Comparison of Augmented Reality and Visual Supports on the Correct and Independent Completion of Vocational Tasks Among Students with Autism and/or Intellectual and Developmental Disabilities

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NORTHERN ILLINOIS UNIVERSITY

Comparison of Augmented Reality and Visual Supports on the Correct and Independent Completion of Vocational Tasks Among Students with Autism and/or Intellectual and Developmental Disabilities

A Capstone Submitted to the

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By

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Capstone Faculty Approval Page

Capstone Title:

Comparison of Augmented Reality and Visual Supports on the Correct and Independent Completion of Vocational Tasks Among Student with Autism and/or Intellectual and Developmental Disabilities

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HONORS CAPSTONE ABSTRACT

Abstract

The purpose of this Capstone project is to compare the effectiveness of augmented reality (AR) supports and visual supports on the accuracy and independent completion of vocational tasks for transition-aged students with autism and/or intellectual and developmental disabilities. At the time of submission of the paper, data collection will still be in progress and only a preliminary analysis of collected data will be available. Due to complications imposed by the COVID-19 pandemic, one 20-year-old student with autism participated in this study. The participant was taught two vocational/daily living skills (i.e., folding clothes and washing dishes). For one skill, the participant was instructed using visual, picture supports. For the second skill, the participant was instructed using augmented reality, video supports. The baseline phase utilized a multiple-opportunity method, and instructional supports were not provided to the participant for any of the intervention tasks. Baseline data were conducted in both the intervention setting with intervention materials as well as in the generalization setting with generalization materials. Upon completion of the baseline phase, a pre-intervention phase was initiated to instruct the participant in using the low-tech and high-tech supports using a comparable skill (i.e., stuffing a folder) to the selected intervention skills (i.e., folding clothes and washing dishes). The study utilized an alternating treatment design when the intervention was implemented. The effectiveness of the intervention was measured by evaluating data on the percentage of steps with independent responding and the percentage of steps with prompts to use technology as well as the comparison between the low-tech, visual supports
and the high-tech, augmented reality supports. Although results are preliminary at this time, the implications of this study are promising in the field of special education and promoting independence among individuals with autism and other developmental disabilities. The preliminary results of this study do imply that further research would be beneficial in strengthening this study.

Keywords: Augmented Reality, Vocational Tasks, Independency, Assistive Technology
Comparison of Augmented Reality and Visual Supports on the Correct and Independent Completion of Vocational Tasks Among Student with Autism and/or Intellectual and Developmental Disabilities

It is unarguable that technology changes our daily life and forces every human to adapt to an everchanging society. With these changes, it has opened a whole new field of research and study to seek possible benefits and improvements. Each technological advancement opens a door to endless possibilities of applications. Such technology includes the development of augmented reality. Augmented Reality (AR) adds a virtual reality layer on top of a physical environment and “can be thought of as the blend, or the ‘middle ground,’ between the completely synthetic and the completely real” (Kipper & Rampolla, 2012). It is different from virtual reality which creates a complete synthetic reality, as AR technology layers virtual information and physical information.

This technology can be created through either software or hardware and must present three characteristics: the combination of virtual and real information, contain interactive components with the viewer in real time, and must operate strictly in a 3D environment (Kipper & Rampolla, 2012). Without the presence of these three characteristics, the technological feature is simply virtual reality and cannot be considered augmented reality. AR technology has two main functions: (1) the augmented perception of reality and (2) the creation of an artificial environment (Kipper & Rampolla, 2012). This technology has the potential to alter a viewer’s reality and create an entirely different representation of what can be seen from one’s own viewpoint. The first AR system emerged in 1968 by researcher Ivan Sutherland which included an overlay head-mounted viewing system called The Sword of Damocles (Kipper & Rampolla, 2012). However, the term augmented reality was not coined until 1990 by researcher, Tom Caudell at Boeing Industries. Since then, AR has
advanced a great amount in the field of technology and has improved a variety of additional fields.

**Augmented Reality in the World**

To date, augmented reality technology has been used across many disciplines to create beneficial interactive experiences like never before. It has been used in medical training programs to facilitate learning complex medical procedures. One study evaluated the validity of seven different augmented reality application for medical professionals’ training in laparoscopic surgeries, neurosurgical procedures, and echocardiogram procedures. It was shown that “relevant scenarios can thus be practiced in surroundings where exploration and troubleshooting are safe” (Barsom et al., 2016). Being able to practice high intensity, constant changing scenarios allows medical professionals to practice adapting to situations under pressure and rapidly responding to unknowns that may arise during procedures. It has been reported that when AR technology is used in medical trainings, patient safety increases along with learning outcomes as well as exhibiting a reduction in costs and morbidity (Barsom et al., 2016).

