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Video Prompting Delivered via Augmented Reality to Teach Transition-Related Math Skills to Adults with Intellectual Disabilities

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ABSTRACT

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The purpose of this study was to determine the effectiveness of a video-based instruction packet as a method of teaching math-based vocational skills delivered through augmented reality to three adults with intellectual disabilities. The dependent variable was the percentage of steps performed correctly to solve each selected type of math problem. The independent variable was the video-based math intervention delivered via augmented reality, which modeled the individual steps for solving three different multi-step math problems: (1) adjusting a recipe to serve a different number of people, (2) calculation of salary, (3) calculation of unit prices. Visual and statistical analysis demonstrated a functional relationship between the video-based math intervention and an increase in the percentage of steps completed correctly for each type of problem. All three participants showed significant gains immediately after receiving the intervention and maintained the learned skills even following the withdrawal of the intervention. Implications for practitioners and further research are discussed.

Keywords: augmented reality, video modeling, transition, math, intellectual disabilities

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DESCRIPTION OF THESIS STRUCTURE

The structure of this thesis, Video Prompting Delivered via Augmented Reality to Teach Transition-Related Math Skills to Adults with Intellectual Disabilities, is presented in a dual/hybrid format, which meets both traditional and journal publication formatting requirements. The preceding pages meet university standards for thesis submissions. The later pages are presented as a "journal-ready" article that meets most educational peer-reviewed journal style requirements. Some journals request that tables be submitted at the end of the main text and therefore tables and figures appear at the end of the article as opposed to throughout the journal-ready manuscript. Appendix A includes a copy of the IRB-approved permission forms used during the study. An example of data collection form, the technology training and assessment, the intervention fidelity checklist, and the social validity questionnaire are included in Appendix B, C, D, and E, respectively.

Background

Over the last few decades, individuals with disabilities have increasingly been integrated into society. The need to discuss and learn more about the challenges associated with disabilities and about the evidence-based practices necessary for learning and successful participation in society has also increased. One of the skills necessary to function in society is basic numeracy, as it is considered necessary for employment and an essential component of independent living (Wei, Lenz, & Blackorby, 2013). Basic numeracy is also one of the most used skills in daily activities, even by individuals with disabilities. Over the past few years, greater emphasis has been placed on teaching math skills to adult individuals with disabilities. As part of this effort, more research is needed to define effective methods to deliver math instruction to this population.

Review of Literature

The target population for the present study is adult individuals with ID. According to the revised (2014) Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) and the American Association on Intellectual and Developmental Disabilities, ID is characterized by significant limitations and global deficits in both intellectual functioning and adaptive functioning (Schalock et al., 2010). The majority of individuals diagnosed with ID often struggle in understanding and correctly performing math skills (King, Lemons, & Davidson, 2016).

Math curriculum for individuals with disabilities. According to Patton, Cronin, Bassett, and Koppler (1997), the math curriculum presented in schools, and specifically at the secondary level, is primarily designed for those students who will continue their studies by going to college. Such curriculum ignores some of the skills that are needed to function at home, in the community, and on the job. For many students without disabilities, such skills are learned in informal ways and by deduction from other more complex skills. However, students with disabilities who are not specifically and directly taught skills pertinent to independent living at home, in the community, and on the job, will lack the knowledge necessary to implement them (Patton et al., 1997). Patton et al. (1997) further advocates that math skills pertinent to the home, the community, and the job must be taught as a matter of routine to all students with disabilities. Too much time and effort are spent in trying to bring students with disabilities up to speed with the core curriculum and too little in focusing instruction on those math skills that will benefit them in a practical way.

Math difficulties. According to the National Center for Education Statistics (NCES), during the 2013-2014 school year, 7% of the students (age 3 to 21) served in special education in the United States had a diagnosis of ID, and was served under Individuals with Disabilities Education Act (IDEA) (Kena et al., 2016). As shown by this statistic, the percentage of individuals with a diagnosis of ID is significant and therefore it is necessary to pay attention to their levels of performance and research ways to improve it. The National Assessment of Educational Progress (NAEP, 2015), conducted by the U.S. Department of Education in 2015, also known as the Nation's Report Card, reported that 92% of 8th grade students with disabilities were below proficient levels in mathematics and that 94% of 12th grade students with disabilities were below proficient levels in mathematics. When compared to the 67% of 8th grade students without disabilities performing below proficiency and the 75% of 12th grade students without disabilities performing below proficiency, it is clear that the math performance of students with disabilities is significantly poorer than that of students without disabilities, and, because of this, the No Child Left Behind Act (NCLB, 2002) is pressuring the public school system to help all students, and in particular those with disabilities, reach proficiency levels in math and in other subjects as well (Wei et al., 2013). Research also shows that students with disabilities, exhibit a slower mathematics achievement growth than students without disabilities (Schulte & Stevens, 2015).

According to King et al. (2016), a possible explanation for the limited percentage of proficient performance in mathematics of students with and without disabilities is the increase of expectations brought by the recently adopted Common Core State Standards in mathematics. Due to the growing gap between expectation and performance, there is also a growing need for targeted remediation and the development of new instructional approaches. Another possible explanation for the limited percentage of proficient performance in mathematics of students with disabilities is mathematics' abstract nature, which is particularly challenging for individuals who tend to primarily rely on the physical world. In addition to the challenge of abstractness, mathematics also requires students to rely on multiple prerequisite skills simultaneously, and this too presents a challenge for students with disabilities who demonstrate difficulties in the areas of semantic and working memories (Yakubova, Hughes, & Hornberger, 2015).

Individuals with ID and video-based interventions. Individuals with ID often struggle in forming social relations (Walton & Ingersoll, 2013), and such difficulty often affects their attending to instructional methods which are based on the interaction between the instructor and the student. Two examples of instructional methods that require an interaction between the instructor and the learner are direct instruction and in vivo modeling. A difficulty attending to such instructional methods leads to limited learning and, consequently, to below proficiency performance. On the other hand, video-based interventions such as Video Modeling (VM) and Video Prompting (VP) are considered effective learning tools because they combine the power of observational learning with the apparent tendency of individuals with ID to be particularly responsive to visually cued instruction (Bellini & Akullian, 2007).

In support of this concept, Walton and Ingersoll (2013) points out that given that individuals with disabilities tend to benefit from visually-cued instruction and may not be as responsive to in vivo behaviors, VM draws on the social learning literature, paired with the visual strengths and preferences of these individuals, to teach a variety of social, educational, adaptive, and vocational tasks to them. Video-based instruction also allows students to progress at their own pace and to have opportunities for repeated practice without having to adhere to the classroom pace. Furthermore, video-based instruction exposes students to relevant information while at the same time limiting extra stimuli that may be distracting and damaging to the students' learning. This aspect of video-based instruction is particularly relevant to students with ID in that they tend to be overly sensitive to the extra stimuli often present in in vivo situations (Yakubova et al., 2015).

In support of alternative methods of instruction such as VM and VP, a systematic review of 15 studies addressing the effectiveness of technology devices such as the iPod, iPod Nano, iPod Touch, iPad, and iPhone used to deliver instruction to individuals with ID shows that such population has the potential to benefit from the integration of these devices as instructional and learning tools because of their ability to enhance academic, communication, leisure, employment, and transitioning skills. The use of the mobile devices is also less stigmatizing than the use of other devices when used as assistive technology, a crucial consideration for the integration of individuals with disabilities into the community (Kagohara et al., 2013).

According to the available literature on this topic, it is clear that video-based instruction delivered through devices such as iPods and iPads is an effective way of teaching individuals with disabilities. Video-based interventions eliminate the struggle that some individuals with disabilities have in interacting with others and in being distracted by the many stimuli present in the environment during other instructional methods such as in vivo modeling and direct instruction. Video-based interventions are also effective because learners tend to see the use of technology as reinforcing and are overall more responsive to the material presented.

Video modeling. Over the past few decades, a lot of time and resources have been devoted to the study of VM interventions, and the results of such studies have deemed VM an evidence-based practice in teaching students with disabilities a variety of skills (Bellini & Akullian, 2007; Kellems & Morningstar, 2012). VM consists of the filming of one or multiple individuals, called model(s), who can be either peers, educators, family members, or the learners themselves (Kellems et al., 2016). The model(s) is filmed while correctly performing a task. The resulting video is then used in instructional interventions for individuals who learn how to perform the task through the processes of memorization, imitation, and generalization of the behavior exhibited in the video (Kellems & Morningstar, 2012). VM shows the performance of a task in its entirety, with the whole sequence of passages shown at once, allowing the learners to get a sense of integration among all the steps of the targeted task. After the delivery of the VM intervention, students are asked to perform the task as they have seen it performed in the video (Cannella-Malone, Sigafoos, O'Reilly, Edrisinha, & Lancioni, 2006).

The effectiveness of VM is often compared to the effectiveness of in vivo modeling. In vivo modeling occurs when an individual, the model, performs a task the same way the students will then be asked to perform it, and he/she does so in the physical presence of the students. Results of studies comparing the effectiveness of in vivo modeling versus VM, show that VM is more effective than in vivo modeling in regards to acquisition and generalization of tasks and behaviors, and is also more time efficient since teachers can maximize classroom availability when students learn more independently (Kellems et al., 2016). Another advantage of VM versus in vivo modeling is that, according to the research, prompting and positive reinforcement may not be needed when instruction is delivered through VM (Allen, Wallace, Renes, Bowen, & Burke, 2010). This may be the result of the more stimulating instruction delivery method of video modeling, which provides the learners with a different learning format from what they usually receive (Gardner & Wolfe, 2013).

The delivery of instruction through VM is often adopted for individuals with disabilities. Allen et al. (2010) conducted a study with the intent of determining the effectiveness of VM in teaching vocational skills to adolescent and young adults with disabilities. A multiple-baseline design across participants was used in this study. The targeted skills were basic forms of interaction with the public in a retail setting. The results of the study show that the VM intervention drastically increased the percentage of time of interaction between the participants and the public between the baseline phase and the intervention/maintenance phases. This study suggests effectiveness of VM in teaching individuals with disabilities.

