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Effect of the UMIGO Transmedia Property on First and Second Grade Students' Math Ability: A Randomized Controlled Trial (RCT) Study

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Background and Objectives

UMIGO Partnership

The UMIGO (yoU Make It GO) Partnership, responsible for the development and evaluation of the UMIGO educational transmedia property, consists of: Windows on the World Communications (WTTW), Chicago's premier public television station, in collaboration with W!ldbrain Entertainment, an entertainment and animation company, and the Michael Cohen Group, LLC (MCG), research and evaluation experts. The partnership was awarded a five-year (2010-2015) Ready to Learn (RTL) competitive grant from the U.S. Department of Education to promote early learning and school readiness through innovative transmedia programming, with an emphasis on reaching low-income children.

Overview

The goal of the UMIGO Partnership is to develop educational media products that help young children achieve basic competencies in mathematics. In 2011, the Nation's Report Card, a national assessment of educational progress, revealed that fifty-three percent of American fourth graders failed to attain proficient standards in mathematics (National Center for Education Statistics, 2011). This failure to achieve early numeracy skills can lead to difficulties in other academic domains. Children who experience trouble with basic math concepts often also experience problems learning how to read (Geary, 2011; Geary, Hoard, Nugent, & Bailey, 2012). A lack of basic mathematics skills increases children's disengagement in school as well as their likelihood of dropping out before high school graduation (Balfanz, 2007). These issues persist throughout the lifespan. Numeracy difficulties in adulthood are associated with low-paying, unskilled job placement and unemployment (Every Child a Chance Trust, 2008). Being unable to understand basic mathematical concepts can affect the management of one's health and finances: Adults with lower numeracy skills make poor health-related

decisions (Reyna, 2007) and are more likely to default on their mortgage payments and experience foreclosure (Gerardi, 2010).

The UMIGO Partnership recognizes the importance of providing all children with a solid foundation in mathematics, especially for low-income American households. The Partnership has set out to create a media-based mathematics curriculum for children aged six to eight years (first and second grade) in the form of transmedia storytelling and activities, with corresponding support materials and digital resources for parents, caregivers, and teachers. Transmedia storytelling is defined as *conveying content and themes to audiences through the well-planned, connected use of multiple media platforms (examples include but may not be limited to: television, video, Web sites, cell phones, e-books, electronic games, handheld devices, and other yet to be developed technologies* (United States Department of Education, 2010). Transmedia platforms are comprised of a number of products from different media sources. Each product exists independently in its complete form (i.e., the music video is designed to be enjoyed by those who have never interacted with any of the other media components), but also forms part of the connected transmedia property. When all of the products are taken together, learning becomes integrated across platforms. UMIGO aims to provide an innovative transmedia experience targeting young children's early mathematics skills. In the following section, we highlight the rationale for designing a transmedia property for educational purposes by reviewing evidence on the popularity of media and technology for children, the growing use of media and technology for educational purposes, and the benefits of using media as a learning tool.

Popularity of media and technology with children. Children's exposure to and use of media and digital technology in the home has increased steadily since 2006 (Michael Cohen Group, 2009). Children aged two to eight spend on average 21 hours a week engaged with media through multiple platforms, including music, books, television, computers, and video games (Common Sense Media, 2011; Michael Cohen Group, 2009). Children's transmedia consumption increases with age; eight- to 18-year-olds now

devote more than 53 hours a week to a multitude of media and technology (Rideout, Feehr, & Roberts, 2010).

Media and technology for educational purposes. Educational technology products are typically either designed to be tools used in a classroom (formal environment) with support from an educator (mediated learning) or to be tools used in the home (informal environment) without instruction (non-mediated learning). Products designed for informal, non-mediated learning, such as educational television programs or learning apps, are necessarily designed to be effective without the presence of an instructor and therefore do not require extensive teacher training. These products typically embed the educational content within a game or narrative. Such educational products need to be highly entertaining and engaging because they must compete with other non-educational activities for children's time and attention.

Educational benefits of media properties for children. Research has examined the effects of educational television programming such as Sesame Street, Barney & Friends, and Word World in enhancing pre-literacy skills, numeracy, and social-emotional development among pre-school aged and older children. Educational television has been found to successfully teach curriculum content and model pro-social behavior (Fisch & Truglio, 2001; Michael Cohen Group, 2009; Singer & Singer, 2001). Specifically, as part of a 2005-2010 RTL grant, viewing of the Word World educational television program was shown to result in gains in pre-schoolers' vocabulary and early literacy skills (Michael Cohen Group, 2009; 2012)[1]. An important component of educational television is its ability to engage and motivate viewers through compelling, reoccurring narratives and songs (Fisch & Truglio, 2001; Hall, Williams, Cohen, & Rosen, 1993). As stated, this high level of engagement and appeal is critical to learning that occurs outside of formal educational settings, where educational media must compete with other

[1] The Word World summative study was submitted to the United States Department of Education as part of the 2005-2010 Ready to Learn initiative, and reviewed and approved by a representative of the Institute for Educational Sciences, as well as an expert panel convened by the Office of Innovation and Improvement.

activities for children's time and attention. However, television and video provide less opportunity for practice of skills compared to computer-based media.

Strengths of computer-aided or computer-based instruction include the abilities to tailor the level of difficulty for each user and to provide repeated practice with immediate feedback on performance. The efficiency of using of computer-based media to tutor primary school children and older learners in rote skills and pre-defined content has been studied (e.g., Fletcher-Flinn & Gravatt, 1995; Kulik & Kulik, 1991), and it appears there is educational potential for using both computerized simulations and games for learning (Tobias & Fletcher, 2012; Young et al., 2012). As part of a 2005-2010 RTL grant, interaction with the Duck's Alphabet online game was shown to result in gains in pre-schoolers' emergent literacy and letter-sound correspondence (Michael Cohen Group, 2012). Initially, computer-aided or computer-based instruction was typically carried out within a formal learning environment, but in the past decade, there has been an explosion of in the availability of such educational technology online, proliferating potential for access.

Recently, numerous learning applications ("apps") with mathematics content have been developed for mobile devices and tablets (Michael Cohen Group, 2013). These apps, which have appeared only over the past few years, primarily target end users and are designed for use outside of the formal school environment. The majority of commercially available learning apps have so far been designed for younger children, including pre-schoolers (Shuler, 2012), and are often designed for short play sessions (30 seconds to 3 minutes), rather than for extended practice and drill (Michael Cohen Group, 2013).

In sum, a growing body of literature indicates that young children learn effectively from entertaining, educational media-based games and tools (e.g., Castellar, Van Looy, Szmalec, & de Marez, 2013; Tamim et al., 2011). Interactivity inherent in new media products can be a powerful means of teaching specific skills and stimulating cognitive development (Calvert, 2005; Linebarger & Walker,

2005). These findings, along with evidence of children's increasing involvement with media, underscore the need to leverage the positive potential of digital media content and related technologies (Gee, 2003; Klopfer, Osterweil, & Salen, 2009).

With the omnipresence of media and technology in children's daily lives and the ever-growing body of research on the educational benefits of individual media products (television and music videos; computer and mobile games), the UMIGO Partnership has set out to create a transmedia property for educational purposes. To assure the effectiveness of the transmedia properties, the RTL grant includes research as an essential and mandatory project component. The use of a randomized controlled trial (RCT) design meets the Institute for Educational Statistics (IES) standards for establishing strong evidence of intervention efficacy. This research design will allow the UMIGO Partnership to establish strong evidence of their products' educational effectiveness. This report presents the results of the first of multiple planned RCT studies as part of the US Department of Education RTL Cooperative Agreement, assessing the educational benefits of UMIGO transmedia materials.

Study Objectives

Prior research on educational technology and digital content has typically involved an intervention delivered through a single platform, or an intervention based on a primary platform with secondary supporting components (e.g., an educational television program with an accompanying activity guide). The current evaluation is intended to contribute to the research literature assessing the educational effects of a multimedia suite of products, including: online games; apps; e-books; music videos; and non-digital content.

We hypothesize children who are in classes randomly assigned to use UMIGO in addition to their regular classroom instruction (UMIGO intervention condition) would show significant increases in math knowledge and skills taught in UMIGO relative to children in classes randomly assigned to regular

classroom instruction plus use of a comparator transmedia property, Math Blaster, that addresses different mathematics curriculum content (Math Blaster control condition).

We focused on learning in four curriculum domains presented in the UMIGO products:

- Early Arithmetic (solving for missing addends and skip counting);
- Solving Inequalities (greater than or less than);
- British system measures of Capacity (cups, pints, quarts, and gallons and their equivalencies); and
- Measurement of Height and Length.

To explore whether UMIGO was more effective for some subgroups of children (detailed below) than for others, the following potential moderators on the effects of UMIGO relative to Math Blaster were assessed:

- Grade level: Comparison of results for students in first grade versus students in second grade;
- Gender: Comparison of results for students who were boys versus students who were girls; and
- Study site: Comparison of results for students in the different locations (Bridgeport, CT; Memphis, TN; or Sedro-Wolley, WA).

Method

Design

The effects of UMIGO on learning of mathematics concepts were tested in a cluster-randomized trial, with randomization stratified by school and grade. Students were recruited from five schools in three cities. Within each school, first and second grade classes were randomly assigned to use either UMIGO or a comparator transmedia property, Math Blaster, in addition to receiving their regular classroom instruction. All procedures and materials were approved by an independent institutional

review board (IRB), the Chesapeake IRB. (See Appendix A for the study Certificate of Approval, the approved protocol, and the approved parental informed consent forms.)

This study was designed to meet the criteria for "strong evidence" outlined by the U.S. Department of Education, including the following:

- Central random assignment of participants to treatment and control conditions;
- Intervention procedures that are standardized and documented to enable replication;
- The use of baseline data to confirm equivalence across conditions prior to the intervention and the statistical control of any differences not removed by randomization;
- The use of validated assessment measures when possible;
- Sample sizes that to provide adequate power to detect treatment effects;
- The inclusion of multiple, geographically diverse sites to maximize external validity;
- Assertive follow-up procedures to limit attrition to less than 25%;
- In cases with substantial attrition, analyses which are conducted on an intent-to-treat basis, using multiple imputation methods to estimate outcomes for subjects lost to follow-up;
- The reporting of effect sizes and statistical significance;
- The reporting of positive and negative findings; and
- The examination of process, setting, and child factors that moderate or mediate treatment effects to further address external validity.

