YouTube's ABCs and 123s:

Describing the quality of early literacy and math videos on YouTube

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Contents

YouTube's ABCs and 123s: Describing the quality of early literacy and math videos on YouTube

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There is little research on the educational quality of early learning videos on YouTube

Online videos have potential to shape young children's early learning and development, yet we know little about the educational value of these videos' content. Young children consume 2.5 hours (ages 2 to 4) to 3 hours (ages 5 to 8) of screen media a day on average (Rideout & Robb, 2020). Young children now spend more time watching videos on sites like YouTube than on any other platform, including streaming services and television shows (Rideout & Robb, 2020). The sheer volume of online video content makes it difficult to categorize or describe young children's online video exposure: On YouTube alone, around 500 hours of content are uploaded each minute (YouTube, n.d.).

> **"I don't like or trust YouTube. [The kids] don't get to watch the platform unless I am in the room. It's too big."**
>
> **-Parent of a first-grade child**

Many parents hope their children will learn something new or explore their interests when watching videos on YouTube, but it can be hard for parents to judge the educational quality of the videos their child watches. Ensuring that young children have access to high-quality educational videos is important, as research shows that children can learn both math and literacy skills from high-quality educational videos (e.g., Hurwitz, 2019; Silander et al., 2016). Early research suggests the quality of online educational videos, on average, may be poor. One study found that only 1 in 20 videos children watch online are of high educational value (Radesky et al., 2020).

> **"I also want them to watch content with educational value, not just entertainment."**
>
> **-Parent of a first-grade child**

To advance our understanding of the likelihood that children will learn from the videos available to them online, this paper focuses on educational videos for prekindergarten and kindergarten children on YouTube. We describe the quality, duration, and popularity of a sample of YouTube videos focused on early literacy and math topics, as defined by the Head Start Early Learning Outcomes Framework for prekindergarten literacy and math (Office of Head Start, 2015), and the Common Core State Standards for kindergarten literacy and math (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). We illustrate findings with quotes from interviews with parents of young children (in prekindergarten through first grade). This study is part of a broader initiative to detect the presence and quality of educational content in online videos using machine learning (National Science Foundation Award No. 2139219).[1]

What makes an educational video high-quality?

Researchers have proposed several components of high-quality educational media. For example, Fisch's (2000) capacity model identifies program characteristics theorized to support comprehension of educational content. Fisch states that educational content should be, among other things, clear, explicit, and integral to the narrative. According to the Four Pillars of Learning framework (Hirsh-Pasek et al., 2015; Meyer et al., 2021), quality educational apps should support social interaction with characters or caregivers and should contextualize learning content within children's everyday experiences.

This paper focuses on five indicators of high-quality early learning videos. To identify these indicators, we reviewed the research literature, including existing rating systems for educational videos (e.g., Jordan et al., 2001; Radesky et al., 2020), and solicited recommendations from an expert advisory board. We tested potential quality indicators on a sample of videos to arrive at five indicators that are well aligned with the types of educational content available on YouTube for young children and that can be clearly operationalized (Exhibit 1).

[1] This project developed a machine learning-based tool to identify early childhood math content in online videos for young children.

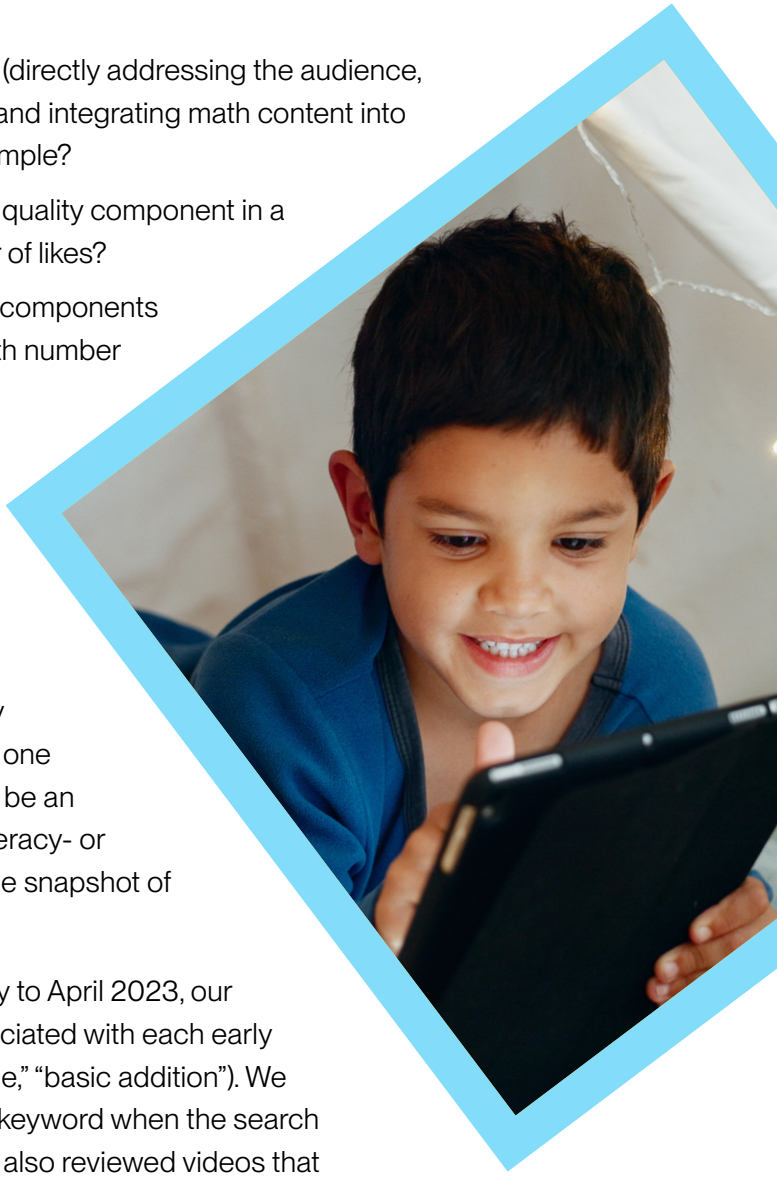
Exhibit 1. Indicators of educational quality in online videos to teach early literacy and math