Another study conducted by Kellems and Morningstar (2012) had the goal of determining the effectiveness of instruction delivered through VM to teach vocational tasks to adults with disabilities. This study was conducted following a multiple probe across behaviors design and with the participation of four young adult individuals with disabilities and who were, at the time, employed in a vocational setting. Three different targeted skills were selected for each participant according to the nature and need of their employment, and separate videos modeling such skills were created for the intervention. Results of this study show an immediate and substantial improvement in the accuracy of performance of the different tasks for each of the participants from the baseline phase to after the delivery of the VM intervention. These findings are similar to the ones of other related studies and confirm the presence of a functional relation between the use of VM and the improvement of the behaviors/skills.

Video prompting. VP is one form of video modeling. The features of VP are the same as those in VM (models performing tasks that the learners will then have to perform themselves), but it differs in the fact that instead of showing a sequence of steps all in one setting, it presents each individual step of a task separately, one clip at a time. With VP, learners have the chance to watch one step and then immediately perform that step before moving on to the next (Kellems et al., 2016; Taber-Doughty et al., 2011). Each clip can be shown multiple times and learners can advance in the completing of a task at their own pace until they become proficient (Banda & Dogoe, 2011).

A study conducted by Kellems et al. (2016) provides evidence of the effectiveness of VP in teaching multi-step math skills to adults with disabilities. A multiple probe design was used for this study and nine young adult participants with various disabilities (Autism Spectrum Disorder, ID, and Learning Disability) were selected. During the baseline phase, the participants were asked to perform three different math-related tasks (calculating a tip, comparing unit prices, and adjusting a recipe) to the best of their abilities and without receiving specific instruction on how to do it. During the intervention phase, the participants were provided with a series of videos providing instruction on how to complete the tasks step by step (VP) and were also asked to complete the different tasks. During the maintenance phase, the participants were asked to again perform the different tasks without the intervention (return to baseline conditions). The results of this study show that eight out of the nine participants showed significant improvement in their performance of the tasks after having received the VP intervention. This study, together with other similar studies, provides evidence that VP is an effective instructional method to teach individuals with disabilities.

Learners with developmental disabilities often struggle with attention and memory, and since a video model needs to be attended to in its entirety in order to be effective, VP has been determined more effective than VM in supporting the learning process and independence of individuals with such disabilities (Cannella-Malone et al., 2011; Taber-Doughty et al., 2011). In support of this concept, Cannella-Malone et al. (2006) conducted a study addressing the comparison of VM and VP in teaching daily living skills to adults with developmental disabilities. A multiple-probe across subjects design was used to conduct this study with the participation of six adults with developmental disabilities. During the baseline phase, the participants were asked to perform two daily living tasks to the best of their ability without receiving instruction on how to do so. During the intervention phase, the participants were divided into two groups and each group received instruction via VM for one task and via VP for the other. The results of this study show that VP was more effective compared to VM in teaching the participants the targeted skills. VP instruction prepared the students to perform significantly better during the intervention phase than during the baseline phase, while VM was found generally less effective. The results of this study are consistent with those of similar studies in proving that VP is more effective and more efficient than VM in teaching individuals with disabilities.

Additional evidence of the higher effectiveness of VP over VM is provided by several reviews of the literature on this topic. Gardner and Wolfe (2013) conducted a review of a total of 18 studies comparing the efficacy of VM and VP. All studies combined provided information about various skills performance of 38 participants (ages 6 to 41) with various disabilities. Banda and Dogoe (2011) conducted another review on 18 studies addressing the effectiveness of VP in teaching individuals with disabilities. A total of 68 participants' performance was analyzed in this review. The results of these reviews reveal that people with disabilities who struggle attending to lengthy videos particularly benefit from instruction delivered through VP since it facilitates and accelerates acquisition, maintenance, and generalization of various skills among which are domestic, life, vocational, academic, and independent living skills.

Even though more research is needed for the specific population of adults with ID, as shown by the extensive supportive evidence in the literature, instruction delivered through VM and especially VP can drastically increase the accuracy of performance of individuals with disabilities. However, the focus of this particular study is to determine the effectiveness of VM and VP instruction when delivered through a relatively new technology called Augmented Reality (AR).

Augmented reality. AR is a technology that allows the combining of the physical world with digital content, enhancing the real world environment by superimposing information about the user's immediate environment with cameras on mobile devices and adding information from digital sources, such as videos and audio (Cihak et al., 2016; McMahon, Smith, Cihak, Wright, & Gibbons, 2015; Sommerauer & Muller, 2014). In other words, AR is a system characterized by (a) the combination of the real and virtual world, (b) a real time interaction, and (c) the alignment of real objects or places and digital information in 3D (Sommerauer & Muller, 2014).

The Cognitive Theory of Multimedia Learning (CTML) provides a possible explanation for the potential effectiveness of AR in the learning process by stating that people learn better from words and pictures than from words alone (Mayer, 1997). AR implements this principle by overlaying printed text, audio, videos, and other virtual content (Sommerauer & Muller, 2014).

AR has the potential to function as an assistive technology (AT) and/or instructional technology (IT), and, in accordance to the principles of the Universal Design for Learning (UDL), support students with disabilities in their learning process (McMahon, 2014). AR has also shown promise in teaching new academic skills to students with ID in an authentic manner by creating a mobile learning environment that moves with the learner through mobile devices (McMahon, Cihak, Wright, & Bell, 2016). Through the use of AR, students can reduce their dependence on teachers and their help and increase their independent learning, which is a critical skill to master, especially when students are preparing for life after school (Lin et al., 2016). The term AR was introduced in 1992, but examples of AR existed since 1968, even though the technology available at the time was immovable, large, and expensive, much different from the affordable mobile devices available today (McMahon, 2014).

It has been stated that AR has high relevance and that its most promising application is in the field of education (Wu, Lee, Chang, & Liang, 2013). Sommerauer and Muller (2014) conducted a large field experiment with the goal of testing the effects of AR on learning performance and its potential to be an effective tool for learning formal content in both formal and informal environments. The study hypothesis was that 101 visitors of a mathematics exposition in a national museum would learn better from augmented exhibits than from non-augmented exhibits. Augmentation was created for 12 exhibits, but each of the two groups, in which the participants were divided, only had access to six augmented exhibits and had to rely on physical information display alone for the other six. A pre-test and a post-test with questions related to the 12 exhibits were administered to all participants, and the analysis of the data indicates a significant overall better performance in the post-test than in the pre-test, and, more specifically, a significantly better performance on post-tests questions related to augmented exhibits than on post-test questions related to non-augmented exhibits. The findings of this study are consistent with the findings of similar studies in that they provide evidence of a significant positive effect on knowledge acquisition and performance due to the use of AR.

For the purpose of this study, it is also necessary to determine if AR provides an effective way of instructing individuals with disabilities. In regards to this, McMahon et al. (2016) conducted another experiment with the purpose of testing the functionality of use of AR in teaching science vocabulary to postsecondary education students with ID. The study used a multiple-probe across behaviors/skills design with the participation of four students with a diagnosis of ID. The assessment materials created for the study consisted of three separate assessments of 20 questions, each on the topics of human bones, human organs, and cell biology. Each assessment covered the 10 selected vocabulary words of each domain; 10 questions asked the students to define the vocabulary words by selecting the appropriate term among four multiple choice options, and 10 questions asked the students to label diagrams or figures by selecting the appropriate vocabulary word from a word bank. During the baseline phase, the participants were asked to complete the assessments without feedback or prompts. During the intervention phase, the students were asked to complete the assessment and afterwards they were provided with AR intervention in the form of videos featuring a vocabulary term, its definition (read aloud), an image used for labeling (same as in the assessment), and a three dimensional simulation of its position. Videos were created for all 30 vocabulary words. This study's results indicate that all four participants improved in their ability to define and label science terms after receiving the augmented reality intervention, and, therefore, it can be concluded that the use of AR is an effective way of teaching science vocabulary words to postsecondary students with ID.

Also relevant to this study, is the evidence of AR effectiveness in teaching chain tasks. Cihak et al. (2016) conducted a study with the goal of examining the effects of using AR to teach chain tasks to elementary students with disabilities. The study used a multiple-probe design across participants with the participation of three male students with disabilities eligible for special education services. The targeted chain task for this study was brushing teeth. During the baseline phase, students were presented with all the necessary materials to complete the task, then the teacher would review with them a five-step, picture task analysis for brushing their teeth, and lastly the teacher would prompt the students to "brush [their] teeth." During the intervention phase, students were presented with all the necessary materials to complete the task and with an AR device, and then prompted to "scan the picture and brush [their] teeth" (training on how to use the AR device had already been delivered). At this point, the students were expected to follow the steps outlined in the provided video and brush their teeth. During the maintenance phase, which lasted nine weeks, students were asked to brush their teeth in conditions similar to baseline to determine if they retained the skill even without the support of the AR intervention. This study's results indicate that the students' independent performance improved right after the introduction of the AR intervention, with 98% non-overlapping data, which denotes a high effectiveness of the intervention. These results, together with the results of similar studies, suggest that AR is an effective intervention to teach chain tasks to individuals with disabilities.

The three articles reviewed above show evidence of the effectiveness of AR in teaching formal content in both formal and informal settings, in teaching vocabulary terms to adult individuals with disabilities, and in teaching chain tasks to younger individuals with disabilities. The available literature provides evidence that AR can be successfully used to teach both individuals without disabilities and with disabilities, including adults. Despite the available evidence of the effectiveness of AR, more research needs to be done to explore the effects of AR in teaching individuals with disabilities, especially with math-related topics.