Outside of the medical field, AR technology has also been used in tourism. One study evaluated the Google Glass application in its use to overlay information cards on a tourist’s field of vision within an art gallery in the UK. The purpose of this combination of AR software and hardware was to make the museum experience truly interactive and more informative. Participants in this study reported that with the augmented reality application, they enjoyed their art gallery experiences even more with the interactive hardware which made for a truly “transformed art gallery experience” (Tussyadiah et al., 2018).
While AR technology has been applied to create interactive tourism, AR technology can also be seen within interactive manufacturing systems opportunities. Within an assembly line, “AR technologies enable the users to visualize and interact with 3D objects more easily than they can through a simulation or a computer screen” (Michalos et al., 2015). This study outlined various applications of AR technology on assembly lines to create an interactive cooperation between humans and robots. The technology had four main functions: “assembly process information provision, robot motion and workspace visualization, visual alerts and production data” (Michalos et al., 2015). With the introduction of AR technology on the assembly line, employees had access to a large informational database. The AR technology allowed the employees to view informational databases as a visual overlay on the machines which facilitated the manufacturing process. These studies provide evidence that augmented reality technology has been introduced in a variety of fields for many differing functions all with the same purpose of improving functionality.

**Augmented Reality in Education**

A huge portion of augmented reality technology research has been conducted in the field of education. Specifically in general education, AR has been used in a variety of settings. One study applied the technology in an early childhood setting which proved that there are various educational benefits of AR applications in the classroom, such as “enhancing attention, providing attractive and effective learning, enhancing motivation, enriching interaction, facilitating learning, enhancing engagement, providing cooperation, triggering creativity, developing imagination, and enhancing spatial ability” (Yilmaz, 2015). This classroom utilized educational magic toys [EMT] that ran with AR technology.
The EMT demonstrated interactive puzzles, flash cards, and match cards to introduce and teach beginning concepts. Results from the study indicated that both students and teachers liked and enjoyed interacting with the activities; however, students showed a low level of cognitive attainment with the EMT.

Across educational settings, AR technology has also been used in language classrooms to help teach vocabulary. Augmented reality technology in this classroom included an animated representation of the vocabulary word alongside the correct pronunciation. Unlike the above study with EMT, this study found a positive correlation between a student’s motivation to learn the language and their academic achievement with the introduction of the AR application. Cognitive attainment with the AR technology at a higher level showed to be beneficial for students. It was determined that “the use of AR technology particularly in language classrooms will provide richer learning environment…which makes learning more productive, effective, interesting, and faster” (Solak & Cakir, 2015).

This idea was also applied to the implementation of an interactive word wall. AR technology when combined with word walls have proved to increase students acquisition and comprehension (Jackson et al., 2017). This technology allows teachers to use the physical words on the word wall as markers, and when an AR application is applied, the teacher can embed pictures, videos, example sentences, etc. for a specific word, creating an interactive word wall. AR technology has been applied vastly across many general education settings, but its beneficial applications can also extend into special education settings.
Augmented Reality in Special Education

Within special education settings, adaptive technology provides a plethora of beneficial resources for students with disabilities to use to exceed not only within the classroom setting but also in their daily lives. One research study evaluated the usefulness of utilizing AR technology to deliver math instruction. This study used the AR application, HP Reveal, to deliver math instruction to secondary students with disabilities, which “transforms the picture of a math problem into a modeled out and guided solving process for the student” by using direct instruction to increase student independence (Kellems, 2019). By using the instructional strategy of task analyses, students use a list of trigger images with the application to access step by step instructions for solving a particular problem. This application of AR technology within a math instruction setting allows students to be in charge of their own learning and grants them added independence.

A similar study used Google Glass hardware equipped with augmented reality software hardware to evaluate explicit instruction through AR technology for students with disabilities. This hardware is a wearable technology that projects virtual images on the lenses to layer virtual information on top of the physical environment in front of the viewer. The study used explicit instruction to teach students with disabilities how to operate an AR device using a 10-step task analysis. Then, data were collected on students following the task analysis independently, which demonstrated the need for explicit and direct instruction for students with disabilities to learn how to use AR technology (Kelley et al., 2016).

Additionally, within a special education setting, researchers have evaluated using AR technology to teach vocabulary words to students with intellectual disabilities and autism. One study used the AR application, Aurasma (now called HP Reveal), to create 30 triggers
for 3D different science terms. Students used the application on an iPad to capture the triggers written on a page. The AR material consisted of a video with the spoken term and definition, followed by an image of the term as well as a simulation showing the location of the science term, ending with the assessment image of the term alongside the oral definition one more time. AR vocabulary intervention accurately and efficiently improved students with disabilities’ acquisition of vocabulary terms and “gain contextual and meaningful vocabulary understanding” (McMahon et al., 2016).

