Mobile Game-based Learning and Student Engagement in Elementary Math Education: Comparison Between Todo Math and Paper-and-Pencil Activities

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Executive Summary

Today, mobile game-based learning is recognized for its potential to enhance children's ability to learn, solve problems, and convey their ideas. Teachers point out that mobile-based instructions are considered effective and practical supplemental tools for explaining difficult and complex math concepts (Charles & Mcalister, 2004), and particularly beneficial for young children who are not motivated by traditional learning instructions (Mouza, 2005).

However, little work to date has been done to guide future practice and pedagogy on using mobile technology in early childhood classrooms. In response to such needs, this study was conducted to explore the effect of a mobile game-based learning application on young children's math learning. We took two notably different approaches: (1) we focused on an important precursor to academic achievement—engagement in learning, and (2) we conducted classroom observations to compare children's engagement differences between a mobile game-based learning session and a traditional paper-and-pencil one.

This study was conducted at a kindergarten classroom in the Berkeley Unified School District. Two researchers visited the classroom two times and observed 19 kindergarteners' math learning. An award winning mobile math app, Todo Math®*, was used as a mobile game-based learning tool. Observers' ratings on kindergarteners' engagement during the Todo Math and paper-and-pencil activities were used for analyses. Key findings are as follows:

- Students were rated more focused on math activities during the Todo Math session, as compared to the paper-and-pencil one.
- Through simple counts of observed chatting with their peers, observers reported more frequent chatting among students during the paper-and-pencil session.
- Reasons for chatting during the sessions are different; for the Todo Math session, students talked to their peers to share problem-solving information, while for the paper-and-pencil activities, they wanted to just chat.
- Based on observers' rating of overall engagement level, most students were rated 'very engaged' and none were 'often distracted' during the Todo Math session.
- Individual case-analysis revealed that a student with special needs showed a greater sign of engagement and actual completion of tasks during the Todo Math session.

In sum, these findings indicate that mobile game-based learning can provide young students with meaningful math lessons where they have the opportunity to demonstrate engagement and overall efforts, along with a collaborative environment where students can share and discuss their learning process eagerly. Most importantly, mobile game-based learning was effective to support children with special needs who often have difficulty engaging in traditional math lessons. In combination with previous research findings, this result supports a need to fully integrate mobile game-based learning into math curriculum to encourage active engagement of diverse young students.

* Todo Math is registered trademark of Enuma, Inc. in the U.S. and other countries.

"Tell me and I forget. Teach me and I remember. Involve me and I learn."
- Benjamin Franklin

Introduction

The use of games in education dates back to the 1980s, when the powerful engagement that games produced inspired a new generation of researchers and educators to consider the learning potential of this exciting new medium (Bowman, 1982). These frontrunners were quick to identify the engaging power of games as a key asset to helping young children learn and were able to apply it to their work. Despite this promising beginning, the subsequent generation of "edutainment" products have been recognized as failing to effectively incorporate the engaging power of games into the learning environment (Kerawalla & Crook, 2005). However, the turn of the millennium has seen a rebirth of interest in game-based learning, paralleled by the advent of innovative mobile devices (Couse and Chen, 2010).

Today, mobile game-based learning is recognized for its ever developing potential to enhance children's ability to learn, solve problems, and convey their ideas. It can facilitate the creation of new learning cultures that better correspond with students' individual learning styles, goals, and interests. More importantly, mobile-based instructions can be considered effective and practical teaching tools for difficult and complex procedures because they: (a) use action instead of explanation, (b) provide immediate feedback, (c) accommodate multiple learning styles and skills, (d) reinforce mastery skills, (e) promote personal motivation and satisfaction, and (f) furnish an interactive learning environment and decision making context (Charles & McAlister, 2004).

These outstanding strengths of mobile game-based learning have encouraged a great number of school districts to purchase tablet devices such as iPads through federal and other grants, including money from the federal 'Race to the Top" competitive grant program (The New York Times, 2011). More standardized assessments, such as Smarter Balanced assessments, are done online, and a growing number of schools are switching from traditional textbooks to digital content. For example, Montgomery County public school district, which has the nation's largest education technology initiative, is halfway through an effort to provide an iPad to every student by 2018; the school system will have used $5.6 million in local and state funds to do so (The Washington Post, 2014).

Although some scholars have argued against the burgeoning use of mobile technology for young children's learning, including concerns about excessive screen time, negative health effects of Wi-Fi signals, and less social interaction (for review, see Hays (2005)), the effect of mobile technology use in educational settings for young children has been increasingly studied and reported positive at large. For instance, children who study in a mobile technology-

supported learning setting showed greater gains in math standardized scores, structural knowledge, problem solving skills, and language skills than the comparison group (Banister, 2010; Kukulaska-Hulme, 2009; Vernadakis et al., 2005).

Furthermore, some teachers pointed out that the integration of mobile technology into the school curriculum is particularly beneficial for young children who were not motivated by traditional learning activities. Also, Mouza (2005) showed in her gaming and learning work that students with disabilities often prefer technology-enhanced learning opportunities to traditional learning ones. Some special education teachers indicate that students with special needs have a higher level of interest in learning (Marino, Israel, Beecher, & Basham, 2013) given the various types of built-in scaffolds in a mobile technology-enhanced setting (Israel, Maynard, & Willamson, 2013).

However, there is a dearth of empirical evidence about the effect of mobile technology on young children's learning processes in formal school settings. Little work to date has been done to guide future practice and pedagogy on using mobile technology in early childhood classrooms (Kebritchi, Hirumi, & Bai, 2010). Methodological flaws in empirical studies are another factor that prevent us from drawing solid conclusions about the positive impact of mobile learning for young children. Frequent problems include a lack of control groups to compare actual effects of mobile learning, along with a failure to isolate mobile learning technology from other things that occur in the classroom (Kong et al., 2014). The quality of mobile-based instructional materials used for studies raises another concern about the validity of study results. Those quality issues necessitate further empirical study to help educators and practitioners better understand, implement, and facilitate the mobile-based instruction in a real classroom setting. Given the digital landscape of today, it is critical to better understand the benefits of mobile game-based learning in early learning environments.