Statement of the Problem

Considering the increasing numbers of individuals diagnosed with either an ID, it is necessary to focus on those methods that will allow them to learn in the most effective and efficient way, so that they can be integrated into society as much as possible. An age group in particular need of attention, and on which limited research is currently available, is the one of young adult and adult individuals (age 16 to 21) who are in the transition phase between school and life after school. This population needs targeted instruction in those areas that are crucial for their functioning in society. Math has been determined to be one of the most critical skills to master in order to achieve as much independence as possible. Therefore, there is an increasing need to research evidence-based practices for the delivery of math instruction to young adults and adults with disabilities, including ID.

Statement of Purpose

The purpose of this study is to determine the effectiveness of using VP delivered via AR to teach transition related multi-step math skills to participants with ID.

Research Questions

This study was guided by the following research questions which the researcher sought answers to:

1. Is there a functional relation between the percentage of steps completed correctly by adults with ID and a VP based intervention package delivered via AR (HP-Reveal) when teaching multi-steps math problems?

2. Were the acquired math skills maintained over time without the support of the intervention?
3. How socially valid is the use of a VP intervention delivered via AR to teach transition related math skills to adults with ID according to the participants themselves?

The first is a demonstrative question with the purpose of observing and analyzing the functional relation between the independent variable (VP intervention delivered via AR) and the dependent variable (percentage of steps completed correctly). Observation, measurement, and analysis of this research question were conducted through data collection based on the task analysis.

The second research question has the purpose of observing and analyzing the levels of maintenance and generalization of the skills learned with the aid of the Video Modeling-VP intervention. Observation, measurement, and analysis of this research question were also conducted through proficient performance in mathematics.

The third research question has the purpose of determining if the independent variable selected for the study is perceived as socially acceptable and valid in the eyes of the participants and also in the eyes of their caretakers (Spear, Strickland-Cohen, Romer, & Albin, 2013). Measurement and analysis of this research question were conducted through informal questionnaires administered to both the participants and their caretakers.

Method

Participants

The participants for the research study were 3 female individuals between the ages of 21 and 24. As reported in Table 1, the participants had Full Scale of Intelligence Quotient standard score of 42or lower according to the WISC-IV, and low functioning scores in both mathematical achievement and adaptive behaviors. As also reported in Table 1, all three participants have a diagnosis of Down syndrome and a classification of Intellectual Disability. They were all verbal; however, Ella and Jane were at times difficult to understand due to their speech impairments. None of the participants exhibited problem behaviors that would have affected the conducting of the study.

<Insert Table 1 here>

Participants were selected based on caregiver/supervisor recommendation and researcher's observation. Cognitive, achievement, and adaptive test scores were taken into consideration during the selection procedure, and only participants who fulfilled the criteria mentioned above were selected. A pre-test, equivalent in nature and difficulty to the targeted skills, was also administered to prospective participants to determine their level of performance. Only participants who did not perform all of the targeted skills at a proficient level were selected. After selection, the participants received instruction from the researcher and other professionals involved in the research project in the designated research space, and through the intervention procedure. Participants did not receive any instruction on the targeted skills in any other way or setting, and from no other instructor. Participants were required to provide parental consent before the beginning of the project.

Institutional Review Board (IRB) approval on the project was obtained prior to the beginning of the study. The IRB approved permission forms were distributed to the participants and their parents and collected again after having being signed.

Setting

The original arrangement was to conduct the study at the Brigham Young University Child and Family Studies Lab; however, for convenience purposes, both the researcher and the participants agreed on conducting it at the participants' residence. The participants participated in a post-secondary education program at a large western university sponsored by a third party. As part of this program participants lived together in an off-campus apartment. The study was conducted as an after-school program independent from school curriculum, activities, and credits. The study was conducted in the residence's kitchen at the kitchen table. The participants worked with the researcher individually while the other participants and other roommates remained outside the kitchen as much as possible in order to limit distractions and excessive stimuli. Due to the open space setup of the apartment, occasional noise and distractions occurred as the other residents walked around or spoke to each other. The study was conducted during both morning sessions and late afternoon sessions.

Target Tasks

The tasks were based on the Common Core mathematics standards for sixth and seventh grade. The standards listed below were chosen because of their potential to become functional academic and vocational skills for the participants. The standards selected are:

1. CCSS.MATH.CONTENT.7.RP.A.2.B. "Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships." Participants are going to demonstrate this standard by calculating the unit price of an item.
2. CCSS.MATH.CONTENT.6.RP.A.3.D "Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities." Participants are going to demonstrate this standard by adjusting the quantities of a recipe based on variation in number of servings.
3. CCSS.MATH.CONTENT.6.RP.A.3.D "Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities."

Participants are going to demonstrate this standard by calculating daily, weekly, and monthly salary given the rate per hour.

A task analysis was developed for each targeted task outlining every step necessary to complete the task. A second researcher or assistant with no involvement in the creation of the task analyses was then asked to perform the tasks by strictly following the task analyses to verify their accuracy. The order in which the participants received treatment for the different tasks was randomized.

Intervention

The intervention packet consisted of videos explaining the different steps of the targeted skills to the participants, and of checklists that visually outlined such steps. While the checklists were provided in hard copy, the videos were delivered via iPads through an AR app called HP-Reveal which allows for on-demand learning. The participants used both the checklist and the videos to complete the targeted tasks step by step. The AR app was not the intervention, but the mean through which the intervention was delivered. Data were collected by the researcher during the sessions.

Materials. Videos were created for each individual step or group of steps that logically fit together. The task analysis served as a script, and the researcher, acting as a model, was filmed with a camera while performing the tasks in the exact way the participants were expected to perform them. The videos were then edited through iMovie ® (Version 2.0: [REF]) on the computer and voice-over instructions were added to clarify each step. The videos were then divided into segments of one or multiple steps (VP).

The segments were uploaded to the HP-Reveal app (v 7.0.0.1570036) on an iPad Air Tablet, 16 GB and individually connected to trigger images specifically created for this project.

The images were selected among Google images and combined on Microsoft ward and Paint to create unique ones. In order to activate a video, the participant had to slide the iPad screen to unlock it, open the HP-Reveal app, and hover the iPad over the corresponding trigger image. The video would then appear and double tapping the screen made it full screen.

The images necessary to trigger the videos through the HP-Reveal app were organized in sequence in booklets. Each segment's trigger image was associated with a number and color coded to match a checklist that outlined the steps of the task analysis. This way, the participants were able to choose between watching all the segments in succession pausing in between them to perform that step or series of steps, or just the segments they felt they needed to perform the task correctly. The checklist served as their guide to determine which trigger image, and consequent video, was associated with each step.

The researchers created 20 different problems for each targeted skill that were written on paper. They were individually cut and participants were able to write on them. Other materials needed were a calculator and writing utensils.

Use of materials by participants. During the baseline phase, the participants were provided with a problem card, a writing utensil, and a calculator. During the intervention phase, the problem card was placed in front of the participant, together with a writing utensil and a calculator, the checklist was placed on the table above the problem card, the booklet with the trigger images was placed to the left of the materials, and the iPad to the right.

Measures and Data Collection

Data collection sheets were created based on the format of the task analysis. A pre-test and a post-test were created which were equivalent in difficulty and addressed all the targeted skills. The pre-test was administered prior to the beginning of the baseline phase and as part of the selection process. If the participants scored below 50% they were selected for the study. Each of the three participants scored 0% on the pre-test and was then assigned a list of the targeted skills with their respective problems in a randomly assigned order. The post-test was administered at the end, after the participants had received the intervention for all the targeted skills. A social validity questionnaire for the participants was also created to determine if they perceived the intervention as useful and functional. The questionnaire was administered at the conclusion of the study with the researcher asking the questions to the participants and recording their answers.

During baseline, intervention, and maintenance phases, the observer recorded data using the data collection sheets that were created following the outline of the task analyses. Each session was recorded using a camera focused on the table area in order to record the work being done. This allowed for interobserver agreement.

Procedures

Baseline. During the baseline phase, the participants only had access to the problem cards, writing utensils, and the calculator. All other intervention materials were not made available to them at this stage. Baseline data on the participants' performance of all the tasks were collected for either a minimum of six data points, until a clear pattern emerged, or until the data stabilized. Data were considered stable if at least three consecutive data points were consistent in level.

Pre-Training. After the collection of baseline data, each participant received direct instruction on how to use the iPad and the specific app (HP-Reveal) through which the intervention was delivered. After receiving instruction on how to operate the iPads, participants were administered a sample test to determine their level of proficiency. After participants demonstrated proficiency in operating the iPad (100%) they were allowed to move on to the intervention phase. The test consisted of a simple task (writing one's name), completely unrelated to the target skills, that the participants had to solve by watching the videos through the HP Reveal app. The participant did not have to perform the task with 100% accuracy, but had to show 100% accuracy in using the iPad, following the checklist, locating the correct trigger images, and triggering the videos.

Intervention. During the intervention phase, each participant was given and iPad, where the HP-Reveal app had already been downloaded and signed into, and where all the instructional videos were stored. The participants had to independently unlock the iPad, locate the app, and enter it in order to use it. They were also given a booklet of trigger images, a checklist of the steps necessary to complete the task, a problem card, and all other materials necessary for the completion of the task (writing utensils and calculator). The participants received the initial prompt: "Please solve the problem," and were then expected to do so. The participants were then able to watch the segments showing the individual steps (VP). The researcher collected data on both the participants' performance of the skills and on which videos they watched. If the participants asked additional questions, or persisted in the same errors, the researcher delivered scripted and precise prompts as outlined in Table 2.

<Insert Table 2 here>

In order to move on to the maintenance phase, the participants had to perform the selected tasks at least 5 times (five sessions of intervention) and with at least 80% accuracy (with the final result still being correct) on at least 3 consecutive sessions. Upon reaching the proficiency goal, the participants moved to the maintenance phase.