McMahon also conducted another research study that evaluated the use of augmented reality technology as a navigation tool for employment opportunities for students with disabilities in a postsecondary transition program. This study “examined the effects of a location-based AR technology to teach college students with [Intellectual Disabilities and Autism Spectrum Disorder] to navigate a city independently to local employment opportunities” (McMahon et al., 2015). The application of AR technology with navigation was evaluated by the efficacy of using a paper map, Google Maps, and the AR application, Layar. Results of the study indicated that students preferred augmented reality maps over other options and they “demonstrated increased independent navigation” with the use of the augmented reality application (McMahon et al., 2015). Overall, it can be seen through various studies that AR technology holds the potential to support students both academically and with functional skills instruction to become more independent. With consideration of these findings, this study was formed.

The purpose of this pilot study was three-fold. This first component of this study was to investigate the effectiveness of an instructional intervention utilizing augmented reality technology on vocational tasks for transition-aged students, as determined through
quantitative data collection on the accuracy and independence of completion of the selected tasks. Additionally, this study was established to compare the effectiveness of augmented reality supports to low-tech, visual supports on the factors stated above. In addition to evaluating instruction, this study was extended by also evaluating the ability of students to generalize across both instructional supports. Specifically, the research team was interested in 1) determining if instructional interventions utilizing augmented reality improved student independence and accuracy of completing vocational tasks, 2) comparing the effectiveness of the high-tech, augmented reality intervention to low-tech, visual supports on the independency and accuracy of completing vocational tasks, and 3) evaluating the generalization of the instructional methods across settings and materials.

**Method**

The following is an overview of the proposed research procedures followed during preparation and implementation of this study.

One male student enrolled in a public, therapeutic day school that serves adolescents with severe and profound disabilities participated in this study. Initially, three male students enrolled in the therapeutic day school participated in this study. However, due to COVID-19 pandemic, data collection was limited to one participant: Edwin (the individual student’s name was changed to maintain confidentiality). The initially selected participants were between the ages of 18 and 20, and the participants came from diverse cultural backgrounds. The participants were referred to enroll in the therapeutic day school when their academic and behavioral needs exceeded what their host school districts could
offer. At this time, this therapeutic day school has eight member school districts that refer students to enroll in their services. Students who attend this school have placements that are fully funded by their referring school districts and have a disability that adversely impacts their daily functioning that makes them eligible to have an IEP. All three participants selected for this study received IEP services under the eligibility category of Autism Spectrum Disorder, and their academic and behavioral needs are best met in this alternate school environment.

**Edwin.** Edwin was a 20 year-old male participating in the study. Edwin’s diagnoses at the time of the project were: Autism Spectrum Disorder, ADHD, and Oppositional Defiant Disorder. He was a very friendly, young man who was very hard working. Edwin had previous exposure to using various visual supports in classroom instruction. In his program, he was instructed in academic, functional, and community-based instruction with the supports of the Picture Exchange Communication System and TouchChat. Edwin was a verbal communicator that benefited from the use of visual supports for instruction. He had some experience with using visual supports for picture-based task analyses but primarily used picture supports to support written comprehension or to promote communication. He was familiar with the use of an iPad for recreational use, which was similar to the device used for the augmented reality intervention. However, he had no previous experience with augmented reality nor when specifically used in instruction.

**Setting**

This study was conducted in a public, therapeutic day school located in the western Chicago suburbs. The school is an alternative school through a special education cooperative, serving students with low-incidence disabilities. The baseline and intervention
sessions were conducted in the school’s mock-apartment. For the generalization baseline and intervention, the school’s laundry room and a micro-business classroom were utilized. The participant in the study was provided with the instructional materials in the school’s mock apartment to complete both vocational tasks: folding clothes and washing dishes. To measure generalization, the participant was provided with the same delivery model of instruction but was provided with generalization materials (i.e., materials that were similar but different than instruction materials) to complete both of the vocational tasks: folding clothes and washing dishes. The folding clothes generalization task occurred in the school’s laundry room, and the washing dishes generalization task occurred in the school’s micro-business classroom.