Quality indicator and description	Example(s) that meet criteria	Example(s) that does not meet criteria	Supporting research
Is primarily educational: The video focuses on teaching preK or K math or literacy content.	A video that focuses on Elmo counting different animals in a barn.	An unboxing video in which a child counts toy accessories. A gaming video in which the host spells the name of the character he is creating while typing it into the character creator.	Fisch's (2000) capacity model states that educational content should be clear and explicit.
Directly addresses the audience: The video asks the viewer to engage in the learning content, then pauses for a response.	After eating some Skittles, a teacher looks at the camera and asks, "How many Skittles do I have left?" and then pauses.	The host looks at the camera and asks, "Are you excited?" One character asks another, "What starts with C?" and the other character responds.	Program familiarity and participatory cues produced the greatest educational content comprehension in a sample of preschool-age children (Piotrowski, 2014).
Involves characters: The video includes any onscreen, verbal character who is involved in the learning content.	Blippi plays with and talks about objects that start with each letter of the alphabet.	A video with voiceover only (no onscreen characters). A video in which the only onscreen character introduces the video but does not participate in learning content (e.g., "Hey kids, let's sing a song!" followed by an educational song with no characters).	Meaningful relationships with media characters can help young children learn early math and other logical reasoning skills (Howard Gola et al., 2013; Lauricella et al., 2011).
Includes concrete examples: The video illustrates learning content with objects or examples a child would encounter in their daily life.	Many early literacy videos take the format of "A is for apple," etc. A geometry video might liken a triangle to a piece of pizza.	A video that describes shapes (e.g., "A triangle has three sides") without likening them to familiar objects in a child's environment.	Children can better comprehend educational content when it activates prior knowledge (Fisch, 2000).
Integrates math content into narrative. Math content is integral to solving the problem within a video's narrative.[a]	A video focuses on planning a birthday party. Characters use counting to determine how many treats to buy for each guest.	A video that does not include narrative (e.g., only includes an educational song).	Children are better able to comprehend educational content when it is integral to a narrative (Fisch, 2000).

[a] *We did not measure this indicator for literacy content because it was uncommon in a test sample of videos.*

Research questions

1. What percentage of educational videos in the sample demonstrate one or more component of quality?
2. How prevalent are educational quality components (directly addressing the audience, involving characters, including concrete examples, and integrating math content into narrative) in early literacy and math videos in this sample?
3. To what extent is the presence of each educational quality component in a video associated with number of views and number of likes?
4. To what extent is the breadth of educational quality components and literacy or math topics in a video associated with number of views and number of likes?



Methods

Searching and screening for videos

Our sample is a curated collection of videos that cover a wide range of prekindergarten and kindergarten literacy and math topics. It consists of videos that include at least one early literacy or math topic. The sample is not intended to be an exhaustive collection or representative sample of early literacy- or math-focused YouTube content, but instead to provide one snapshot of the types of videos available on YouTube.

To identify candidate videos for the sample, from February to April 2023, our team conducted YouTube searches using keywords associated with each early literacy and math content category (e.g., "learning to rhyme," "basic addition"). We instructed trained research assistants to switch to a new keyword when the search results no longer appeared relevant. Research assistants also reviewed videos that YouTube recommended adjacent to the videos that were included in the sample. Video titles and/or descriptions were usually indicative of the presence of early literacy or math content, but research assistants were instructed to watch the first minute or so of each video to confirm the content was present and intended for prekindergarten- or kindergarten-age children. We aimed to ensure that the sample included a variety of representations of each literacy and math content code (Exhibit 2). If one channel had several similar videos covering a narrow scope of content—for example, a channel that had 26 different videos that described each letter of the alphabet—we asked research assistants to only screen and annotate the first few videos before moving on to a different channel or search topic.

