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Research Paper

Educational content features of screen media for preschoolers: links with later language, literacy and maths ability

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ABSTRACT

An increasingly prominent environmental influence for young children is their screen media exposure. For preschoolers (children aged 2-5 years), television and video viewing remains the most common type of screen media consumed. In this research we aimed to examine children's natural television viewing habits (i.e., the television shows most frequently watched) at age 2 in relation to later language, literacy, and maths skills prior to school entry (age 4.5). Content viewed by children was coded for inclusion of language, literacy and maths instructional features. Data was collected as part of the longitudinal *Growing Up in New Zealand* study, with data available for 5,338 children and their mothers. Our results provide stronger evidence in favour of children learning language and maths skills than literacy skills from television, although in both cases learning was dependent on a moderated effect. Positive effects of language instructional features on vocabulary and communication were only seen among children from areas of high socioeconomic deprivation. With regards to numeracy skills, higher levels of television viewing were predictive of lower counting skills when children watched content with a low frequency of maths instructional features. Conversely, higher levels of television viewing were predictive of higher counting skills when children watched content with a high frequency of maths instructional features. Literacy instructional features were not associated with child outcomes. Our results indicate that for some children, exposure to educational media may help support the development of language and maths skills, highlighting the importance of high-quality educational media for preschool-aged children.

1. Introduction

Early childhood is a critical period for the development of foundational skills that set children on trajectories towards long-term well-being and educational success (Norris et al., 2019). Optimal development arises from the dynamic interplay of multiple factors within the child's family, home, and societal environments (Bronfenbrenner & Morris, 2006). An increasingly prominent environmental influence for young children is their screen media exposure. For preschoolers (children aged 2-5 years), television and video viewing remains the most common type of screen media consumed (Mann et al., 2025). Parents report that their children begin to pay attention to television at approximately 9 months of age, and that children are generally quite attentive to television by age 2 (Linebarger & Walker, 2005; Schmitt, Woolf, & Anderson, 2003).

Existing research suggests potential for both positive and negative influences of screen use in early childhood. While some research highlights the fact that excessive screen use can disrupt social interactions and physical play, with negative results for child development (e.g. Corkin et al., 2021; Gath et al., 2025; Li et al., 2020; Stewart et al., 2019), other research points to the learning opportunities presented by high-quality, educational media content (e.g., Jing et al., 2023; Mares & Pan, 2013; Watson et al., 2021). Leading health organisations, including the World Health Organization (2019) and the American Academy of Pediatrics (Munzer et al., 2026), recommend limiting screen use for very young children, typically to no more than one hour per day of high-quality programming for children aged 2–5 years. Despite these recommendations, screen media exposure remains a common part of young children's daily lives (Mann et al., 2025). Importantly, when exposure is relatively limited, the *quality and content* of that exposure may be particularly consequential. Understanding what children are watching, and the educational features embedded within that content, may be especially important during this developmental period, as even small amounts of exposure could have meaningful implications for

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learning. In this research, we examined educational content features within preschoolers' television programming in relation to later language, emergent literacy, and maths skills.

1.1. Early literacy and language development

Emergent literacy refers to the skills, knowledge, and attitudes considered to be developmental indicators and pre-cursors to conventional types of reading and writing (Sulzby & Teale, 1991). The components of emergent literacy include language, letter knowledge, phoneme-grapheme correspondence, linguistic awareness, emergent reading, and emergent writing (Whitehurst & Lonigan, 1998). Whitehurst and Lonigan (1998) identify two interdependent sets of skills involved in literacy acquisition: oral language skills and code-related skills. Oral language skills place written language into context to support children's interpretation and understanding of print, while code-related skills are required for the translation of print into sounds and vice versa, in order to make meaning from print symbols. Communication and language skills start developing from birth, while children begin to demonstrate code-related skills such as letter naming and rhyming as early as age 2-3 (Worden & Boettcher, 1990).

In the present study, these conceptual distinctions guide the operationalisation of outcomes. Language skills are indexed through measures of vocabulary and communication, reflecting children's oral language abilities. Emergent literacy is operationalised through code-related skills, including letter knowledge (e.g., letter fluency) and early writing behaviours. This distinction is consistent with theoretical models that emphasise the complementary but separable roles of oral language and code-related processes in early literacy development (Whitehurst & Lonigan, 1998).

1.2. Early understandings of mathematical concepts

Similar to emergent literacy, early maths skills are an integral part of children's school readiness and are strong predictors of later reading and mathematical skills (Duncan et al., 2007; Lonigan et al., 2008). Key mathematical concepts for preschool-aged children include counting and cardinality, patterning, geometry, and measurement and data (Clements et al. 2016a). All of these early skills have been found to be predictive of later mathematical skills, with numeracy (counting and identifying amounts in sets) emerging as the most foundational set of competencies for preschoolers (Clements et al., 2016a; Claessens & Engel, 2013). Basic fundamental concepts such as matching (understanding of "sameness"), grouping of objects together, and ordering or seriation can be observed in children as young as 2-years-old and continue to develop between the ages of 2 and 4 (Bhargava & Kirova, 2002). In line with this framework, early mathematical ability in the present study is indexed through counting skills, which reflect foundational numeracy competencies that underpin later mathematical learning.

1.3. Learning from educational television

Since the advent of educational television for children in the 1960s, research studies have been used to examine the efficacy of educational media for children's learning (Huston & Wright, 1998). Although the results are mixed, there is a general consensus that children can and do learn from educational television (i.e., programming designed to intentionally or incidentally educate or enlighten; Kirkorian & Anderson, 2008). To date, more research has examined associations between children's television and oral language skills than code-related skills. Existing research suggests that young children can learn specific words featured within educational media content, and that children who watch educational television programs have higher expressive language vocabularies (Linebarger, 2006; Wright et al., 2001; Pasnik et al., 2007). Less research has examined children's code-related skills in relation to educational television content; however, there is some research to suggest that exposure to television programming designed to explicitly teach code-related skills can support children's gains in recognizing the initial sounds in words, sound awareness, and blending, key elements contributing to reading achievement (Prince et al., 2002; Linebarger, 2006; Pasnik et al., 2007). Studies in this area have largely focused on a single television program that has been specifically developed as an "educational" program, with most research in the field examining *Sesame Street* (e.g., Fisch, 2005; Fisch & Truglio, 2001; Kearney et al., 2019; Mares & Pan, 2013), *Between the Lions* (e.g., Jennings et al., 2009; Linebarger et al., 2004; Prince et al., 2002) or *Blue's Clues* (e.g., Anderson et al., 2000; Bryant et al., 1998; Bryant et al., 1999; Crawley et al., 1999)

Compared to the literature examining children's language and literacy learning from educational television, there is a paucity of research on children's mathematical learning from television. A thesis by Perkins (2024) coded the presence of math concepts in two popular television shows, *Bubble Guppies* and *Bluey,* focusing on the concepts of: geometry and spatial sense, measurement, numbers and operations, displaying and analysing data, and pattern and algebraic thinking. It was found that each type of concept appeared at least once per episode of *Bubble Guppies*, but most of the conceptual categories appeared at frequencies of less than once per episode for *Bluey*. Geometry and spatial sense was the most coded conceptual category across both shows (Perkins, 2024). However, this research examined only frequency of math concepts and did not extend to examine associations with child learning.

Two studies suggest that toddlers' learning of seriation (ordering of objects from smallest to largest) from television can occur when children are familiar with the television character, but is unlikely to occur when children are not familiar with the television character (Howard Gola et al., 2013; Lauricella et al., 2011). While there are recent examples of television programs designed to teach preschoolers math concepts (e.g., *Team Umizoomi, Numberblocks, Peg + Cat;* Jensen, 2010; Moorthy, 2014; Morgan, 2025) there is little research examining whether preschoolers actually learn mathematical concepts from television. Available research on *Peg+Cat* (Moorthy, 2014) involved sessions in which children watched videos as well as playing games and activities related to the video ("transmedia"), making it impossible to know whether children would learn from the video content itself without the aligned activities. It is clear that further research is needed to understand the extent to which popular television programming for preschoolers includes mathematical concepts and whether this content is effective in developing preschoolers' mathematical skills.

While prior research has demonstrated that children can learn from educational television, less attention has been paid to the *specific instructional features* within programs that may support this learning. Educational content is not a unitary construct; rather, it is conveyed through a range of features such as direct address, prompting, repetition, labelling, and opportunities for viewer participation. These features may operate as instructional supports that scaffold children's attention, comprehension, and engagement, drawing on principles consistent with broader theories of learning such as guided participation and active processing. For example, directly addressing the viewer and prompting responses may encourage active engagement, while repetition and labelling may support encoding and retention of new information. Indeed, prior research has noted that programs associated with positive language outcomes (e.g., *Blue's Clues, Dora the Explorer*) frequently incorporate such strategies (Linebarger & Walker, 2005), yet these features have rarely been systematically quantified across children's natural viewing environments or linked to later developmental outcomes.

1.4. Moderated effects of educational television

In addition to the direct effects outlined above, whereby children learn specific cognitive or academic skills, there are also indirect effects of educational content features within television programming that might influence child outcomes. These indirect effects operate through influencing motivation or by modelling desirable behaviors that facilitate children's functioning within academic environments. For example, children exposed to high levels of educational programming devote more time to reading and educational activities (Wright & Huston, 1995) and viewing educational programs in early childhood is suggested to result in differences in academic motivation and self-concept (e.g., viewing oneself as smart and capable in academic domains; Anderson et al., 2001). To have a meaningful influence over motivation, interests, and behavior, children likely need to be exposed to a certain extent of educational content. In this way, the amount of television exposure could moderate the impact of educational content on child learning, with stronger effects at higher "dosages" of high-quality television exposure (e.g., Mares & Pan, 2013; Wright et al., 2001).

Baydar et al (2008) suggest that there will be variability in the effects of educational television content based on characteristics of the child or their environment. Specifically, Baydar and colleagues outline two potential types of non-linear effects: *supplementary effects* of educational television, in which children from advantaged developmental ecologies (e.g., high socioeconomic status) benefit more from educational television; or *compensatory effects,* in which children with low levels of skills and from disadvantaged ecologies (e.g., low socioeconomic status) benefit more from educational television than others. In general, research has found compensatory effects, with educational television having more benefits for children with lower levels of skills and from socioeconomically disadvantaged backgrounds (e.g., Baydar et al., 2008; National Center for Education Statistics, 1999) but in some cases these effects are not observed (e.g., Linebarger et al., 2004).