In response to such needs, this study was conducted to explore the outcomes of mobile game-based learning use among young children through a classroom observation method. Instead of examining the effect of mobile game-based learning on students' test scores, we focused on an important precursor to actual academic achievement – students' engagement in their learning process. This experiment of integrating mobile game-based learning into the learning process may indicate that there is an intrinsic link between technology's core power of engagement and its learning contents, which leads to students' increased academic performance. However, studies on young children's engagement level during mobile technology-supported sessions have made little comparisons with engagement's effect on academic outcomes. Through examining relationship between mobile game-based learning and students' engagement, we may expect to acquire practical insight into utilizing mobile math learning contents to promote students' positive learning experiences.

The Product: Todo Math

(a) Daily adventure (b) Mission mode (c) Monster collection

(d) Free choice (e) My info (f) Parent page

Figure 1. Learning Features of Todo Math

Todo Math is a mobile game-based supplemental learning application containing basic math concepts for from Pre-K to 2nd grade. This application is designed to help and encourage students who are struggling in math or have different learning styles to become actively involved in their math learning process. Todo Math is a suite of multi-level games with over 500 stages and various types of learning features: daily adventure, mission mode, free choice mode, and monster collection.

As shown in Figure 1, Todo Math provides a variety of learning features that can enable young children to be independent, engaging learners, and teachers and parents to effectively help students learn math both at school and at home. This application is organized to offer daily math practice like a formal workbook would so students can solve assigned math problems every day. After completing a daily practice session, students move forward a spot on the map, and when they reach the final spot, they are able to acquire a virtual gift (Figure 1-a). Successful completion of daily practice adventures makes students feel proud of mastering the content assigned daily, which may encourage students to solve more problems voluntarily, make them feel comfortable with math, and help increase gradually their confidence in their math skills.

Todo Math's learning contents are well aligned with Common Core State Standards (CCSS, 2010). "Mission mode" (Figure 1-b) is designed to support young children's math learning based on the CCSS. Each mission includes 5 to 7 math games. When students solve all assigned games within each mission, they get one virtual key. Furthermore, students' learning progress can be assessed through "Monster Collection" (Figure 1-c). Each monster featured in the

Monster Collection represents one math concept or skill mastered based on CCSS. Getting 80% of answers correct in the daily adventure or mission mode enables students to capture a monster. Students can also attain a sense of their achievement by admiring their monster collection. An overview of the monsters collection can guide teachers and parents on how to support their students' and children's math learning. The "Free Choice" mode is also one of the many learning features in Todo Math that promote children's math engagement (Figure 1-d). The free choice mode offers over 19 basic math games where students can freely choose their favored types of games, which are carefully attuned to their proficiency level.

In addition to those learning features, Todo Math offers other supporting functions to facilitate effective learning. For example, the "My Info" feature (Figure 1-e) shows students' learning progress graphically. This feature provides additional personal input features to accommodate students' diverse needs, such as a left-handed keypad, dyslexia font, and a help button, and to also support localization, including language selection of English, Korean, and Chinese, etc. Lastly, parents can benefit from the "Parent Page" feature by receiving their child's learning progress reports and obtaining useful education-related information to scaffold their child's learning at home (Figure 1-f).

Todo Math utilizes the **Universal Design for Learning (UDL)** framework as a theoretical underpinning for designing the product. UDL provides proactive scaffolds to curricula for students with diverse learning styles and needs. The National Education Technology Plan affirms the importance of this framework by strongly stating that implementation of the three key UDL principles can lead to improved outcomes for diverse learners. UDL's key principles are as follows (Hall, Meyer, & Reise, 2012): (1) UDL supports multiple means of representation to demonstrate or explain fundamental concepts; (2) UDL provides various means of action and expression to help students better understand math concepts and improve their problem-solving skills; and (3) UDL uses a variety of means of engagement. Incorporating these three UDL principles into Todo Math's design contributes to create a mobile learning environment where the diverse needs of students are met, and math learning becomes engaging and motivating.

Study

Objectives

The primary objective of this study is to investigate how a mobile game-based learning app, named Todo Math, affects students' engagement in a kindergarten classroom setting. To clearly show the benefits of Todo Math as a learning supplement in an early elementary classroom, we provided two types of learning content: the mobile game-based learning game (Todo Math) and traditional paper-based learning contents (paper-and-pencil sheet).

Participants

The participants of this study were 19 kindergarteners (aged 5 to 6) of a public elementary school in the Berkeley Unified School District. Out of the 19 participants, 9 were girls and 10 were boys. The target kindergarten classroom voluntarily used Todo Math as one math activity for around 10 months from 2014 to 2015. This partnership started in response to the classroom teacher's request to adopt Todo Math to a math center in her classroom. A math center was an activity that this classroom ran to help students practice math problems by providing various forms of math learning content, such as math games, work sheets, and web- or mobile-based math games to students. During the math center, there were five tables for math activities in a classroom. The whole class was divided into five groups, and each group was instructed to rotate approximately every 10 minutes between one of the five math activities. After one activity was completed, each group moved to the next math table until all groups completed all five math activities. After several months of usage, the teacher was extremely satisfied with Todo Math as she noticed that more students in her classroom became actively engaged in math learning with the use of Todo Math. After the new academic year started, she asked to use Todo Math for a new class of students; in this collaboration, Enuma®† was able to observe the classroom twice: at 10:40 AM – 11:40 AM both on January 28th, 2016 and February 4th, 2016.

