

# Efficacy of digital videos and games for improving children's computational thinking skills:

## An evaluation of PBS KIDS *Work it Out Wombats!*

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# Background: Computational thinking & young children

*Computational thinking (CT)* is the process of framing and solving problems in ways that can be carried out by humans or machines.

CT skills include:

- Sequencing and Algorithmic Thinking
- Problem decomposition
- Debugging
- Design process



# Background: Computational thinking & young children

- Promoting CT skills in young children can support acquisition of general **problem solving (PS)**, **executive function (EF)**, and **social emotional learning (SEL)** (Bers et al., 2022; Falloon, 2016; Myers, 2021).
- CT-related skills, including problem solving and social-emotional skills (e.g., persistence, cognitive flexibility) provide a **foundation for school readiness** (Burchinal, et al., 2022).
- Early CT experiences may be important for **computer science academic and career pathways** (Madill et al., 2007; Metz. 2007).
- Meta-analyses demonstrate that **digital media can improve children's literacy** (0.21-0.35) and **math** (0.22-0.29) learning (Kim et al., 2021).
- **Less evidence** about how to support **CT skills in young children**. Most CT studies focus on direct instruction of coding for elementary-age children (Metin, 2022; Arfé et al., 2020; Bers, 2018).

# *Work It Out Wombats!*



Designed to help kids ages 3–6 develop CT skills to prepare them for the classroom and careers of the future.

The Wombats face situations that they tackle together using CT, problem solving, creativity, and social-emotional skills.

Videos, digital games, and hands-on resources available for free via PBS KIDS.

# Research Questions

Does providing 8 weeks of access to *Wombats* resources via a tablet improve low-income 4- and 5-year-old children's:



## Primary RQs

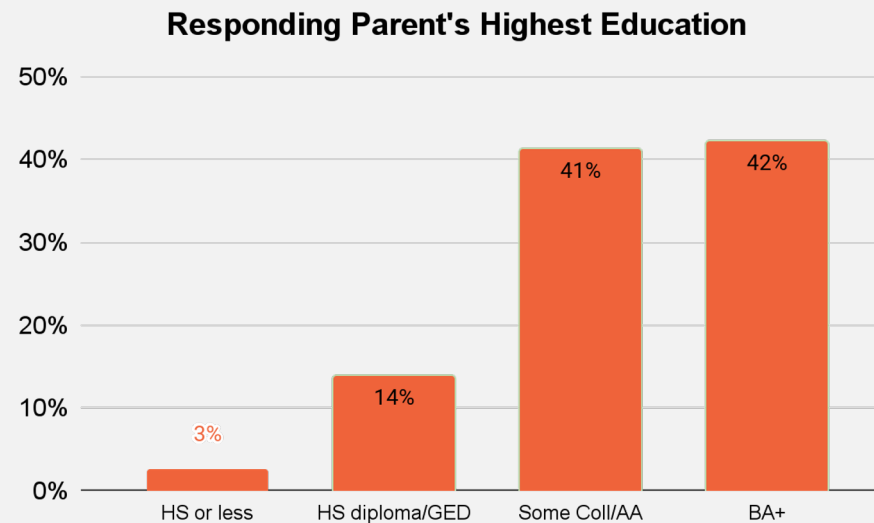
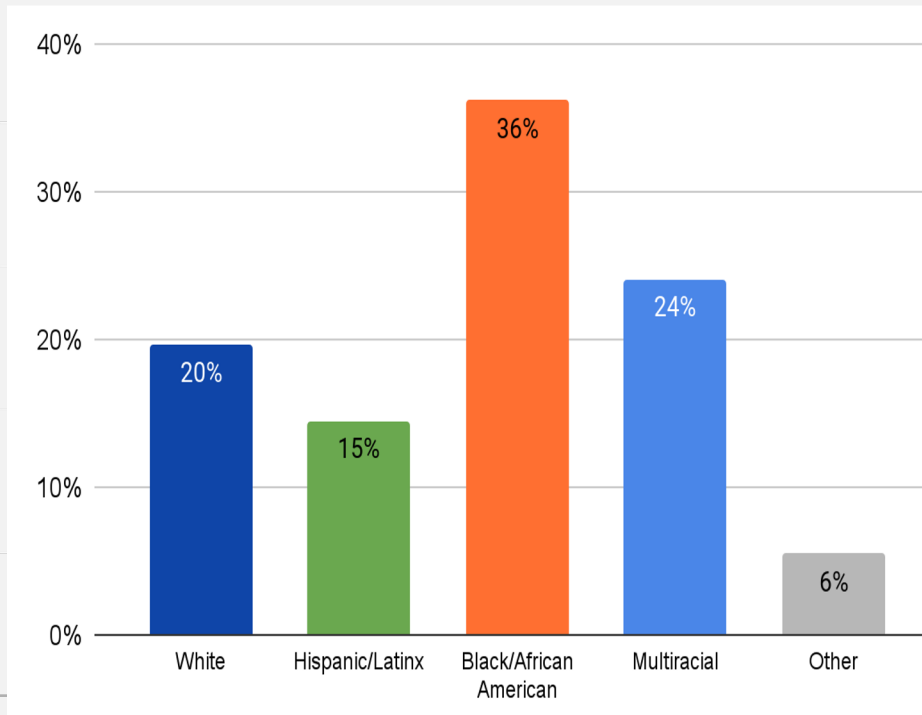
- computational thinking skills (RQ1)?
- problem-solving skills (RQ2)?
- social-emotional learning skills (RQ3)?