Maintenance. Maintenance data were collected in one week increments after the completion of the intervention phase. Each skill was tested for maintenance for at least 1 session (1 week).

Interobserver agreement. Each session of each phase (baseline, intervention, and maintenance) was recorded with a camera. The problem and the solving process were the main focus of the recordings. At the end of the study, 35% of the recorded sessions (randomly selected) of each phase for each participant, were watched and scored again by a second researcher with experience in special education and trained in the data collection procedures. Percentages of agreement were then calculated dividing the total number of agreements by the total number of agreements plus disagreements. An overall agreement of 98.7% was achieved while Table 3 shows a breakdown of the percentages of agreement for each phase across tasks and participants. According to Table 3, the agreement percentages for Sophie were 100%, 99%, and 100% for recipe adjustment's baseline, intervention, and maintenance respectively; 98%, 100%, and 100% for calculation of salary's baseline, intervention, and maintenance respectively; and 96%, 100%, and 100% for calculation of unit prices' baseline, intervention, and maintenance respectively. The agreement percentages for Ella were 100%, 99%, and 100% for recipe adjustment's baseline, intervention, and maintenance respectively; 96%, 100%, and 100% for calculation of salary's baseline, intervention, and maintenance respectively; and 97%, 98%, and 100% for calculation of unit prices' baseline, intervention, and maintenance respectively. The agreement percentages for Jane were 100%, 99%, and 100% for recipe adjustment's baseline, intervention, and maintenance respectively; 87%, 100%, and 100% for calculation of salary's baseline, intervention, and maintenance respectively; and 97%, 100%, and 100% for calculation of unit prices' baseline, intervention, and maintenance respectively.

<Insert Table 3 here>

TAU-U numbers and p-values. TAU-U effect size and P-value numbers were calculated with the aid of a calculator application (Vannest, Parker, Gonen, & Adiguzel, 2016) in order to determine the effectiveness of the AR intervention packet. Tau-U numbers provide information about the non-overlapping data between the baseline phase and the intervention phase (Parker, Vannest, Davis, & Sauber, 2011), and about the effect size both individual and combined.

P-values provide information about the significance of the difference in the data between the baseline phase and the intervention phase. P-values smaller than 0.05 are considered of high significance as they reject the null hypothesis.

Intervention fidelity. To assure intervention fidelity, a checklist was developed. The checklist provided a guideline to implement the intervention in a consistent manner across sessions and participants. It addressed elements such as setting up and cleaning up the materials, providing initial prompts to the participants and additional ones if needed, and collecting data. The intervention fidelity checklist was printed out, laminated, and checked off for every data collection session or groups of sessions to make sure that all elements of the intervention were implemented correctly. The intervention fidelity checklist was followed with 100% accuracy across tasks and participants.

Social validity. Social validity is an important measure of this study. According to Wolf (1978), it is significant to determine if the target behavior, the procedure, and the intervention are acceptable and pleasing to all those involved. In order to determine whether the participants consider the tasks and the intervention useful and functional, they were administered a questionnaire at the conclusion of the study. The questionnaire addressed the questions outlined in Table 4. The answers were then recorded and summarized as overall positive or negative and considered in the overall evaluation of the effectiveness of the study.

<Insert Table 4 here>

Research Design

The design selected for this study is a multiple probe design across tasks (Kennedy, 2005) and it adhered to the standards set forth by the What Works Clearinghouse (WWC) for this specific design (Kratochwill et al., 2010). Each participant received the intervention in all the selected tasks, but the order in which they received the intervention was randomized. Intervention for the second and third tasks started only when the participant had shown proficiency (minimum of 80% accuracy) in the previous task(s). The study also included a maintenance phase to determine if task acquisition would be maintained in the absence of the intervention.

Data Analysis

Data was analyzed through visual analysis according to the procedures set forth by Horner et al. (2005). The analysis of graphs guided the researcher through the process of visualization, interpretation, and summary of the results. In addition to visual analysis the data were analyzed statistically utilizing Tau-U and P Values to determine the effectiveness of the treatment and to determine if a functional relation between the independent and the dependent variables was present.

Results

Percentage of Steps Completed Correctly

The first research question addressed the relationship between the dependent variable (percentage of steps completed correctly) and the independent variable (the intervention) for three targeted tasks. The individual results for the selected tasks are shown below:

Sophie. The results for Sophie's performance are reported in Table 5 and Figure 1. During the baseline phase of the recipe adjustment task, Sophie completed 0% of the steps correctly over six sessions. During the intervention phase of the recipe adjustment task, Sophie's performance accuracy increased to 28% immediately after the introduction of the intervention, reached 100% accuracy after three sessions, and remained at 100% for six consecutive sessions.

During the baseline phase of the calculation of unit prices task, Sophie completed an average of 17% of the steps correctly, with a range of 13% to 25% over nine sessions with the last six stabilizing at 13%. During the intervention phase of the calculation of unit prices task, Sophie's performance accuracy increased to 100% immediately after the introduction of the intervention and remained at 100% for eight consecutive sessions.

During the baseline phase of the calculation of salary task, Sophie completed an average of 30% of the steps correctly, with a range of 25% to 62% over 12 sessions with the last four stabilizing at 38%. During the intervention phase of the calculation of salary task, Sophie's performance accuracy increased to 100% immediately after the introduction of the intervention and remained at 100% for six consecutive sessions.

Ella. The results for Ella's performance are reported in Table 5 and Figure 2. During the baseline phase of the calculation of unit prices task, Ella completed an average of 4% of the steps correctly, with a range of 0% to 13% over six sessions with the last three stabilizing at 6%.

During the intervention phase of the calculation of unit prices task, Ella's performance accuracy increased to 100% immediately after the introduction of the intervention and remained at 100% for eight of the nine sessions and with seven consecutive ones at 100%.

During the baseline phase of the calculation of salary task, Ella completed an average of 39% of the steps correctly, with a range of 13% to 62% over nine sessions with the last three stabilizing at 62%. During the intervention phase of the calculation of salary task, Ella's performance accuracy increased to 75% immediately after the introduction of the intervention, reached 100% accuracy after two sessions, and remained at 100% for five consecutive sessions.

During the baseline phase of the recipe adjustment task, Ella completed 0% of the steps correctly over 12 sessions. During the intervention phase of the recipe adjustment task, Ella's performance accuracy increased to 100% immediately after the introduction of the intervention and remained at 100% for six consecutive sessions.

Jane. The results for Jane's performance are reported in Table 5 and Figure 3. During the baseline phase of the calculation of salary task, Jane completed an average of 26% of the steps correctly, with a range of 25% to 38% over six sessions with five of those stabilizing at 25% with only one exception at 38%. During the intervention phase of the calculation of salary task, Jane's performance accuracy increased to 100% immediately after the introduction of the intervention and remained at 100% for seven consecutive sessions.

During the baseline phase of the recipe adjustment task, Jane completed 0% of the steps correctly over nine sessions. During the intervention phase of the recipe adjustment task, Jane's performance accuracy increased to 100% immediately after the introduction of the intervention and remained at 100% for six of the eight sessions and with five consecutive ones at 100%.

During the baseline phase of the calculation of unit prices task, Jane completed an average of 30% of the steps correctly, with a range of 13% to 62% over 12 sessions with four out of the last six stabilizing at 37%. During the intervention phase of the calculation of unit prices task, Jane's performance accuracy increased to 100% immediately after the introduction of the intervention and remained at 100% for six consecutive sessions.

Task Maintenance

The purpose of the second research question is to determine the ability of the participants to maintain the skills learned without the aid of the intervention. Maintenance data were collected in one week increments after the completion of the intervention phase for each target task. As reported in Table 5, the overall average percentage of steps completed correctly during the maintenance phase was 100% across tasks. The individual results for the selected tasks' maintenance are shown below:

Sophie. The results for Sophie's maintenance performance are reported in Table 5 and Figure 1. During the maintenance phase of the recipe adjustment task, Sophie completed 100% of the steps correctly over 3 sessions in one-week increments. During the maintenance phase of the calculation of unit prices task, she completed 100% of the steps correctly over 2 sessions in one week increments. During the maintenance phase of the calculation of salary task, she completed 100% of the steps correctly over 1 session.

Ella. The results for Ella's maintenance performance are reported in Table 5 and Figure 2. During the maintenance phase of the calculation of unit prices task, Ella completed 100% of the steps correctly over 3 sessions in one week increments. During the maintenance phase of the calculation of salary task, she completed 100% of the steps correctly over 2 sessions in one week increments. During the maintenance phase of the recipe adjustment task, she completed 100% of the steps correctly over 1 session.

Jane. The results for Jane's maintenance performance are reported in Table 5 and Figure 3. During the maintenance phase of the calculation of salary task, Jane completed 100% of the steps correctly over 3 sessions in one week increments. During the maintenance phase of the recipe adjustment task, she completed 100% of the steps correctly over 2 sessions in one week increments. During the maintenance phase of the calculation of unit prices task, she completed 100% of the steps correctly over 1 session.

<Insert Table 5 here>

<Insert Figure 1 here>

<Insert Figure 2 here>

<Insert Figure 3 here>

Post-Test. The post-test, similar in difficulty to the pre-test (which each participant completed with 0% accuracy), confirmed the performance accuracy percentage shown in the maintenance phase. All three participants completed the post-test with 100% accuracy.