Method

Data for this study was collected through the direct observation of the classroom. Two observers visited the target kindergarten classroom twice. In each visit, they observed one math activity for 10 minutes and filled in the observation form by carefully observing how students engaged in the activities and what they did during the assigned session, focusing on two target activities: Todo Math and a paper-and-pencil activity. We adopted the classroom observation method to get a deeper understanding of young children's behavioral engagement during the mobile game-based learning session. We observed whether children were intrinsically engaged to use technology, as evidenced by their spending a shorter amount of time to figure out math problems and having more focused sessions with the mobile screen, compared with traditional paper-and-pencil activities.

Instrument

Math Activities: Domino and Tallies' Lab

For effective application of Todo Math within a classroom setting, Todo Math was inserted as one of the activities during the math center, which is used to help students practice math in an elementary classroom. A math center is composed of five different math activities, and three of them are math games such as a block game or board game led by a teacher or a room helper. The remaining two activities were the study's target activities: a paper-and-pencil activity and a Todo Math activity. To keep all other conditions the same, we chose two math games from Todo

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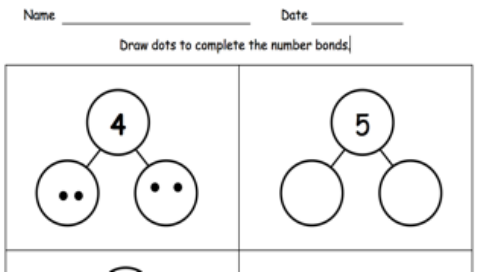
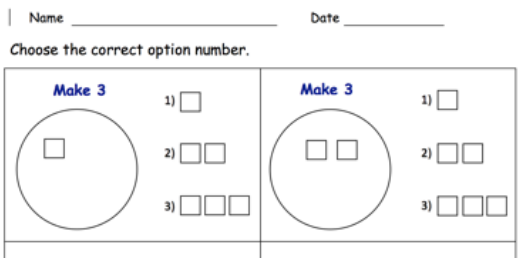
Math (Domino and Tallies' Lab) that are aligned with the current curriculum and created a new paper-and-pencil activity counterpart per a game based on discussion with the room teacher (see Figure 2). The chosen curriculum was number bond. It is a very basic and essential math concept for understanding how numbers work and relate with each other. It demonstrates relationships among numbers and how to combine each number to make the target number, such as 3 + 4 = 7 and 4+ 3 = 7 or 7 – 4 = 3. 3, 4, and 7 can be a number bond. It is an important foundation for young students learning addition and subtraction.

(a) Todo Math: Domino



(b) Paper-and-pencil: Domino Counterpart

(c) Todo Math: Tallies' Lab



(d) Paper-and-pencil: Tallies' Lab Counterpart

Figure 2. Todo Math vs. Paper-and-pencil Session Tools

Student Engagement: Behavioral and Overall Engagement

The conceptualization of engagement has been part of a larger model of human motivation theory over the last several decades (Deci & Ryan, 2000; Skinner, 1991). The engagement concept has attracted growing interest as a precedent to academic achievement. Prior research has shown that children's active, enthusiastic and effortful participation in learning activities in the classroom predicts their achievement and completion of tasks (see Fredricks et al., 2004, for a review). In particular, the concept of behavioral engagement has been frequently used in classroom observational studies partly due to its convenient nature of measurement (Lee & Anderson, 1993; Newmann, 1992). Behavioral engagement draws on the idea of participation;

key markers of engagement behaviors include effort exertion, persistence, as well as indicators of mental effort, such as attention and focus.

Following this conceptualization of engagement, this study had observers rate young children's engagement in math using two indicators -- students' attentiveness to math activities and signs of distraction. Student attentiveness to math activities mainly measured their level of focus on the assigned learning contents. To help standardize the rating process, it is categorized into five types, including 'Focused' and 'Unfocused.' With regard to assessing signs of students' distraction, two behavioral indicators were used: (1) Chatting with peers and (2) Calling out for teacher attention (hereby referred to as, 'calling for teachers'). Instead of simply counting frequencies of these two behaviors, observers were instructed to check reasons for those behaviors as well. Specific categories for each behavior are listed in Table 1. After rating three behavioral indicators, observers evaluated students' overall engagement level using a likert scale, rating from 0 to 3. Table 1 summarizes operations and categories of each engagement indicator.

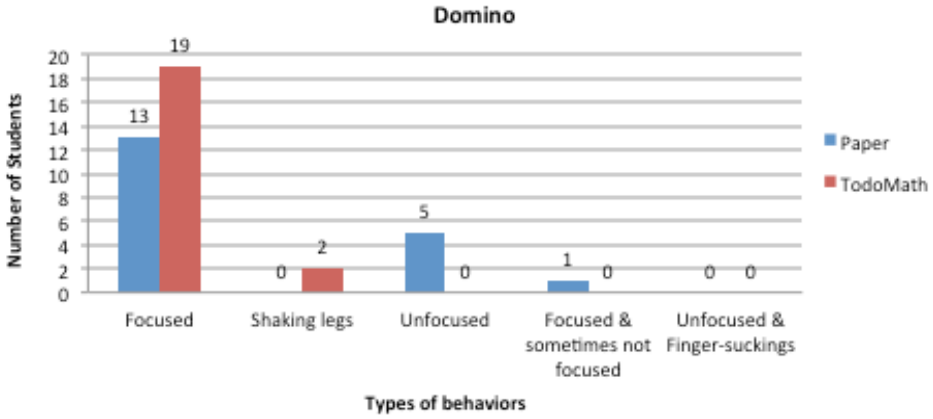
Table1. Operationalization of the Engagement during Observations