Exhibit 2. Early literacy and math codes based on the Head Start Early Learning Outcomes Framework for prekindergarten and the Common Core State Standards for kindergarten

Literacy

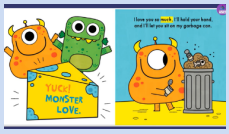
Letter names

Letters in words

Letter sounds

Sounds in words

Sight words

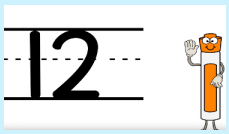


Following words left to right

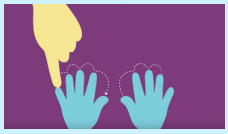
Rhyming

Math

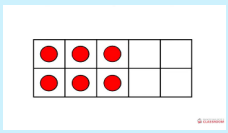
Counting

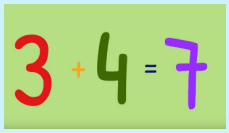


Written numerals

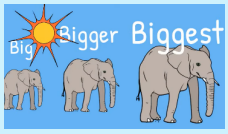

Cardinality


Comparing 2 or more groups

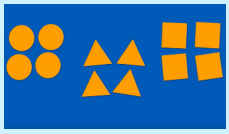

Subitizing



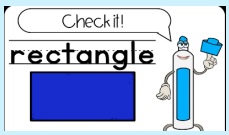
Addition and subtraction



Measurable attributes

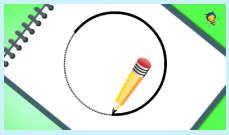

Sorting

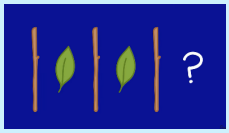
Spatial language



Shape names

Shape analysis and comparison


Building and drawing shapes



Patterns

Note: *Screenshots are from YouTube videos sharable under Creative Commons CC BY 3.0 license. See "Video Image Sources" for citations.*

Each video in our final screened sample contained at least one early literacy or one early math topic. We defined these literacy and math topics using a codebook based on the Head Start Early Learning Outcomes framework for prekindergarten and the Common Core State Standards for kindergarten (see Exhibit 2; National Governors Association Center for Best Practices Council of Chief State School Officers, 2010; Office of Head Start, 2015). In addition, we excluded videos with any of the following characteristics:

- Videos in a language other than English
- Videos obviously not intended for prekindergarten- or kindergarten-age children
- Videos longer than 15 minutes

Final video sample

The final video sample consisted of 1,198 videos: 648 videos with early literacy content (54% of the sample) and 550 videos with early math content (46% of the sample).

The videos in this sample were uploaded to 670 unique YouTube channels.[2] Exhibit 3 presents all channels that produced more than 1% of either the early literacy or math videos in the sample. On average, each channel created 1.8 videos in this dataset, ranging from 1 to 75 videos. The channels that created more videos in this dataset tended have more followers, $r = .08$, $p < .05$. This may indicate that the YouTube algorithm pushed more content from popular channels.

Exhibit 3. Channels that produced more than 1% of the early literacy or math videos in this dataset

Channel	Videos in dataset	Percent of subsample (literacy or math)
Literacy videos n (N=648)		
Jack Hartmann Kids Music Channel	75	11.6%
Alphablocks	17	2.6%
ChuChu TV Nursery Rhymes & Kids Songs	15	2.3%
Rock 'N Learn	13	2.0%
Super Simple ABCs	12	1.9%
Learning Time Fun	11	1.7%
Read Kids	11	1.7%
Scratch Garden	8	1.2%
HeidiSongs	7	1.1%
Kids Academy	7	1.1%
Little Learners	7	1.1%
Teach for Life	7	1.1%
The Sea Star's Virtual Classroom!	7	1. 1%
Math videos (N=550)		
Jack Hartmann Kids Music Channel	22	4%
Kids Academy	20	3.6%
JoAnn's School	12	2.2%
MatholiaChannel	9	1.6%
Learning Time Fun	8	1.5%
Roving Genius	6	1.1%
Scratch Garden	6	1.1%
Smile and Learn – English	6	1.1%