**Skills Selected for Instruction**

The participant in the study was taught one skill in each of the instructional conditions (i.e., one skill taught with visual supports (pictures) and one taught with video supports (augmented reality)). Both of the selected skills fall within the vocational and daily living skills domains of instruction (folding clothes and washing dishes). The skill sequences were selected based on teacher input, student skill level, and level of performance required at community jobs. Edwin was taught these two skills, one with visual supports and one with augmented reality supports. If the COVID-19 pandemic allowed for all three participants to participate in the study, all three students would have been taught the same two skills: folding clothes and washing dishes; however, the skills would have been counter balanced across participants (i.e., one student would have AR with washing dishes and VS with folding clothes, another student would have VS with
washing dishes and AR with folding clothes). The two tasks were similar in difficulty and length (i.e., 34 steps for folding clothes, and 38 steps for washing dishes).

**Instructional Equipment and Materials**

The following is an overview of the AR technology and its accompanying device used to deliver the intervention instruction as well as the visual support materials used in comparison to the AR supports. The intervention task and generalization task materials are also expanded upon in this section.

**Flipgrid AR.** Flipgrid AR is a software program which allows an individual to upload videos and create individual QR codes that pair with each video. A user can scan the QR code using the Flipgrid AR application on any iOS or Android Device to play the associated video in an augmented environment. The participant in this study used this application to scan the instructional QR codes and watch their associated videos during the implementation of the AR condition. For the purpose of this study, the Flipgrid AR application was downloaded onto Lenovo Tablets, and was downloaded from this link: [https://play.google.com/store/apps/details?id=com.vidku.app.flipgrid](https://play.google.com/store/apps/details?id=com.vidku.app.flipgrid). The observers monitored the participant use of the application throughout the study and prompted the participant to use the technology as needed. The research team first taught the participant how to use the Flipgrid AR application with a ‘stuffing folder’ training task.
Figure 1. Flipgrid AR Software accessed through the website: https://info.flipgrid.com/ (left); Flipgrid AR application home screen (right)

**Lenovo Tab 4.** The participant in this study used a Lenovo Tab 4 to access the Flipgrid AR software. Further information on the Lenovo tablet used throughout this study can be found at this link: https://www.lenovo.com/us/en/tablets/android-tablets/tab-4-series/Lenovo-TB-8504/p/ZZITZTATB08. During the AR condition in the intervention phase, a Lenovo tablet was used with the downloaded Flipgrid AR application. The tablet was given to the participant with the application already opened on the tablet, and he pointed the QR scanner on the device at the QR code to watch the instructional video. The observers monitored the participant’s use of the device and prompted them to use the device as needed. The participant was first taught how to use the device with a ‘Stuffing a Folder’ training task before the intervention phase began.
Figure 2. Lenovo Tab 4 used for AR intervention (left); AR visuals used in the intervention phase (right)

**Visual Supports.** The participant in this study were provided with visual supports during the visual supports (VS) condition in the intervention sequence. Visual supports were made by taking a photo of each completed step in the intervention task. The visuals were printed one per page in full color and were placed in a binder for organization. The participant was instructed to use the visuals to complete the intervention task. Observers monitored the participant’s use of the visual supports and prompted them to use the visuals as needed. The participant was trained in using the visual supports before the intervention phase began using the ‘Stuffing a Folder’ training task.

Figure 3. VS materials used in the intervention phase
**Intervention Task Materials.** Throughout the intervention phase, for both AR and VS conditions, the participant used the same task materials as used in the instructional videos and visuals. For the intervention task of washing dishes, the participant used the same scrub brush, plate, bowl, cup, fork, and knife as those used in the videos and visuals. The participant also washed the dishes in the same environment where the videos and visuals were created, the school’s mock-apartment. For the intervention task of folding clothes, the participant used the same t-shirt, long sleeve, jeans, sweatpants, pair of socks, and laundry basket as those depicted in the AR videos and visual supports. The participant also folded the clothes in the same environment as in the videos and visuals, the school’s mock-apartment.

![Figure 4. Materials used for the folding clothes task (left) and washing dishes task (right) in the intervention phase](image)

**Generalization Task Materials.** Throughout the generalization phase, for both the AR and VS conditions, the participant used materials that were different than the ones used in the instructional videos and visuals. For the intervention task of washing dishes, the participant was provided with the same types of instructional materials, but they differed from the ones shown in the instructional videos and visuals. He was given a scrub brush,
plate, bowl, cup, fork, and knife that differed from the ones shown in the videos and visuals. Also, this intervention task was completed in a different sink a different environment, the micro-business classroom. For the intervention task of folding clothes, the participant was provided with the same types of instructional materials, but they differed from the ones shown in the instructional videos and visuals. He was given a t-shirt, long sleeve, jeans, sweatpants, pair of socks, and laundry basket that differed from the ones shown in the videos and visuals. Also, this intervention task was completed in a different environment, the school’s laundry room.