Social Validity Summary

The purpose of the third research question was to determine if the participants perceived the skills taught and the intervention used as socially valid and overall useful. The three participants answered a nine-question questionnaire which addressed the questions found in Table 4. All the participants responded overall positively to the questionnaire. They all reported they liked learning the skills because they were new and about things they do every day like shopping and cooking, but that their favorite task was the recipe adjustment because it involved food, which they like. All the participants enthusiastically said that they will use the new skills especially while cooking and shopping and Jane reported she has already started adjusting the number of servings on recipes while cooking with her family. The participants unanimously said that they enjoyed using the iPad to learn because it is different from usual instruction and it is more fun. Sophie said using the iPad makes her feel smart and accomplished because she can learn things by herself. Ella also reported that watching the videos was easier than listening to a person explaining a task because the instruction is always the same and it helps them remember it better. Furthermore, all of them said that the videos used clear steps, which helped their learning, that the iPad and the HP-Reveal app were easy to use and that the fact that they already knew how to use an iPad helped. Ella and Jane, however, mentioned they had difficulty with double tapping the videos once they were triggered in order to make it full screen. All the participants became very excited in telling the researcher that they would like to learn other things using the videos/pictures on the iPad. Ella mentioned she would like to learn about science and specifically about the ocean and the creatures in it through the same intervention packet. Jane mentioned she loves theater and would like to learn how to make props through videos. Sophie said she would like to learn more about cooking in general and about baking techniques specifically. All of them said that the intervention was good, but that math is not their favorite subject and that the problems were difficult in the beginning and they did not like that. The three participants also provided some suggestions to improve the intervention and the materials; the main ones were to have problems with pictures to help them understand the text better and to have the problems written in bigger font.

TAU-U Numbers and P-Values Results

The average Tau-U effect size between baseline and intervention for the *Recipe Adjustment Task* was 1.0, the *Calculation of Unit Prices Task* was 1.0, and the *Calculation of*

Salary Task was 1.0. Tau-U effect size numbers for the individual participants across all tasks can be found in Table 6. All values denote a clear difference in the students' performance between the baseline phase and the intervention phase and support the hypothesis of the functionality of the intervention. The combined TAU-U effect size numbers for the three participants are also available in Table 6.

The combined *p*-value for the *Recipe Adjustment Task* was 0.0010, the one for the *Calculation of Unit Prices Task* was 0.0009, and the one for the *Calculation of Salary Task* was 0.0016. P-values for the individual students across all tasks can be found in Table 6. All values denote a high relevance in regards to the data collected and the findings of the study because they show a significant difference between students' performance between baseline and intervention phases. The combined P-value measures for the three participants are also available in Table 6.

<Insert Table 6 here>

Discussion

The purpose of this study was to determine the effectiveness of using VP delivered via AR to teach transition-related math skills to participants with ID. The results of the study extend the abundant literature supporting the effectiveness of VP, and VM in general, in teaching academic-related material and other skills to individuals with disabilities (Burton, Anderson, Prater, & Dyches, 2013; Kellems et al., 2016). Specifically, this study provides additional evidence that iPads can be used as teaching tools to help adults with disabilities learn academic skills (Kagohara et al., 2013; Kellems & Morningstar, 2012). The findings of this study also support the claim that the use of AR has great promise in the field of education (Wu et al., 2013), and has the potential to be an effective tool for learning formal content such as mathematics

(Sommerauer & Muller, 2014), even though extensive research is still needed to determine its effectiveness in connection with different subjects and groups of people with various disabilities and needs.

The maintenance results (100% across tasks and participants) stand as evidence of the durability of the intervention in helping participants maintain the learned skills. Such results are consistent with the findings of Kellems, Okray, Sauer-Sagiv, and Washburn (2017) in demonstrating that individuals with disabilities can learn and maintain skills taught to them via VM over extended periods of time. Such results also suggest that the intervention packet was effective in both guiding the participants through the completion of the targeted tasks through the step by step videos, and also in teaching them the steps that they were later able to perform on their own without the aid of the intervention materials. The fact that the percentage of performance accuracy did not decrease with the withdrawal of the intervention supports the hypothesis of its functionality in teaching academic material such as math, and also in helping the participants retain the information.

The social validity findings of the study are similar to the ones reported by Kellems et al. (2016). Both Kellems et al. and the present study recounted that the participants expressed their desire to learn about other subjects with the aid of the same intervention materials, which they perceived as easier to use, more entertaining, and more engaging than in-vivo instruction. The enthusiastic responses that the students provided to the questionnaire indicate that the intervention was not only statistically successful, but it was also perceived as a functional and effective way of learning.

Recent literature has indicated the need for conducting additional research on effective ways of teaching math-related skills to individuals with disabilities (Browder, Spooner, Ahlgrim-

Delzell, Harris, & Wakemanxya, 2008). The present study adds to the literature by providing information about an emerging intervention used to teach math content to individuals with disabilities.

Limitations

There are a number of limitations that should be noted about the study conducted which should be addressed in future research. The technology used in this study (HP-Reveal) was developed in 2011 and is still relatively new and therefore relatively little is known about how to operate it to the full extent of its potential. Also, only three participants were selected for the study, and they all were classified as having ID, which did not allow for a comparison with other disabilities. The creation of the materials was time consuming, and several pieces of equipment needed to be set up at the beginning of each session. As a result of the multiple baseline design, students learned some tactics from the first and second tasks which they started using in the second and third tasks, causing the baseline accuracy percentages to moderately increase while still, however, remaining low enough for the intervention to be necessary and meaningful. The math problems were, for the most part, written following the same format. This could represent a problem when trying to determine if the participants understand the difference between the various components of a problem or if they simply follow and remember the directions provided through the intervention packet while using the same problem format. Lastly, the mathematical concepts taught are abstract until generalized and applied in other settings. The abstract nature of math in general and this study's targeted skills specifically could be challenging for students whose disability causes them to rely mostly on the physical and tangible world.

Suggestions for Future Research

Drawing from the limitations of this study, future research should focus on delivering the intervention packet to participants of different age, with different disabilities, with a different level of mathematical ability, and in different settings. Future research should also explore how the use of this intervention, or of a similar intervention including AR and VP, might be used to teach a wider range of math skills (geometry, etc.) and other subjects such as English, science, and art. Furthermore, additional research could focus on determining which electronic devices are the most functional and relevant in teaching target skills.

Implications for Practitioners

In order to become contributing members of society, individuals with disabilities should be proficient in those target math skills that will allow them to access competitive employment and to live as independently as possible. Just like their non-disabled peers, individuals with disabilities should be systematically taught such skills in a way that will help them learn effectively and to also retain the information for extended periods of time. Practitioners who work with individuals with disabilities should rely on evidence-based practices to teach them whenever possible. The present study's intervention is anchored in the extensive research available on the effectiveness of VM and VP and can therefore be considered a valid tool to teach individuals with disabilities target math skills. Not as much research is available on the use of AR, but the studies that have been conducted about it all indicate its potential, especially in the field of education (Wu et al., 2013).

Conclusion

The presented study sought to examine the use of an AR intervention package in teaching math skills pertinent to transition vocational skills to adult individuals with ID. A functional relationship between the dependent and the independent variable was established by comparing students' performance during baseline and after the introduction of the intervention package. All students showed a fast and significant improvement in their performance after receiving the intervention and also maintained the learned skills after the removal of the intervention. Further research is needed to provide more evidence of the effectiveness of AR in teaching individuals with disabilities not only math-related content, but also other subjects and skills.

References

Allen, K. D., Wallace, D. P., Renes, D., Bowen, S. L., & Burke, R. V. (2010). Use of video modeling to teach vocational skills to adolescents and young adults with ASDs. *Education & Treatment of Children, 33*, 339-349.

Banda, D. R., & Dogoe, M. S. (2011). Review of VP studies with persons with developmental disabilities. *Education & Training in Autism & Developmental Disabilities, 46*, 514-527.

Bellini, S., & Akullian, J. (2007). A meta-analysis of video modeling and video self-modeling interventions for children and adolescents with ASDs. *Exceptional Children, 73*, 264-287.

Browder, D. M., Spooner, F., Ahlgrim-Delzell, L., Harris, A. A., & Wakemanxya, S. (2008). A meta-analysis on teaching mathematics to students with significant cognitive disabilities. *Exceptional Children, 74*(4), 407–432. http://dx.doi.org/10.1177/001440290807400401

Burton, C. E., Anderson, D. H., Prater, M. A., & Dyches, T. T. (2013). Video self-modeling on an iPad to teach functional math skills to adolescents with autism and intellectual disability. *Focus on Autism and Other Developmental Disabilities, 28*(2), 67-77. doi:10.1177/1088357613478829

Cannella-Malone, H., Fleming, C., Chung, Y., Wheeler, G. M., Basbagill, A. R., & Singh, A. H. (2011). Teaching daily living skills to seven individuals with severe intellectual disabilities: A comparison of video prompting to video modeling. *Journal of Positive Behavior Interventions, 13*, 144-153. doi:10.1177/1098300710366593

Cannella-Malone, H., Sigafoos, J., O'Reilly, M., de la Cruz, B., Edrisinha, C., & Lancioni, G. E. (2006). Comparing video prompting to video modeling for teaching daily living skills to six adults with developmental disabilities. *Education and Training in Developmental Disabilities*, 344-356.

Cihak, D. F., Moore, E. J., Wright, R. E., McMahon, D. D., Gibbons, M. M., & Smith, C. (2016). Evaluating Augmented Reality to Complete a Chain Task for Elementary Students with Autism. *Journal of Special Education Technology, 31*, 99-108.

Gardner, S., & Wolfe, P. (2013). Use of video modeling and video prompting interventions for teaching daily living skills to individuals with Autism Spectrum Disorders: A review. *Research and Practice for Persons with Severe Disabilities, 38*, 73-87.

Horner, R. H., Carr, E. G., Halle, J., McGee, G., Odom, S., & Wolery, M. (2005). The use of single-subject research to identify evidence-based practice in special education. *Exceptional children, 71*(2), 165-179.