1.5. *Longitudinal studies of children's natural viewing*

Previous studies demonstrating the benefits of educational television have largely focused on either specific television programs developed with the explicit intent of supporting educational skills (e.g., *Sesame Street, Between the Lions*; e.g., Fisch, 2005; Jennings et al., 2009) or have used experimental paradigms that involve manipulating video segments to compare the impacts of differences in visual information, timing, dialogue, or other presentational aspects (e.g., Fisch et al., 2001; Carter et al., 2017; Pasnik et al., 2007). Thus, this research tells us that children *can* learn from educational content, but not whether children *do* learn from television through their natural viewing behaviors. Less research has examined children's natural viewing to understand the extent to which educational features are included within the most popular shows for children, and which specific content features are most predictive of educational outcomes. In the present research, we were interested in understanding whether the ways in which children are actually watching television are resulting in beneficial outcomes for their educational skills.

A small number of longitudinal studies have examined the educational content of children's natural television viewing in relation to their later language or emergent literacy skills. Linebarger and Walker (2005) examined cumulative exposure to 9 different television programs watched by preschoolers when they were aged 6 through 30 months of age. After controlling for child and family background characteristics, the researchers found that watching *Blue's Clues* and *Dora the Explorer* was associated with a higher vocabulary at 30 months, while *Barney & Friends* and *Teletubbies* was associated with a lower vocabulary at 30 months. Linebarger and Walker (2005) highlight the fact that both *Blue's Clues* and *Dora the Explorer* use particular strategies designed to promote language production and vocabulary acquisition, such as speaking directly to the child, actively eliciting participation including opportunities to respond, and labelling objects. In another longitudinal study, Wright and colleagues (2001) examined television viewing over a three-year period (from ages 2-5 or 4-7) in children from low- to moderate-income families. Television programs were classified into one of four categories based on whether they were aimed at children vs a general audience, whether they were educational, and whether they were animated. Results indicated that a higher frequency of viewing child-directed educational programming at age 2 and 3 was associated with higher scores on subsequent letter-word skills, number skills, receptive vocabulary, and school readiness (at age 5). Wright et al (2001) found that early environmental television exposure at age 2 was a better predictor of later school readiness and vocabulary outcomes than concurrent viewing suggesting the critical, formative nature of television viewing at this age.

Despite evidence that children can learn from educational television, several key gaps remain. First, relatively little is known about the extent to which the television programs that children naturally watch contain educational content, particularly with respect to specific instructional features embedded within programming. Second, while prior research has linked exposure to educational programming with language and literacy outcomes, less is known about how variation in specific content features relates to children's learning across multiple domains, including mathematics. Third, it remains unclear which types of educational content features are most strongly associated with developmental outcomes, and whether these associations vary depending on children's level of exposure or broader contextual factors. Addressing these gaps is important for understanding not only whether children learn from television, but *how* and *under what conditions* such learning may occur.

1.6. *Research objectives*

Building on existing research, the present study examines children's natural viewing habits (i.e., the television shows most frequently watched, as reported by their mothers) at age 2 in relation to later language, literacy, and maths skills just prior to school entry. Specifically, the study aims to:

1. Examine the extent to which popular children's television programs include educational content, including features aimed at supporting language, literacy, and maths skills
2. Investigate the associations between exposure to educational television content and later language, literacy, and maths skills, and to test whether these associations are moderated by the amount of television exposure and socioeconomic status.
3. Identify which specific educational content features are most strongly associated with children's learning outcomes.

Together, these aims allow for a more nuanced understanding of how the content and context of early television exposure may contribute to children's developmental outcomes.

2. Methods

2.1. *Sample*

Data was collected as part of the prospective, longitudinal *Growing Up in New Zealand* study (Morton et al., 2010; 2013; 2015), which has been following over 6,000 children since before birth. The present analysis included data collected when children were aged 2-years-old and aged 4.5-years-old. When the children were aged 2 ($M_{\text{age}} = 2.07$, $SD = 0.16$; interquartile range 1.98 – 2.09), data was available from 6, 327 children and their mothers. At age 4.5, data was available for 6,156 children and their mothers (97.3% retained between assessment points). In New Zealand, children start school on their 5$^{\text{th}}$ birthday and thus the age 4.5 assessment occurred prior to the start of formal schooling. At both assessment points, Computer Assisted Personal Interviews (CAPI) were undertaken with the child's mother by trained interviewers, most often in the child's home. In addition, at both assessment points developmental assessments of children were conducted by the trained interviewers. The study was conducted according to the guidelines of the Declaration of Helsinki, and was approved by the New Zealand Health and Disability Ethics Committee before every data collection wave.

The sample at age 2 was 51.6% male. The ethnicity of the children was 64.8% European, 17.9% Māori, 15.4% Pacific Island, and 15.0% Asian (participants could report multiple ethnic affiliations). Socioeconomic deprivation, as measured using the New Zealand Deprivation Index deciles (NZDep; Atkinson et al., 2019), was relatively well-distributed, with 27.4% of the sample from areas of low deprivation (deciles 1-3), 36.7% from areas of mid deprivation (deciles 4-7), and 35.9% from areas of high deprivation (deciles 8-10).

2.2. Measures

2.2.1. Exposure to educational television content

When children were aged 2, mothers were asked: *"Thinking about the last weekday, i.e. [YESTERDAY/LAST FRIDAY], how many hours did [CHILD NAME] spend at home watching all types of TV, DVDs, and videos?"* Mothers could either select "None" or report the total number of hours. When mothers reported anything other than None, they were asked the follow-up question of: "*Could you please name the three TV programmes [CHILD NAME] watches most?*" A list of 17 popular television shows for young children was provided to select from, as well as three open text boxes to write in television shows not included on the list. These open text responses were coded and the top 23 shows (out of the listed options and the open text responses) were put forward for analysis. However, publicly available episodes could not be sourced for one of the programs, The Go Show, so this program was not coded and was excluded from analysis. Thus, 22 television programs were included in the final analysis.

For each television show, 60 minutes of content was coded, ± 10 minutes to ensure only full episodes were included. To select 60 minutes of content per show, a research assistant generated a list of episodes from the chosen television shows and a random number generator was used to select episodes from the list. If a video file for a selected episode could not be found or was incomplete, the next closest episode (in chronological order) was selected. As the age 2 assessment of the GUINZ sample took place in 2012, wherever possible episodes included were those first aired in 2012. If the show did not air episodes in 2012, episodes from the closest year prior to 2012 were included, under the assumption that episodes that aired prior to 2012 would have re-run in 2012.

The coding scheme for educational instructional features is provided in Table 1. A full description of the development and validation of the coding scheme is provided in Gath et al. (2026). In brief, language and literacy instructional features were adapted from Linebarger et al. (2017) and maths instructional features were adapted from Outhwaite et al. (2023)'s framework for analysing mathematics applications. Coding was frequency-based, with a running tally for each instance of an instructional feature. Using the total video length, the rate of educational strategy use (e.g., number of educational features per minute) was calculated. Coding for the maths domain was grouped into subdomains of mathematical concepts and totalled at the sub-domain level. Two research assistants were trained on the coding scheme, and preliminary coding was undertaken using episodes outside of the analysis sample until interrater agreement of at least 80% was achieved. One research assistant then served as the primary coder and scored all episodes within the analysis sample. The second coder scored 20% of all selected episodes for the purpose of calculating interrater reliability (Gwet, 2012). Interrater reliability was assessed as the Intraclass Correlation (*ICC*) between the two coders. Reliability was high for language features ($ICC = 0.95$) and maths features ($ICC = 0.88$) but moderate for literacy features ($ICC = 0.65$).

After calculating the rate of educational strategy use for each television show, we next calculated each child's rate of exposure to educational content by averaging across the child's most watched

Table 1
Coding categories of educational instructional features.

Educational Domain	Instructional Features	
Language	1. *Matched labelling objects/actions* was coded whenever the name of an object or action was presented onscreen, including simple naming using one word (e.g., "ball") or more detailed (e.g., "This is a red ball"). Includes characters introducing themselves and other characters (if directed to the viewer). Object or character must be on screen when labelled. 2. *Summary* was coded for any language and/or visual presentation that provided a summary of relevant prior knowledge that learners had learned in a previous lesson. 3. *Proto-conversational strategies* was coded when a character looked directly at the viewer and spoke or asked a question, or if the narrator asked a question. Also included instances of praise and reinforcement, when a character praised or commented positively about or to the audience (e.g., "You are working hard", "Great work"). 4. *Verbal vocabulary definition* was coded when the meaning of a word was explicitly provided.	
Literacy	1. *Onscreen print focus* was coded when there was a clear visual focus on print (excluding credits). This included: when characters interacted with the print in some way; when a visual technique was accompanied print onscreen and was used to draw attention to the font including print movement (e.g., print flies across the screen) and visual production technique (e.g., print flashes or is highlighted). 2. *Alphabet/letter identification* was coded when a character or narrator specifically named a letter (e.g., "This is the letter W") or recited the letters of the alphabet in sequential order. 3. *Spelling* was coded when a character or narrator verbally spelled out the letters in a word or phrase (in some instances accompanied by the onscreen letters). 4. *Phoneme letters and sounds* was coded when specific letter sounds or parts of words were emphasized by a character or narrator alongside onscreen print. 5. *Storybook* was coded when onscreen print was embedded within a storybook presented on the television.	
Math Concepts	Number representation and relationships	1. Number representation with Arabic digits (symbolic), verbal, or written number word recognition. 2. Transcoding between Arabic digits and number words. 3. Recognition of number of items within a set (i.e., subitising). 4. Comparison of magnitude of symbolic (i.e., 5 is less than 8) and non-symbolic number (i.e., 5 dots is less than 8 dots). 5. Mathematical language, relating to more/less, before/after, most/least, equal to. 6. Position of numbers on a number line (e.g., 0-10, 0-20, and/or 0-100). 7. Number bonds to 10 and/or 100. 8. Odd and even numbers.
	Counting	1. Support for one-to-one correspondence. 2. Counting sequence (in ones) forwards and backwards to 10, 20 and/or 100. 3. Support for cardinality- the last number counted represents the set. 4. Counting of a range of different objects (i.e., understands oneness, twoness, threeness with abstraction principle). 5. Counting on from a specified number (e.g., count from 5 to 8). 6. Skip counting (e.g., in twos, threes, fives, and/or tens). 7. Given a number, identify one more and one less.
	Arithmetic	1. Arithmetic calculation including addition and subtraction, and any more complex calculations. 2. Familiarisation with arithmetic (e.g., + - =) and/or mathematical symbols (e.g., < >) and associated language (e.g., add, take-away, equals, more than, less than).
	Shape, Patterns, and Measurement	1. *Shape:* 2D and/or 3D shape recognition. 2. *Shape:* Understanding of 2D and/or 3D shape properties (e.g., triangle has 3 corners, line of