![Figure 5. Materials used for the folding clothes task (left) and washing dishes task (right) in the generalization phase](image)

**Research Conditions and Procedures for Each Phase**

The following includes information on research conditions and procedures followed during each phase of this research study. The procedures and measures listed were followed and implemented during the planning and implementation of this study.

**Baseline.** During the baseline phase of the study, the participant was asked to perform both intervention tasks in the same location as the intervention sessions, with the same materials used in the instructional videos and visuals. The order of sub-tasks was
changed each session (i.e., order for folding clothes in first session: t-shirt, long sleeve, sweatpants, jeans, and socks, then for second sessions, order was changed to: sweatpants, t-shirt, sock, long sleeve, and jeans), and the order was determined before the start of data-collection. For example, the order in which the student washed the dishes in and folded clothes changed each session and was completely randomized. A multiple-opportunity method was used throughout this phase. The participant was instructed to complete the intervention task with the prompt “Wash Dishes” or “Fold Clothes” without any accompanying prompting nor visuals supports. Instructional supports were not provided to the participant for any of the intervention tasks during the baseline phase. If the participant completed the step incorrectly or failed to initiate the step within five seconds, the instructor said “My turn. Turn around.” and completed the step for the student. After completing the step for the participant, the instructor said, “Your turn.” which prompted the participant to turn back around and continue the intervention task in front of them. These procedures were repeated until the task was complete.

A total of three baseline data points were collected for each participant using the instructional materials in the instructional settings. The same procedures as described above were used for the generalization baseline phase; however, the sessions were conducted in different locations using different stimulus materials. Also, a multiple-opportunity method was used throughout this phase, and three baseline data points were collected for each participant using the generalization materials and settings.

**Pre-Intervention.** Before the intervention began, it was imperative the research team counter-balanced and assigned the tasks and conditions to the participants in the study. The participants’ performance and scores collected during the baseline phase were
taken into consideration alongside the task difficulty and participants’ performance with the designated tasks. In counter-balancing the assigned tasks and conditions, the research team avoided assigning tasks with higher baseline scores all to one condition. The participants were assigned to tasks and conditions taking counter-balancing considerations into mind. The task and conditions assignments for each participant in reflected in Figure 6 below.

![Figure 6. Table outlining the task and condition assignments for each of the participants in the study](image)

Also, before the intervention began, instructional materials needed to be created. During the AR condition, the QR code reader application, Flipgrid AR, was used to activate the QR codes embedded in AR markers to play the associated instructional video. Once the instructional videos were recorded and paired with individualized QR codes, the AR markers with the embedded QR codes were printed one per page and organized into a binder. The same approach was followed when created the VS materials. Once the photos were taken of each completed step, the photos were printed one per page and organized into a binder. The individual pages were color-coded to correspond to the specific intervention task and condition. For example, the blue pages in the binder were associated with the AR intervention task and the pink pages were associated with the VS intervention task. Each participant received their own binder with the correct AR and VS instructional pages to corresponded with their assigned intervention tasks and conditions.
After the instructional materials were created, before the intervention was to occur, it was imperative that there be training to teach the student how to use the new technology. A simple task was chosen to teach the student how to use the technology and visuals independently. The training task chosen for this pre-intervention phase was ‘Stuffing a Folder’. The materials developed for the training task mirrored those used in the intervention. For example, the training binders presented to the student included the same color-coded organization with the AR and VS materials as used in the intervention phase. To teach the participant to use the AR and VS materials, the instructor used a model-lead-test format to teach.

Researchers used a “Model-Lead-Test” format to teach the participant to use the technology supports. The specific procedures used to teach the participant how to use the AR and VS materials are as follows. During the modeling phase, the instructor presented the binder of visuals and set out the needed materials. Then, the instructor modeled how to use the binder with the prepared AR and VS materials while completing the training task. After modeling, the instructor moved to the lead phase of the lesson, where the instructor presented the binder of visuals and materials with the guiding verbal prompt of “Your turn.” The instructor prompted the participant through using the device and visuals in the binder until they completed the training task in the same manner as in the modeling phase. In the testing phase, once the participant demonstrated understanding of how to use the device and visuals in the binder, the instructor refrained from giving any prompting until they could use device/booklet independently for at least three consecutive sessions. The order of the sub-tasks needed to be completed the task were changed for each session and they were completely randomized as in the instructional tasks in the intervention phase.
**Intervention.** After the participant completed training to use the high-tech, AR supports and the low-tech, visual supports, the intervention phase began. The participant completed the same intervention tasks as in the baseline phase.