## Exploratory RQs

- ability to use the design process to solve problems (RQ4)?
- sequencing skills (RQ5)?

# Participants

- Diverse group of 4- to 5-year-old children from low-income households (N=458)
- Low attrition rate (~5%)



**English is Primary language in home**

**71%**

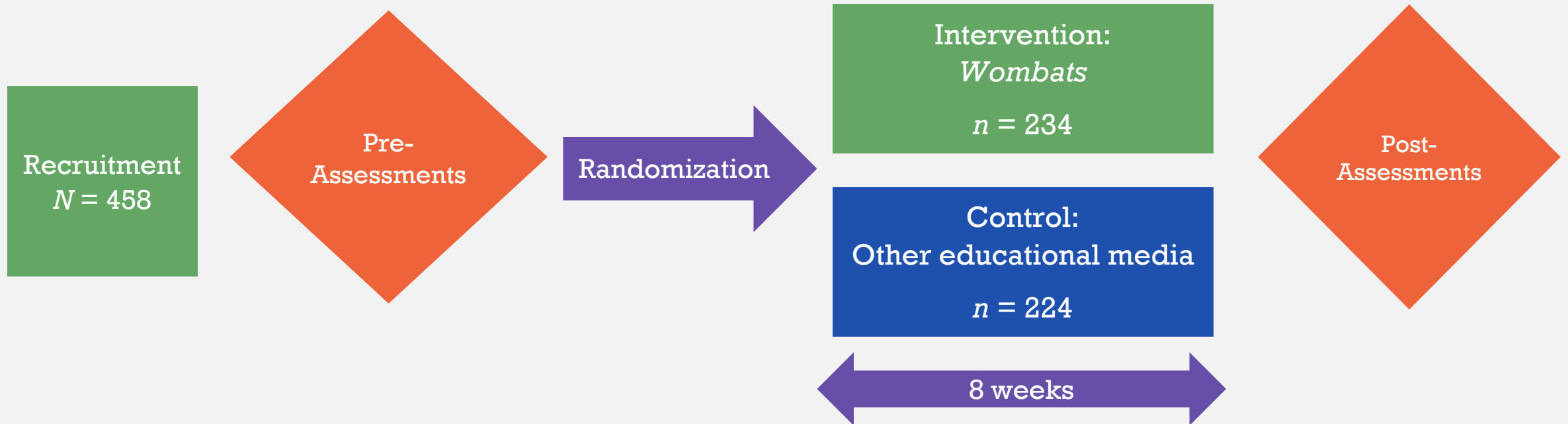
**Child has an IEP or 504 plan**

**17%**

**Family annual income <\$50k**

**56%**

# Study Design



# Randomized Controlled Trial





	Treatment Group received	Comparison Group received
New tablet with data	X	X
PBS KIDS video and games apps blocked on tablet	X	X
Instruction to have child use media for ~90 mins/week	X	X
Weekly reminder and survey texts	X	X
Wombats videos, games, and off-screen activities	X	
Calendar with suggested schedule	X	



# Wombats Intervention

40 episodes	4 digital games
16 interstitials	5 hands-on activities

organized into 8 weeks, with themes like:

	<b>Step it Out</b> (Sequencing & Algorithmic Thinking)
	<b>Create, Test, Improve</b> (Design Process)
	<b>Break it Down</b> (Problem Decomposition)
	<b>Check Your Steps &amp; Fix it</b> (Debugging)

# Measures

Construct	Measure	Administration	
		Pre	Post
RQ1: Computational thinking	STEM+C (Dominguez et al., 2022)	X	X
RQ2: Problem solving skills	Picture problem solving task (Fusaro & Smith, 2018)		X
RQ3: SEL skills	PROMIS EC (parent report) (Blackwell et al. 2022)	X	X
RQ4: Ability to use design process to solve problems (50% of sample)	Design process assessment		X
RQ5: Sequencing (50% of sample)	Picture sequencing task		X
Executive function	Minnesota Executive Function Scale (MEFS) (Carlson & Zelazo, 2017)	X	
Family and child background, child media use, use of intervention	Parent survey	X	X

# Methods

## Impact Models

- We examine impacts of the *Wombats* intervention using OLS regression

$$Y = \beta_0 + \beta_1\text{TRT} + \beta_2\text{pretest} + \beta_3\text{covars} + \beta_4\text{site} + \varepsilon$$

- Models include controls for corresponding pretest (STEM+C, PROMIS EC) MEFS scores, site, prior exposure to *Wombats*, and child and family background characteristics
- To explore whether the treatment effect varied by child demographics and baseline EF, analyses added a moderator by treatment interaction term for the demographic variable of interest

# Substantial exposure

Children in the treatment group used *Wombats* substantially during the study.

During the study, the treatment group:

- Averaged **1205 minutes** using *Wombats* videos and games (~2.5 hrs per week) on their tablet
- Accessed an average **32 videos and/or games** at least once (range 1-60)