(*continued on next page*)

Table 1 (*continued*)

Educational Domain	Instructional Features
	symmetry).3. *Shape:* Manipulate shapes to make and/or decompose other shapes. 4. *Patterns:* Recognise and continue patterns with shapes and/or objects (i.e., not number). 5. *Patterns:* Order objects in a set (i.e., first, second, third). 6. *Patterns:* Sequence of events in chronological order. Needs to include sequence, i.e. 'we found the first clue, time to find the second clue' not enough to just mention the 'first clue'. 7. *Measurement:* Compare or group sets of objects on a defining feature (e.g., all the blue balls). 8. *Measurement:* Mathematical language relating to length, height, weight, capacity, spatial position (e.g., left, right, top, bottom), money, and time. 9. *Measurement:* Use of measurement units (e.g., m/cm, kg/g, litres/ml, £/p). Can include non-standard measurement (i.e. in Blue's Clues, Steve measured distance using 'Steve Steps'), or time using number of sleeps.

shows. This process is depicted in Fig. 1. Mothers were asked to report their child's three most watched television shows, and for more than half of children all three of their favourite shows were within the 22 that were coded (n = 2,770 three shows; n = 1683 two shows; n = 885 one show). Rate of exposure for each child was calculated based on the number of television shows with coded data available for that child. For children with only one or two television shows in our sample of coded shows, their estimate of exposure is based on those one or two shows rather than across all three.

2.2.2. Maternal education

Maternal education was assessed by asking mothers to select their highest completed qualification from: No secondary school qualification, Secondary school, Diploma/Trade certificate, Bachelor's degree, or Higher degree.

2.2.3. Time spent watching television

When children were aged 2, in addition to reporting their child's favourite television shows, mothers also reported on their child's screen time in hours. Mothers were first asked: *Thinking about the last weekday, how many hours did [CHILD] spend at home watching TV, DVDs, or videos?* They were then asked a follow-up question of: "*Of this time, how much was spent watching just children's television programming, including free-to-air and pay TV, and children's TV programmes on DVD, but not children's movies on DVD*". We used responses to this second question as our measure of children's total TV time.

2.2.4. Child vocabulary at age 2

Child vocabulary at age 2 was assessed using the short form of the MacArthur-Bates Communicative Development Inventory (CDI; Fenson et al., 2000). Mothers reported on whether or not children could say each of a list of 100 words (such as dog, car, no, mum, hi, and 'uh oh'). The list of words could be administered in six languages: English, Māori, Samoan, Tongan, Cantonese, or Mandarin. See Reese et al (2015; 2018) for further information about the translation of the scale and psychometric properties.

Total scores were calculated by tallying the total number of 'yes' responses out of 100. If the list of words was administered in multiple languages (e.g., English and Māori), total scores were calculated by tallying the lists across languages. In this case, total scores remained out of 100, but children received a point for each word that they could say in at least one language.

2.2.5. Parenting at age 2

Home environment factors examined when children were 2 years old were protective parenting and harsh discipline. These factors were selected based on previous research linking these characteristics to both children's screen time as well as aspects of screen content quality (e.g., Cárdenas-Fuentes et al., 2022; Howe et al., 2017; Mann et al., 2025; Trinh et al., 2020; Zhang, 2025). Mothers reported on a total of eleven items using a 5-point Likert scale ranging from 1 (Never) to 5 (Very often). *Protective parenting* was measured with four items, including how frequently mothers: attempt to shield their child from life's challenges; prioritise the child's needs over their own; feel distressed when leaving the child with others regardless of familiarity; and allow the child to take risks in the absence of serious safety concerns (reverse coded). These items were combined to form an overall protective parenting score.

Harsh discipline was assessed using seven items, which asked how often mothers engaged in specific responses when the child misbehaved, including ignoring, smacking, shouting, using time-out, removing treats, telling the child off, or offering sweets/treats as a bribe. Each item was rated on the same 5-point scale, and a total harsh discipline score was calculated by summing across all seven items. McDonald's omega for both scales showed moderate consistency (protective parenting: ω = 0.50; harsh discipline: ω = 0.64).

2.2.6. Child outcomes at age 4.5

Vocabulary. An adapted version of the Peabody Picture Vocabulary Test 3rd Edition (PPVT-III; Dunn et al., 1997) was used as a measure of

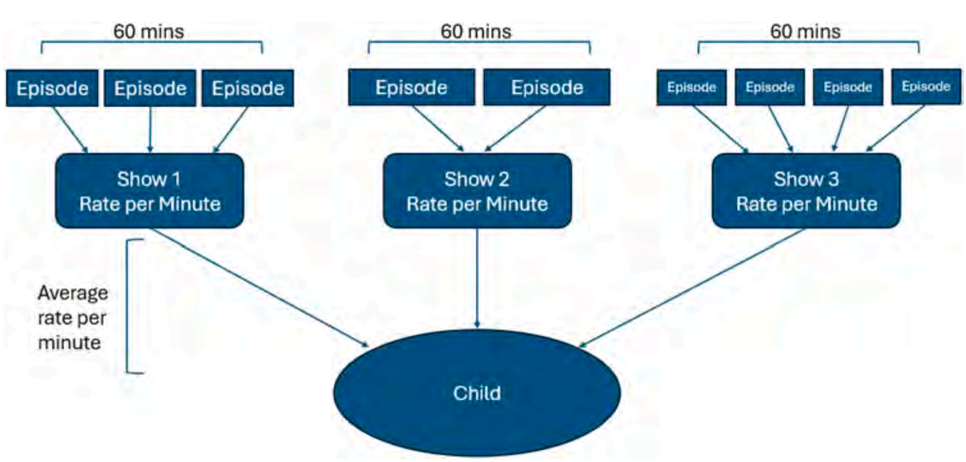

Fig. 1. Calculation of rate of exposure to educational features within television viewing.

children's receptive vocabulary. This adapted version is based on work done for the Head Start Impact Study, and includes some word modifications for use in Australia (Rothman, 2005). Children were presented with a series of black-and-white line drawings and prompted to select the drawing that best corresponds to a stimulus word spoken by the examiner. The adapted version comprises a selection of 40 items. We used latent factor scores on the PPVT as our measure of vocabulary. The psychometric properties of the PPVT have been established in a New Zealand sample, including test-retest reliability (0.61-0.89), alternate forms reliability (0.89-0.90), and convergent validity (Reese & Read, 2000).

Communication skills. Children's communication skills were assessed using the five-item Parent Rating of Oral Language and Literacy (PROLL; Dickinson et al., 2001). The first two items were rated on a 4-point scale ranging from Never to Often: *How often does your child try out new words?* and *How often is your child understandable when speaking to adults other than you or other family members?* The remaining three items were rated on similar 4-point scales appropriate to the question asked: *Which of the following best describes your child's pattern of asking questions?* ("Never or rarely asks adults questions" to "Often askes adults interesting or long questions"); *Which of the following best describes your child's ability to communicate personal experiences in a clear and logical way*? ("Very tentative, only offers a few words" to "Tells experiences in a way that is nearly always complete, logical and understandable"); *Which of the following best describes your child's ability to communicate when they are not first understood?* ("Never continues trying" to "Will work hard to be understood"). A mean score was calculated across the 5 items as a measure of children's oral communication skills ($\omega = 0.51$).

Writing. Children's early writing skills were assessed with two tasks from the 'Who Am I'? Developmental Assessment used by the Longitudinal Study of American Children (LSAC; de Lemos & Doig, 1999). In these tasks, children were asked to write their name and then write some numbers. Each writing task was scored on a scale from 0 to 4 according to the standard scoring manual (Rothman, 2005), and a total writing score was calculated by summing the two task scores (correlation between tasks was $r = .47$). Reliability estimates for these writing tasks range from 0.87 to 0.91 (de Lemos & Doig, 1999).

Letter fluency. Letter knowledge was assessed with the Letter Naming Fluency subtest from the Dynamic Indicators of Basic Early Literacy Skills (DIBELS). This subtest assessed children's knowledge of letters, their ability to verbally say or name the letters, and letter naming speed. This scale has previously been validated with New Zealand children, with inter-rater reliability coefficients over 0.90 (Schaughency & Suggate, 2008). An overall letter fluency score was calculated as the total number of letters correctly named in a 1-minute period.

Numeracy. Two tasks from the 'Who Am I'? Developmental Assessment were also used to assess children's numeracy skills (de Lemos & Doig, 1999). Interviewers asked children to first count from 1 to 10, and then to count down from 10 to 1. Both counting tasks were scored according to the number of correct responses in the longest number sequence achieved by the child (i.e., without any interruptions or inclusion of other words/numbers). The sum of the scores on the two counting tasks was used as the total score of numeracy (correlation between tasks was $r = .38$).

2.3. Statistical analyses

All analyses were conducted using R (version 4.5.2). Descriptive statistics were first computed to characterise children's television viewing patterns and the frequency of instructional content features across programs. Instructional features were coded as rates per minute and aggregated to create domain-level scores (language, literacy, and maths) as well as a total educational content score.