Sample

This multi-site trial was based in three geographically diverse locations: Bridgeport, CT; Memphis, TN; and Sedro-Woolley, WA. A total of 514 first and second grade students were recruited from five schools. All schools were Title One schools that were equipped with computer labs capable of running the UMIGO and Math Blaster websites. Participating schools and teachers were offered a nominal stipend to compensate for their time and efforts. Sixteen classes (256 children) were

randomized to the UMIGO condition and 15 classes (258 children) were randomized to the Math Blaster control condition (see Table 1).

Subject retention. All of the classes participated in the posttest. Of 514 children recruited, 484 (94%) were retained at posttest. Retention rates did not differ significantly between the UMIGO (*N*=245, 96%) and Math Blaster conditions (*N*=239, 93%; chi square (1 df) = 2.3, *ns*).

Table 1.

Subject Characteristics by Condition

	UMIGO		Math Blaster	
	Classes	Children	Classes	Children
N	(16)	(256)	(15)	(258)
School				
A	4 (25%)	55 (21%)	2 (13%)	48 (19%)
B	3 (19%)	66 (26%)	4 (27%)	74 (29%)
C	1 (6%)	29 (11%)	1 (7%)	27 (10%)
D	4 (25%)	51 (20%)	5 (33%)	65 (25%)
E	4 (25%)	55 (21%)	3 (20%)	44 (17%)
Grade				
1	9 (56%)	129 (50%)	8 (53%)	130 (50%)
2	7 (44%)	127 (50%)	7 (47%)	128 (50%)
Gender				
Male	--	123 (48%)	--	139 (54%)
Female	--	130 (51%)	--	118 (46%)
Missing gender	--	3 (1%)	--	1 (<1%)

Stimuli

The products covered a wide range of first- and second-grade math topics (see Table 2) delivered through a variety of media platforms (e.g. world wide web, mobile device (iPad) apps, workbooks, music videos, and a board game). A DVD is enclosed with each product in one of the following forms: the product material itself (music videos, worksheets), or a video demonstrating its use (online programs, apps), or detailed instructions for game play (board game) is enclosed with the manuscript and will also be made available for download by request (send an e-mail to kyoshida@mcgrc.com).

UMIGO intervention. Students in classes randomized to the UMIGO condition received their usual classroom instruction plus use of the UMIGO product suite. The suite of products was organized into four topics that reflect the learning objectives specified by the UMIGO curriculum consultants. A breakdown of the specific UMIGO products is provided in Appendix B. The UMIGO suite addressed four curriculum domains:

(1) Inequalities (greater than or less than relations)
- A music video (provided on DVDs); and
- An e-book and craft demo video (provided on iPads).

(2) Early Arithmetic
- Two music videos (DVDs);
- Activity workbook;
- A board game; and
- An online game (accessed through computers).

(3) Height and Length
- A music video (DVDs); and
- An online game (computers).

(4) Measures of Capacity
- A music video (DVDs);
- A mobile game (iPads); and
- An e-book and video (iPads).

Math Blaster control products. For this type of evaluation, given that the "variable" being assessed is a complex educational activity rather than a single ingredient, a primary challenge is the determination of an adequate control group. One option would have been to simply compare the UMIGO condition (regular instruction plus UMIGO) to an instruction-as-usual control (i.e., no additional product exposure). However, this would have made it too difficult to determine whether any effects of UMIGO on learning were due UMIGO's educational content, or due to non-specific effects of using a transmedia property (e.g., novelty, fun, excitement, engagement). Further, the RTL Government Performance Review Act (GPRA) measures dictate inclusion of comparison properties that are "similar non-RTL-funded digital properties" or "other more traditional educational materials". Therefore, a non-RTL-funded digital educational control product was sought that was similar to the UMIGO suite in the following ways:

- Offers a transmedia suite of online (or PC based) activities, non-digital activities (e.g., board games or worksheets), and touch screen based activities that are unified by common characters, narratives, or brand identity; and
- Includes activities that reflect the first/second grade math curriculum.

After reviewing over 100 digital games, the *Math Blaster* suite of activities was selected as the most appropriate comparison property for the following reasons:

- Math Blaster is one of the few transmedia properties for young children that includes touch screen apps for math learning;
- Math Blaster includes branded characters that could foster continuity and greater engagement; and
- Math Blaster products include educational orientation specific to first and second graders.

The suite of Math Blaster products in the comparator condition included iPad games (e.g., Hyper Blast, Zapper, B-Force Blaster), online games (e.g., Hyperblast, Zapper, Angle Attack, OOZAMI, Risk It), and printed worksheets[2]. Most of the games involved multiple curriculum concepts within the same game (e.g., a game may involve addition, subtraction, multiplication, and division problems). A breakdown of the curriculum of the specific Math Blaster products is provided in Appendix B.

Table 2.

Curriculum Content of UMIGO and Math Blaster Suites of Products

	UMIGO	Math Blaster
Height and Length #	X	--
Measures of Capacity #	X	--
Greater Than, Less Than #	X	--
Early Arithmetic #	X	--
Addition	--	X
Subtraction	--	X
Multiplication	--	X
Division	--	X
Standard form	--	X
Numbers Place	--	X
Angles	--	X
Money	--	X

UMIGO-specific domains assessed in the outcomes measure.

Measures

Children received approximately 8 hours of exposure to either the UMIGO or Math Blaster properties over a four-week period. This amount of exposure to UMIGO was expected to be sufficient to

[2] Worksheets are available online at http://www.mathblaster.com/teachers/math-worksheets/1st-grade-math-worksheets and http://www.mathblaster.com/teachers/math-worksheets/2nd-grade-math-worksheets.

produce changes on proximal outcomes (learning of curriculum content directly taught in the UMIGO materials). However, it was not expected to produce changes on more distal outcomes, such as overall mathematics achievement, as assessed by standardized tests or previously validated measures.

This assessment was therefore focused on proximal outcomes, which were primarily assessed with measures developed specifically for this study based on content validity. Where appropriate, questions were included from the following scales: the Assessment for the California Mathematics Standards Grade 1; California Standards Tests Grade 2 Mathematics; and the Georgia Criterion-Referenced Competency Tests (CRCT) 1st and 2nd Grade Math Tests (14 questions in total). The assessment questionnaire targeted ability in the four included UMIGO curriculum domains (see Appendix C): Early Arithmetic; Inequalities; Capacity; and Height and Length.

Procedure

After obtaining signed parental consent (see Appendix A), all children completed an initial assessment in February 2013. UMIGO or Math Blaster products were provided to teachers for each participating class in the form of DVDs burned with the music videos; iPads loaded with apps and e-books; logins created for access to online games; printed copies of worksheets; and physical copies of the board games. Teachers were instructed to have students interact with the products for approximately 25 minutes a day during 19 days[3], for a total of about 470 minutes, or roughly 8 hours, over the course of the study. Schedules were designed so that, where possible, the products were introduced in the order specified by the curriculum consultants. Typically, this involved first introducing a music video, then a digital game, and then a non-digital activity. About half of the schedule (245 minutes) was spent with digital products (web sites, mobile games, e-books) and the remainder was spent with non-digital products (music videos, worksheets, and the board games). Overall time and digital/non-digital use was balanced between conditions. At all schools, two different orders were

[3] The 19 day schedule was designed for four weeks (generally five days per week, except one week with a federal holiday, i.e., one four-day week).

provided for each condition (UMIGO and Math Blaster) in an effort to reduce scheduling conflict for materials. Orders differed slightly between schools based on computer lab and other equipment availability. The schedules provided to one school are shown in Appendix D.

UMIGO and Math Blaster materials are designed to be used by children independently, without mediation by a teacher. Therefore, in the current study, teachers were instructed to present students with the activities and to ensure that students were able to use them properly, rather than providing intensive scaffolding (e.g., for the apps, teachers ensured that students found and opened the correct app, but no more). The only exception to this was for the UMIGO board game, for which teachers were required to explain the rules of the game.

Analysis Plan

Outcomes analyses are based on the 484 students who completed both the pretest and posttest.[4] All outcome scores are presented as normed T-Scores, where the mean of the baseline scores is set to equal 50 and the pretest standard deviation is set to equal 10. Use of T-scores does not alter statistical significance, but facilitates interpretation in two ways. First, it puts scores for all four outcomes into the same units, making it easier to compare results across different outcomes. Second, it makes it easier to understand the magnitude of pre-post change, since a change of 10 points equals one standard deviation in mean scores.

All statistical analyses were conducted using the SPSS 17.0 mixed models procedure. Mixed modeling accounts for observations being clustered within groups, and is appropriate for studies where entire classes, rather than individuals, are randomly assigned to treatment conditions.

[4] Ninety-five percent of participants were retained with no difference in the retention rate between conditions. This high rate of retention results in minimal potential for bias due to participant attrition, making multiple imputation of missing data unnecessary. The results are thus based on the observed data for children who completed both assessments.

Primary analyses were conducted to assess the effects of UMIGO and Math Blaster on learning outcomes (Early Arithmetic, Inequalities, Height and Length, Capacity). Secondary analyses were conducted to explore potential moderators (grade, gender, study site) of the intervention effects.

For the basic model used to assess learning outcomes, predictors (fixed effects) were pretest score on the outcome measure, intervention condition, gender, grade, and city. Classrooms within school were included as a random effect; this controls for the extent to which children within the same classroom and school tend to have similar scores. When exploring the potential moderators, interaction terms were added to the basic model. Predictors in this model were pretest score, intervention condition, gender, grade, city, condition x grade interaction, condition x gender interaction, condition x city interaction (all fixed effects) and class within school (random effect). If any of the interaction terms (e.g., condition x gender, condition x grade, or condition x city) were significant, this would indicate that the effects of UMIGO relative to Math Blaster were stronger among some subgroups of children than among others.