Kagohara, D. M., van der Meer, L., Ramdoss, S., O'Reilly, M. F., Lancioni, G. E., Davis, T. N., ... & Green, V. A. (2013). Using iPods® and iPads® in teaching programs for individuals with developmental disabilities: A systematic review. *Research in developmental disabilities, 34*(1), 147-156. doi:10.1016/j.ridd.2012.07.027

Kellems, R. O., Frandsen, K., Hansen, B., Gabrielsen, T., Clarke, B., Simons, K., & Clements, K. (2016). Teaching multi-step math skills to adults with disabilities via video prompting. *Research in Developmental Disabilities, 58*, 31-44. doi:10.1016/j.ridd.2016.08.013

Kellems, R. O., & Morningstar, M. E. (2012). Using video modeling delivered through i-pods to teach vocational tasks to young adults with autism spectrum disorders. *Career Development and Transition for Exceptional Individuals, 35*, 155-167. doi:10.1177/0885728812443082

Kellems, R. O., Rickard, T. H., Okray, D. A., Sauer-Sagiv, L., & Washburn, B. (2017). iPad® video prompting to teach young adults with disabilities independent living skills: a maintenance study. *Career Development and Transition for Exceptional Individuals,* 2165143417719078.

Kena, G., Hussar, W., McFarland, J., de Brey, C., Musu-Gillette, L., Wang, X., ... & Barmer, A. (2016). The Condition of Education 2016. NCES 2016-144. *National Center for Education Statistics.*

Kennedy, C. H. (2005). *Single-case designs for educational research.* Boston, MA: Pearson Education, Inc.

King, S. A., Lemons, C. J., & Davidson, K. A. (2016). Math interventions for students with autism spectrum disorder. *Exceptional Children, 82*, 443-462. doi:10.1177/0014402915625066

Kratochwill, T. R., Hitchcock, J., Horner, R. H., Levin, J. R., Odom, S. L., Rindskopf, D. M, & Shadish, W. R. (2010). Single case designs technical documentation. In What Works Clearinghouse: Procedures and standards handbook (version 2.0). Retrieved from What Works Clearinghouse website: http://ies.ed.gov/ncee/wwc/pdf/wwc_procedures_v2_standards_handbook.pdf

Lin, C., Chai, H., Wang, J., Chen, C., Liu, Y., Chen, C., Huang, Y. (2016). Augmented reality in educational activities for children with disabilities. *Displays, 42*, 51-54. doi:10.1016/j.displa.2015.02.004

Mayer, R. E. (1997). Multimedia learning: Are we asking the right questions?. *Educational psychologist, 32*(1), 1-19.

McMahon, D. D. (2014). Augmented reality on mobile devices to improve the academic achievement and independence of students with disabilities (Doctoral Dissertation). University of Tennessee, Knoxville.

McMahon, D. D., Cihak, D. F., Wright, R. E., & Bell, S. M. (2016). AR for teaching science vocabulary to postsecondary education students with ID and autism. *Journal of Research on Technology in Education, 48*, 38-56. doi:10.1080/15391523.2015.1103149

McMahon, D. D., Smith, C. C., Cihak, D. F., Wright, R., & Gibbons, M. M. (2015). Effects of digital navigation aids on adults with intellectual disabilities: Comparison of paper map, Google Maps, and augmented reality. *Journal of Special Education Technology, 30*, 157-165.

No Child Left Behind Act of 2001, P.L. 107-110, 20 U.S.C. § 6319 (2002).

Parker, R. I., Vannest, K. J., Davis, J. L., & Sauber, S. B. (2011). Combining nonoverlap and trend for single-case research: Tau-U. *Behavior Therapy, 42*(2), 284-299.

Patton, J. R., Cronin, M. E., Bassett, D. S., & Koppel, A. E. (1997). A life skills approach to mathematics instruction: Preparing students with learning disabilities for the real-life math demands of adulthood. *Journal of Learning Disabilities, 30*, 178-187.

Schalock, R. L., Borthwick-Duffy, S. A., Bradley, V. J., Buntinx, W. H., Coulter, D. L., Craig, E. M., ... & Shogren, K. A. (2010). *Intellectual disability: Definition, classification, and systems of supports.* American Association on Intellectual and Developmental Disabilities. 444 North Capitol Street NW Suite 846, Washington, DC 20001.

Schulte, A. C., & Stevens, J. J. (2015). Once, sometimes, or always in special education: Mathematics growth and achievement gaps. *Exceptional Children, 81*, 370-387. doi:10.1177/0014402914563695

Sommerauer, P., & Muller, O. (2014). Augmented reality in informal learning environments: A field experiment in a mathematics exhibition. *Computers & Education, 79*, 59-68. doi:10.1016/j.compedu.2014.07.013

Spear, C. F., Strickland-Cohen, M. K., Romer, N. R., & Albin, R. W. (2013). An examination of social validity within single-case research with students with emotional and behavioral disorders. *Remedial and Special Education*, *34*, 357-370.

Taber-Doughty, T., Bouck, E. C., Tom, K., Jasper, A. D., Flanagan, S. M., & Bassette, L. (2011). Video modeling and prompting: A comparison of two strategies for teaching cooking skills to students with mild intellectual disabilities. *Education and Training in Autism and Developmental Disabilities, 46*, 499-513.

U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics.

Vannest, K.J., Parker, R.I., Gonen, O., & Adiguzel, T. (2016). Single Case Research: web-based calculators for SCR analysis. (Version 2.0) [Web-based application]. College Station, TX: Texas A&M University. Retrieved Tuesday 19th June 2018. Available from singlecaseresearch.org

Walton, K. M., & Ingersoll, B. R. (2013). Improving social skills in adolescents and adults with autism and severe to profound intellectual disabilities: A review of the literature. *Journal of Autism and Developmental Disorders, 43*, 594-615. doi:10.1007/s10803-012-1601-1

Wei, X., Lenz, K. B., & Blackorby, J. (2013). Math growth trajectories of students with disabilities: Disability category, gender, racial, and socioeconomic status differences from ages 7 to 17. *Remedial & Special Education, 34*, 154. doi:10.1177/0741932512448253

Wolf, M. M. (1978). Social Validity: The case for subjective measurement or how applied behavior analysis is finding its heart. *Journal of Applied Behavior Analysis*, *11*, 203-214.

Wu, H.-K., Lee, S. W.-Y., Chang, H.-Y., & Liang, J.-C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education, 62*, 41–49.

Yakubova, G., Hughes, E., & Hornberger, E. (2015). Video-based intervention in teaching fraction problem-solving to students with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 45*, 2865-2875. doi:10.1007/s10803-015-2449-

Tables

Table 1

Participant Information

Participants	Age	Gender	Classification Category (IDEA)	Cognitive		Achievement (Math)		Adaptive	
				Test	FSIQ	Test	Score	Test	Score
Sophie	24	F	ID	WISC-IV	42	WJ III	44	BASC	39
Ella	21	F	ID	WISC-IV	40	WJ III	39	Vineland	62
Jane	21	F	ID	WISC-IV	42	WJ III	39	Vineland	63

Table 2

Intervention Prompts and Conditions

#	Condition	Prompt	Who	When
1	The participant will stop working and get distracted	“Keep going”	The researcher	After 1 session
2	The participant seems to be stuck on a step	“Watch the video” or “Watch the video again”	The researcher	After 1 session
3	The participant performs the whole task or a step without watching the videos and does not complete it correctly	“Watch the videos before solving the problem”	The researcher	After 2 consecutive sessions
4	The participant persists in an error even after the videos	“Watch the video carefully”	The researcher	After 3 consecutive sessions
5	The participant persists in the error even after prompt # 4	Receive error correction through explicit instruction	The researcher	After 2 consecutive sessions
6	The participant asks for help	“Use the videos”	The researcher	After 1 session
7	The participant seems to be done but does not say so	“Let me know when you are done”	The researcher	After 1 session

Table 3

Average Individual Percentages of Interobserver Reliability

Participants	Recipe Adjustment			Calculation of Salary			Calculation of Unit Prices		
	BL	INT	MT	BL	INT	MT	BL	INT	MT
Sophie	100%	99%	100%	98%	100%	100%	96%	100%	100%
Ella	100%	99%	100%	96%	100%	100%	97%	98%	100%
Jane	100%	99%	100%	87%	100%	100%	97%	100%	100%

Table 4

Social Validity Questions

Questions
Did you like learning about the different tasks? Why?
What is your favorite thing you learned?
Do you think you are going to use the skills you learned in the community/at home?
Did you like using the iPad to learn? Why?
Did you like watching the videos? Why?
Was it easy or was it hard to use the iPad
What is another thing you would like to learn using the videos on the iPad?
Is there anything you did not like? Why?
What would you change? How?