To examine differences in exposure to educational media content across sociodemographic and home environment characteristics, independent samples *t*-tests were used for categorical variables (child gender), and Pearson correlations were used for continuous variables (maternal education, socioeconomic deprivation, and parenting measures). Given the large sample size, effect sizes (Cohen's *d* and *r*) were used to guide interpretation of meaningful effects.

Bivariate associations between educational media content and child outcomes were assessed using Pearson correlations. To examine longitudinal associations, a series of multiple regression models were estimated predicting child outcomes at age 4.5 from exposure to educational media content at age 2. Models included controls for child gender, maternal education, socioeconomic deprivation, parenting variables, total screen time, and baseline vocabulary at age 2. Outcome variables were standardised (z-scores) prior to analysis.

Multivariate multiple regression models were used when predicting multiple related outcomes simultaneously (i.e., language and literacy domains), while standard linear regression models were used for single outcomes (i.e., numeracy). Interaction terms were included to test whether associations between educational media content and child outcomes were moderated by total screen time and socioeconomic deprivation. Where significant interactions were identified, simple slopes were examined and Johnson–Neyman regions of significance were calculated to probe the nature of these effects. Missing data was handled with listwise deletion.

Finally, to examine the unique contribution of specific instructional content features, regression models were estimated including individual feature variables within each domain (language, literacy, and maths), while controlling for the same set of covariates. Both predictors and outcomes were standardised prior to these analyses.

2.4. Transparency and openness

Data and research materials used in this study are available through an application process at https://www.growingup.co.nz/. Data were analyzed using RStudio, version 2024.04.2. Analysis code for this study are available by emailing the corresponding author. This study was not preregistered.

3. Results

Using the top 22 most frequently reported TV programs, there were 5,338 children at age 2 with at least one of these shows reported as one of their top three favourite shows ($n = 2{,}770$ three shows; $n = 1{,}683$ two shows; $n = 885$ one show). Children whose three shows were all within the coded sample were higher in socioeconomic deprivation (p's $< .003$), lower in maternal education (p's $< .001$), and spent more time watching television (p's $< .02$) than children with only one or two shows available.

There were 939 children with no data on their favourite TV programs. Of these, 546 (8.6% of the total sample) were reported to not watch any TV or movies, and 443 (7.0% of the total sample) were either missing data or said they did not know their child's favourite TV shows. Within the 5,338 children with coded television show data available, there were 5,018 with educational outcome data available at age 4.5 (94.0%). Our examination of the presence of instructional features in television content and sociodemographic characteristics associated with viewing educational television includes the sample of 5,338 children at age 2, and our analysis of associated outcome variables at age 4.5 includes the sample of 5,018 children with follow-up data available. Note that this means our analysis was necessarily restricted to children who watched television.

Within this sample of children who watched television, mothers reported that children watched an average of 1.64 hours ($SD = 1.35$) of television, DVDs, or videos per day at age 2. Of this, time spent watching children's television programming averaged 1.34 hours ($SD = 1.11$) per day.

3.1. RQ1: to what extent do popular children's television programs include educational content?

Instructional content features were coded on their frequency and then calculated as a rate per minute. Fig. 2 shows the mean rates of each instructional feature across the 22 shows. Language instructional features were most frequent, with labelling and proto-conversational features emerging as the two most frequent types of educational content. Literacy features were least common, with the most common form of literacy content being onscreen print focus. Across all episodes coded in this analysis, there were no instances of the use of storybooks. The most frequent forms of maths instructional content were numbers, counting, and measurement. The error bars showing standard deviations in Fig. 2 indicate that there was substantial variability among shows. In other words, while some rates are low overall, this is often a result of a substantial number of shows having no instances of a strategy. Correlations among all content features are provided in Appendix A.

For our first set of analyses, we examined instructional features at the domain level (language, literacy, and maths) as well as total educational content scores before later moving on to examine the effects of specific content features. The combined domain scores represent the total rate per minute of each of language features, literacy features, and maths features. Table 2 provides a list of the 22 TV shows included in analysis ranked according to the frequency of language, literacy, and maths instructional features, as well as overall rankings (across all three domains).

3.2. RQ2: is exposure to educational television content associated with later language, literacy, and maths skills?

We next aimed to investigate the associations between exposure to educational television content and later language, literacy, and maths skills, and to test whether these associations were moderated by the amount of television exposure and socioeconomic status. We first examined child and family differences in exposure to educational screen content before running regression models to examine linear and moderated effects of content exposure on child outcomes.

3.2.1. Child and family differences in exposure to educational screen content

We first examined whether exposure to educational media content differed based on children's sociodemographic characteristics and home environment. The sociodemographic characteristics examined were child gender, maternal education, and socioeconomic deprivation. Home environment factors examined were protective parenting and harsh discipline.

Independent samples t-tests were used to compare educational media scores (language, literacy, maths, and total educational scores) based on gender. Correlation coefficients were used to examine associations between these educational media scores and maternal education, socioeconomic deprivation, protective parenting, and harsh discipline. Given our large sample size, we used the thresholds of Cohen's $d \geq 0.20$ and $r \geq .10$ to indicate meaningful effects (Cohen, 1992; Hemphill, 2003).

There were significant gender differences across all domain scores as well as total educational content scores [total scores: $t(5275) = 15.15$, $p < .001$; Males ($M = 1.98$, $SD = 0.96$), Females ($M = 2.45$, $SD = 0.99$; Cohen's $d = 0.48$]. Across all domains, girls were exposed to higher levels of educational media content than boys.

Educational media content exposure was not associated with maternal education (all $r < |.02|$), socioeconomic deprivation (all $r < |.06|$), protective parenting (all $r < |.02|$), or harsh discipline (all $r < |.03|$) Thus, aside from gender, children's exposure to education content features at age 2 did not depend on demographic or parenting factors.

3.2.2. Associations between educational media content and child outcomes

Table 3 provides the bivariate correlations between educational media content variables and child language, literacy, and numeracy outcomes at age 2 and age 4.5. As seen in Table 3, children's educational media content scores were not associated with their language, literacy or numeracy skills. This finding is not entirely unexpected, given our expectation that the association of educational media content with child outcomes could be moderated by either the amount of exposure to media content or by socioeconomic deprivation.

Table 4 provides the correlations between aspects of the child's home environment (maternal education, socioeconomic deprivation, parenting), screen exposure (total number of hours per day the child spends at home watching children's television programming), and child outcome variables. As seen in Table 4, higher levels of maternal education were associated with higher levels of child language, literacy, and numeracy, while higher levels of socioeconomic deprivation were associated with lower skills across all areas. Overprotective parenting and the amount of time children spent watching media were both negatively associated with child vocabulary at both age 2 and age 4.5.

We ran a series of multiple regression models to predict child

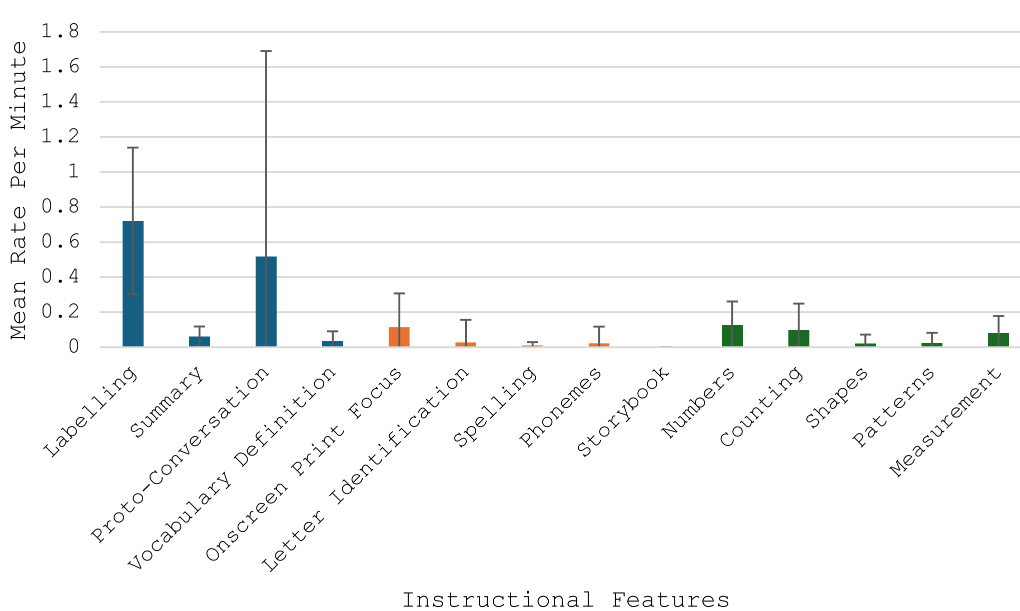

Fig. 2. Mean rate of educational instructional features in children's television shows.

Table 2
Rankings of Educational Programs based on Frequency of Instructional Features.

