audio, add foley and sound effects, and compose original music as a score.

The visual storytelling element of the film would be stronger in series. The set would be on a soundstage with a fully constructed playhouse or treehouse and the hive would be

surrounded by nature. The elements found within the playhouse and hive would reflect the theme of the episode, an element I tried to incorporate through woven flower-patterned blankets, a flower on Audrey's shirt, and palm leaves on the carpet. This will unconsciously cue children to the subject matter they will learn in the episode. The flowers surrounding the hive would be real rather than fake. The puppets and props would align with the overall color pallet and design. The yellow of the bee costume would match that of the children's shirt and bee puppet. There would be an additional set where the children could enter the hive and perform the waggle dance within the colony and surrounded by honeycomb.

The animation would also be aesthetically unified. The bee puppet would serve as a model for the animated bee in the "Waggle Dance" description and son "Head, Thorax, Wings, and Sting." The flower and magnifying glass animation would be identical to the flower used in the live action demonstration. By unifying the style of the visual elements, children will require less explanation of what is happening on screen and be immersed in the educational content through both the visual and written narrative.

CONCLUSION

Children inherently are tiny scientists with inquisitive minds and explorative natures. They are eager and able to learn. Yet, many preschool-aged children lack the accessibility to science, technology, engineering and math education due to the lack of standards developed for the age range. Another issue is a deficit of children attending preschool. In this thesis, I proposed that there is a singular solution: expose children to STEM topics through television programming—a medium they already spend an average of 3 hours per day viewing. Research conducted by child development scientists have proven that introducing children to STEM subjects early in their lives in both school and through television prepares them for success in school in the future.

Advances in both preschool STEM educational standards and E/I programming still need to be made in order to fully achieve a child's learning potential in the sciences. It the hope of the author that with a Framework, this film, and a future career in children's media, progress in STEM preschool programming will continue to move forward.

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APPENDICES

APPENDIX A

DEVELOPMENTAL MILESTONES: SPEECH AND LANGUAGE

Developmental Milestones: Speech and Language

	Hearing and Understanding	Talking
Birth-3 Months	• Startles to loud sounds. • Quiets or smiles when spoken to. • Seems to recognize caregiver's voice and quiets if crying. • Increases or decreases sucking behavior in response to sound.	• Makes pleasure sounds (cooing, gooing). • Cries differently for different needs. • Smiles when sees primary caregiver(s).
4-6 Months	• Moves eyes in direction of sounds. • Responds to changes in the tone of the caregiver's voice. • Notices toys that make sounds. • Pays attention to music.	• Babbling sounds more speech-like with many different sounds, including *p, b* and *m*. • Chuckles and laughs. • Vocalizes excitement and displeasure. • Makes gurgling sounds when left alone and while playing with their caregiver.
7 Months-1 Year	• Enjoys games like peek-a-boo and pat-a-cake. • Turns and looks in direction of sounds. • Listens when spoken to. • Recognizes words for common items like "cup", "shoe", "book", or "juice." • Begins to respond to requests. (i.e. "Come here" or "Want more?")	• Babbling has both long and short groups of sounds such as "tata upup bibibibi." • Uses speech or non-crying sounds to get and keep attention. • Uses gestures to communicate (waving, holding arms to be picked up). • Imitates different speech sounds. • Has one or two words (hi, dog,dada, mama) around first birthday, although sounds may not be clear.
1-2 Years	• Points to a few body parts when asked. • Follows simple commands and understands simple questions ("Roll the ball," "Kiss the baby," "Where's your shoe?"). • Listens to simple stories, songs, and rhymes. • Points to pictures in a book when named.	• Has a word for almost everything. • Uses two- or three- words to talk about and ask for things. • Uses *k, g, f, t, d,* and *n* sounds. • Speech is understood by familiar listeners most of the time. • Often asks for or directs attention to objects by naming them.
2-3 Years	• Understands differences in meaning ("go-stop," "in-on," "big-little," "up-down"). • Follows two requests ("Get the book and put it on the table"). • Listens to and enjoys hearing stories for longer periods of time.	• Has a word for almost everything. • Uses two- or three- word sentences to talk about and ask for things. • Uses *k, g, f, t, d,* and *n* sounds. • Speech is understood by familiar listeners most of the time. • Often asks for or directs attention to objects by naming them.
3-4 Years	• Hears when someone calls them from another room. • Hears television or radio at the same loudness	• Talks about activities at school or at friends' homes. • People outside of the family usually

	level as other family members. • Answers simple "who?," "what?," "where?" and "why?" questions.	understand child's speech. • Uses a lot of sentences that have four or more words. • Usually talks easily without repeating syllables or words.
4-5 Years	• Pays attention to a short story and answers simple questions about them. • Hears and understands most of what is said at home and in school.	• Uses sentences that give lots of details ("The biggest peach is mine"). • Tells stories that stick to topic. • Communicates easily with other children and adults. • Says most sounds correctly except a few like *l, s, r, v, z, ch, sh, th.* • Says rhyming words. • Names some letters and numbers. • Uses the same grammar as the rest of the family.