Engagement construct	Participant indicator	Categories or Ratings
Behavioral engagement		
1) Attentiveness to academic activities	Focus-level during learning	5 categories -Focused -Focused & sometimes unfocused -Shaking legs -Unfocused -Unfocused & finger-suckings
2) Signs of distraction	Frequency and reasons for chatting with peers	Counts of frequency 3 categories -Share problem-solving information -Just chatting -Others
	Frequency and reasons for calling out for teachers' attention	Counts of frequency 3 categories -Understanding assigned problems -Asking for what to do next -Gaining teacher's attention
Overall engagement		
	Observers' direct ratings on engagement	4 scale ratings 0 (very distracted) to 3 (very engaged)

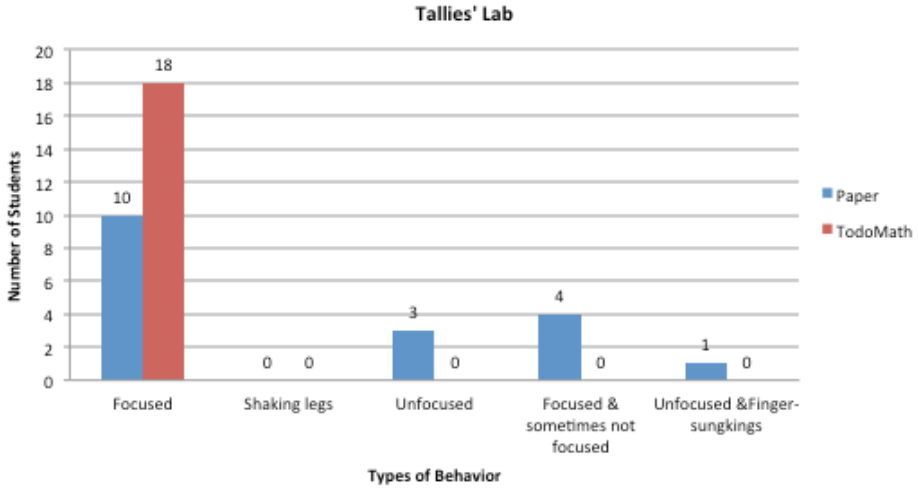
Result

Group-level Analysis: Engagement Comparison of Todo Math vs. Paper-and-pencil Activities

Students' attentiveness to math activities



(a) Activity #1. Domino



(b) Activity #2. Tallies' lab

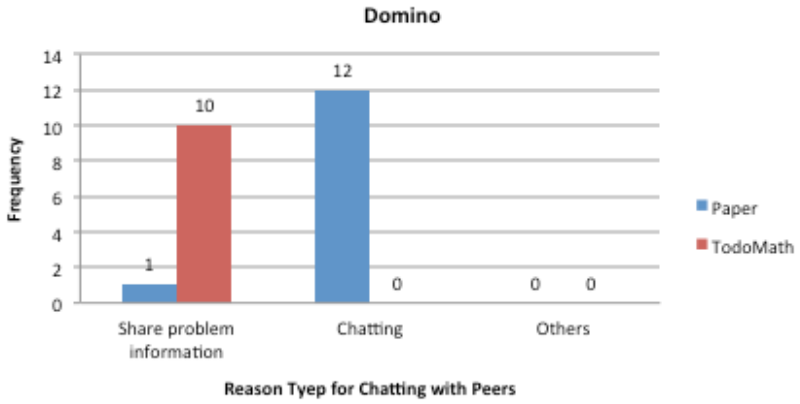
Figure 3. Student Attentiveness to Learning During Todo Math vs. Paper-and-pencil Activities

Overall, students were rated more focused on math activities during the Todo Math session, as compared to the traditional paper-and-pencil session. Specifically, in the case of the Domino problem, 19 students were observed 'Focused' on learning and 2 students were 'Shaking Legs' during the Todo Math session, while 13 students were 'Focused' during the paper-and-pencil

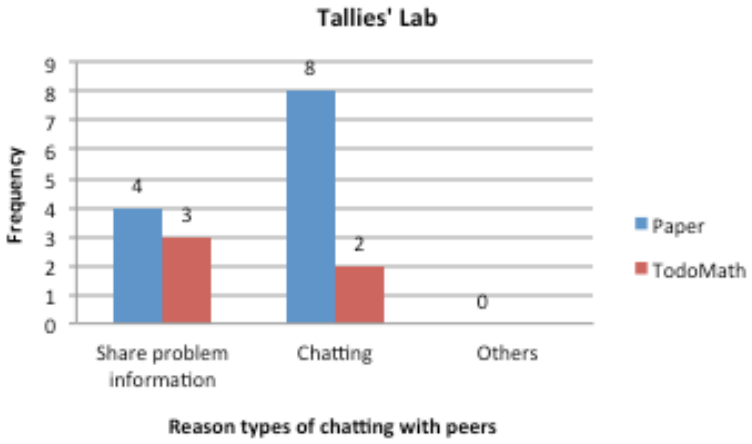
session and other 6 students displayed ‘unfocused’ behaviors. This difference became more prominent when solving the ‘Tallies’ Lab’ questions. 18 students displayed ‘focused’ behavior during the Todo Math session, while only 10 students displayed ‘focused’ behavior during the paper-and-pencil session.