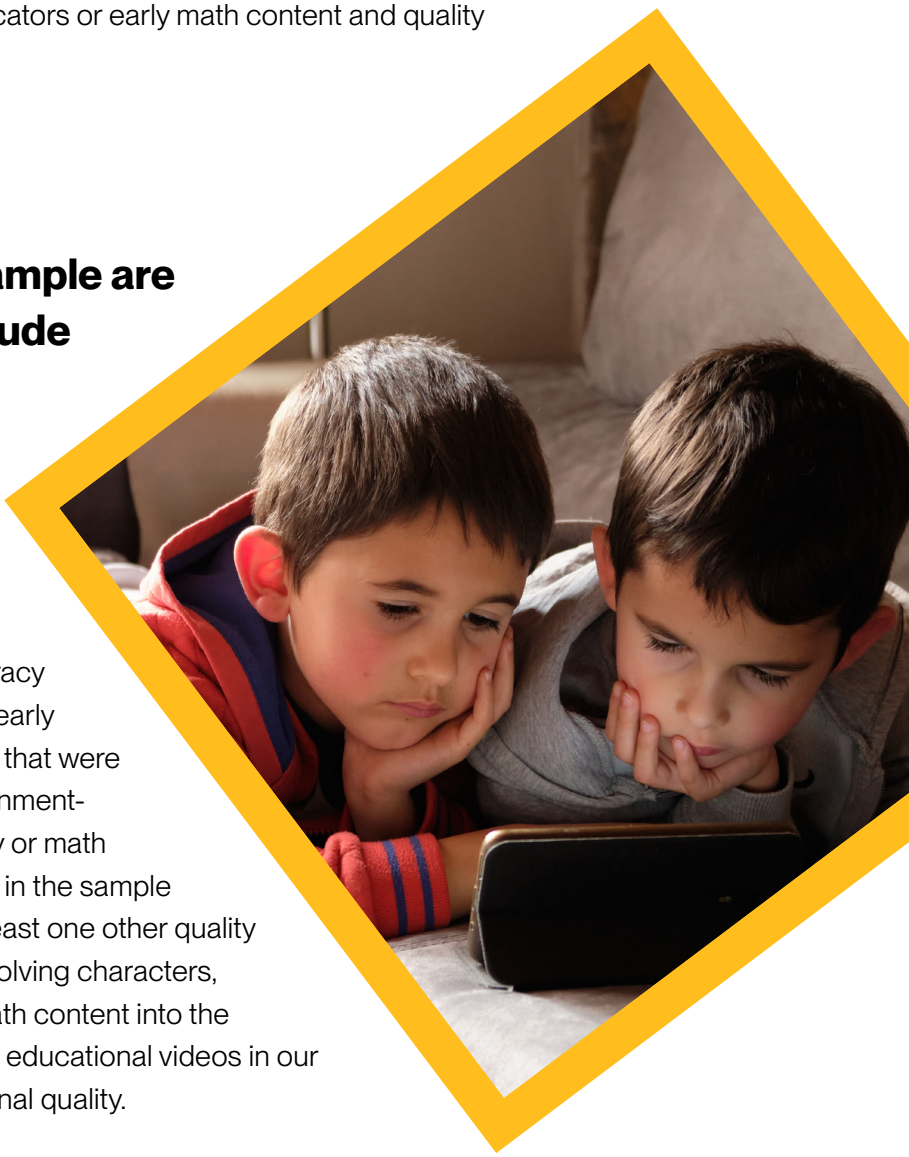
[2] A YouTube channel is the home page for a user's YouTube account, which houses all videos created by that user.

Annotation

We trained a team of three research assistants to use the codebook to assign content categories and quality indicators to each video—a process we refer to as *annotation* (see Appendix A for additional details). Research assistants began annotating on their own (operational annotation) upon reaching at least 80% agreement with an expert annotator on a training set of videos. Research assistants annotated videos from March 2022 to October 2023. Videos were annotated in batches, with annotation of each batch lasting about 4 weeks. To reduce draft during annotation, during each annotation round, research assistants annotated one video per week in common and discussed discrepancies. Research assistants annotated each video for the subject area in which it was screened; that is, videos were annotated for either early literacy content and quality indicators or early math content and quality indicators, but not both.

Results and discussion

Nearly all videos in the final sample are primarily educational and include at least one other indicator of educational quality



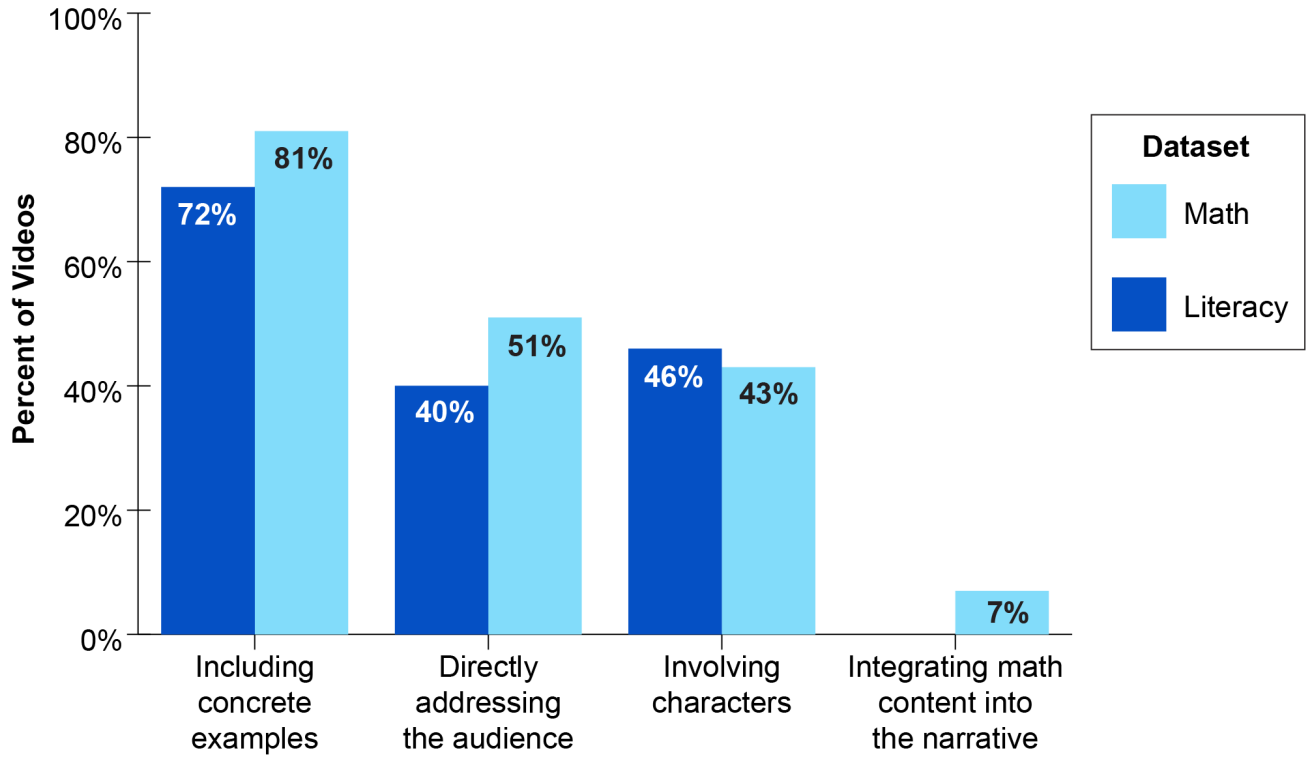
Nearly all (88%) of the videos in our final sample appeared primarily educational in purpose. This is likely a result of our screening process, as the sample only includes videos that both appeared in a search for an early literacy or math keyword and did in fact include some early literacy or math content.[3] Videos in the sample that were not primarily educational tended to be entertainment-focused videos that included incidental literacy or math content. Similarly, nearly all (84%) of the videos in the sample both are primarily educational and include at least one other quality indicator (directly addressing the audience, involving characters, including concrete examples, or integrating math content into the narrative). This result suggests that most of the educational videos in our sample have at least some degree of educational quality.