Table 5

Average Individual and Overall Percentages of Performance Accuracy

Participants	Recipe Adjustment			Calculation of Salary			Calculation of Unit Prices		
	BL	INT	MT	BL	INT	MT	BL	INT	MT
Sophie	0%	82%	100%	30%	100%	100%	17%	100%	100%
Ella	0%	100%	100%	39%	96%	100%	4%	100%	100%
Jane	0%	99%	100%	26%	100%	100%	30%	100%	100%
Overall	0%	94%	100%	32%	99%	100%	17%	100%	100%

Table 6

TAU-U Numbers and P-Values

Tasks	Recipe Adjustment		Calculation of Unit Prices		Calculation of Salary	
Participants	TAU-U	P Value	TAU-U	P Value	TAU-U	P Value
Sophie	1	0.0019	1	0.0005	1	0.0007
Ella	1	0.0007	1	0.0015	1	0.0015
Jane	1	0.0005	1	0.0007	1	0.0027
Averages	1	0.0010	1	0.0009	1	0.0016
Combined	1	0	1	0	1	0

Figures

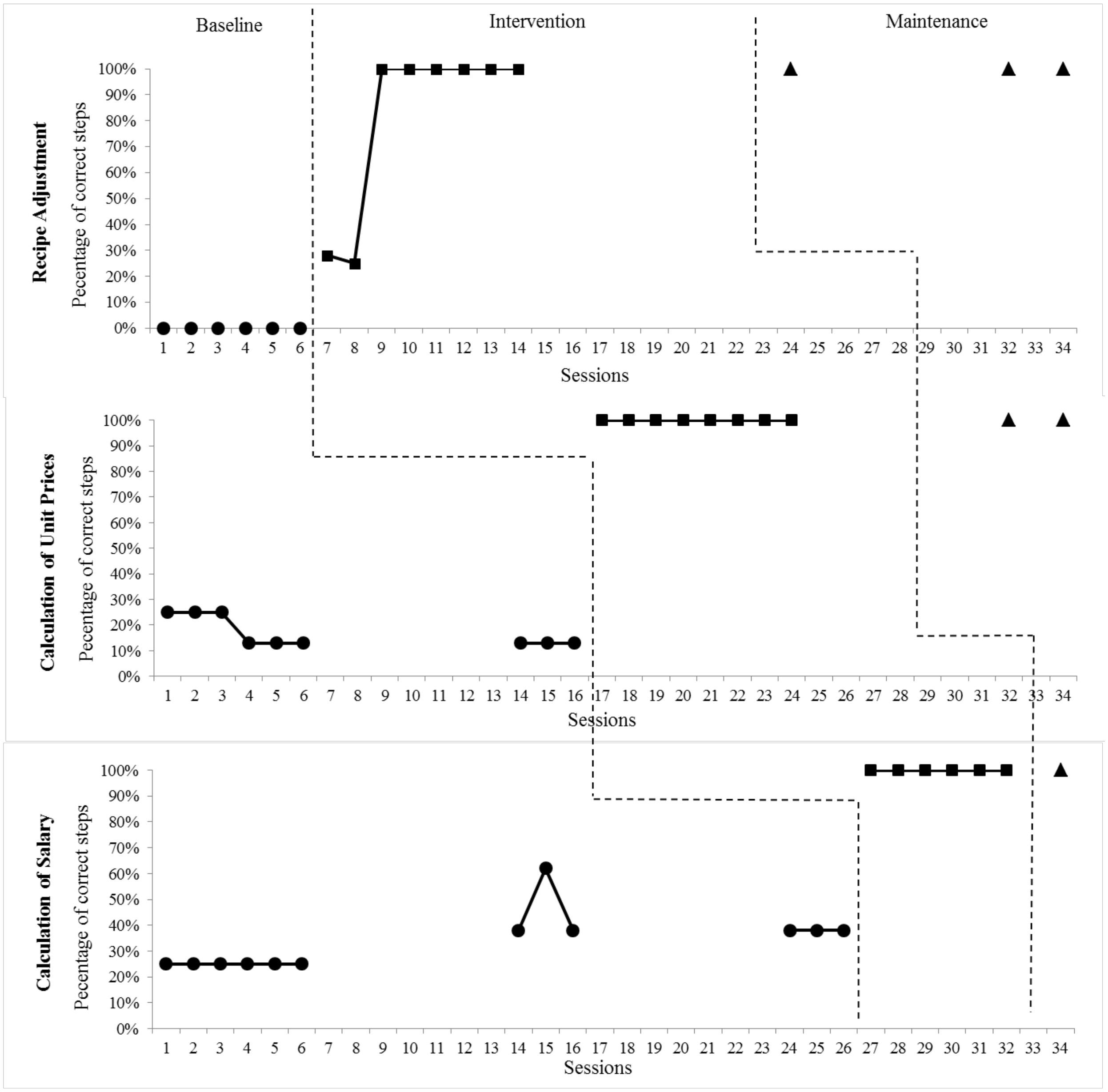

Figure 1. Percentage of steps completed correctly by Sophie

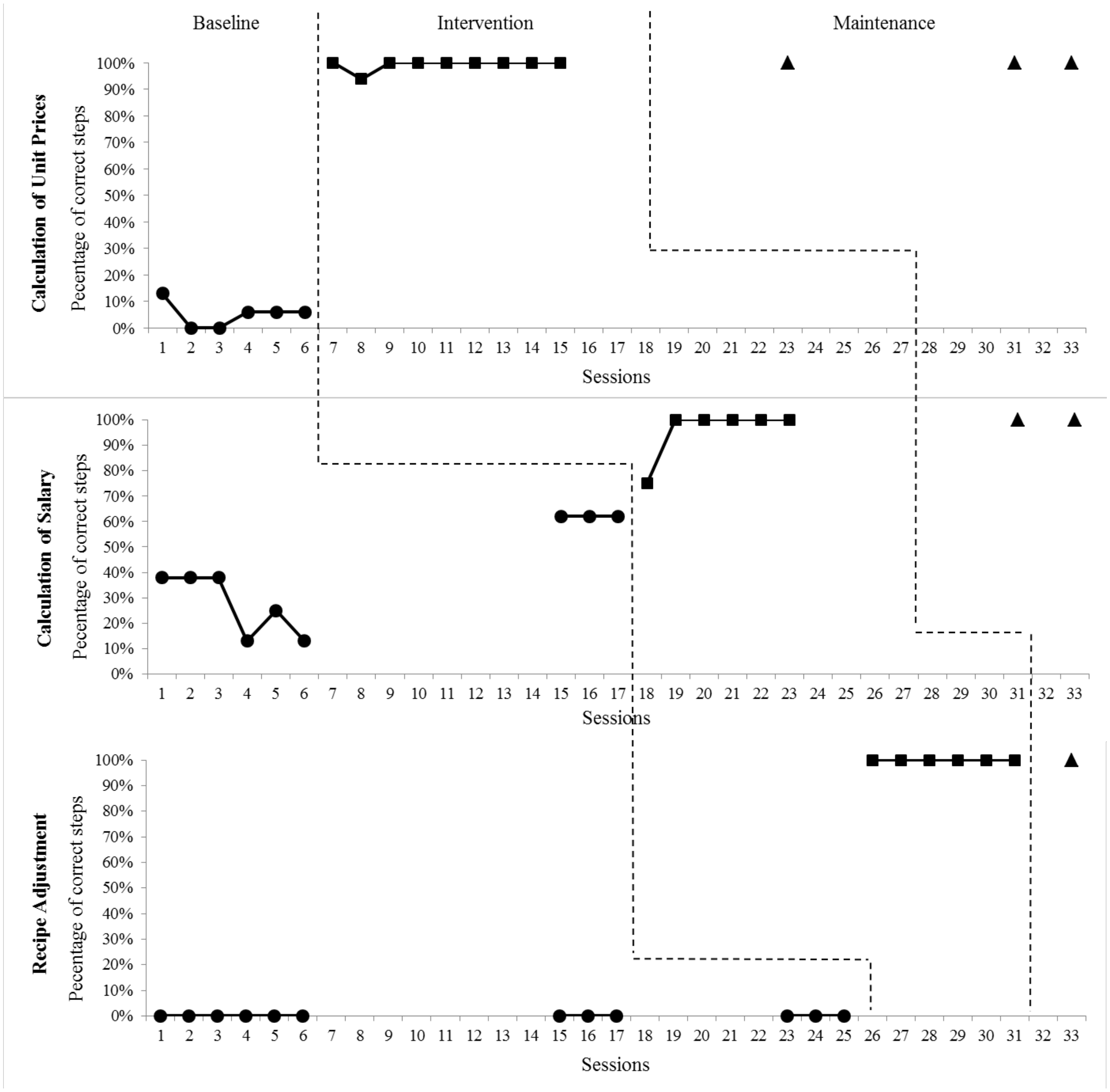

Figure 2. Percentage of steps completed correctly by Ella

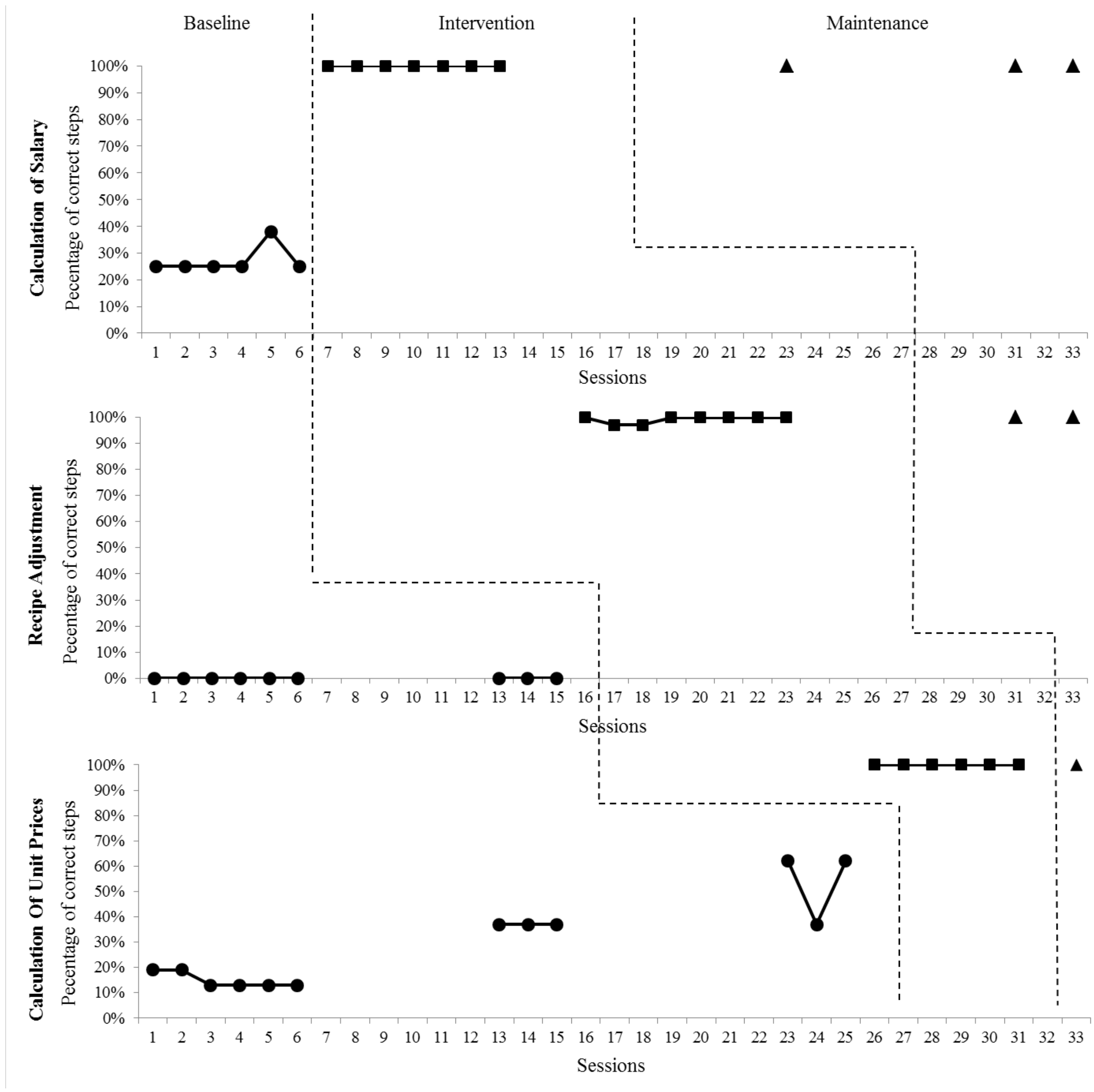

Figure 3. Percentage of steps completed correctly by Jane

APPENDIX A: Permission Forms

Consent for Participants over 18 (Without Guardianship)

Introduction
Your child is invited to participate in a research study conducted by Giulia Cacciatore, a Master's student of Special Education at Brigham Young University under the supervision of Ryan Kellems, PhD. The purpose of this study is to see if video prompting and modeling delivered through augmented reality (a technology that blends real world with digital world) can help individuals with disabilities learn math skills used in daily life.
Your child is being invited to take part in the research because he/she has a disability and has the potential to benefit from using this intervention.

Procedures
If your child participates, the investigators will ask you (the caregiver) to provide them with your child's IEP (Individualized Education Plan), IQ scores (through WJ III, WJ IV, or similar), and adaptive behavior scores (through SIB-R or similar) to verify his/her qualification for special education services.

The research will take place at the BYU Child and Family Studies Lab, and will take place over approximately 12 weeks as we collect data. There will be about 2 sessions per week and each session should take approximately 45 minutes, for a total of approximately 20 hours.
As part of the intervention, your child will watch a video representation of certain tasks (calculating the unit price of an item, adjusting the quantities of a recipe based on variation in number of servings, calculating daily, weekly, and monthly salary given the rate per hour) and then complete the tasks observed in the video.
All sessions of the study will be recorded if consent is obtained (you can provide consent at the bottom of this form).
At the conclusion of the study, both you (the caregiver) and your child will be asked to answer some survey questions about their opinion in regards to the usefulness of the study. The survey will take approximately ten minutes to be completed.

Risks
Your child may feel uncomfortable or nervous during the observations and feel some stress as he/she learns new skills. The researcher will minimize the discomfort by carefully instructing your child about how to use the iPad and how to ask for a break or for the session to stop.

Benefits
There are no direct benefits for your child participation in this project. However, we hope that he/she will be able to improve in his/her math skills related to daily living skills and complete more activities independently.

Compensation
Your child will receive a $30 Visa card for their participation. Your child will receive this amount at the end of the study, or if they decide to discontinue for any reason, your child will still receive full compensation.

Confidentiality
Any information that is obtained in connection with this study and that can be identified with your child will remain confidential and will be disclosed only with your permission. Your child's identity will be kept confidential. Your child's name will not be associated in any way with the information collected or with the research findings from this study. The researcher(s) will use a pseudonym instead of your child's name in any publication/presentation. This information will be used by the investigator for a period of three years from the study's start date. At the conclusion of the three years, all hard copy materials will be shredded, all electronic materials will be permanently deleted, and all video recordings will be permanently deleted as well. Your permission indicates that this information will be kept open to the investigator for that time period, but your child's name and any identifying information will not be shared or distributed.

Video Consent
As part of this project, the researchers will be making video recordings of you/your child during your/his/her participation in the research study. This can greatly help in the collection and analysis of the data.

Please indicate what use of this videos you are willing to permit, by initialing next to the uses you agree to. This choice is completely up to you. We will only use the videos in the way(s) that you agree to for a period of three years. In any use of the video, you/your child will not be identified by name.

______ The videos can be studied by the research team for use in the research project **(strict confidentiality)**.

______ The videos can be used for scientific publications.

______ The videos can be shown at scientific conferences or meetings.

______ The videos can be shown in classrooms to students (elementary, middle, high, college).

______ The videos can be shown in public presentations to non-scientific groups.

Participation
Your child's involvement is voluntary. If you decide to allow your child to participate please fill out the consent to participate form. You are free to decline to have your child participate in this research study. You may withdraw you child's participation at any point.