Results

Psychometric information for the four outcome subscales created for this study is shown in Table 3. Strong internal consistency (alpha > .80) was found for the Early Arithmetic and Inequalities subscales. Internal consistency was lower for the other subscales, likely because items included more distinct elements related to the overall construct. For example, on the Capacity subscale, one child might be familiar with quarts, but not pints, whereas another child might know about cups but not gallons.

Table 3.

Psychometric Properties of Outcome Subscales

	Internal Reliability (Cronbach's Alpha)	Correlation of Pretest and Posttest

Subscale	Range	Pretest	Posttest	r
Early Arithmetic	0-45, 0-51*	.80	.84	.84
Inequalities	0-16	.82	.83	.68
Capacity	0-14	.53	.66	.35
Height & Length	0-10	.53	.67	.49

* An additional item (worth up to six points) was added to the Early Arithmetic subscale at posttest.

Equivalence of Conditions at Pretest

Because classes were randomized within schools, city and school did not vary across condition (see Table 1). There was no significant difference in the proportion of boys and girls assigned to each condition (chi square (1,510 = 1.5, ns). Preliminary mixed model analyses confirmed there were no significant differences (all $p > .15$) in pretest scores between the two conditions. Nonetheless, all analyses controlled for pretest scores to increase statistical power.

Primary Aims: Effects of UMGO on Learning Outcomes

Mean T scores on the four learning domains (without controlling for covariates) are shown in Table 4. The mixed models analysis showed statistically significant ($p < .01$) effects of intervention condition on posttest scores in two learning outcomes: Inequalities and Capacity (see right column of Table 4). Posttest scores on the other two learning outcomes, Early Arithmetic and Height and Length, did not differ significantly by condition.

Table 4

Observed Outcome Scores at Pretest and Posttest, by Condition

	Pretest	Posttest	Significance of Difference at Posttest (controlling for covariates)

Subscale	UMIGO	Math Blaster	UMIGO	Math Blaster	*F*	*p* <
N	(245)	(239)	(245)	(239)		
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)		
Early Arithmetic	50.5 (10.1)	49.6 (10.0)	54.6 (10.4)	53.3 (10.5)	*F* (1, 19) = 0.1	.79
Inequalities	51.0 (10.0)	49.0 (10.1)	53.7 (9.7)	50.6 (9.9)	*F* (1, 18) = 8.8	.01
Capacity	50.5 (10.4)	49.3 (9.4)	61.7 (11.1)	56.4 (8.7)	*F* (1, 25) = 8.7	.01
Height and Length	49.6 (10.5)	50.3 (9.5)	54.0 (10.8)	52.3 (10.8)	*F* (1, 23) = 0.6	.44

Results for learning outcomes are shown as normed T-scores in Figures 1 through 2. Children in both conditions showed substantial gains in knowledge regarding Capacity measures, but gains were significantly stronger in the UMIGO condition than in the Math Blaster condition. Capacity T-scores of children in classes randomized to UMIGO improved by a mean of 11.2 points (equivalent to a pre-post change of 1.12 SD), significantly more than gains in the Math Blaster condition (gain of 7.1 points, or pre-post change of .71 SD; see Figure 1). Children in both conditions showed smaller but statistically significant gains in Inequalities, and those gains were stronger among children in the UMIGO condition (mean improvement of 2.7 points, or .27 SD units) than children in the Math Blaster condition (mean gain of 1.6 points, or .16 SD units; see Figure 2).

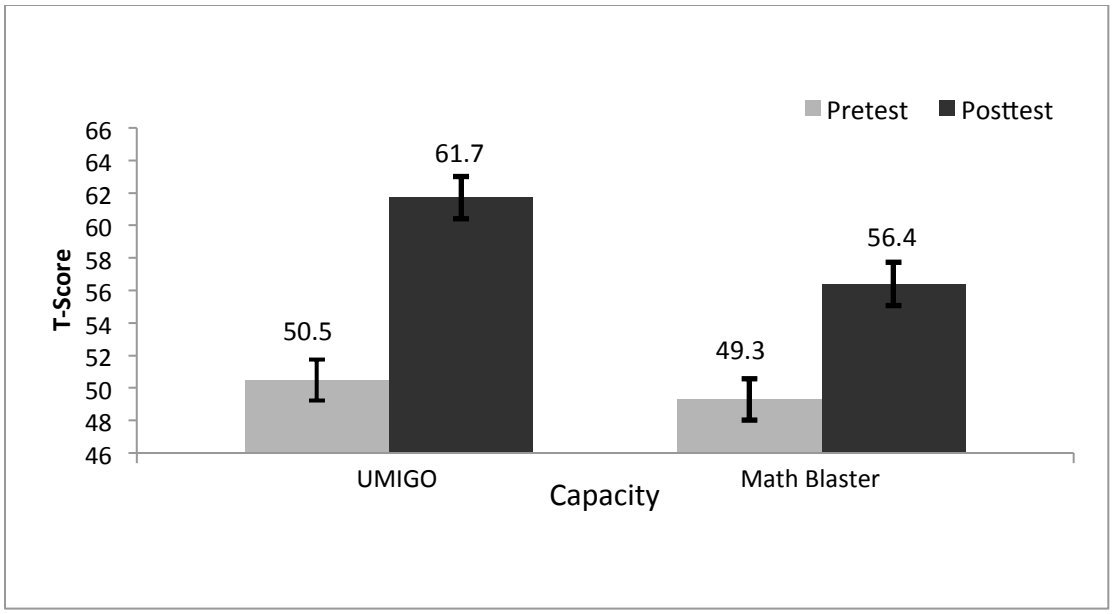


Figure 1. Capacity Gains Differed Significantly by Condition.

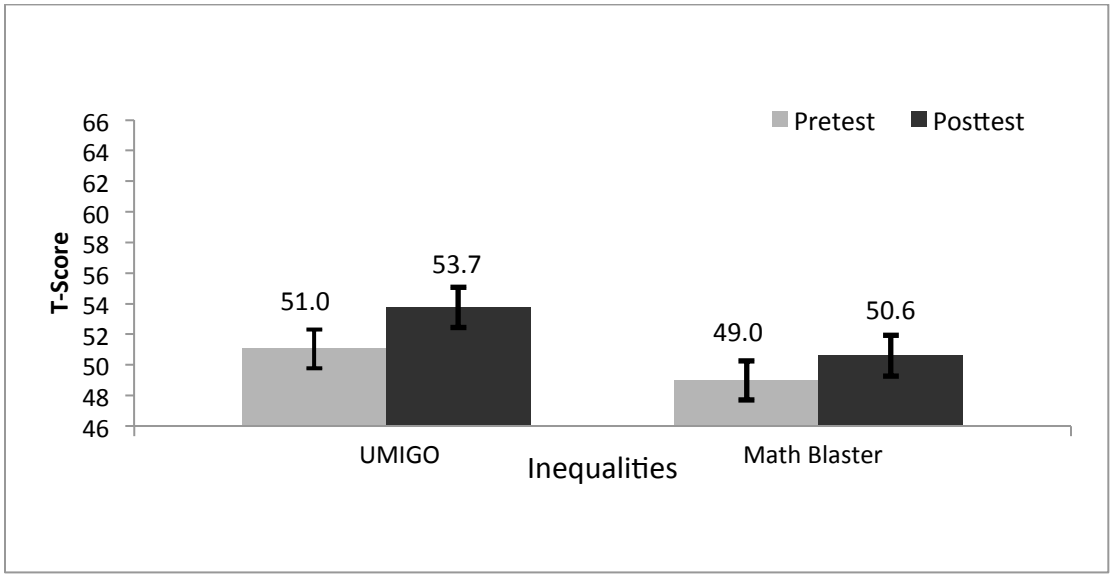


Figure 2. Inequalities Gains Differed Significantly by Condition.

Children in both conditions showed modest gains in knowledge about measures of Height and Length and Early Arithmetic, but the observed gains were not statistically different between the two conditions. Knowledge about measuring Height and Length improved by an average of 4.4 points or .44 SD in the UMIGO condition and 2.0 points or .20 SD in the Math Blaster condition (see Figure 3). Mean

improvement in children's ability to solve Early Arithmetic problems was 4.1 points or .41 SD in the UMIGO condition and 3.7 points or .37 SD in the Math Blaster condition (see Figure 4).

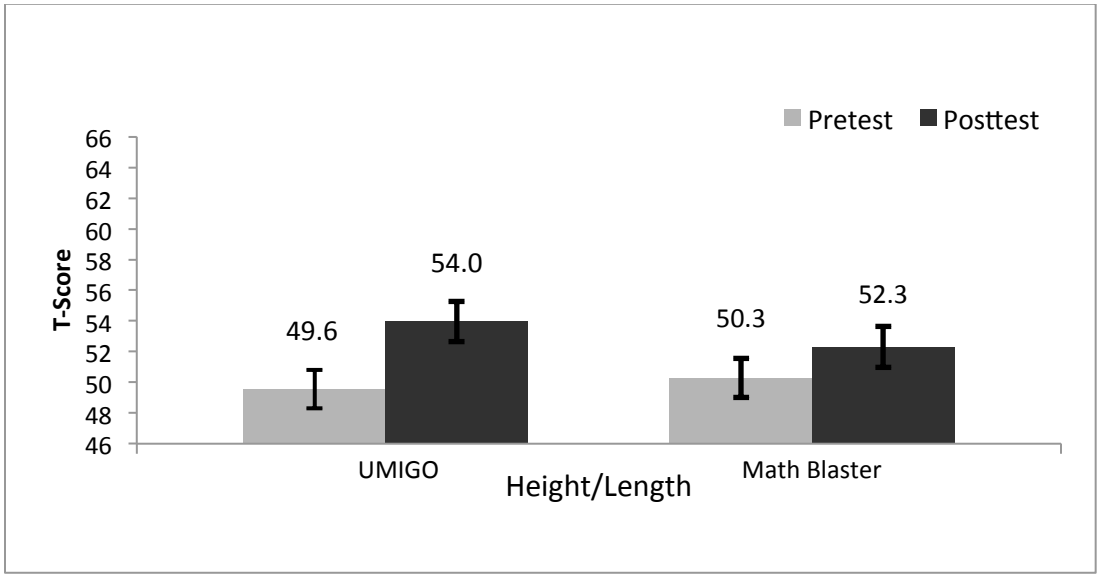


Figure 3. Height and Length Improved Similarly in Both Conditions.