[3] An example of a video that might have appeared in our search but been screened out is a music video for adults associated with the search term "rhyming."

Concrete examples are the most common quality component in early literacy and math videos; integrating math into the narrative is least common

The channels in our sample used different strategies to teach educational content, as indicated by wide variation in the prevalence of educational quality indicators (Exhibit 4). For example, 81% of early math videos used concrete examples, whereas only 7% of math videos included math content that was integral to the narrative.

Exhibit 4. Prevalence of educational content quality indicators in videos that include early literacy and math content



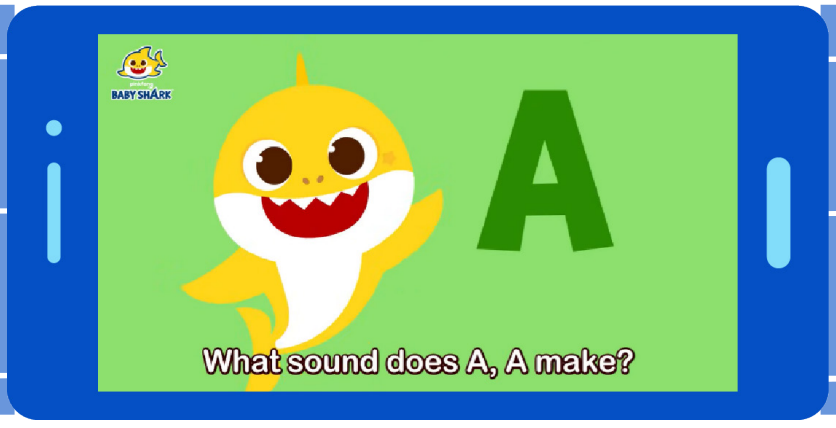
Unsurprisingly, most videos in our sample (72% of literacy videos and 81% of math videos sampled) included **concrete examples**, or examples a child can relate to their own life. For example, most alphabet videos include objects common to many children, such as apples and balls, and many math videos involve counting familiar objects (Exhibit 5). The relative frequency of this quality indicator makes sense: An audiovisual medium requires visuals, and familiar objects are an obvious choice.

Exhibit 5. An alphabet video that uses concrete examples (in this case, "f" for frog)

Note: *Screenshots are from YouTube videos sharable under Creative Commons CC BY 3.0 license. See "Video Image Sources" for citations.*

About half of math videos (51%) and two fifths of literacy videos (40%) **directly address the audience** in relationship to the educational content. Many videos address the audience by asking the child either to sing along with a familiar song such as the alphabet, or to count along (Exhibit 6). Directly addressing the audience may be more challenging in videos that present more complex or less familiar content, or in videos with narratives that do not break the "fourth wall."