Students’ sign of distraction

Frequency and reasons for chatting with peers



(a) Activity #1. Domino



(b) Activity #2. Tallies’ Lab

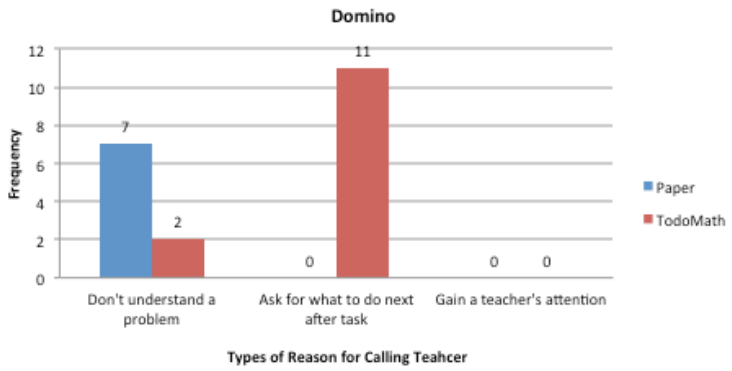
Figure 4. Frequency of Chatting with Peers During Todo Math vs. Paper-and-pencil Activities

Observers recorded how often students talked to their neighboring peers. When solving the Domino problem, frequency of chatting with peers was slightly higher during Todo Math (n=13) than the paper-and-pencil session (n=10). In contrast, when solving the Tallies’ lab problem, frequency of chatting with peers was markedly higher during the paper-and pencil session (n=12). However, this simple counting of frequency can be misleading. Understanding reasons

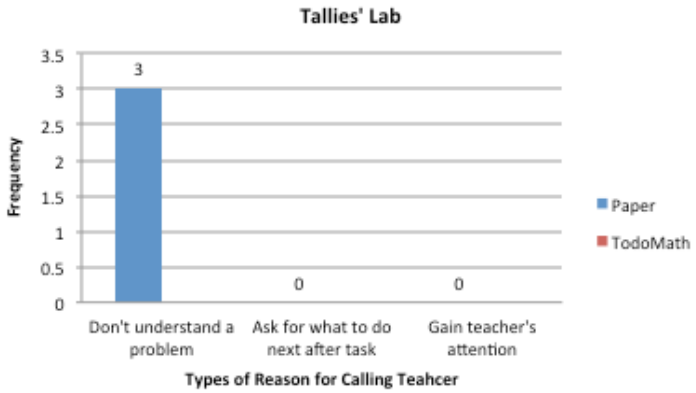
for chatting is critical to correctly assessing the nature of children's engagement in math learning. Thus, this study collected additional observation data about why students initiated in chatting with their peers. As Figure 4 displays, in the case of the Domino activity, most times (12 out of 13) with paper-and-pencil activity, students wanted to chat and the remaining time (1 out of 13) was to share problem-solving information. On the other hand, ten counts with the Todo Math session were for sharing problem-solving related information with peers.

Frequency and reasons of calling teacher

In the case of the Domino problem, students were reported to call for teachers 13 times during the Todo Math session and 7 times during the paper-and-pencil session. These seven times during the paper-and-pencil session were students asking for help when they did not understand the math problems. On the contrary, only two instances of students asking for help during the Todo Math session were observed. Most of cases of calling for teachers (11 out of 13) during the Todo Math activity happened because students wanted to ask what to do next after the assigned task.



(a) Activity #1. Domino

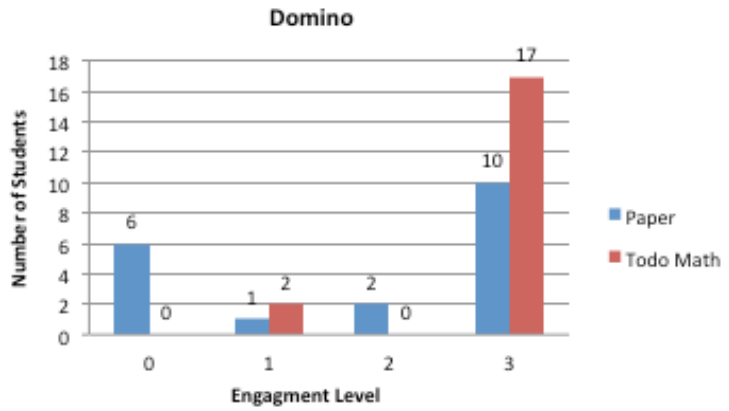


(b) Activity #2. Tallies' Lab

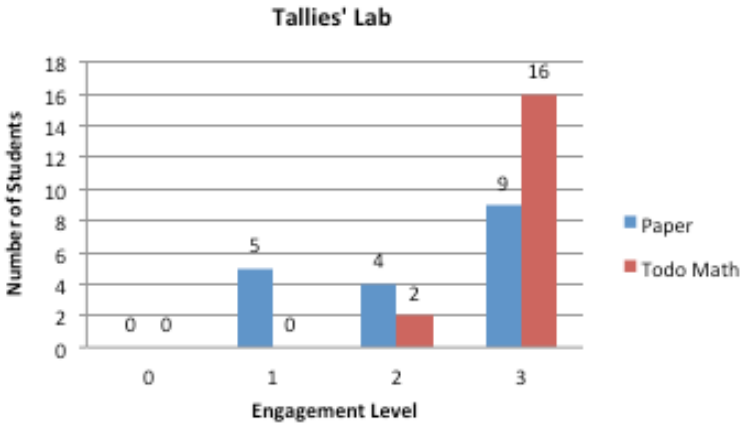
Figure 5. Frequency and Reasons of Calling for Teachers During Todo Math vs. Paper-and-pencil Activities

Overall student engagement level

Observers were asked to rate each student's engagement level using a number from 0 (very distracted) to 3 (very engaged). This result may be subjective based on observers, but it may be an important indicator to identify overall student engagement level for each activity. In the case of the Domino problem, most students (17 out of 19) were 'very engaged' during the Todo Math activity and only two students were 'sometimes engaged', as illustrated in Figure 6. In contrast, 10 students were 'very engaged' and six students were 'often distracted' during the paper-and-pencil activity. Similarly, in the case of the Tallies' lab problem, students were more likely to be rated as 'very engaged' during the Todo Math session.