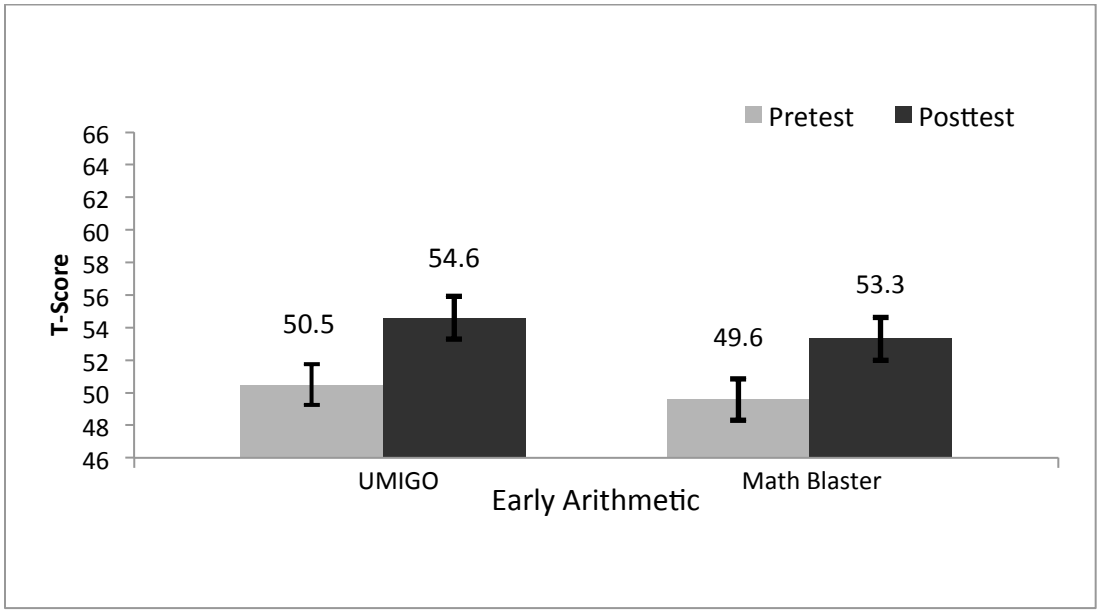


Figure 4. Early Arithmetic Improved Similarly in Both Conditions.

Testing for significance of multiple outcomes can potentially increase Type I error for the study as a whole. The Benjamini-Hochberg (1995) method was used to correct for the multiple comparisons, and the pattern of results remained identical, with significant effects on two out of four outcomes (see Table 5).

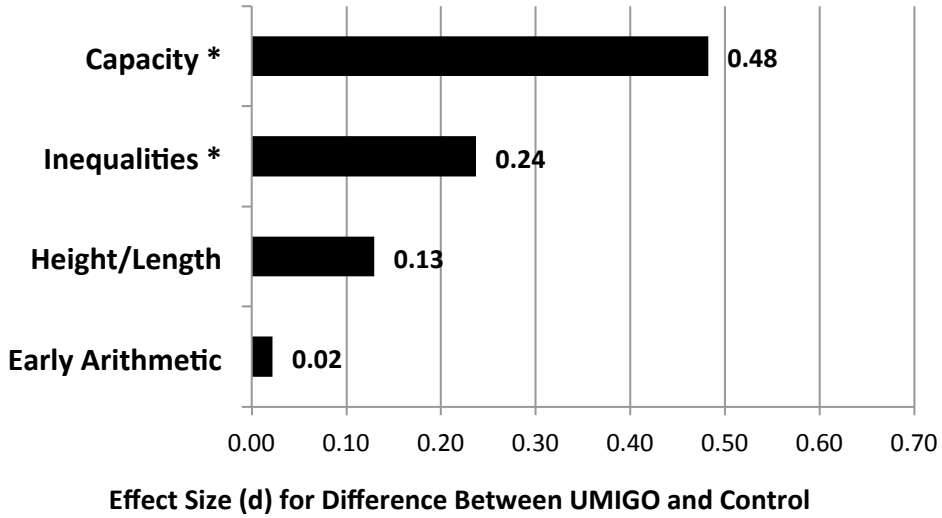
Table 5.

Benjamini-Hochberg Correction for Multiple Comparisons

p_i' = i x alpha /number of outcomes = i x .05/4 = i x .0125

p value	*p* value rank	p_i' = i x .05/5	$p_i < p_i'$?
.01	1	.0125	Yes
.01	2	.025	Yes
.44	3	.0375	No
.79	4	.05	No

To facilitate comparison with results of other randomized trials, differences between the conditions at posttest are shown in Figure 5 terms of standardized effect sizes (Cohen's d or standardized mean difference). This is the mean difference in posttest scores of children in the UMIGO and Math Blaster conditions (adjusted for covariates), divided by the standard deviation of the posttest. The difference between UMIGO and Math Blaster in Capacity scores was a medium-sized effect (*d* = .48). The difference between UMIGO and Math Blaster in knowledge about Inequalities was a small- sized effect (*d* = .24; see Figure 5). The small advantage (*d* = .13) for UMIGO in Height and Length outcomes was not statistically significant. The differences in outcomes for Early Arithmetic was negligible (*d* = .02) and not statistically significant.



* Statistically significant effect

Figure 5. Effect Sizes for Difference in Posttest Scores between UMIGO and Math Blaster Conditions, Controlling for Pretest Scores, City, School, Grade and Gender.

Secondary Analysis: Moderators of Intervention Effects

Additional analyses included interaction terms to assess whether the effects of UMIGO (relative to Math Blaster) on the four learning outcomes varied by grade, gender, or study site. Results from these models are shown in Table 6. None of the interaction terms (condition x grade, condition x gender, or condition x city) emerged as significant predictors of any of the learning outcomes. This indicates that the effects of UMIGO relative to Math Blaster were relatively consistent across grade levels, genders, and cities.

Table 6

Significance Tests for Effects of Main Effects and Moderators on Learning Outcomes

	Outcome							
	Capacity		Inequalities		Height/ Length		Early Arithmetic	
Source	*b*	*F*	*b*	*F*	*b*	*F*	*b*	*F*
Pretest score	0.21	*F* (1, 459) = 23.7**		*F* (1, 390) = 92.3**		*F* (1, 456) = 34.9**	0.76	*F* (1, 453) = 448.6**
UMIGO condition (reference = Math Blaster)	8.88	*F* (1, 19) = 5.9*	4.92	*F* (1, 11) = 6.9*	4.03	*F* (1, 18) = 0.5	0.59	*F* (1, 14) = 0.1
Grade 1 (reference = grade 2)	-3.78	*F* (12,22) = 3.4	-5.60	*F* (1, 22) = 31.6**	-1.68	*F* (1,21) = 1.8	-2.61	*F* (1, 19) = 7.4*
Male Gender (reference = female)	0.38	*F* (1, 457) = 0.1	0.02	*F* (1, 459) = 0.0	-2.28	*F* (1, 446) = 0.3	0.75	*F* (1, 457) = 1.4
City (reference = Sedro-Wooley)		*F* (2, 20) = 0.5		*F* (2, 13) = 12.0**		*F* (2, 20) = 6.3**		*F* (2, 16) = 0.4
Bridgeport	-3.84		-6.28		-8.78		-1.56	
Memphis	-0.70		-1.67		-2.97		-1.11	
UMIGO Condition x Grade 1	-0.57	*F* (1, 23) = 0.0	-0.29	*F* (1, 17) = 0.0	0.97	*F* (1, 21) = 0.1	0.36	*F* (1, 17) = 0.0
UMIGO Condition x Male Gender	1.13	*F* (1, 457) = 0.5	0.02	*F* (1, 459) = 0.0	-2.49	*F* (1, 447) = 2.7	0.34	*F* (1, 459) = 0.1
UMIGO Condition x City		*F* (2, 20) = 0.5		*F* (2, 13) = 0.4		*F* (2, 19) = 0.2		*F* (2, 15) = 0.1
UMIGO x Bridgeport	-5.97		-2.76		-0.83		-0.49	
UMIGO x Memphis	-3.20		-2.55		-3.16		-1.14	

* = p < .05. ** = p < .01.

Discussion

This is one of the first studies to examine the educational effects of a specific multimedia suite of learning products on children's mathematics understanding and achievement. The present findings indicate that children randomly assigned to using the UMIGO transmedia suite of products showed significantly greater learning gains in certain mathematics curricula. Specifically, children who used the UMIGO materials for a total of eight hours over a four-week period showed greater improvement in their ability to measure capacity and to solve inequalities than children who used a comparison set of commercially-available products, Math Blaster. These gains in learning are uniquely attributable to use of the UMIGO materials, rather than to typical classroom instruction (which was comparable in both conditions), or to non-specific Hawthorne effects from using any type of mathematics app. Moreover, the effect size for gains in Capacity (d = .48) was fairly substantial for a media intervention. The effect size for Inequalities (d = .24) was more modest, but similar to the effects observed in RCTs of several other educational media interventions for young children, including the summative evaluations of the *Word World* television series (d = .28) and the *Duck's Alphabet* online game (d = .21) (Michael Cohen Group, 2012). The outcomes did not vary significantly by grade, gender, or study site, indicating that both first and second graders of both genders from across the country benefitted from the UMIGO materials. This study provides strong evidence that the UMIGO suite of products engendered children's early mathematics skills, specifically, their understanding of measures of Capacity and knowledge of Inequalities. These findings provide evidence that multimedia properties can be an effective means of educational intervention.