Exhibit 6. A counting video that directly addresses the audience by asking them what sound "A" makes



Note: *Screenshots are from YouTube videos sharable under Creative Commons CC BY 3.0 license. See "Video Image Sources" for citations.*

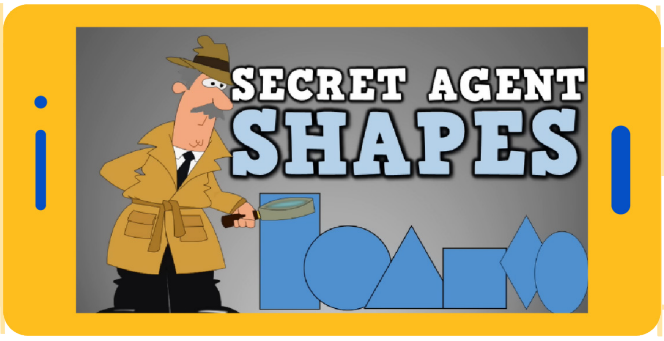
Slightly less than half of videos in this sample (46% of literacy videos and 43% of math videos sampled) include the **involving characters** quality component. Examples of popular characters in educational YouTube videos for children include Blippi, Jack Hartmann, and the Alphablocks (Exhibit 7). That the majority of early literacy and math videos in this sample do not include relatable characters is surprising and may represent a significant departure from educational television programs, which typically include one or more characters. Songs are common examples of educational YouTube videos that do not include characters. For example, an "A is for apple" type of alphabet song might present letters and objects voiced by an off-screen narrator but include no visible characters. These kinds of videos may be simpler to produce than videos with original characters, but research suggests they may be less effective in supporting children's learning (Howard Gola et al., 2013; Lauricella et al., 2011).

Exhibit 7. A video with characters who teach shapes

Note: *Screenshots are from YouTube videos sharable under Creative Commons CC BY 3.0 license. See "Video Image Sources" for citations.*

Few early math videos in our sample (7%) **integrated math content into the narrative** (Exhibit 8). This is likely because few videos on YouTube have a clear narrative arc into which math could be integrated. For example, song-based videos rarely include a narrative. This may be a key difference between online videos and studio-produced educational television programs for children, in which the plot often centers around solving a problem. For example, a prior study found that television programs that teach social-emotional learning frequently use educational content to advance the plot (Christensen & Myford, 2014).

Exhibit 8. An educational video in which a character needs help with a secret mission to find the missing shapes



Note: *Screenshots are from YouTube videos sharable under Creative Commons CC BY 3.0 license. See "Video Image Sources" for citations.*

Sample videos that directly address the audience are less popular, as measured by number of views and likes

We used metadata associated with the videos in our sample to explore the relative popularity of videos that include each educational quality indicator, compared with videos that do not (Exhibit 9). Videos that directly address the audience had fewer views and likes, on average, than videos that do not address the audience. That these videos had fewer views may suggest that the YouTube algorithm recommends them less frequently. That these videos had fewer likes may suggest that viewers find them less engaging. Because these videos break the fourth wall, they may be less narrative-centered and more didactic in structure, and thus children may find them less appealing.

Exhibit 9. Correlations between the presence of four quality indicators and duration, view count, and like count

Quality indicator	View count	Like count
Is primarily educational	-.020	-.056+
Includes concrete examples	.007	.021
Involves characters	-.015	.023
Directly addresses the audience	-.074*	-.093**
Integrates math content into the narrative	-.025	-.030

** p < .05. ** p < .01. + p < .10.*

Sample videos that include more variety of math content tend to have fewer views and likes

While the number of literacy and quality codes in a video was unrelated to number of likes and views in this sample, videos in our sample with more math codes had fewer views and likes, whereas videos with fewer math codes had more views and likes (Exhibits 10 and 11). This finding may indicate both that the YouTube algorithm is more likely to recommend "deep dives" into fewer topics and that parents are searching for specific math topics for their children to watch. That more narrowly focused videos have more likes may suggest that viewers are more likely to enjoy them. Perhaps videos focusing on a smaller number of math topics have more time to devote to other engaging elements, such as music or humor.

Exhibit 10. Correlations between variety of literacy, math, and quality codes and duration, view count, and like count

Variable	View count	Like count
Count of literacy codes	.018	-.035
Count of math codes	-.093*	-.096*
Count of quality codes	-.050+	-.045

** p < .05. + p < .10.*

Exhibit 11. An educational video that includes several math topics such as counting, written numerals, and cardinality (left) and another video that only incorporates one math concept of written numerals (right)

Note: *Screenshots are from YouTube videos sharable under Creative Commons CC BY 3.0 license. See "Video Image Sources" for citations.*

Conclusion

Although young children watch more videos online than on television (Rideout & Robb, 2020), little is known about the characteristics and quality of online educational videos for young children. To sketch this landscape, this study describes a dataset of prekindergarten- and kindergarten-level literacy and math videos on YouTube. In this section, we present key findings and implications for parents, content creators, and researchers.

Fewer than half of the videos in our sample include relatable characters, and only 7% use math skills to further the narrative.

For parents: Whereas most educational television programs include narratives and characters, fewer online educational videos do. There is more rigorous evidence for the learning benefits of high-quality educational television programs than for educational online videos.

For content creators: Educational content creators can distinguish themselves in this crowded field by weaving educational content into narratives with relatable characters.

For future research: To what extent do the inclusion of narratives and characters influence children's learning from educational videos? While prior research has explored the role of familiar versus unfamiliar characters (Howard Gola et al., 2013; Lauricella et al., 2011), less is known about whether the presence versus the absence of narratives and characters influences learning.