Questions about the Research
If you have any questions, please feel free to contact Giulia Cacciatore (801-618-7648) or Ryan Kellems, PhD, (801-422-6674), 237-C MCKB, Brigham Young University, Provo UT 84602. Questions about your child's rights as a study participant or to submit comments or complaints about the study should be directed to the IRB Administrator at Brigham Young University in A-285 ASB, Provo, UT 84602. Call (801) 422-1461 or send emails to irb@byu.edu.

If you wish for your child to participate in the study, please print your name and the name of your child and then sign and return the form.

You will be given a copy of this consent form to keep.

Child's Name: ____

Parent Name: ____

Signature: ____ Date: __________

Youth Assent (14-18 years old)

What is this research about?

My name is Giulia Cacciatore, and I am a Master's student at BYU studying Special Education. I want to tell you about a research study I am doing. A research study is a special way to find the answers to questions. We are trying to learn more about how to help you learn skills by watching videos. You are being asked to join the study because you have a disability and we think you could learn from using these videos.

Procedures

If you decide you want to be part of the study, you will come to the BYU Child and Family Studies Lab, and here's what will happen:

- First we will ask you to do something that you might not know how to do. For example, we will ask you to calculate the unit price of an item, adjust the quantities of a recipe, and calculate daily, weekly, and monthly salary. It's okay if you can't do it, we just want you to try.
- Then we will show you a video telling you how to do what we're asking you. Just watch the video and listen to what it says. Then we will ask you to do what the video showed you. We will ask you to come to the lab 2 times a week for about 3 months, each session will take about 45 minutes. You will come back a few times, watch the video, and then do what the person in the video does.
- We will video record you as you work. This will help us with the study.
- At the end of the study, you will be asked to answer some questions about your opinion on the usefulness of the study. The questions will take approximately 10 minutes to be completed.

Can anything bad happen to me?

You might get embarrassed or nervous when we watch you do what the video says. If you don't want to do what we ask you, tell us and you will be able to either take a break or stop.

Can anything good happen to me?

We hope that we will be able to teach you how to do the skill you watch from the video. You will also be rewarded for participating in the study with a $30 gift card.

Do I have other choices?

You can choose not to be in this study.

Will anyone know I am in the study?

We won't tell anyone you took part in this study. When we are done with the study, we will write a report about what we learned. We won't use your name in the report.

What happens if I get hurt?

If you get hurt during the study, your parent(s)/guardian will know what to do—we talked to them too.

<u>What if I do not want to do this?</u>
You don't have to be in this study. It's up to you. If you say yes now, but change your mind later, that's okay too. All you have to do is tell us.
Before you say yes to be in this study; be sure to ask Giulia to tell you more about anything that you don't understand. You can call Giulia at the number (801)-618-7648.
If you wish to participate in the study, please print your name and then sign and return the form. You will be given a copy of this consent form to keep.

Name (Printed): _____________________ Signature: ____________________ Date: ______

APPENDIX B: Data Collection Form

Name												
Age												
Gender												
Date												
Baseline (B) Intervention (I) Maintenance (M)												
Session												
Steps	+/-	VW	+/-	VW	+/-	VW	+/-	VW	+/-	VW	+/-	VW
Step #1												
Step #2												
Step #3												
…												
Total %												
Whole video watched												

*VW: Video Watched

APPENDIX C: Technology Training and Assessment

Direct Instruction on How to Use the iPad	
Read the problem written on the card	
Pick up the iPad	
Unlock the iPad	
Open the HP-Reveal app	
Open the camera mode on the app	
Read the first step on the checklist	
Find the corresponding trigger image in the booklet	
Hover iPad over the trigger image (will trigger the individual step)	
Watch the video	
Do the step as modeled in the video	
Repeat steps 6-10 for all additional steps necessary to complete the task	
Percentage Correct	/11

APPENDIX D: Intervention Fidelity Checklist

Check	**Intervention Fidelity Checklist**
	Setting up the recording device
	Preparing the materials for the task (problem, iPad, trigger images, etc.)
	Welcoming the participant
	Turning on the recording device
	Providing initial prompt (please solve the problem)
	Providing any additional prompt according to need (following prompt chart)
	Recording data (as the participant works or immediately after)
	Turning off the recording device
	Thanking the participant/providing reinforcement
	Cleaning up

APPENDIX E: Social Validity Questionnaire

Questionnaire for the Participant
Participant Name/Number: ____   Did you like learning about the different tasks? Why?   What is your favorite thing you learned?   Do you think you are going to use the skills you learned in the community/at home?   Did you like using the iPad to learn? Why?   Did you like watching the videos? Why?   Was it easy or was it hard to use the iPad   What is another thing you would like to learn using the videos on the iPad?   Is there anything you did not like? Why?   What would you change? How?