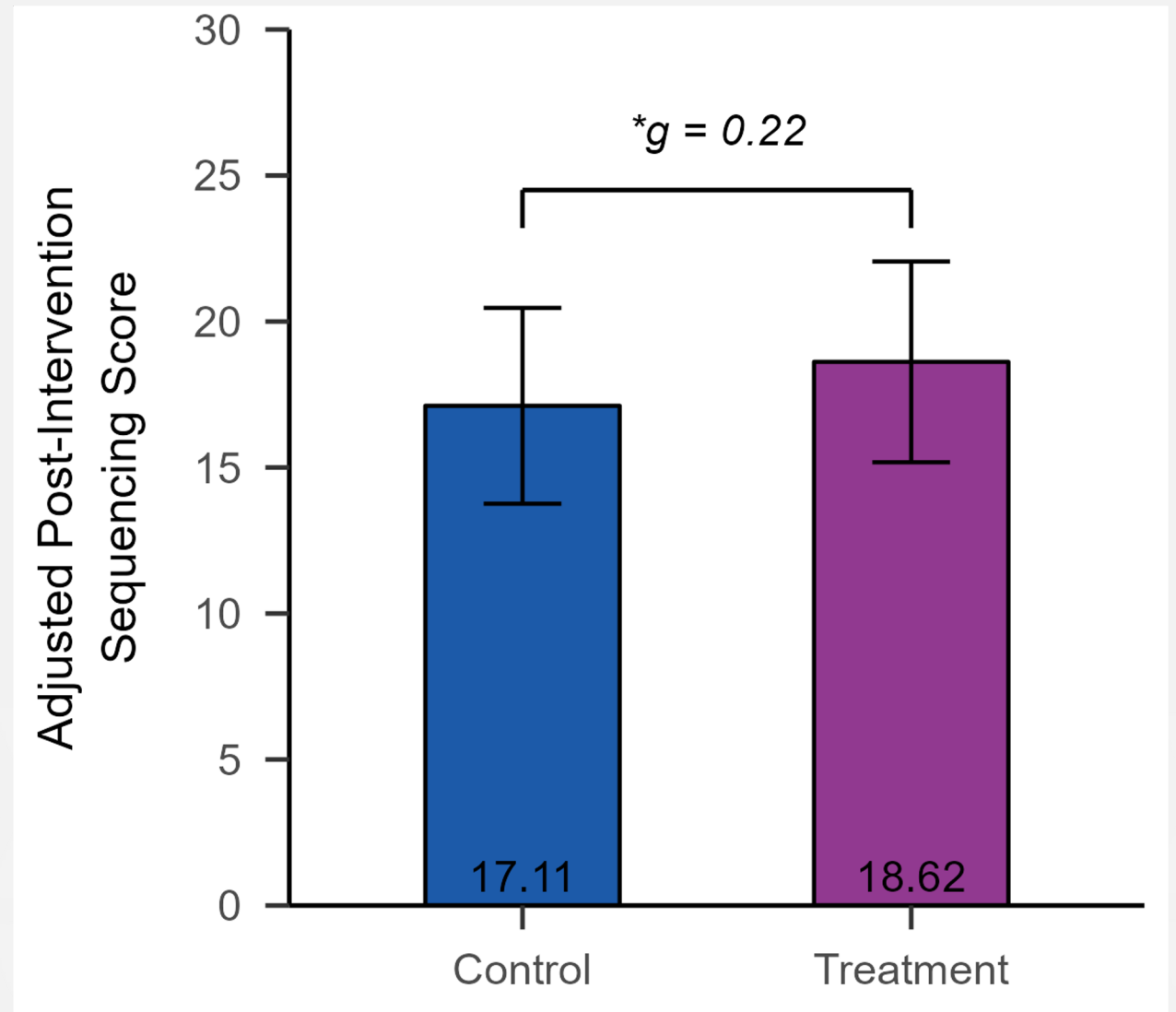


## Wombats did not affect computational thinking, problem solving, or social-emotional learning

Measure	Purpose (RQ): Construct	<i>g</i>	<i>p</i>
<b>STEM+C</b>	Main outcome (RQ1): Computational thinking	-0.01	.34
<b>Picture problem solving task</b>	Main outcome (RQ2): Problem solving skills: Item score	< -0.01	.78
	Fluency score	-0.07	.44
<b>PROMIS EC</b>	Main outcome (RQ3): SEL skills: Persistence	0.15	.84
	Frustration tolerance	0.09	.54
	Flexibility	-0.18	.76
<b>Design process assessment</b>	Exploratory outcome (RQ4): Ability to use design process to solve problems (50% of sample)	-0.01	.62
<b>Picture sequencing task</b>	<b>Exploratory outcome (RQ5): Sequencing (50% of sample)</b>	<b>0.22</b>	<b>.03*</b>