Among the educational videos in our sample, those that directly address the audience had fewer views and likes than those that do not.

For parents: Talk with children about what they learn from educational online videos. It can help kids get more out of the videos they watch.

For content creators: Content creators are experts in creating effective calls to action, such as calls to like and subscribe. There is an opportunity to use this expertise to create more engaging calls for children to interact with educational content in videos.

For future research: What is the effect of participatory cues (directly addressing the audience) in short-form videos on engagement, interaction, and comprehension? While some research indicates that participatory cues support children's learning from educational television programs (e.g., Piotrowski, 2014), these cues may function differently on YouTube, where children may have a stronger expectation of passive entertainment and a greater temptation to skip to the next video.

Among our sample of early math videos, those with deeper, rather than broader, topic coverage had more views and likes.

For parents: When searching for math videos for children on YouTube, use keywords specific to a skill your child is working on (e.g., counting) rather than their age or grade level (e.g., kindergarten math), which may yield videos with a broader focus.

For content creators: The algorithm may be more likely to recommend math videos focused on fewer topics than videos focused on a wider range of topics.

For future research: Are there other video characteristics that may explain why videos presenting fewer math topics get more views and likes? For example, do more narrowly focused videos include other engaging elements?

Limitations and Next Steps

One key limitation of our dataset is its context: The dataset was pre-screened to include examples of early literacy or math videos. Our findings may not generalize to videos typically watched by prekindergarten- and kindergarten-age children. More research is needed to describe children's actual content exposure when using YouTube. We intend to use the machine learning algorithm we are developing with these data to describe videos that children watch when browsing YouTube naturalistically.

Until very recently, young children watched most of their educational content in the form of television programs created by major studios. As their screen time shifts online, they are increasingly exposed to user-generated, rather than studio-created, educational videos. There is a great need to understand the content and quality of these user-generated videos as a context for children's early learning and development. Our analyses highlight important ways that user-generated educational videos may differ from educational television programs, including the breadth of creators producing this content and decreased reliance on narratives and characters. In addition, our findings hint at novel influences on the content and quality of online videos, such as the likelihood that the algorithm will recommend a video or that a viewer will like it. More research is needed to guide the creation of effective educational content in this uncharted territory.

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Video Image Sources

Video images included in this report are taken from YouTube videos with Creative Commons licensing. They are not drawn from our annotated sample of videos.

Exhibit 2, Literacy column (top to bottom)

ABC Sounds and Words (Learn Alphabet Letter Sounds and Words) [Video], by English Learning Fun Station, 2021, November 22, YouTube (https://www.youtube.com/watch?v=EEXEg1_OEF4). CC BY 3.0.

ABC Phonics – ABC Letter Sounds – Say It – Sound It – Alphabet Letters for Kids [Video], by Funny Bunny Teacher, 2023, December 6, YouTube (https://www.youtube.com/watch?v=gDNojkrNosE). CC BY 3.0.

How to Learn ABCD Beginning Letter Sound S Words Their comparison With M and R Word [Video], by MOON KIDS tv, 2022, May 29, YouTube (https://www.youtube.com/watch?v=UqlcqU2XTMM). CC BY 3.0.

Phonics Song for Children| Alphabet Song | Letter Sounds | Signing for Babies | Learn Uppercase | #27 [Video], by Learn with Jokjizz, 2023, March 29, YouTube (https://www.youtube.com/watch?v=_BdhScnwlng). CC BY 3.0.

Learn ONCE in This Short Video Kids || Only Sight Words [Video], by KIDS Channel With Titi Bird, 2021, September 17, YouTube (https://www.youtube.com/watch?v=xgbyrSRbXVw). CC BY 3.0.

Read Along Storybook for Kids Ages 2–4 | Monster Love [Video], by Curious World, 2017, May 23, YouTube (https://www.youtube.com/watch?v=ZhvZ-KjQlWE). CC BY 3.0.

Rhyming Two Out of Three [Video], by Teach for Life, 2019, September 22, YouTube (https://www.youtube.com/watch?v=UFs2FKQIFgs). CC BY 3.0.

Exhibit 2, Math column (left to right, top to bottom)

Counting Song [Video], by DaileyKailey, 2021, April 19, YouTube (https://www.youtube.com/watch?v=hPj908UW0iI). CC BY 3.0.

Counting to 10 – Thanksgiving [Video], by The Primary Techie, 2022, October 26, YouTube (https://www.youtube.com/watch?v=zQK7XDKv3W4). CC BY 3.0.

Counting on Fingers [Video], by Teach for Life, 2019, September 22, YouTube (https://www.youtube.com/watch?v=8Qf4SfPLp-s). CC BY 3.0.

Counting Objects [Video], by Teach for Life, 2019, September 25, YouTube (https://www.youtube.com/watch?v=MBPhqzWw0xY). CC BY 3.0.

Flashcards Practice: Ten Frames 02 Numbers 0 to 7 [Video], by Professor Pete's Classroom, 2015, March 7, YouTube, (https://www.youtube.com/watch?v=zsCbkuz4zGk). CC BY 3.0.