In two other curricular areas, Early Arithmetic and measures of Height and Length, no difference was found between children in the UMIGO and Math Blaster conditions. Children in both conditions showed improvements, but the degree of improvement did not vary significantly by condition; it cannot be determined whether these improvements were due to regular classroom instruction, or whether

similar degrees of learning from both sets of products might have also contributed to these gains. However, there are a number of reasons why significant learning effects may not have been found in these curricular areas. First, it is important to note that because UMIGO products are still in ongoing development, there was a limited amount of materials available for all curricular groupings at the time of testing, particularly for the Height and Length grouping (only two products).[5] It is possible that, had the entire suite of Early Arithmetic and Height and Length products been available, stronger effects of learning in the UMIGO condition may have emerged. It is also possible that those UMIGO suites may have been sufficient but required a longer intervention time or more frequent use. Due to the overall large number of products in the four UMIGO suites, children only interacted with each product a few times over the month. More instances of use, over a longer period of time, may have further boosted learning.

Overall, the initial findings are promising, and this study raises additional questions to be explored in future research. First, since the media packages were tested as a whole, the efficacy of specific components in reaching the established learning goals is unknown. For example, without disaggregating specific components, it is difficult to determine how much of children's learning about measures of Capacity resulted from the music video versus the mobile game, the e-book, or a synergistic interaction among all of those components. It is also unknown whether the learning observed is additive, i.e., the sum of learning from the individual properties, or whether the properties potentiate each other, resulting in exponentially greater learning. This could be assessed in more a fine-grained study, such as a multiple baseline case study series in which components are introduced in different orders to different children.

Relatedly, it remains unknown how participants conceptualize their experience with the transmedia educational materials. The UMIGO materials are distributed across multiple platforms

[5] Note that significant effects were found in response to the Inequalities suite, which also only contained two products, but this curricular area is much narrower in scope.

(multimedia) but are also intended to be unified or integrated through common characters and a sense of narrative across platforms (transmedia). This study was not designed to determine to what extent children experienced a sense of integration and sustained narrative across the platforms, and if so, whether this contributed to their engagement and motivation to interact with these materials. The whole area of multimedia and transmedia research is very new (Kaolgeras, 2013): research paradigms are still being developed that can differentiate whether users experience materials in a multimedia way (i.e., they interact with disparate sets of materials) or as a transmedia phenomenon, in which interactions with diverse media components are integrated by the user into a common narrative.

It also remains unknown how the individual users interacted with specific media components. Teacher logs recorded use of the products on a classroom level, rather than on an individual level. Individual-level data would require much more documentation and tracking of individuals' use, including the incorporation of individual identification codes, with participants logging in to the digital products before each session. To ease usage requirements and maximize time dedicated to product use, the current study did not include this step. However, in future studies, data on individual users will be sought to allow tracking of individual trajectories of product use, and to relate these usage patterns to learning outcomes. This would provide a better sense of how products are used in conjunction with each other.

This first investigation into the efficacy of UMIGO was an unmediated intervention in a formal/school setting. The effectiveness of these products remains to be assessed in an informal/home environment, where the products would have to compete with other media products and leisure activities for use and attention. The formal setting facilitated subject recruitment, reduced study costs, and ensured that children were afforded designated time to use these properties. The resulting findings, obtained with participants who were following a directed schedule of use, confirms the potential of UMIGO products for enhancing young learners' math skills. Future planned research will build on these

findings to test the appeal, use, and learning outcomes of UMIGO media products within an unmediated environment. Note that a free-use study, with no directed schedule, brings up an inherent challenge still to be resolved in transmedia studies: RCTs include application of a standardized intervention, however, by design, transmedia product usage is not intended to be standardized; users should be able to interact with products in a variety of orders and permutations.

Finally, the educational potential of constructivist technology tools with young children requires more scientific research. Current research on the use of simulations, media-creation tools, and other constructivist applications of technology in education is primarily focused on college and secondary school students; there has been less examination of such tools in primary grades. The concept of UMIGO was to provide opportunities for children to not only solve defined problems, but to also create their own problems to solve. UMIGO includes opportunities for children to create a digital racing car, make their own music videos, or even use a "universal toolkit" (with elements such as virtual tape measures, cutting tools, cogs, wheels, giant rubber bands) to create things and solve problems in the online UMIGO world. Such components were not fully developed at the time of this evaluation, and were not assessed in the present evaluation. Nonetheless, understanding the role of constructivist technology components in learning, especially in non-mediated learning of mathematics concepts, remains an important area for further research.

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Appendix A. IRB-Approved Materials

Chesapeake Research Review, Inc.

Providing Human Research Protections Services
IRB Services • Consultation • Education
7063 Columbia Gateway Drive, Suite 110
Columbia, MD 21046-3403
410.884.2900

PROTOCOL APPROVAL

DATE: 16 Jan 2013

TO: Michael Cohen, Ph.D.
Michael Cohen Group

PROTOCOL: United States Department of Education - Ready to Learn Grant - 307, UMIGO: Summative Research (Pro00008026)

APPROVAL DATE: 16 Jan 2013

EXPIRATION DATE: 16 Jan 2014

IRB APPROVED DOCUMENTATION:

Protocol Version:
- 307 Summative Research Protocol (Dated 01/14/13)

Consent Templates:
- 307 Parent ICF Batalla (Chesapeake IRB Approved Version 16 Jan 2013)
- 307 Parent ICF Beardsley (Chesapeake IRB Approved Version 16 Jan 2013)
- 307 Parent ICF Hanley (Chesapeake IRB Approved Version 16 Jan 2013)
- 307 Parent ICF Freeman (Chesapeake IRB Approved Version 16 Jan 2013)
- 307 Parent ICF Mary Purcell (Chesapeake IRB Approved Version 16 Jan 2013)

Other Materials:
- 307 UMIGO Summative Products (Not Dated)
- 307 UMIGO Summative Schedule (Not Dated)
- Site Agreement Mary Purcell (Dated January 7, 2013)
- Site Agreement Freeman (Dated January 4, 2013)
- Site Agreement Beardsley (Dated January 11, 2013)
- Site Agreement Hanley (Dated January 4, 2013)
- Site Agreement Batalla (Dated January 4, 2013)
- 307 UMIGO Math Blaster Hyper Blast Video Demo (Not Dated)
- UMIGO Research Project Narrative/Proposal (Not Dated)

The IRB approved the above referenced protocol with modifications to the Informed Consent Forms on 16 Jan 2013.

The IRB reviewed the project in accordance with the 45 CFR Part 46, Subpart D Federal Regulations which provide for additional protections for children as research subjects.

The IRB determined that the research study meets the criteria found in the risk category described as follows:

- 45 CFR 46.404: *"Research not involving greater than minimal risk." Permission of one parent is required.*

Please review the Investigator Handbook by accessing CIRBI™ (www.cirbi.net). Log on to your CIRBI homepage ("My Home") and select the "Reference Materials" tab for IRB requirements and guidance. A copy of the most recent IRB roster is also available under "Reference Materials".

Thank you for selecting Chesapeake IRB to provide oversight for your research project.

Project UMIGO: Summative Research Protocol

01/14/13

Research Objectives

This research project is part of a cooperative grant sponsored by the United States Department of Education's Ready to Learn (RTL) program. The goal of RTL is to create effective educational media to engender early literacy and numeracy acquisition among disadvantaged children aged 2-8 years.

The overarching purpose of this research study is to measure the effects of a new educational media property called UMIGO (short for "yoU Make It GO") created by W!ldbrain Entertainment, Inc. W!ldbrain has been developing the UMIGO property for young children (3-8 yrs) for different media platforms, such as online games, videos, digital applications, books, and board games. Michael Cohen Group (MCG) has conducted numerous iterative formative research studies since the start of the grant, and plans to conduct summative research on the property thus far.

This research project encompasses all summative testing for the UMIGO property and aims to gather detailed information on the effectiveness of it as an educational tool. This kind of research will involve exposure to the property as it has been developed to date, and standardized testing to measure academic achievement (see *307 UMIGO_Summative Products* for full list and description). The majority of products have been approved by Chesapeake IRB as part of previous studies under UMIGO Formative Research (Pro0006223).

Procedure

The methodology for the summative testing for UMIGO includes several phases. The following is a detailed description of the proposed study.

> *Recruitment.* The study will take place at multiple school sites in various geographical locations (Connecticut, Tennessee, Washington). Letters of agreement from external sites will be forwarded to the IRB. In total, up to 600 children will be recruited through the study sites. About half the participants will be in first grade, and the other half will be in second grade.
>
> In order for a parent to enroll a child in the study, s/he will need to give informed consent (see *307 Parent ICF* for each site). Site staff will physically distribute the forms (as well as provide photocopies for personal records) to parents at pick-up/drop-off times, or through backpack mail. Site staff will collect them after a parent has the opportunity to review the form. The site will then forward the consent forms to MCG. Parents will be able to discuss the project with MCG researchers via phone or email (contact provided on the consent form). Arrangements can be made to meet in person if necessary. However, parents will not see study materials before the study to ensure an unbiased sample.

Pre-test. In the first phase of research, MCG researchers will administer the same battery of assessments to measure mathematical ability and attitudes with each child individually. These include the *California Standards Test*, *Georgia Criterion-Referenced Competency Test*, and measures written by Michael Cohen Group (see *California Standards1st, California Standards2nd, Georgia CRCT1st, Georgia CRCT2nd,* and *UMIGO_Summative_Measures*).

Intervention. In the second phase of research, participants will be assigned by the classroom to one of the following conditions for 19 school days during class time. The interventions are considered supplemental to regular curriculums, and will be administered once per day in no longer than 30-minute sessions.

1. *UMIGO*: Children will be exposed to and interact with a number of UMIGO products in their current state of development. See *307 UMIGO Summative Products* for a list of products, and *307 UMIGO Summative Schedule* for an intervention schedule.

2. *Math Blasters*: Children will be exposed to and interact with a control intervention consisting of the Math Blasters property. See *307 Math Blaster Hyper Blast Demo* for video footage of the mobile game and *307 UMIGO Summative Schedule* for an intervention schedule.