(a) Activity #1. Domino



(b) Activity #2. Tallies' Lab

Figure 6. Overall Student Engagement Level

Individual Case Analysis -- A Breakthrough for Sam (a kindergartener with special needs)

In the participating classroom, Sam (pseudonym) was identified as a student with special needs. With respect to confidentiality of study participants' information, any specific information about types or severity of this student's special needs was not available. The direct observation showed that Sam was unmotivated and inattentive during traditional instruction (paper-and-pencil activity); she/he behaved as though the instructed materials did not attract her/his interests, and seemed unable or unwilling to solve the paper-version problems. She/he did not complete both Domino and Tallies' lab problems within the assigned time limit (10 min) during the paper-and-pencil session.

In contrast, during the Todo Math session, her/his engagement and interest in math problems changed markedly. She/he actually showed high interest in the Domino problem and made an effort to solve the problem in 4.5 minutes even if other students solved their problems in 2 or 3 minutes. Her/his completion of activity is very important because she/he did not complete the Domino counterpart (paper-and-pencil) problem in the assigned time and she/he only answered the first two problems with the teacher's help. Based on his engagement ratings, he displayed "focused" engagement for both problems and no sign of "stress" or "distraction" during the Todo Math session. Tables 2 and 3 present the observational ratings on Sam's task completion and engagement during the paper-and-pencil vs. Todo Math sessions.

Table 2. Sam's Task Completion Time and Problem-solving Method

	Completion time		Problem-solving method	
	Paper-and-pencil	Todo Math	Paper-and-pencil	Todo Math
Domino	No completion	4.5 min	N/A	Trial & Error
Tallies' lab	No completion	10 min *	N/A	Think & Solve

*: It means that a student started solving but did not answer all problems in the assigned time (10 minutes)

Table 3. Table 3. Sam's Engagement Ratings

	Behavioral engagement		Overall engagement	
	Paper-and-pencil	Todo Math	Paper-and-pencil	Todo Math
Domino	Unfocused	Focused	0.3	3.0
Tallies' lab	Unfocused	Focused	1.0	3.0

Discussion

Overall, observations of students within both the paper-and-pencil and Todo Math activities clearly show that students were more on-task, attentive, and engaged in the Todo Math session, in comparison to the traditional paper-and-pencil one. This result indicates that Todo Math environments provided young students with purposeful and meaningful lessons where students had the opportunity to demonstrate engagement and overall effort, which may lead to improved academic performance.

It should be noted that during our observation sessions, social collaboration was more likely to be exhibited within the mobile game-based learning session, compared with the paper-and-pencil session. This result is contrary to popular public belief that individualized nature of mobile game-based learning may hinder students from working collaboratively with peers and lead to greater isolation of each student. However, during our observation, participating kindergarteners were eager to share their progress and performance, and were passionate to discuss newly learned information from Todo Math, all of which made the whole classroom learning environment more dynamic and engaging.

Todo Math's inclusive nature for students with special needs is another remarkable finding of this study. If students' learning style does not match or does not correlate to the classroom environment, the results could be traumatic for students. Lack of a preferential environment could cause a student stress during the school day and a lack of academic progress. Because all students have different multiple intelligences and acquire information uniquely, using individualized learning through mobile devices is more likely to increases their ability to attend to specific instruction. Analysis of Sam's (student with special needs) engagement data clearly conveys this point. Unlike her/his complete disengagement in the paper-and-pencil session, Sam was on-task to solve math problems during the Todo Math session. After finishing the problem, she/he asked the teacher what she/he can do next. When children with special needs use an appealing, individualized tool, they can be more focused and attentive to learning or to instruction. Sometimes in a traditional classroom, where teachers are asking questions, the ones that are quick to understand the concepts are answering the queries, and the ones who may take a little longer to process them may not have time to respond and engage. Those that may require a bit more time, or a different approach, to processing the learning can use a mobile tool much easier than they can try to solve with a paper and pencil. Mobile devices allow students to work at their own pace and with a level of privacy formerly unheard of in the classroom. That can help remove the stigma that often comes with being special needs students.

Then, what makes students more engaged in Todo Math, compared with the traditional paper-and-pencil method? Collected observation results gave us some insights about the educational benefits that Todo Math can bring to enhance young children's engagement in math learning. First, Todo Math can make learning fun and interesting. Incorporation of fun and appealing game-based design into learning contents engages young minds in the learning process. Its'

focus on self-exploration and self-motivation, instead of repetition or direct instruction, is particularly beneficial to explain complex math concept to young learners more intuitively.

Furthermore, Todo Math can provide positive learning experiences among young students. An important element of game-based learning is the feedback learners see if they answer incorrectly. Typically, children's math learning games are designed to provide explicit negative signs (e.g., an error sound, shaking, or color change) to indicate that they have answered incorrectly. In contrast, rather than just telling children they were right or wrong, Todo Math provides feedback that shows the quantitative implications of a mathematical answer or scaffolds their learning with a help function. This positive experience and hints play a critical role in encouraging young children to continue their learning without frustration, and they build everyday habits for children to engage in math learning.

However, providing only fun-packed materials cannot meet educators' goals. The key is to create a game that is both fun and educational, which is a significant challenge. We believe that one of the major strengths of Todo Math is the well-established balance between instructional content and game characteristics. This balance helps young children to become independent, engaging and competent learners.

Conclusion

Despite the hype around how mobile game-based learning can make education more engaging and meaningful, more rigorous research is still called for. The findings of this research present an important step toward this goal. We have identified educational opportunities for mobile game-based learning in engaging kindergartners' math learning. In combination with prior research findings of the positive influence of mobile game-based learning, the findings of this study suggest that the question educators and practitioner ask should no longer be about whether and to what extent technology should be used with young children in the classroom, but rather how it should be used. The challenge in early education then becomes discovering new ways to more fully integrate technology into the curriculum to encourage active engagement and thinking among young children.