**Condition 1: AR Intervention.** During the implementation of condition 1, the participant used the AR materials to complete his assigned intervention task for the AR condition. In each intervention session, the sub-tasks in the AR assigned task was changed and randomized, so the order of completing each sub-task was different in every session. During the AR condition, the participant used the Flipgrid AR software on the device to scan the AR marker to play an instructional video. Directly after watching the instructional video, the participant was to complete the presented step (i.e., video prompting). Again, a multiple opportunity method was used throughout the intervention phase and data were collected for a minimum of five intervention sessions for the participant. Data were collected on the participant’s correct completion of each step as well as the correct sequence order in completing each sub-task in the assigned intervention task for this condition. Also, data were collected on the number of prompts given to the participant to use the technology.

**Condition 2: VS Intervention.** During the implementation of condition 2, the participant used the VS materials to complete his assigned intervention task for the VS condition. In each intervention session, the sub-tasks in the VS assigned task was changed and randomized, so the order of completing each sub-task was different in every session. During the VS condition, the participant used the step-by-step visuals in the binder to guide their completion of the intervention task. The
participant used the photos of each completed step as a model when completing the same task independent of direct, teacher instruction. Again, a multiple opportunity method was used throughout the intervention phase and data were collected for a minimum of five intervention sessions for the participant. Data were collected on the participant’s correct completion of each step as well as the correct sequence order in completing each sub-task in the assigned intervention task for this condition. Also, data were collected on the number of prompts given to the participant to use the technology.

**Generalization.** The same methods and procedures listed above for the intervention phase were used during the generalization phase of this research study. However, the sessions were conducted in different locations and stimuli differed from those used in instructional sessions and shown in the instructional videos, visuals, and intervention tasks. The folding clothes generalization task occurred in the school’s laundry room with different stimuli, and the washing dishes generalization task occurred in the school’s micro-business classroom, which had a sink with different stimuli. These differing locations and stimuli presented created an intervention atmosphere that allowed for the participant to demonstrate his generalization of the learned tasks during the instructional intervention. Again, a multiple opportunity method was used throughout the generalization phase and data were collected for five sessions in each task for the participant. Data were collected on the participant’s correct completion of each step as well as the correct sequence order in completing each sub-task in the assigned generalization task and correlating condition assigned in the intervention phase. Also, data were collected on the number of prompts given to the participant to use the technology.
Experimental Design

An alternating treatments design was implemented to compare the effectiveness of augmented reality supports and visual supports on the correct and independent completion of the functional tasks with a vocational focus, washing dishes and folding clothes. By utilizing this experimental design, multiple treatment conditions can be introduced at a time with rapid shifts between their presentation. It also allows for the complete randomization of presentation of tasks to allow for the reliable comparison of the effects of multiple conditions on the same behavior or skill. However, when distance is increased between data paths, it demonstrates a larger effect on the reliability of collected data due to the rapid nature of this experimental design. This experimental design was chosen, as it allows the two conditions of AR and VS materials and instructional intervention to be evaluated in a rapid and randomized matter to ensure reliable comparison in the dependent measures collected and evaluated.

Dependent Measures and Data Collection

The following are dependent measures and data collection procedures used throughout each phase of the study. The procedures listed were followed and data were collected in the baseline, intervention, and generalization phases of the study.

Percentage of Steps with Independent Responding. During each of the sessions in the baseline, intervention, and generalization phases, data were collected on each step in the task analysis for both intervention tasks. Data collectors recorded if the step was completed correctly, incorrectly, or in the incorrect sequence. After the session was complete, data collectors counted the number of steps the participant completed correctly
and independently and divided it by the total number of steps in the task analysis to calculate the percentage of steps with independent responding.

**Percentage of Steps with Prompts to Use Technology.** During each of the sessions in the baseline, intervention, and generalization phases, data were collected on each step in the task analysis for both intervention tasks in relation to the number of prompts to use the low-tech or high-tech technology. Data collectors recorded if the instructor prompted the participant to use the technology by placing a check mark next to the corresponding step in the task analysis. After the session was complete, data collectors counted the number of prompts given to the participant and divided by the total number of steps in the task analysis to calculate the percentage of steps with prompts to use technology.

**Interoobserver Agreement and Treatment Fidelity**

In order to verify the accuracy of the data, at least 25% of the sessions, across all of the baseline, intervention, and generalization phases, had a secondary observer and they were required to have at least 85% agreement on all data marked on the data sheet. To calculate Interoobserver Agreement (IOA), the percentage agreement index was found by taking the number of agreements and dividing it by the number of agreements plus disagreements, and finally multiplied by 100. This calculation gave the research team the percentage of steps recorded with agreement. With the data that were collected so far, the mean interobserver agreement for this study was 95% with a range of 92-100%.