	Language		Literacy		Maths		Total Educational Score	
Ranking	Program	Score	Program	Score	Program	Score	Program	Score
1	Dora the Explorer	4.00	Tiki Tour	0.95	Hi-5	0.98	Tiki Tour	5.31
2	Tiki Tour	3.75	The Wiggles	0.70	Sesame Street	0.87	Dora the Explorer	4.46
3	Blue's Clues	3.45	Blue's Clues	0.42	Mickey Mouse Clubhouse	0.82	Blue's Clues	4.31
4	Little Einsteins	3.10	Sesame Street	0.27	Tiki Tour	0.60	Little Einsteins	3.86
5	Mickey Mouse Clubhouse	2.24	Little Einsteins	0.25	The Wiggles	0.57	Mickey Mouse Clubhouse	3.15
6	Bubble Guppies	1.92	SpongeBob SquarePants	0.20	Little Einsteins	0.51	The Wiggles	2.79
7	The Wiggles	1.52	Chuggington	0.12	In The Night Garden	0.46	Sesame Street	2.58
8	Sesame Street	1.44	Mickey Mouse Clubhouse	0.10	Dora the Explorer	0.45	Bubble Guppies	2.39
9	Wonder Pets	1.23	Hi-5	0.08	Blue's Clues	0.43	Hi-5	2.09
10	Hi-5	1.03	Thomas the Tank Engine	0.08	Bubble Guppies	0.40	Wonder Pets	1.38
11	The Wot Wots	1.03	The Wot Wots	0.08	Handy Manny	0.31	The Wot Wots	1.19
12	Bob the Builder	0.97	Bubble Guppies	0.08	Chuggington	0.30	Bob the Builder	1.18
13	Barney	0.49	Wonder Pets	0.08	Barney	0.22	Handy Manny	0.84
14	Thomas the Tank Engine	0.47	Handy Manny	0.06	Bob the Builder	0.18	Chuggington	0.79
15	Handy Manny	0.47	In The Night Garden	0.05	Postman Pat	0.18	Barney	0.74
16	Chuggington	0.38	Postman Pat	0.05	SpongeBob SquarePants	0.11	In The Night Garden	0.69
17	SpongeBob SquarePants	0.37	Disney Toons	0.04	Thomas the Tank Engine	0.09	SpongeBob SquarePants	0.68
18	Roary the Racing Car	0.37	Roary the Racing Car	0.03	Roary the Racing Car	0.08	Thomas the Tank Engine	0.65
19	Postman Pat	0.35	Barney	0.03	The Wot Wots	0.08	Postman Pat	0.57
20	Disney Toons	0.32	Bob the Builder	0.03	Wonder Pets	0.08	Roary the Racing Car	0.49
21	Fireman Sam	0.22	Fireman Sam	0.03	Fireman Sam	0.06	Disney Toons	0.38
22	In The Night Garden	0.19	Dora the Explorer	0.02	Disney Toons	0.02	Fireman Sam	0.32

NOTE: Scores represent the total rate per minute of each of language features, literacy features, and maths features within the content coded. Total Educational Scores are the rate per minute using all features combined.

Table 3
Bivariate correlations between educational media content and child outcomes.

	MC:L	MC:M	MC:Ed	Voc2	Voc4	Com	Let	Wri	Num
Media Content: Language	0.04	**0.38**	**0.96**	0.06	0.04	0.03	0.02	0.07	0.05
Media Content: Literacy (MC:L)	-	**0.30**	**0.24**	-0.01	-0.03	0.01	0.02	0.03	0.00
Media Content: Maths (MC:M)		-	**0.59**	0.03	0.04	0.04	0.04	0.07	0.05
Media Content: Education Total (MC:Ed)			-	0.06	0.04	0.04	0.02	0.08	0.05
Vocabulary - Age 2 (Voc2)				-	**0.36**	**0.31**	**0.12**	**0.19**	**0.20**
Vocabulary - Age 4.5 (Voc4)					-	**0.32**	**0.23**	**0.25**	**0.39**
Communication - Age 4.5 (Com)						-	**0.13**	**0.17**	**0.20**
Letter Fluency - Age 4.5 (Let)							-	**0.46**	**0.45**
Writing - Age 4.5 (Wri)								-	**0.42**
Numeracy - Age 4.5 (Num)									-

Shaded cells indicate correlations between educational media content and child outcomes
Coefficients ≥ .10 are considered to be significant and bolded

Table 4
Bivariate correlations between home environment, screen time, and child outcomes.

	FG	MEdu	Dep	PP	HD	ST
Child (female) Gender (FG)	-					
Maternal Education (MEdu)	-0.02	-				
Socioeconomic Deprivation (Dep)	-0.02	**-0.30**	-			
Protective Parenting (PP)	0.00	**-0.16**	**0.19**	-		
Harsh Discipline (HD)	-0.04	-0.08	0.04	0.00	-	
Screen Time (ST)	0.02	**-0.18**	**0.18**	**0.20**	0.07	-
Vocabulary - Age 2	**0.14**	**0.13**	**-0.16**	**-0.13**	0.05	**-0.13**
Vocabulary - Age 4.5	0.05	**0.24**	**-0.29**	**-0.20**	-0.03	**-0.12**
Communication - Age 4.5	0.08	**0.11**	**-0.12**	-0.07	0.01	-0.08
Letter Fluency - Age 4.5	0.06	**0.19**	**-0.13**	-0.02	-0.08	-0.02
Writing - Age 4.5	**0.21**	**0.18**	**-0.16**	-0.04	-0.05	-0.05
Numeracy - Age 4.5	-0.02	**0.22**	**-0.20**	-0.08	-0.05	-0.05

Coefficients ≥ .10 are considered to be significant and bolded

outcomes at age 4.5 from educational media content at age 2 while controlling for confounding factors and examining whether screen exposure or socioeconomic deprivation moderated the effect of educational media content on child outcomes. We also controlled for child vocabulary at age 2. As this was our only indicator of pre-existing child educational ability, we included this in all models.

Each set of models included the predictors of media exposure (total TV time), socioeconomic deprivation, educational media content as well as the two-way interactions of educational media content X media exposure and educational media content X socioeconomic deprivation, while controlling for maternal education, gender, age 2 vocabulary, protective parenting, and harsh discipline. All dependent variables were standardized to a z-score prior to entering in the model.

Total Educational Content. We first ran a multivariate multiple regression model using total educational content as the predictor (total of language, literacy, and maths content) and including all dependent variables at age 4.5: vocabulary, communication, letter fluency, writing, and counting. Multivariate testing indicated significant effects of gender ($p < .001$), maternal education ($p < .001$), socioeconomic deprivation ($p < .001$), protective parenting ($p < .001$), harsh discipline ($p = .006$), vocabulary at age 2 ($p < .001$), as well as a significant interaction between educational content and socioeconomic deprivation ($p = .001$), such that female gender, higher maternal education, higher vocabulary at age 2, lower protective parenting, lower harsh discipline, and lower socioeconomic deprivation were related to higher educational outcomes.

Table 5 (Model 1) provides the univariate results for each dependent variable. Maternal education and earlier vocabulary (age 2) were significantly predictive of children's language, literacy and numeracy skills, such that higher maternal education and higher early vocabulary were related to higher educational outcomes. Gender, socioeconomic deprivation, protective parenting, and harsh discipline were predictive of some but not all outcomes (see Table 5). Additionally, the interaction between educational media content and socioeconomic deprivation was significant when predicting both vocabulary and communication skills. The interaction predicting vocabulary is depicted in Fig. 3 by plotting the association between educational media content and vocabulary at three levels of socioeconomic deprivation (-1 SD, mean, and +1 SD, representing low, mid, and high deprivation, respectively). For children from areas of low and mid socioeconomic deprivation, there was no

Table 5
Multiple regression model results.

Predictors	Vocabulary	Communication	Letter Fluency	Writing	Counting
Model 1: Total Educational Content					
Female Gender	-0.00	0.07*	0.11**	0.38***	-0.10**
Maternal Education	0.13***	0.05**	0.16***	0.14***	0.16***
Protective Parenting	-0.10***	-0.02	0.02	0.02	-0.01
Harsh Discipline	-0.03	0.00	-0.07***	-0.03*	-0.04*
Vocabulary (Age 2)	0.30***	0.28***	0.07***	0.12***	0.16***
Socioeconomic Deprivation (DEP)	-0.30***	-0.15***	-0.12**	-0.06	-0.16***
Media Time (TIME)	-0.02	-0.04	0.03	-0.03	-0.05
Total Educational Media Content (EDU)	-0.03	0.02	0.00	0.03	0.05
EDU X DEP	0.05***	0.04*	0.02	-0.02	0.02
EDU X TIME	-0.00	0.01	-0.00	0.01	0.03
Model 2: Language Instructional Content					
Female Gender	-0.00	0.08*			
Maternal Education	0.14***	0.06**			
Protective Parenting	-0.11***	-0.02			
Harsh Discipline	-0.03	-0.01			
Vocabulary (Age 2)	0.30***	0.28***			
Socioeconomic Deprivation (DEP)	-0.27***	-0.15***			
Media Time (TIME)	-0.01	-0.04			
Language Content (LANG)	0.04	0.02			
LANG X DEP	0.05**	0.05*			
LANG X TIME	-0.00	0.01			
Model 3: Literacy Instructional Content					
Female Gender			0.11**	0.40***	
Maternal Education			0.16***	0.14***	
Protective Parenting			0.02	0.03	
Harsh Discipline			-0.07***	-0.03	
Vocabulary (Age 2)			0.08***	0.13***	
Socioeconomic Deprivation (DEP)			-0.08***	-0.11***	
Media Time (TIME)			0.03	-0.01	
Literacy Content (LANG)			0.03	0.02	
LIT X DEP			-0.02	-0.01	
LIT X TIME			0.04	0.01	
Model 4: Maths Instructional Content					
Female Gender					-0.11**
Maternal Education					0.17***
Protective Parenting					-0.02
Harsh Discipline					-0.04*
Vocabulary (Age 2)					0.17***
Socioeconomic Deprivation (DEP)					-0.12***
Media Time (TIME)					0.02
Maths Content (MATH)					0.06**
MATH X DEP					-0.01
MATH X TIME					0.06**

Cell values are parameters estimates from multiple regression models
*** $p < .001$; ** $p < .01$; * $p < .05$

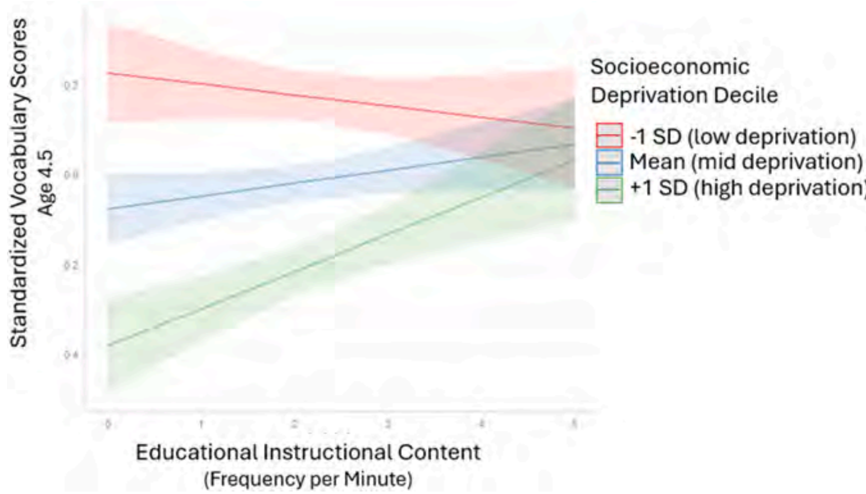

Fig. 3. Standardised and adjusted vocabulary scores at age 4.5 based on total educational media content at age 2 and socioeconomic deprivation.

significant effect of educational media content on vocabulary (low: $b =$ -0.02, $p = .28$; mid: $b = 0.03$, $p = .07$). However, for children from areas of high socioeconomic deprivation, exposure to educational media content was positively associated with later vocabulary (high: $b = 0.08$, $p < .001$). A Johnson-Neyman regions of significance analysis indicated educational media content was significantly predictive of higher vocabulary scores at deprivation levels of 5.99 and higher (on NZDep deciles ranging 1-10).