In total, approximately half of the participants will be assigned the UMIGO experimental condition, and half will be assigned the Math Blasters control condition. Interventions will be assigned by classroom, with approximately half the classrooms in each school being assigned one or the other condition. All schools have agreed to provide computers with internet connections, and MCG will be provide mobile devices (i.e. iPads) to conduct the intervention.

Post-test. In the third and last phase of research, MCG researchers will administer the same battery of assessments to measure mathematical ability and attitudes with each child individually. These include the *California Standards Test*, *Georgia Criterion-Referenced Competency Test*, and measures written by Michael Cohen Group (see *California Standards1st, California Standards2nd, Georgia CRCT1st, Georgia CRCT2nd,* and *UMIGO_Summative_Measures*).

Compensation. External sites will typically receive a $500 honorarium (written as a check) for participating in the study.

Audiotaping/ videotaping. Participants may be audiotaped or videotaped for research purposes only. Participants will be informed of this in the consent process. See below in Confidentiality section for details on data security.

Confidentiality

MCG maintains strict confidentiality for all research participants. No participant will be identified by name or personal identifying information in any presentation of the findings unless they have been notified, and signed consent has been received to use individual attributable verbatims for endorsement purposes. The only instance confidentially may be breached is in the case of suspected child abuse. Original data is kept in locked storage and housed at the MCG office in New York, New York for the duration of grant activity. This data security plan also applies to audio and video recordings, which will be securely stored in a digital format on hard disk drives.

All recordings will be securely stored in digital format on hard disk drives for the duration of grant activity (including analysis), after which they will be destroyed.

Parent or Legally Authorized Representative

Consent Form

STUDY TITLE: Project UMIGO: Summative Research

PROTOCOL NUMBER: 307 (Summative)

PRINCIPAL INVESTIGATOR: Michael Cohen, Ph.D.

TELEPHONE: 212-431-2252

ADDRESS: (School name and address here)

BACKGROUND AND PURPOSE: Your child is invited to participate in a research study conducted by Michael Cohen Group as part of a program sponsored by the United States Department of Education that aims to create educational media to promote early literacy and numeracy skills in children. Michael Cohen Group is an international research and consulting firm that specializes in children and educational media.

We are currently testing whether or not a new line of children's educational media products (i.e. online games, videos, board games, books, etc.) affects academic achievement in comparison to a pre-existing line of educational products. If your child participates, s/he will be asked to participate in several standardized tests measuring math ability before and after interacting with the children's educational media products.

PROCEDURES:

As part of this research project, our team of researchers (all trained to work with young children) will introduce themselves to your child and conduct several standardized tests measuring math ability. Your child will then be randomly assigned to receive either the new or pre-existing educational material during the school day for a total of 19 days. The intervention will be in addition to, not in place of, your child's regular academic curriculum. Then our team of researchers will conduct the standardized tests again with your child. The test results will NOT be shared with you or your child's school. About 175 children from the school (and up to 600 children across the United States) will participate in total.

POSSIBLE RISKS AND BENEFITS:

We do not anticipate any risks associated with being in this study. Although we do not promise that your child will receive any direct benefits from this study, your child will receive supplemental exposure to

educational materials. Also, we anticipate that most children will enjoy participating in the research process.

COMPENSATION:

At the end of the study, your child will be thanked for his/her participation. We will not be offering any monetary compensation for participating. The school where the study is taking place will be offered an honorarium for use of the space and help of the staff.

PARTICIPANTS' RIGHTS:

Participation in this study is voluntary. We will not work with your child unless you give your consent. If you give permission for your child to be in the study, but your child does not want to participate, then your child will not be in the study. Your child will be reminded that participation is voluntary by our researchers before the start of the activities. You and your child both have the right to change your mind and withdraw your consent or discontinue participation at any time without any penalty or loss of the benefits to which s/he is otherwise entitled. Your child has the right to refuse to answer particular questions. All your personal information will be held in strict confidentiality. The only instance where confidentiality may be compromised is in the case of suspected child abuse.

The research will not be used in any advertising. Your child will not be identified in any reports. All data will be identified only by an ID number, not by any child's name. The research may be audio taped or videotaped for research purposes only. Any audio or videotapes collected as part of the research will be destroyed once the study analysis is complete. We respect your child's privacy and will maintain strict confidentiality – your child's name will never be used in any documentation of our research findings. Your child's comments, voice, or image will never appear in public without your written consent.

CONTACT INFORMATION:

***** Questions, Concerns, or Complaints: If you have any questions, concerns or complaints about this research study, its procedures, risks and benefits, please contact the Project Director, at the telephone number listed on the first page of this form.

***** If you have any questions or complaints about your rights as a research subject, contact:

- By mail:

  Study Subject Adviser

  Chesapeake IRB

  7063 Columbia Gateway Drive, Suite 110

Columbia, MD 21046

- or call **collect**: 410-884-2900
- or by **email**: adviser@irbinfo.com

Please reference the following number when contacting the Study Subject Adviser:
[*Pro00008026*]

Please discuss this study with your child. Please complete the section below if you agree to allow your child to participate.

My child, _____, has my permission to participate in
(Name of Child)

this research project with the Michael Cohen Group. I have also discussed the study with my child and s/he has indicated that s/he would like to participate in the study. My child and I both understand that my child or I may stop his/her participation at any time.

My child is a: Boy
(Circle One)
Girl

My child's date of birth is: _____
(Month/Day/Year)

My child's age is: ___ Years, ___ Months

_____ _____
Signature of Parent or Legal Guardian Date

_____
Print First and Last name of Parent or Legal Guardian

A copy of this consent form will be given to you to keep.

Appendix B. Curriculum Content of UMIGO and Math Blaster Products

Curriculum Content of UMIGO Products

	Music Videos					Online Games		iPad Games and e-books				Non-Digital	
Early Arithmetic	Break It Down	That Makes Ten	--	--	--	Mix 'n Fix	--	Pop-arazzi	--	--	--	U-Make-It-Fun activity guide	Stack Attack board game
Greater Than or Less Than (GTLT)	--	--	GTLT	--	--	--	--	--	GTLT e-book & video	--	--	--	--
Height and Length	--	--	--	The Ruler	--	--	Stack Chal-lenge	--	--	--	--	--	--
Capacity	--	--	--	--	A Cup Fills Up	--	--	--	--	Capa City game	Capa City e-book & video	--	--

Curriculum Content of Math Blaster Products

	Online and iPad Games		Online Games			iPad Game	Non-Digital
Addition	Hyper Blast	Zapper	--	--	--	--	worksheet
Subtraction	Hyper Blast	Zapper	--	--	--	--	worksheet
Multiplication	Hyper Blast	Zapper	--	--	--	--	worksheet
Division	Hyper Blast	Zapper	--	--	--	--	worksheet
Fractions	Hyper Blast	--	--	--	Risk It	--	worksheet
Standard form	Hyper Blast	--	--	OOZAMI	--	--	--
Numbers place	--	--	--	--	--	--	--
Angles	--	--	Angle Attack	--	--	B-Force Blaster	--
Multiples	--	--	--	--	--	B-Force Blaster	--
Money	--	--	--	--	Risk It	--	worksheet
Reasoning	--	--	--	--	Risk It	--	--
Other concepts	--	--	--	--	--	--	worksheet

Appendix C. Assessment Measure

Student ID #: _____ Student Initials: _____

Date: _____ Grade: _____

Age: _____ Researcher's Initials: _____

Part I: Missing Addends

M1 **What two numbers added together equals 5. How many can you think of?** *Child answers verbally, researcher records answers.*

M2 **Think of two numbers that add up to 7. How many can you think of?** *Child answers verbally, researcher records answers.*

M3 **Think of two numbers that add up to 10. How many can you think of?** *Child answers verbally, researcher records answers.*

M4 **Can you skip count by 2 to 20?** *Child answers verbally, researcher records answers.*

2 _____ _____ _____ _____ _____ _____ _____ _____ _____

M5 **Can you skip count by 5 to 50?** *Child answers verbally, researcher records answers.*

5 _____ _____ _____ _____ _____ _____ _____ _____ _____

M6 **Can you skip count by 10 to 100?** *Child answers verbally, researcher records answers.*

10 _____ _____ _____ _____ _____ _____ _____ _____ _____

What number goes in the blank here? *Researcher reads each question in turn, records answers. After two minutes, the researcher asks the child to move on.*

M7 **3 + __ = 5**

M8 **2 + __ = 5**

M9 **__ + 4 = 5**

M10 **2 + __ = 8**

M11 **__ + 3 = 8**

M12 **__ + 5 = 8**

M13 **6 + __ = 10**

M14 **__ + 2 = 10**

M15 **__ + 3 = 10**

M16 **4 + __ = 10**

M17 **Look at these dogs. Count all of their ears. How many ears are there all together?** *Researcher circles answer and checks box to indicate skip counting.*

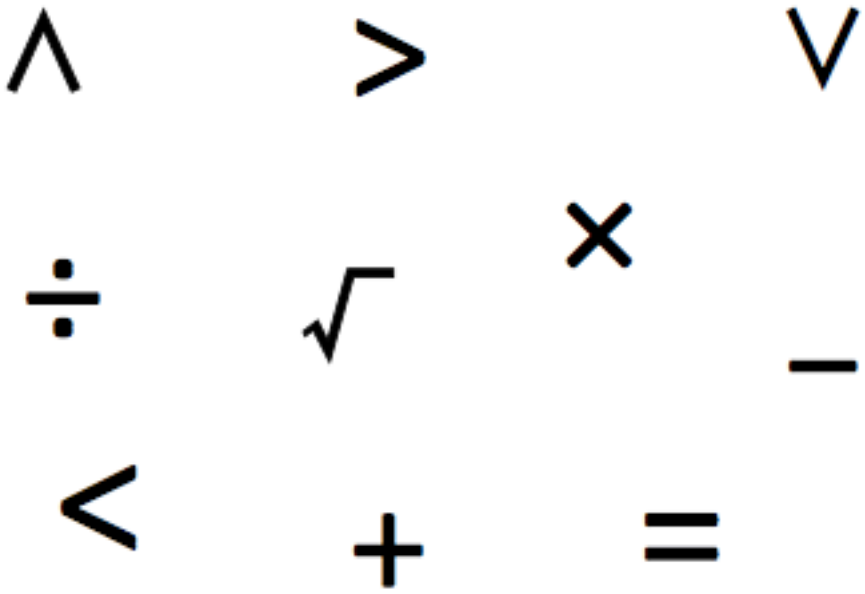
A. 8

B. 12

C. 16

Skip Counting Y☐ N☐

Part II: Greater Than or Less Than



G1 **Which symbol means "greater than"?** *Child points to answer, researcher records symbol.*