Additionally, the secondary observer answered several fidelity questions at the end of each observational session to establish procedural reliability and treatment fidelity. The questions asked of the secondary observer were as follows:
1) Did experimenter implement correct planned condition A-(Baseline), AG (Generalization), B-(AR Intervention), C (VS intervention)?

2) Was error correction (EC) implemented correctly (i.e., look away/cover eyes and completed by experimenter)?

3) Was the wait time at least 5 seconds before providing EC?

4) Were correct tech materials used for each task? (No visuals for baseline/generalization, AR materials for AR task, Visuals for picture sequence)?

5) Were correct materials used (baseline/instructional materials vs. generalization materials)?

6) Were order of subtasks changed each session on instructional materials and data sheets?

7) Were students given assistance or prompts to use technology during instructional sessions if necessary (Please note, this item will only be calculated during intervention sessions).

Procedural reliability was calculated by dividing the number of correct measures by the total number of assessed measures and finally multiplying by 100. Data collected on procedural reliability were collected in sessions with a secondary observer. With the data that were collected so far, procedural reliability for this study is currently 97%.

Social Validity. At the end of the study, the participant and teachers were asked which procedure they preferred and provided feedback on the feasibility of using the procedures and measurement devices. Questions asked to teachers/case managers/caregivers include:

1) Can you describe your student’s independence when engaging in X activity?

2) Have you ever used AR before?
3) Do you think AR is easy to use?

4) Do you think you/ your school/business could afford to purchase the necessary items needed to implement AR?

5) Did you think the Augmented Reality tool was helpful for increasing the independence of your students/clients when completing identified daily tasks?

6) Did you think the Augmented Reality tool was helpful for improving the correct performance of your students/clients when completing new tasks?

7) Did you like using the Augmented Reality tool as a supplement to instruction?

8) If so, what did you like most? What did you like least?

9) Would you use this Augmented Reality tool again in the future?

Questions asked to the participant in the research study include:

1) Is it hard for you to X activity?

2) Do you need help doing X activity?

3) Is it hard to use the AR device?

4) Did you like using the Augmented Reality device?

5) Did you feel like it helped you to know what to do?

6) Did you feel like it helped you learn new tasks?

7) What did you like most about the Augmented Reality device? (Show pictures of device, video, and QR code booklet)

8) What did you like least? (Show pictures of device, video, and QR code booklet)

9) Would you want to use Augmented Reality devices again in the future?
Assessments for these procedures were adapted for the participant to ensure accurate feedback was obtained. At this time, social validity data has not been collected. Once data collection is completed, these questions will be asked to the participant and his answers will be recorded.

**Results**

The following is an overview of results across the evaluated dependent measures that was collected to date. Due to the COVID-19 pandemic, data collection has been slower and more limited than expected when the research design was created before the pandemic began. After this paper is submitted, data collection will continue until completed.

**Percentage of Steps with Independent Responding**

Preliminary results of this study began to indicate differences between baseline and intervention phases in regard to the percentage of steps with independent responding in both assessed tasks. For the folding clothes task, which utilized VS in the intervention phase, a total of three baseline and two intervention data points were collected. While this only suggest a preliminary analysis of results, the average percentage of step with independent responding in baseline was 40% in comparison to with 41% average number of steps with independent responding in the intervention phase. These averages do not display any significant growth with the implementation of the VS intervention. The percentages of steps with independent responding collected from each session with the folding clothes task is displayed in Figure 7.
For the washing dishes task, which utilized AR in the intervention phase, a total of three baseline and two intervention data points were collected. While this only suggests a preliminary analysis of results, the average percentage of steps with independent responding in baseline was 23% in comparison to the 40% average number of steps with independent responding in the intervention phase. The final data point collected for the washing dishes task was 53% of steps with independent responding, which displays a large increase from the mean of 23% of steps with independent responding during baseline. The percentage of steps with independent responding collected from each session with the washing dishes task is displayed in Figure 7. Between the two tasks, which were instructed using different supports during the intervention phase, there is a significant difference in individual student growth in regard to the percentage of steps with independent responding. This difference in percentage of steps with independent responding between baseline and intervention for the two tasks is: 1% for folding clothes (VS) and 30% for washing dishes (AR).
Percentage of Steps with Prompts to Use Technology

Preliminary results of this study began to indicate strong differences between VS and AR in regard to the percentage of steps with prompts to use technology in the intervention phase. Since the low-tech and high-tech supports were only used within the intervention phase, there were only two data points collected for each of the tasks. For the folding clothes task, Edwin required a prompt to use the visual supports for 47% of the steps in both sessions. However, for the washing dishes task, Edwin required a prompt to use the AR device for only 18% of the steps in both sessions. The percentages of steps with prompts to use technology collected during the intervention phase of both tasks is displayed in Figure 8. The difference in the percentage of steps with prompts to use technology between the folding clothes task (VS) and the washing dishes task (AR) is 29%. Edwin
required fewer prompts to use the technology supports with the AR, video supported task than with the picture, visually supported task.