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Appendix 1: Observation Protocol

Researcher_____
Date_____
Class_____
School_____
Time of Observation_____

FIELD NOTES
Field notes are an important part of qualitative research, serving as a record of your experiences at your research site and a way for you to reflect on what you are doing and learning.

In-Class Observations

A) General Observations
This section is particularly important at the very beginning of the visit.

- Give a DETAILED description of the research site
  : Describe the location/atmosphere of the school, structures/environment of the school, classroom structures (including desk, chairs, board, etc.), students' seat arrangement, and computer facilities

- Provide a general description of all the activities you took part in that day.
  : Describe exactly what happened, *blow by blow*. Report anything significant that was said, *in as close as possible to the exact words*.

B) Focused Observations

- Describe the **participation structures**

What are the game and/or activity children engaged in? What materials are they using? Give a DETAILED description of the activity and the students participating.

- Describe the child's **engagement level (Paper-pencil vs. Todo Math)**
  - For 10 minutes time frame (in the middle of session), estimate the duration of time (or percentage?) the child who has eyes on iPad screen.
  - For 10 minutes (in the middle of session), record the number of levels the child completed.
  - Are there any disengaged children?
  - How often do children get distracted?
  - Describe the mood (facial expressions), mannerisms, attitudes towards the activity

- Teacher-children and children-children interactions
  - For 10 minutes, how many times the child calls his/her teacher for help? Why?
  - For 10 minutes, how many times the child talks to his/her peers just for chat? For how long? With what kinds of topic?
  - For 10 minutes, how many times the child talk about the activity? Have they talked

about their progress on the lessons/levels? Have they discussed anything about issues that they have?

C) Reflections.

Write at least one good detailed paragraph on what you thought and felt about your visit, and especially what happened in the activities described in your Focused Observations section.

- What did you learn from this activity?
- Is there any issue that was raised during the activities?

Appendix 2: Observation Form

Researcher_____
Date_____
Class_____
School _____
Time of Observation_____

Topic: type the topic
Please describe a child's behavior!

Measurement Index
Facial Expression

Facial Expression	Index	Meaning	Etc.
Cry & Frown	1	Sadness & grief	Need for help or comfort from others (teachers)
Smile	2	Happiness	Comfort, confidence
Harsh Facial (angry)	3	Anger & annoyance	Angry
Wide eye and stretched lips and wrinkled	4	Worry or fear	Sensitive

Behavior

Manner	Index	Meaning
Focused	1	Engaged
Shaking legs	2	Nervous
Unfocused (day-dreaming)	3	Totally distracted
Pencil spinning or scratching hair	4	Thinking
Sigh & hit the table & Finger-suckings (etc.)	5	Distracted

Form

Child Name (Initial)	Task Completion Length	Attitudes towards the activity		Trial and Error (1)/ Think and Solve (2)	Calling Teacher for help		Chatting with Peers		Overall Note for Engagement level (1 ~10) 1:distracted 10:highly engaged
		Expression (1~4)	Manner (1~5)		Frequency	Why	Frequency	Why	

Reflections

Write at least one detailed paragraph on what you thought and felt about your visit, and especially what happened in the activities described in your Focused Observations Section.

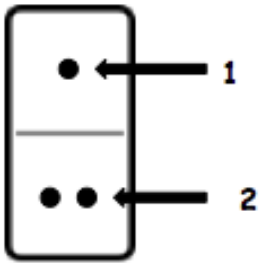
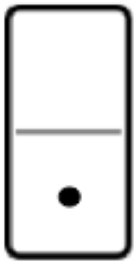
- What did you learn from this activity?
- Is there any issue that was raised during the activities?