G2 **Which symbol means "less than"?** *Child points to answer, researcher records symbol.*

G3 **Which symbol means "equal to"?** *Child points to answer, researcher records symbol.*

Which symbol goes in the box? Greater than, less than, or equal to? *Researcher reads each question in turn and records answer.*

> < =

G4 1 ☐ 3

G5 4 ☐ 5

G6 8 ☐ 4

G7 7 ☐ 7

G8 2 ☐ 2

G9 8 ☐ 9

G10 **Which symbol goes in the box?** *Researcher circles answer.*

96 ☐ 87

A. =

B. <

C. >

G11 **Which symbol goes in the box?** *Researcher circles answer.*

5 + 8 ☐ 13

A. >

B. <

C. =

G12 **Which one is correct?** *Researcher circles answer.*

A. 359 < 375

B. 359 > 375

C. 359 < 359

D. 359 > 359

G13 **Which symbol goes here?** *Researcher circles answer.*

22 + 10 ☐ 32

A. =

B. +

C. >

D. <

G14 **Which number goes here?** *Researcher circles answer.*

91 > ___

A. 90

B. 92

C. 93

D. 94

G15 Which sign goes here? *Researcher circles answer.*

6 – 2 ☐ 1

A. >

B. =

C. <

D. –

G16 **Which is correct?** *Researcher circles answer.*

A. 307 = 307

B. 307 > 307

C. 370 < 370

D. 307 > 370

Part III: Capacity

C1 **Which words do you use to measure capacity?** *Researcher points to each word and reads it aloud. For each word, the researcher asks, "Is this a word you use to measure capacity?" The researcher then circles answer.*

mip mip		pint
yard	acre	bundle
quart		cup
glass	ounce	gallon

Which of these holds the most? *Researcher points to each container and names it aloud. The researcher writes a "1" under the one the child chooses.* **Which one holds the 2nd most? Which one holds the 3rd most? Which one holds the least?** *Researcher goes through remaining containers in turn, pointing and naming, and writing the corresponding number under the container chosen for each question.*

_____ _____ _____ _____

C2 **How many ounces are in a cup?** *Child answers verbally, researcher records answers.*

C3 **How many ounces are in a pint?** *Child answers verbally, researcher records answers.*

C4 **How many ounces are in a quart?** *Child answers verbally, researcher records answers.*

C5 **How many ounces are in a gallon?** *Child answers verbally, researcher records answers.*

C6 **How many quarts are in a gallon?** *Child answers verbally, researcher records answers.*

C7 **How many pints are in a gallon?** *Child answers verbally, researcher records answers.*

C8 **How many cups are in a gallon?** *Child answers verbally, researcher records answers.*

C9 **How many cups are in a pint?** *Child answers verbally, researcher records answers.*

C10 **How many pints are in a quart?** *Child answers verbally, researcher records answers.*

C11 **Which can hold more, 3 cups or 2 gallons?** *Child answers verbally, researcher checks answer.*

OR

☐ ☐

C12 **Which can hold more, 2 pints or 1 gallon?** *Child answers verbally, researcher checks answer.*

OR

☐ ☐

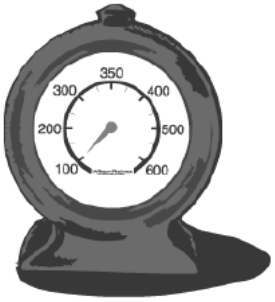
C13 **Which can hold more, 3 pints or 2 quarts?** *Child answers verbally, researcher checks answer.*

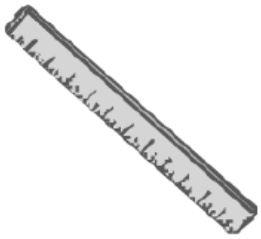
OR

☐ ☐

Part IV: Height and Length

V1 **Which of these helps us measure height and length?** *Researcher points to each item, and circles the child's answer.*

A. 

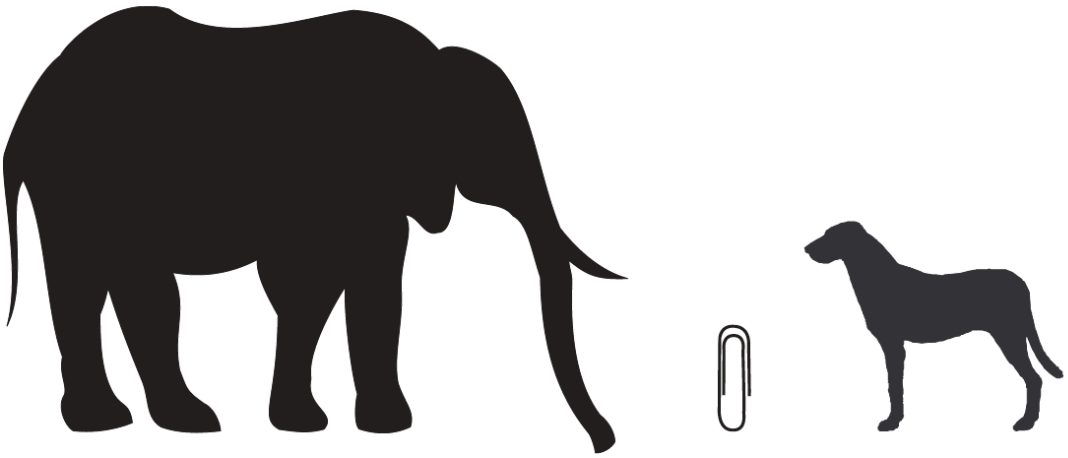
B. 

C. 

V2 **Circle all of the words that you use to measure height and length.**
Researcher points to and names each word aloud and asks the child, "Is this a word you use to measure height and length?" The researcher circles the words the child chooses.

meter		byte
heavy	pound	centimeter
watt		inch
feet	gram	mill

Use this picture to answer the following questions.

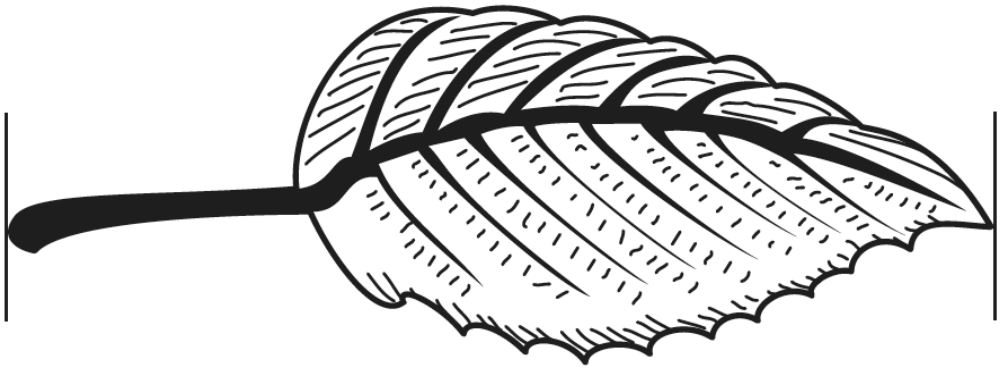


V3 **About how many paper clips tall is the dog?** *Child answers verbally, researcher records answers.*

V4 **About how many paper clips tall is the elephant?** *Child answers verbally, researcher records answers.*

V5 **Use your ruler to measure the length of the leaf and stem in inches?**

Researcher circles answer.



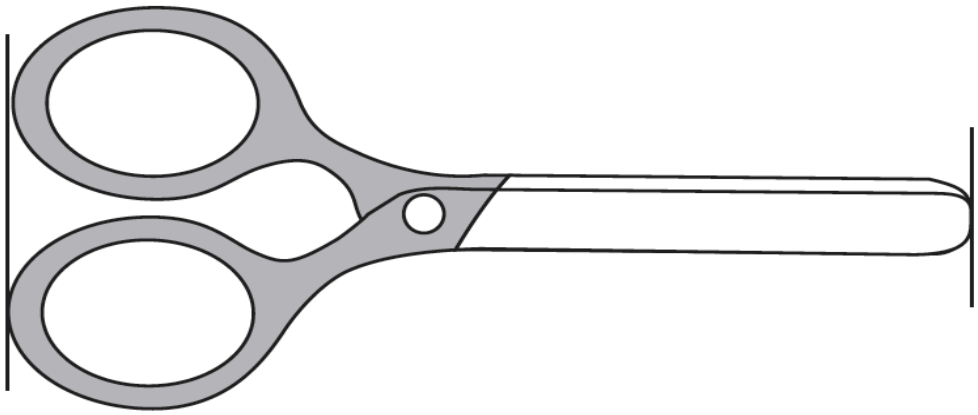
A. 4 inches

B. 5 inches

C. 6 inches

D. 7 inches

V6 **Use your ruler to measure the length of the scissors. How many inches long are the scissors?** *Researcher circles answer.*



A. 2 inches

B. 4 inches

C. 5 inches

D. 10 inches

V7 **How many centimeters equal an inch?** *Child answers verbally, researcher records answers.*

V8 **How many inches are in a foot?** *Child answers verbally, researcher records answers.*

Appendix D. Sample Schedule of UMIGO and Math Blaster Product Use

A full schedule was provided of daily UMIGO or Math Blaster daily activities. To help avoid scheduling conflict with materials (e.g., iPads, computer lab, television screens) two different orders were used for each condition. All four schedules are equivalent in overall time, as well as time spent interacting with digital and non-digital content.