Addition for Kids Kindergarten [Video], by Learning Channel for Kids, 2020, November 30, YouTube (https://www.youtube.com/watch?v=Yj0-NexNtZc). CC BY 3.0.

Compare Sizes for Kindergarten – Big and Small [Video], by Learning Channel for Kids, 2020, December 4, YouTube (https://www.youtube.com/watch?v=HCKmOvYJTil). CC BY 3.0.

Sorting by Shape [Video], by Teach for Life, 2019, September 22, YouTube (https://www.youtube.com/watch?v=hjFITU6AEYc). CC BY 3.0.

Position Words [Video], by Teach for Life, 2019, September 22, YouTube (https://www.youtube.com/watch?v=rrnHWXHGVkw). CC BY 3.0.

2D Shapes [Video], by The Primary Techie, 2022, July 13, YouTube (https://www.youtube.com/watch?v=sYxDzQ6URzw). CC BY 3.0.

Learn Shapes in the Jungle | Pinkfong Shape Songs | 15-Minute Learning With Baby Shark [Video], by Pinkfong Baby Shark – Kids' Songs & Stories, 2023, November 25, YouTube (https://www.youtube.com/watch?v=EmUsz5GVWok). CC BY 3.0.

Learning Videos for Toddlers Shapes // FUN #Episode 3 [Video], by Learnkids, 2019, February 18, YouTube (https://www.youtube.com/watch?v=patjOtWL3mE). CC BY 3.0.

Patterns Using Natural Materials [YouTube], by Teach for Life, 2019, September 22, YouTube (https://www.youtube.com/watch?v=3YcNc3uLZoo). CC BY 3.0.

Exhibit 5

ABC Sounds and Words (Learn Alphabet Letter Sounds and Words) [Video], by English Learning Fun Station, 2021, November 22, YouTube (https://www.youtube.com/watch?v=EEXEg1_OEF4). CC BY 3.0.

Exhibit 6

Learn Shapes in the Jungle | Pinkfong Shape Songs | 15-Minute Learning With Baby Shark [Video], by Pinkfong Baby Shark – Kids' Songs & Stories, 2023, November 25, YouTube (https://www.youtube.com/watch?v=EmUsz5GVWok). CC BY 3.0.

Exhibit 7

Learning Videos for Toddlers Shapes // FUN #Episode 3 [Video], by Learnkids, 2019, February 18, YouTube (https://www.youtube.com/watch?v=patjOtWL3mE). CC BY 3.0.

Exhibit 8

Secret Agent Shapes (Song for Kids About Finding Basic Shapes in the Room) [Video], by Harry Kindergarten Music, 2015, June 26, YouTube (https://www.youtube.com/watch?v=7aStqhksCuY). CC BY 3.0.

Exhibit 11 (left to right)

Let's Count With Dinosaurs | Dinosaur Cartoon | Pinkfong Dinosaurs for Kids [Video], by Pinkfong Dinosaurs for Kids, 2023, December 30, YouTube (https://www.youtube.com/watch?v=IaqyUCwRDo0). CC BY 3.0.

Shapes Song | Kids Learning Video | Baby Rhymes & Songs for Children [Video], by Zoobees Kids ABC TV – Baby Songs & Nursery Rhymes, 2019, October 3, YouTube (https://www.youtube.com/watch?v=SS4ntXD10r8). CC BY 3.0.

Appendix A: Video annotation

Training the annotation team

We trained our staff on a process we refer to as *annotation*—using the codebook to assign early literacy and math content categories and quality indicators to videos. Three research assistants with previous experience in early education but no formal background in education research or early childhood media research were trained to annotate videos. The team was trained and led by an experienced education researcher who helped develop the codebook. We trained the research assistants on the kindergarten codebook first and the prekindergarten codebook second. During each training, the three research assistants reviewed the prekindergarten or kindergarten content categories and quality indicators and watched exemplar videos. They were asked to independently annotate a set of 20 videos for prekindergarten and a set of 20 videos for kindergarten. The annotation team lead reviewed the annotations and provided feedback, and the research assistants revised accordingly. The research assistants began annotating on their own (operational annotation) once they reached at least 80% agreement with the lead. To reduce draft during annotation, during each annotation round, research assistants annotated one video per week in common and discussed discrepancies.

Applying the codebook

Research assistants used an online scoresheet to record each video's early literacy or math content. As they watched each video, they checked off any content categories and quality indicators that occurred at least once. The scoresheet then asked follow-up questions about the selected content categories, such as whether the video included related audio and/or visual information. We used this information to verify that the selected content categories met the criteria in the codebook. We used some follow-up items to automatically categorize videos as including either prekindergarten or kindergarten literacy or math content. For example, the *counting* content category is relevant to both prekindergarten and kindergarten standards. The prekindergarten standards focus on counting 0–20 whereas the kindergarten standards focus on counting 0–100. If *counting* was selected as a content code, a follow-up item on the scoresheet asked research assistants to indicate the lowest number in the count sequence so that videos with numbers above 20 will not be identified as containing prekindergarten content. After selecting content categories, research assistants indicated whether any quality indicators were present at least once in the video.

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