A similar pattern was observed for the interaction between educational media content and socioeconomic deprivation when predicting communication skills. An examination of the simple slopes indicated that there was no significant effect of educational media content on communication skills for children from low and mid deprivation areas (low: $b =$ -0.02, $p = .45$; mid: $b = 0.02$, $p = .37$). However, for children from areas of high socioeconomic deprivation, exposure to educational media content was positively associated with later communication skills (high: $b = 0.05$, $p = .04$). A Johnson-Neyman regions of significance analysis indicated educational media content was significantly predictive of higher communication scores at deprivation levels of 8.18 and higher (on NZDep deciles ranging 1-10).

Language Instructional Content. We next ran a multivariate model predicting the two language outcomes (vocabulary and communication skills) from language instructional content, while including the same control variables and interaction terms as above. Multivariate test statistics indicated significant effects of gender ($p = .04$), maternal education ($p < .001$), protective parenting ($p < .001$), vocabulary at age 2 ($p < .001$), socioeconomic deprivation ($p < .001$), as well as a significant interaction between socioeconomic deprivation and language media content ($p = .002$). Univariate results for each of vocabulary and communication skills are provided in Table 5 (Model 2). After controlling for child background characteristics, there was a significant interaction between socioeconomic deprivation and language instructional features. This interaction is depicted in Fig. 4, which plots the association between language instructional content and communication skills at three levels of socioeconomic deprivation. For children from areas of low and mid socioeconomic deprivation, there was no association between language instructional features and communication skills (low: b = -0.03, $p = .32$; mid: $b = 0.01$, $p = .46$); however, there was a positive association between language instructional features and communication skills for children from areas of high socioeconomic deprivation ($b =$ 0.06, $p = .04$). A Johnson-Neyman analysis indicated language instructional content was significantly predictive of higher communication scores at deprivation levels of 8.25 and higher.

A similar pattern was seen for vocabulary skills, whereby there was no association between language instructional features and vocabulary skills in children from areas of low socioeconomic deprivation ($b =$ -0.02, $p = .50$); however, in this case there was a positive association between language instructional features and vocabulary skills for

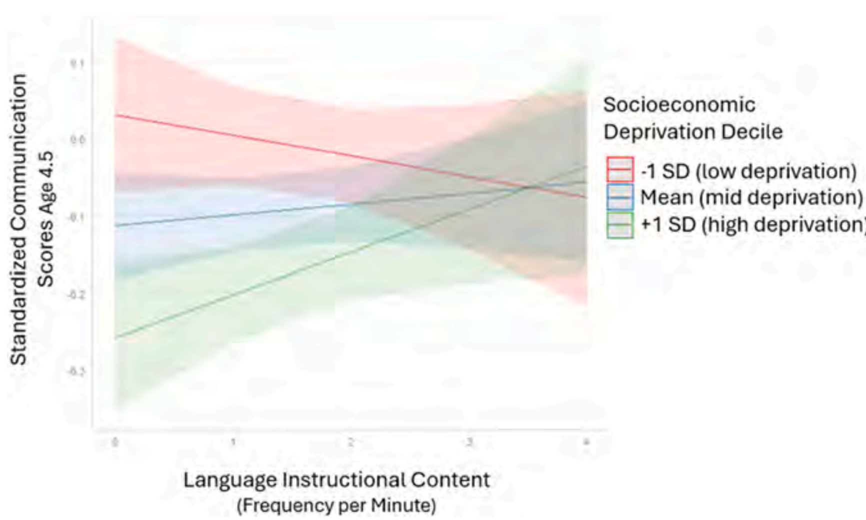

Fig. 4. Standardised and adjusted communication scores at age 4.5 based on language instructional media content at age 2 and socioeconomic deprivation.

children from areas of mid and high socioeconomic deprivation, with a stronger effect for children in areas of high deprivation than mid (mid: $b = 0.04$, $p = .05$; high: $b = 0.09$, $p < .001$). A Johnson-Neyman analysis indicated language instructional content was significantly predictive of higher vocabulary scores at deprivation levels of 5.80 and higher. Thus, when children from areas of high deprivation were exposed to a high rate of language instructional features within the television programs they watched at age 2, they had higher communication and vocabulary scores at age 4.5.

Considering these results from another perspective, the findings suggest that at low levels of educational media content, children from advantageous socioeconomic backgrounds have better language and communication scores. However, at levels of high educational media content, differences based on socioeconomic deprivation are not apparent. This is shown in Fig. 5 which presents the association between socioeconomic status and communication skills at levels of educational media content. When children are exposed to high quality media content, socioeconomic deprivation is not predictive of language and communication skills.

Literacy Instructional Content. We next ran a multivariate model predicting the two literacy outcomes (writing and letter fluency) from literacy instructional content, while including the same control variables and interaction terms as above. Multivariate test statistics indicated significant effects of gender ($p < .001$), maternal education ($p < .001$), harsh parenting ($p < .001$), vocabulary at age 2 ($p < .001$), and socioeconomic deprivation ($p < .001$). Univariate results for each of letter fluency and writing are provided in Table 5 (Model 3). There was no association between literacy instructional content and children's literacy skills.

Maths Instructional Content. A multiple regression model was run predicting children's counting ability at age 4.5 from maths instructional content and including the same control variables and interaction terms as outlined above. Results are provided in Table 5 (Model 4). Gender, maternal education, harsh discipline, earlier vocabulary, and socioeconomic deprivation were all significantly associated with children's counting ability. Further, higher levels of maths instructional content were associated with higher counting skills; however, this was qualified by an interaction between total TV time and maths instructional content. This interaction is shown in Fig. 6 by plotting the association between time spent watching television and later counting at differing levels of maths content: low frequency (0.0 features per minute), medium frequency (0.3 features per minute), and high frequency (0.6 features per minute). In this case, the extent of television children watched had no association with counting scores for children who watched content with a medium frequency of maths instructional content (e.g., average rate of 0.3 features per minute; $b = -0.02$, $p = .38$). However, when children watched content with a low frequency of maths content (e.g., average rate of 0.0 features per minute), higher levels of television viewing were associated with lower counting scores ($b = -0.11$, $p = .03$). On the other hand, when children watched content with a high frequency of maths instructional content (e.g., average rate of 0.6 features per minute), higher levels of television viewing were associated with higher counting scores ($b = 0.06$, $p = .01$). A Johnson-Neyman regions of significance analysis indicated that maths instructional content was significantly predictive of lower counting scores when children watched content with 0.12 maths features per minute or less and predictive of higher counting scores when children watched content with 0.50 maths features per minute or more.

3.3. RQ3: which specific educational content features are most strongly associated with children's learning outcomes?

We next turned to examining the specific content features that were most important to the prediction of children's language, literacy, and numeracy skills. For these analyses, we again focused on the content features from each educational domain of the coding scheme (language, literacy, maths) in relation to their proximal dependent variables. In other words, we examined language instructional content features in relation to vocabulary and communication skills, literacy instructional content features in relation to letter fluency and writing, and mathematical instructional content features in relation to counting. We ran multivariate linear regressions for each of language and literacy outcomes and a linear regression predicting numeracy. Each model predicted the outcome variables from the instructional content features, while controlling for child gender, maternal education, total number of screen hours, protective parenting, harsh discipline, earlier vocabulary (age 2), and socioeconomic deprivation. Outcome variables and instructional content features were standardised to a mean of 0, standard deviation of 1 prior to the regression analyses.

3.3.1. Language instructional content features

A multivariate regression model was run predicting vocabulary and communication skills from the four language content feature variables and the child and family covariates. Prediction of both outcomes was significant [vocabulary: $F(11,3250) = 86.46$, $p < .001$; $R^2 = 0.23$; communication: $F(11,3250) = 37.15$, $p < .001$; $R^2 = 0.11$]. Results are

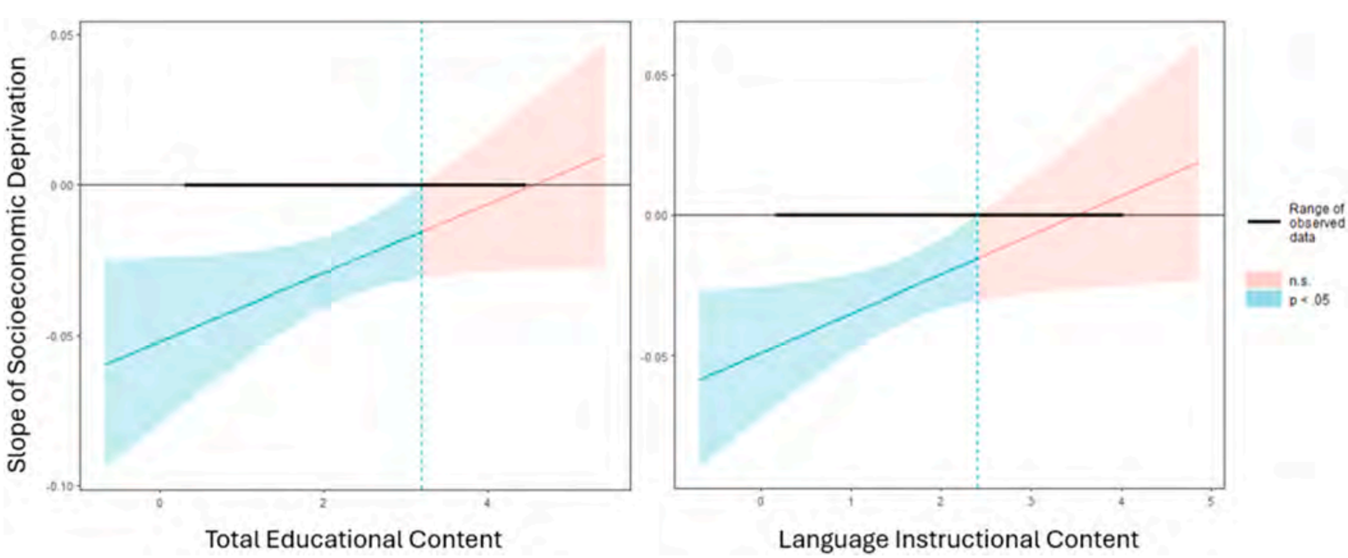

Fig. 5. Association between socioeconomic deprivation and communication skills at differing levels of educational media content.