# Children with access to Wombats had significantly higher sequencing skills

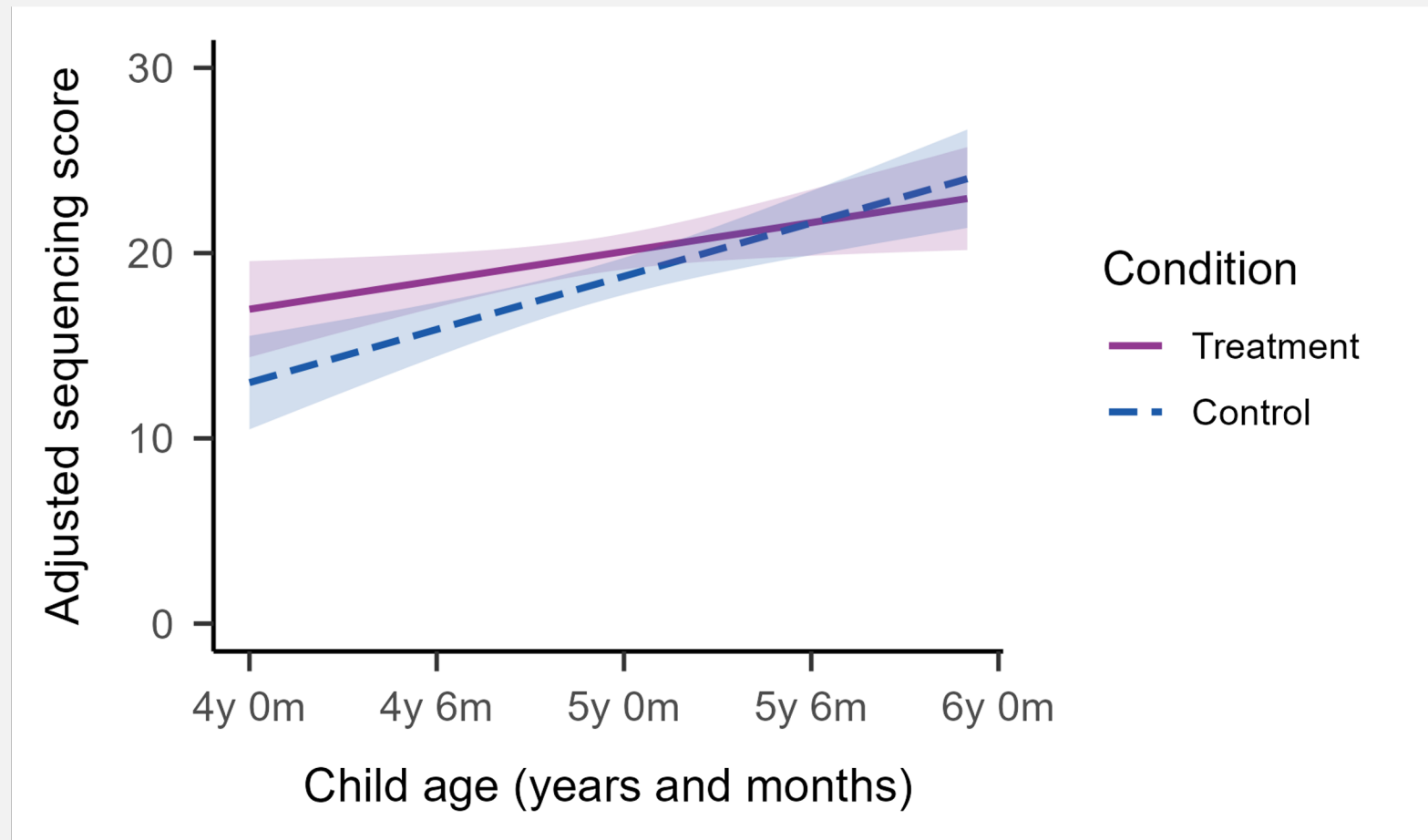
- Treatment group scored higher on sequencing at post-test than control group, controlling for executive function and demographics
- Effect size was small and statistically significant ( $g = .22$ ;  $SE = 0.11$ ,  $p = .03$ )