Appendix 3: Paper-and-pencil activity sheets

Domino

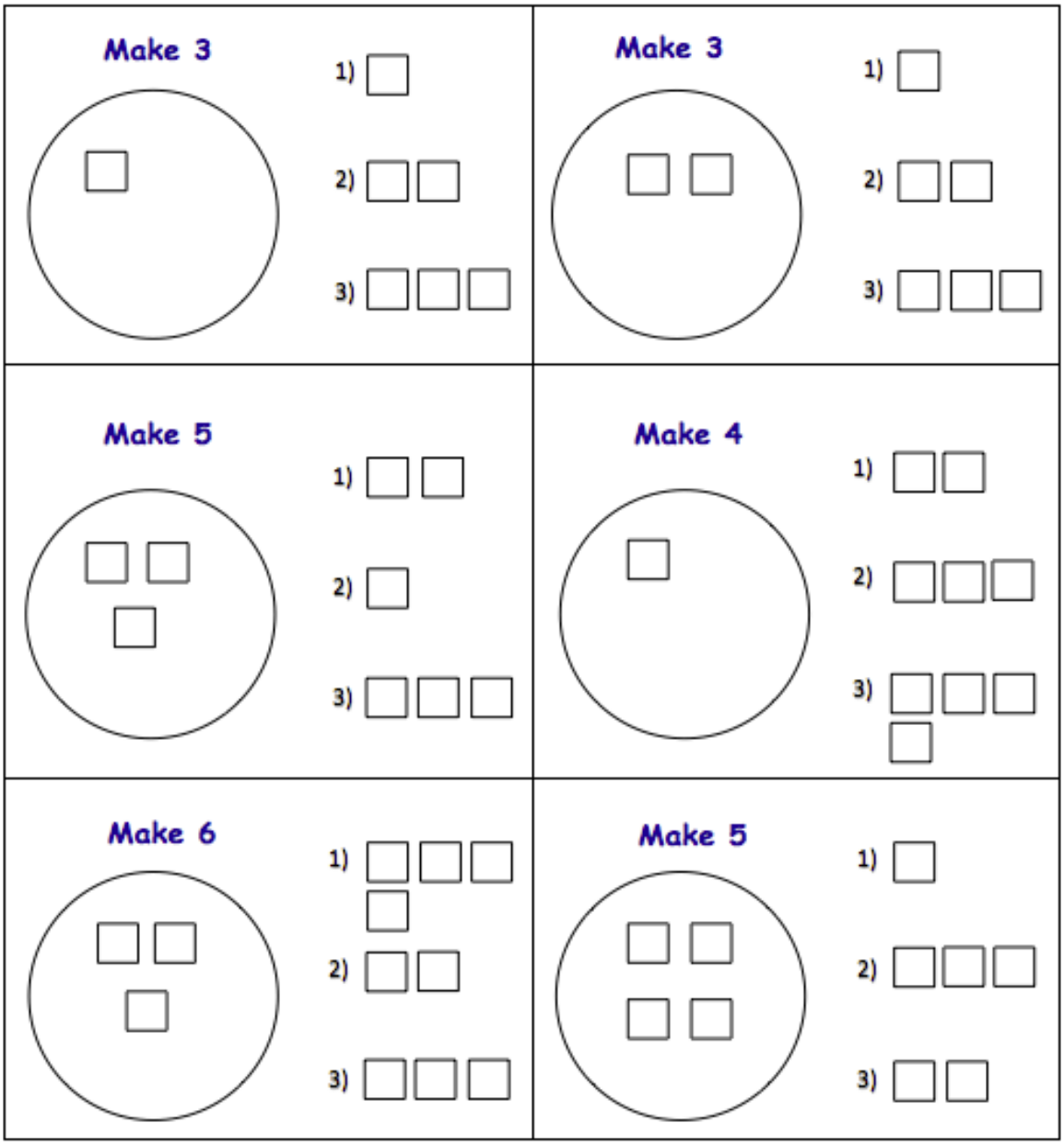
Name _____ Date _____

Fill in the domino with dot.

Make 3 	Make 5 
Make 6 	Make 4 
Make 2 	Make 3 

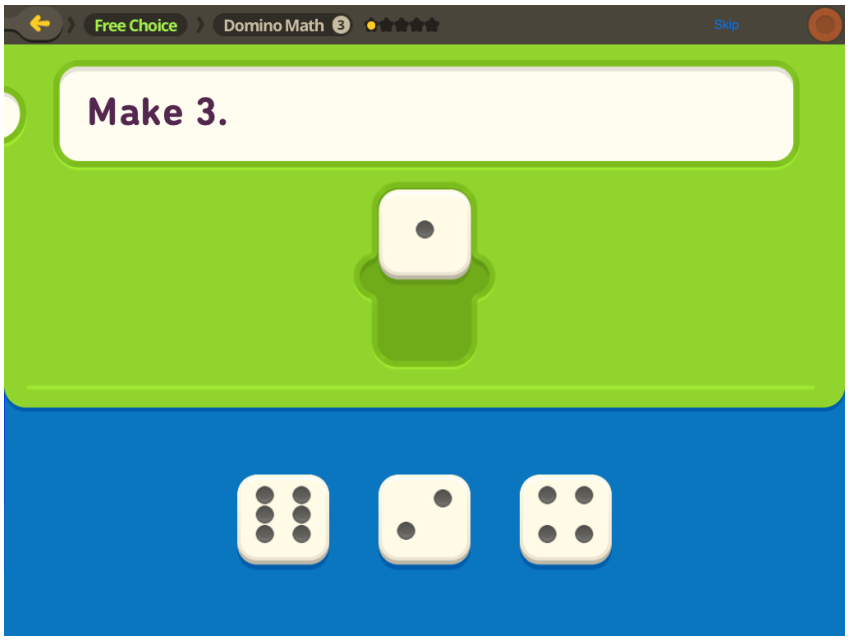
Name _____ Date _____

Choose the correct option number.

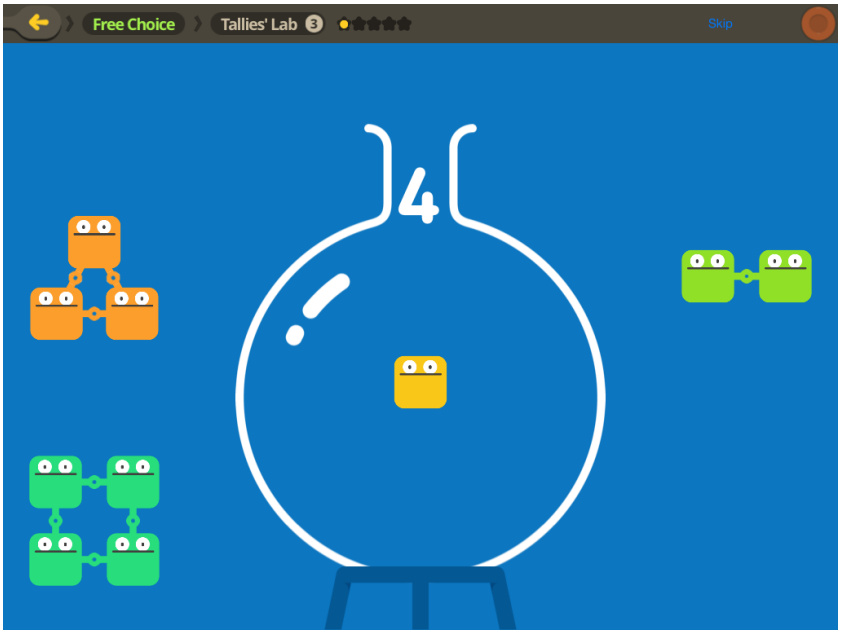


Appendix 4: Todo Math Games

Domino



Tallies' Lab



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