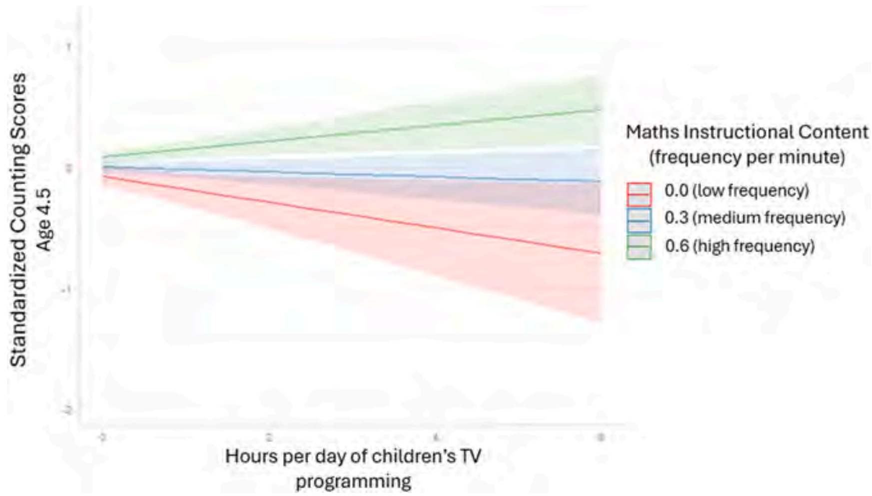

Fig. 6. Standardized and adjusted counting scores at age 4.5 based on maths instructional media content at age 2 and time spent watching children's media at age 2.

provided in Table 6. In addition to the significant effects of covariates, children's vocabulary scores were significantly predicted by their exposure to *summary* content features. Communication skills were significantly predicted by exposure to *matched labelling* content features. Both proto-conversational strategies and vocabulary definition were not significantly predictive of children's language outcomes on their own.

3.3.2. *Literacy instructional content features*

A multivariate regression model was run predicting letter fluency and writing from the four literacy content feature variables and the child and family covariates. Prediction of both outcomes was significant [letter fluency: F(11,3169) = 17.39, p < .001; R^2 = 0.05; writing: F(11,3261) = 38.99, p < .001; R^2 = 0.11]. Results are provided in Table 7. After accounting for the significant effects of covariates, the only literacy content feature that was predictive of child outcomes was a significant effect of *phoneme* content features on children's letter fluency.

3.3.3. *Mathematics instructional content features*

A regression model was run predicting children's counting scores from the five math instructional content features and child and family covariates. The model was significant [F(12,3260) = 31.14, p < .001; R^2 = 0.10]. Results are provided in Table 8. Results indicate that *measurement* content features were significantly predictive of children's later counting abilities.

Table 6
Regression models predicting vocabulary and communication skills from language content features.

	Dependent Variable	
	Vocabulary	Communication Skills
Child and Family Covariates		
Female Gender	0.01 (0.03)	0.10 (0.03)**
Maternal Education	0.12 (0.01)***	0.04 (0.02)**
Socioeconomic Deprivation	-0.18 (0.02)***	-0.08 (0.02)***
Protective Parenting	-0.11 (0.02)***	-0.03 (0.02)*
Harsh Discipline	-0.02 (0.02)	-0.01 (0.02)
Vocabulary (Age 2)	0.30 (0.02)***	0.30 (0.02)***
Total Screentime	-0.01 (0.02)	-0.02 (0.02)
Instructional Features		
Matched Labelling	0.04 (0.03)	0.06 (0.03)*
Summary	0.06 (0.02)**	0.05 (0.02)
Proto-Conversational Strategies	-0.04 (0.04)	-0.06 (0.04)
Vocabulary Definition	0.03 (0.02)	0.01 (0.02)

Table provides regression coefficients (standard error)
* p < .05
** p < .01
*** p < .001

Table 7
Regression models predicting letter fluency and writing skills from literacy content features.

	Dependent Variable	
	Letter Fluency	Writing Skills
Child and Family Covariates		
Female Gender	0.11 (0.04)**	0.40 (0.03)***
Maternal Education	0.13 (0.02)***	0.12 (0.02)***
Socioeconomic Deprivation	-0.08 (0.02)***	-0.12 (0.02)***
Protective Parenting	0.02 (0.02)	0.02 (0.02)
Harsh Discipline	-0.07 (0.02)***	-0.03 (0.02)
Vocabulary (Age 2)	0.07 (0.02)***	0.14 (0.02)***
Total Screentime	0.03 (0.02)	-0.00 (0.02)
Instructional Features		
Onscreen Print Focus	-0.04 (0.04)	-0.01 (0.03)
Letter Identification	-0.02 (0.02)	-0.01 (0.02)
Spelling	0.01 (0.02)	0.03 (0.02)
Phonemes	0.07 (0.04)*	0.03 (0.03)

Table provides regression coefficients (standard error)
* p < .05
** p < .01
*** p < .001

4. Discussion

Given the prevalence of screen media within children's lives, there is the potential for television and video content developed for young children to provide opportunities for supporting and developing early educational skills. In the present research we examined the extent to which television programming popular among preschoolers includes educational features, and the extent to which exposure to these features relates to children's later educational skills. This analysis took place within the context of children's natural viewing behaviors.

Overall, we found that language-building features were more common than literacy or maths focused features, and that there was substantial variation among popular programs in the rate at which these features were used. Interestingly, the only demographic difference we found in exposure to educational media content was that girls watched more educational content than boys. This could result from differences in the types of content that parents select for their daughters to watch versus their sons, or differences in the content that is created and targeted for boys versus girls, and represents an area for further research.

Table 8
Regression models predicting counting skills from mathematical content features.

	Dependent Variable Counting
Child and Family Covariates	
Female Gender	-0.10 (0.04)**
Maternal Education	0.14 (0.02)***
Socioeconomic Deprivation	-0.12 (0.02)***
Protective Parenting	-0.02 (0.02)
Harsh Discipline	-0.04 (0.02)*
Vocabulary (Age 2)	0.17 (0.02)***
Total Screentime	0.01 (0.02)
Instructional Features	
Number	0.02 (0.03)
Counting	0.01 (0.04)
Shapes	0.00 (0.03)
Patterns	0.03 (0.02)
Measurement	0.04 (0.02)*

Table provides regression coefficients (standard error)
* $p < .05$
** $p < .01$
*** $p < .001$

We found no significant association between socioeconomic status and children's rate of exposure to educational media. While existing research suggests that children from lower socioeconomic backgrounds tend to have more screen viewing time (De Craemer et al., 2018; Ke et al., 2023; Salway et al., 2019), much less is known about the extent to which exposure to educational media content differs based on socioeconomic status. Our results indicate similar levels of educational content features within the television programs viewed by 2-year-olds from differing socioeconomic backgrounds. This finding is consistent with that of Dore et al. (2025) who similarly found no differences in educational content exposure based on socioeconomic status amongst first graders. Girls in the Dore et al. sample also had higher levels of educational media exposure than boys, mirroring the current pattern of findings.

4.1. *Learning language from television*

Our results provide evidence of a positive effect of high-quality television viewing on language skills for some children. We found that exposure to media content containing a high rate of language-building features was associated with higher communication and vocabulary scores, but only within children from areas of high socioeconomic deprivation. Thus, we found evidence of Baydar et al. (2008)'s *compensatory hypothesis,* in which children from disadvantaged ecologies benefit more from educational television than others. This finding is consistent with existing research, such as that of Zill (2001) who found that *Sesame Street* viewing was more strongly associated with emergent literacy and numeracy in 4-year-old children from low-income families than in children from higher-income families.

Previous research has established an association between socioeconomic status and the quality of the home language and literacy environment (Hart & Risley, 1995; Singh et al., 2023), including the fact that children from higher socioeconomic families tend to receive richer linguistic input (Hoff, 2003; Rowe, 2008; 2018; Vanormelingen & Gilles, 2016). Thus, if socioeconomic deprivation is serving as a proxy for the home language environment in our study, our results may indicate that watching educational television might help to support the language development of children who do not have a linguistically-rich environment during the preschool years. The implications for children from socioeconomically advantaged households is that exposure to educational media content may have negligible effects on their language skills, as these children were observed to score high on vocabulary and communication skills regardless of the extent to which their media viewing including language-building strategies.

It is important to note that previous research has identified that within preschool-aged children, learning from screen media is not as beneficial as learning that occurs within face-to-face interactions, termed the *video deficit effect* (Anderson & Pempek, 2005; Barr, 2010; Strouse & Samson, 2021). For example, Krcmar et al (2007) used a repeated measures design to examine how well toddlers could learn novel words across five conditions. Children were significantly less likely to learn novel words from a television segment compared to a live presentation by an adult. The video deficit effect is most apparent at 2-3 years of age, when across various learning domains children learn less from video than from equivalent real-life experiences (Jing & Kirkorian, 2020). Thus, learning (including language learning) is most beneficial when provided through face-to-face interactions; however, when high-quality face-to-face interactions are lacking, which may be more likely within socioeconomically disadvantaged households, educational television may be an alternative support for children's language development.