Week /Day	UMIGO A	UMIGO B	Math Blaster Control A	Math Blaster Control B
1/1	1. GTLT (music video, 4 minutes) 2. GTLT (ebook and trivia, 15 minutes)	1. Ruler (Music video, 4 minutes) 2. That Makes Ten (Music video, 3 minutes) 3. Mix n Fix (Online game, 20 minutes)	1. On Time (worksheet, 15 minutes) 2. Add Up Total (worksheet, 15 minutes)	1. Marble Math (Worksheet, 10 minutes) 2. Wanted Posters (Worksheet, 10 minutes)
1/2	1. A Cup Fills Up (Music video, 5 minutes) 2. Break it down (music video, 4 minutes) 3. U-Make-It-Fun (Monster Dots Activity Guide, 5 minutes)	1. Break it Down (music video, 4 minutes) 2. Stack attack – (board game, 20 minutes) 3. U-Make-it-Fun (Monster Dots) 5 minutes	1. Math Blaster Space Zapper (Mobile game, 20 minutes) 2. Math Blaster Hyperblast 2 (Mobile game, 15 minutes)	1. Math Blaster Online World (Online World, 30 minutes)
1/3	1. Ruler (Music video, 4 minutes) 2. Stack Attack (Board game, 20 minutes)	1. Ruler (music video, 4 minutes) 2. Mix n Fix (online game, 20 minutes)	1. Wonderful Webs (worksheet 5 minutes) 2. Marble Math (worksheet, 10 minutes) 3. Sneak a peek (worksheet, 10 minutes)	1. Math Blaster Space Zapper (Mobile game, 20 minutes) 2. Math Blaster Hyperblast 2 (Mobile game, 15 minutes)
1/4	1. A Cup Fills Up (Music video, 5 minutes) 2. That Makes Ten (music video, 3 minutes) 3. Mix n Fix (Online game, 15 minutes)	1. A Cup Fills Up (Music video, 5 minutes) 2. GTLT (music video, 4 minutes) 3. That Makes Ten (music video, 3 minutes) 4. Break it down (music video, 4 minutes)	1. Wanted Posters (Worksheet, 10 minutes)	1. Math Blaster Hyperblast 2 (Mobile game, 30 minutes)
1/5	1. Break It Down (music video, 4 minutes) 2. U-Make-It-Fun (Mix up puzzle from Activity	1. Poparazzi (Mobile game, 15 minutes) 2. Capa City (Mobile game, 15 minutes)	1. What's That Number? (Worksheet, 10 minutes) 2. What's For Dinner? (Worksheet, 15 minutes)	1. Math Blaster Online World (Online game, 20 minutes)

	Guide, 15 minutes)			
2/6	1. Ruler (Music Video, 4 minutes) 2. Mix n Fix (Online Game, 20 minutes)	1. Ruler (Music video, 4 minutes) 2. A Cup Fills Up (Music video, 5 minutes) 4. Stack attack – (board game, 20 minutes)	1. Fraction Action (Worksheet, 15 minutes) -Pencil	1. Math Blaster Hyper Blast (Mobile Game, 15 minutes) 2. Math Blaster B Force Blaster (Mobile Game, 20 minutes)
2/7	1. A Cup Fills Up (Music video, 5 minutes) 2. Break it down (music video, 4 minutes) 3. Stack attack – Counting and Numbers (board game, 20 minutes)	1. That Makes Ten (music video, 3 minutes) 2. Mix n Fix (Online Game, 20 minutes)	1. Math Blaster Hyper Blast (Mobile Game, 15 minutes) 2. Math Blaster B Force Blaster (Mobile Game, 20 minutes)	1. What's For Dinner? (Worksheet, 15 minutes)
2/8	1. That Makes Ten (Music video, 3 minutes) 2. U-Make-It-Fun (A Game of Umis, Activity Guide, 20 minutes) 3. U-Make-It-Fun (Silly Straw Count, Activity Guide, 10 minutes)	1. Capacity (ebook and trivia, 10 minutes) 2. GTLT (ebook and trivia, 10 minutes) 3. Capa City (Mobile game, 15 minutes)	1. Odd-Even (Worksheet, 10 minutes) – Crayons (Blue/Green) 2. Worms Pals (worksheet, 15 minutes) – Crayons (R/G/B/Y)	1. Add Total (Worksheet, 15 minutes) – Pencil 2. What's the time (worksheet, 10 minutes)
2/9	1. Poparazzi (Mobile game, 15 minutes) 2. Capacity (ebook and trivia, 10 mins) 3. GTLT (ebook and trivia, 10 minutes)	1. Stack attack – Counting and Numbers (board game, 30 minutes)	1. Piece O' Cake (Worksheet, 10 minutes) - Crayons 2. Small Change Snacks - Pencil (Pre-color coins) (worksheet, 10 minutes)	1. It's About Time (worksheet, 15 minutes) - Pencil 2. On Time (worksheet, 15 minutes) - Pencil
2/10	1. GTLT (Music video, 4 minutes) 2. Break it Down (music video, 4 minutes) 3. That Makes Ten (Music video, 3 minutes)	1. GTLT (Music video, 4 minutes) 2. Ruler (Music Video, 4 minutes) 3. A Cup Fills Up (Music video, 5 minutes)	1. Math Blaster Hyper Blast (Mobile Game, 30 minutes)	1. What's That Number? (Worksheet, 10 minutes) 2. Sneak a peek (worksheet, 10 minutes)

3/11	1. Ruler (music video, 4 minutes) 2. Mix n Fix (Online game, 25 minutes)	1. Poparazzi (Mobile game, 15 minutes) 2. Capa City (Mobile game, 15 minutes)	1. What's the Difference? (Worksheet, 5 minutes) 2. Adding Along the Way (Worksheet, 10 minutes)	1. Ant Antics (worksheet 10 minutes) 2. What's the difference? (worksheet, 5 minutes)
3/12	1. GTLT (Music video, 4 minutes) 2. Break it Down (Music video, 4 minutes) 3. Stack attack – Counting and Addition (board game, 20 minutes)	1. GTLT (ebook and trivia, 15 minutes) 2. Capacity (ebook and trivia, 15 minutes)	1. Math Blaster (Online world, 30 minutes)	1. Number Mixup (Worksheet, 10 minutes) 2. Worms Pals (worksheet, 15 minutes)
3/13	1. A Cup Fills Up (Music video, 5 minutes) 2. Ruler (Music video, 4 minutes) 3. Capa City (Mobile game, 15 minutes) 4. Capacity (ebook, 10 minutes)	1. Break it Down (Music video, 4 minutes) 2. A Cup Fills Up (Music video, 5 minutes) 3. Ruler (Music video, 4 minutes)	1. What's the Time? (Worksheet, 10 minutes) 2. Shape Sums (Worksheet, 10 minutes) 3. Car trains Gridlokia (Worksheet, 10 minutes)	1. Math Blaster (Online world, 25 minutes)
3/14	1. That Makes Ten (Music video, 3 minutes) 2. Poparazzi (Mobile game, 15 minutes) 3. GTLT (ebook and trivia, 10 minutes)	1. GTLT (music video, 4 minutes) 2. That Makes Ten (Music video, 3 minutes) 3. U-Make it Fun (Monster dots, 5 minutes) 4. U-Make it Fun (Any choice, 5 minutes)	1. Math Blaster Online World (Online game, 20 minutes)	1. Odd/Even (worksheet, 10 minutes) 2. Fraction Action (Worksheet, 15 minutes)
3/15	1. Capa City (Mobile game, 15 minutes) 2. Capacity (ebook and trivia, 15 minutes)	1. A Cup Fills Up (Music video, 5 minutes) 2. Stack Attack – Counting and Addition (Board game, 20 minutes)	1. Math Blaster Online World (Online game, 15 minutes) 2. Ant Antics (Worksheet, 10 minutes)	1. Don't Bug Beetle Boss (Worksheet, 10 minutes) 2. Shape Sums (Worksheet, 10 minutes) 3. Adding Along the Way (Worksheet, 10 minutes)
4/16	1. That Makes Ten (music video, 3 minutes) 2. GTLT (music video, 4 minutes) 3. Ruler (Music video, 4	1. U-Make-It-Fun (Silly Straw Count, Activity Guide, 10 minutes) 2. Break It Down (music video, 4 minutes)	1. Math Blaster Space Zapper (Mobile game, 20 minutes) 2. Math Blaster B Force Blaster (Mobile Game, 15 minutes)	1. Math Blaster Online World (Online game, 20 minutes)

	minutes)	3. GTLT (music video, 4 minutes)		
4/17	1. Stack Attack –Teacher's Choice (Board game, 30 minutes)	1. Poparazzi (Mobile game, 15 minutes) 2. GTLT (ebook and trivia, 10 minutes) 3. Capacity (ebook and trivia, 10 minutes)	1. It's About Time (Worksheet, 15 minutes) 2. Don't Bug Beetle Boss (Worksheet, 10 minutes)	1. Coin Caper (worksheet, 10 minutes) 2. Car trains Gridlokia (Worksheet, 10 minutes)
4/18	1. A Cup Fills Up (Music video, 5 minutes) 2. GTLT (music video, 4 minutes) 3. U-Make-It-Fun (Any choice from Activity Guide, 5 minutes)	1. Break it down (music video, 4 minutes) 2. GTLT (music video, 4 minutes) 3. U-Make-It-Fun (Mix Up Puzzle Activity Guide, 15 minutes)	1. Coin Caper (Worksheet, 10 minutes) 2. Number Mix Up Fix Up (worksheet, 10 minutes)	1. Math Blaster Space Zapper (Mobile Game, 20 minutes) 2. Math Blaster B Force Blaster (Mobile Game, 15 minutes)
4/19	1. Poparazzi (Mobile game, 15 minutes) 2. Capa City (Mobile game, 15 minutes)	1. That Makes Ten (Music video, 3 minutes) 2. U-Make-It-Fun (A Game of Umis, Activity Guide, 20 minutes)	1. Math Blaster Online World (Online World, 20 minutes)	1. Piece O' Cake (Worksheet, 10 minutes) 2. Small Change Snacks (worksheet, 10 minutes) 3. Wonderful Webs (Worksheet, 5 minutes)