# Few differences in treatment effects by child characteristics

Child characteristic (moderator)	STEM+C	Sequencing
Age (months)	No	Yes
Gender (female)	No	No
IEP/504/special services status	No	No
Family income (>\$50K)	No	No
Child race/ethnicity	No	No
Study site	No	No
Baseline executive function	No	No

# Benefits of Wombats for sequencing skills were greater for younger children






## Parent Perspectives (n=16)

Parents reported growth in children's problem-solving and organizational skills & positive changes in children's attitudes when approaching challenges

*“I could just see him practicing what he would learn, like in everyday life. I would hear him go like this, “step it out,” and he'd be, like, “oh, well, we have to break it down into smaller steps” in regards to, like, cleaning his room or if he had to get his clothes ready.”*

*“I'd say he learned how to plan for something that had initially been overwhelming. Tying his shoes, getting dressed in the morning, things like that. So now when we use phrases like “step it out,” it's more of a fun thing to do. Not so overwhelming. Yeah, I'll say I've seen a lot of growth.”*

# Reflections

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- More scaffolding or more prolonged exposure may be necessary to improve children's CT skills
  - CT skills may develop sequentially: young children might have to first develop sequencing before other CT-related skills
  - Some domains of CT and related skills may be more readily taught through educational media than others, especially for young children
  - Our measures might not have captured all aspects of CT or problem-solving

# Thank you!

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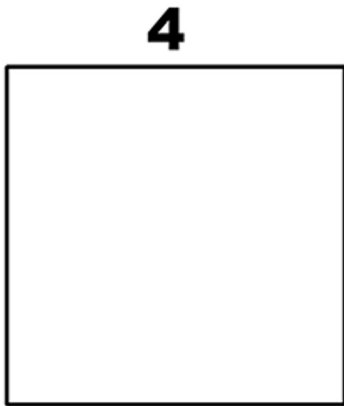
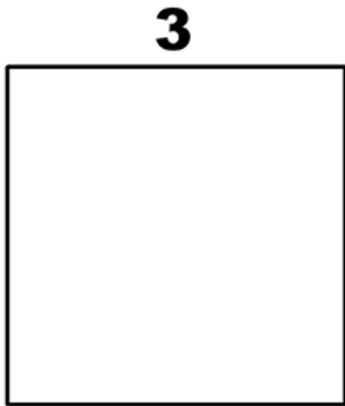
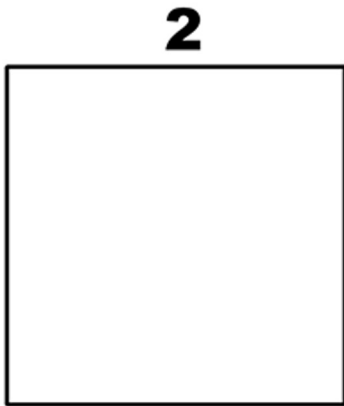
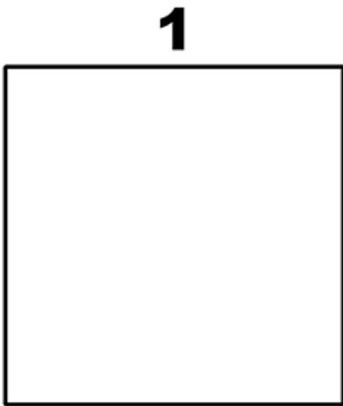
More RTL research:



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# Wombats sequencing task



# Attrition

Measure	Overall attrition	Differential attrition	WWC cautious boundary for differential
<b>STEM+C</b>	5%	1%	6%
<b>PROMIS EC</b>	6%	3%	6%
<b>Design Process</b>	8%	4%	6%
<b>Picture Problem Solving</b>	7%	1%	6%
<b>Sequencing</b>	7%	2%	6%