4.2. *Learning maths from television*

Our study is one of the first to look at maths content features within children's media in relation to child outcomes. Watson et al. (2021) showed a beneficial impact of a popular cartoon show on the math skills of a large, nationally-representative sample of Tanzanian children; however, this study focused on older children aged 6-16 years. In the present study, we found that exposure to a high rate of mathematics instructional features within popular television programs was predictive of children's later numeracy skills, depending on how much time children spent watching television. When children were watching content with a high frequency of maths instructional content, more viewing time was beneficial for their counting abilities. However, when children watched content with a low frequency of maths features, higher viewing time predicted lower counting scores. In other words, the association between time spent watching television and counting skills was dependent on the type of content viewed. Our results indicate that higher viewing time was associated benefits for numeracy when children were exposed to maths features at a rate of 0.5 features per minute or more. In the present sample of television shows examined, there were six shows meeting this threshold: *Hi-5, Sesame Street, Mickey Mouse Clubhouse, Tiki Tour, The Wiggles,* and *Little Einsteins*.

This interactive effect with total exposure time could perhaps suggest the importance of repetition or a greater number of exposures to maths content features for learning to take place. Alternatively, as discussed earlier regarding the indirect effects of educational television on child learning, those children who spend more time watching television with high levels of maths content may be spending more time on maths activities generally (e.g., due to their interests and motivation). Further, Howard Gola and colleagues (2021) highlight the importance of parasocial relationships to children's learning of maths skills from media characters. The authors of this study examined whether toddlers could learn seriation (ordering nesting cups from smallest to largest) from a video demonstration and found that learning only occurred when children had been familiarised with the video character ahead of time (which occurred over a 3-month period prior to testing). Thus, in the present research total time spent watching television might also reflect children's familiarity with the television shows and characters that they are watching. Familiarity might be particularly relevant when learning more cognitively challenging skills like mathematical concepts.

4.3. *Learning literacy from television*

We found stronger evidence in favour of children learning language and maths skills than literacy skills from television. Overall, we found that exposure to literacy instructional features (combined at a domain level) was not predictive of emergent literacy skills, although we did find a specific effect of a focus on phonemes on later letter fluency. However, it is important to note that children were 2-years-old when their television viewing data was collected. While vocabulary and communication skills, as well as early maths skills like counting, are developmentally relevant for 2-year-olds, some of the literacy instructional features we examined might not have been within the zone of proximal development for this particular age (e.g., spelling). If we examined the shows children were watching later in the preschool years (e.g., at age 4), we might find a more influential effect of these literacy features.

4.4. Content features beneficial for child development

The specific content features that we found were predictive of positive child outcomes were matched labelling and summary strategies (promoting language skills), a focus on phonemes (promoting literacy skills), and measurement (promoting counting skills). These findings provide evidence of the features that should be considered when designing media content for preschoolers in the future.

The finding that phoneme-focused instructional features were predictive of children's letter fluency is consistent with a substantial body of research highlighting the importance of phonological awareness for early literacy development. Phonological awareness, particularly sensitivity to the sounds within words, has been identified as a key precursor to letter knowledge and later reading achievement (e.g., National Early Literacy Panel, 2008; Whitehurst & Lonigan, 1998). Instructional moments in which letter sounds or parts of words are explicitly emphasised, especially when paired with visual representations such as onscreen print, may support children's ability to form connections between phonemes and graphemes. This type of multimodal input aligns with evidence that children benefit from integrated auditory and visual cues when learning about print (Bus et al., 1995; Evans et al., 2000). Thus, exposure to phoneme-focused content within television programming may provide opportunities for children to develop foundational code-related skills, which in turn support the acquisition of letter knowledge.

Interestingly, measurement-related instructional features, rather than counting-focused content, were predictive of children's later counting skills. One possible explanation is that measurement content may provide a broader and more conceptually-rich foundation for early numeracy. As defined in the present study, measurement features included comparing and grouping objects, the use of mathematical language (e.g., bigger/smaller, more/less, spatial terms), and engagement with units and quantities. These experiences may support children's understanding of underlying quantitative concepts such as magnitude, comparison, and relational reasoning, which are foundational for the development of counting and number knowledge. In contrast, counting content in television programming may often emphasise rote recitation (e.g., counting sequences) without necessarily supporting deeper conceptual understanding. This interpretation is consistent with research suggesting that early numeracy development is supported not only by counting practice, but also by broader quantitative reasoning skills, including comparison, classification, and the use of mathematical language (e.g., Clements et al., 2016b; Mix et al., 2002). Additionally, measurement-related content may be more likely to be embedded in meaningful, real-world contexts (e.g., comparing sizes, measuring distance, or describing spatial relationships), which could enhance children's engagement and facilitate transfer of learning. Together, these findings suggest that exposure to mathematically rich and conceptually integrated content, even when not explicitly focused on counting, may play an important role in supporting early numeracy development.

Labelling and summary strategies were found to predict later language skills. One explanation for these findings is that both matched labelling and summary strategies support core processes involved in language learning. Matched labelling, where an object is verbally named while it is visually present, provides temporally aligned verbal and visual information that facilitates word-referent mapping and reduces ambiguity during vocabulary learning. This is consistent with evidence that children learn new words more effectively when labels coincide with their focus of attention (e.g., Shimpi & Huttenlocher, 2007; Luce & Callanan, 2010). In contrast, summary strategies may enhance learning by activating prior knowledge and encouraging children to integrate new information with previously learned concepts. This aligns with theories of meaningful learning and multimedia learning, which propose that activating existing knowledge structures promotes comprehension and long-term retention (Mayer, 2024). Together, these findings suggest that educational television may be particularly effective when it explicitly supports children's encoding and integration of language, rather than simply increasing their exposure to it.

Interestingly, we found that proto-conversational strategies, such as talking directly to the viewer, and asking the viewer questions and waiting for a response, were not predictive of child language outcomes. This is interesting given a longstanding assumption that these features are beneficial for child language development (e.g., Linebarger et al., 2017; Linebarger & Walker, 2005; Santomero, 2016). Research by Carter and colleagues (2017) highlights some of the issues with proto-conversational strategies as typically utilised, specifically that the pauses left for children to respond within the proto-conversation are not long enough for preschoolers to formulate a response, and that children very quickly learn that the television program/character is not actually contingent upon their responses. Recent research experimenting with the use of an AI character that enabled contingent interaction opportunities while watching a science video resulted in more verbal engagement from children and improved understanding of science concepts compared to a non-interactive video (Xu et al., 2022). However, the present results may also reflect the fact that proto-conversational strategies are a method of engaging with the audience, rather than a form of educational content itself. Thus, many shows may use this strategy even when not explicitly teaching educational content, and proto-conversational strategies may therefore function more as a moderator of learning rather than resulting in the type of direct effect tested for in the present analysis.

5. Limitations

There are a number of limitations of the current study that need to be acknowledged. First, while our use of the *Growing Up in New Zealand* dataset enabled us to examine longitudinal outcomes, the television viewing data that was the focus of our analysis was collected in 2012. Children's media landscape has changed significantly in the 14 years since this data was collected, potentially limiting the applicability of our analysis to more contemporary datasets. While television and video viewing remains the most common way preschoolers consume screen media (Mann et al., 2025), there has been a substantial shift from viewing broadcast television to watching television and videos on streaming services. This likely has impacts for both the ways that children watch media (e.g., watching a full episode versus frequent shifts between content) as well as the content they consume (e.g., due to a lack of content regulation on streaming services; Perkins, 2024). Additionally, our analysis was necessarily restricted to children who watched television when they were 2-years-old, given our focus on the content of television viewing. We did not consider or compare outcomes to children who did not watch any television when they were 2 years-old; however, this would be an interesting direction for future research.

Our analysis was also limited in a number of ways by the measures that were used as part of the GUINZ study. Measures of child media use and child communication skills were based on maternal report, which could be subject to recall or reporting bias. Additionally, some of the items measuring communication (e.g., "Never or rarely asks adults questions") may be measuring constructs other than communication ability, such as social skills or the willingness to communicate. Further the measure of maths ability was also limited compared to the measures available for language and literacy. Our measure of child media use was also limited to a single point in time (age 2). However, it is possible that media viewing habits as captured at age 2 reflect a persistent pattern of viewing behaviors, whereby children who watch more educational media at age 2 also watch more educational media at ages 3 and 4 (when children are better able to learn from media), and this later exposure may be a more proximal cause of the outcomes reported at age 4.

Finally, given the time required to undertake manual coding for each television show, we limited our analysis to the 22 most common shows mentioned within the dataset. This means that for some children, some or all of their favourite television shows may not have been coded. If, for example, a child only had one of their three favourite shows within the 22 coded shows, their rate of exposure to educational content would be based solely on the one coded show. While this occurred for only a minority of children, there will be some impacts on data accuracy; however, we believe our methods used the information available to us to arrive at the best estimate of the child's exposure to educational content.

6. Conclusions

Our results provide stronger evidence in favour of children learning language and maths skills than literacy skills from television, although in both cases learning was dependent on a moderated effect. Positive effects of language instructional features on vocabulary and communication were only seen among children from areas of high socioeconomic deprivation. With regards to numeracy skills, higher levels of television viewing were predictive of lower counting skills when children watched content with a low frequency of maths instructional features. Conversely, higher levels of television viewing were predictive of higher counting skills when children watched content with a high frequency of maths instructional features.

The preschool years are an important development period, when building language and emergent literacy and maths skills will help set children on a positive achievement trajectory prior to formal literacy instruction. Our results indicate that for some children, exposure to educational media may help support the development of language and maths skills, highlighting the importance of high-quality educational media for preschool-aged children.

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CRediT authorship contribution statement

Megan Gath: Writing – review & editing, Writing – original draft, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Cara Swit:** Writing – review & editing, Project administration, Methodology, Funding acquisition, Data curation, Conceptualization. **Mia McLean:** Writing – review & editing, Project administration, Methodology, Conceptualization. **Ying Wang:** Writing – review & editing, Project administration, Methodology, Conceptualization. **Jen Smith:** Writing – review & editing, Methodology. **Jenna Gawn:** Writing – review & editing, Project administration, Methodology, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ecresq.2026.08.001.

Data availability

Data used in this study are available through an application process at https://www.growingup.co.nz/.

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