![Graph representing data points collected to measure the percentage of steps with prompts to use technology during the intervention phases of both washing dishes (AR) and folding clothes (VS) tasks](image)

**Figure 8.** Graph representing data points collected to measure the percentage of steps with prompts to use technology during the intervention phases of both washing dishes (AR) and folding clothes (VS) tasks

**Generalization**

Preliminary baseline data were collected in the generalization phase of this study. Due to the multiple opportunity method that was utilized, the baseline phase became frustrating for the participant. During baseline, there was no instruction provided to the participant, and once the project progressed into performing the same tasks in the generalization locations with the generalization materials, the participant was no longer willing to work with the research team. With the possibility of losing rapport with the participant, which could have halted progress for the project, it was decided to discontinue the generalization baseline phase and move onto the intervention phase. For the
generalization baseline phase, only one data point for each task was collected. The participant’s percentage of steps with independent responding in the generalization baseline phase was comparable with this measure in the intervention baseline phase.

For the washing dishes task, the participant’s percentage of steps with independent responding in the generalization baseline was 21% of steps in comparison to the mean percentage of 23% of steps in the intervention baseline. Also, for the folding clothes task, the participant’s percentage of steps with independent responding in the generalization baseline was 35% of steps in comparison to the mean percentage of 40% of steps in the intervention baseline. Baseline data collected in both tasks across intervention and generalization locations and materials are comparable with generalization baseline data falling slightly lower than the percentage of steps with independent responding in the intervention baseline. The percentage of steps with independent responding in the generalization baseline phase is displayed in Figure 9. The generalization phase of this study will extend beyond the submission of this paper and the data collected from this phase will be compared with the data collected from the intervention phase in regard to the measures: percentage of steps with independent responding and percentage of steps with prompts to use technology.
Overall Summary

Although data collection will be continuing for this study beyond the submission of this paper, there are some patterns that are beginning to emerge. For the research variable of percentage of steps with independent responding, Edwin began making progress in both tasks. However, his increase in performance in the washing dishes task (AR) was greater. In comparison with the folding clothes task (VS), Edwin demonstrated 29% greater growth from baseline to the intervention with respect to the percentage of steps with independent responding. For the research variable of percentage of steps with prompts to use technology, Edwin demonstrated a steady percentage in his performance in both tasks. He demonstrated two sessions at 47% of steps with prompts to use technology for the folding clothes task and 18% of steps with prompts to use technology for the washing dishes task. The AR task required a lower percentage of steps with prompts to use technology in
comparison to the VS task, which suggest increased independence. Interestingly, for both tasks, Edwin required a prompt to use technology on the same steps in the task analysis in each of the sessions. In both tasks, the participant required a prompt to use the technology after each dish was washed and after each piece of clothing was folded. After one item was complete, the learner required a prompt to turn back to the booklet and use the technology in both the AR task and VS task.

Discussion

The purpose of this pilot study was to compare the effectiveness of picture supports versus augmented reality supports in teaching the correct and independent completion of vocational/daily living skills to individuals with autism and/or developmental disabilities. The effectiveness of the interventions were measured by comparing the percentage of steps with independent responding and percentage of steps with prompts to use the low tech/high tech technology supports for each vocational skill during the instructional phase and growth from pre- to post- measures using instructional and generalization materials and settings.

Preliminary results of this study indicated a contrast between the use of augmented reality, video supports (AR) and visual, picture supports (VS) in the instruction of functional/vocational tasks. From the data that were collected, it is shown that there is greater growth of independence with the use of AR in comparison to VS. The student who participated in this study demonstrated an average of 30% increase in performance from baseline with respect to the percentage of steps with independent responding with the support of AR in comparison to the average of 1% increase in performance from baseline
with respect to the percentage of steps with independent responding with the support of VS.

Student independence was also measured through the variable, percentage of steps with prompts to use technology. The student who participated in this study demonstrated a steady 47% of steps with prompts to use VS during the folding clothes task in comparison to the steady 18% of steps with prompts to use AR during the washing dishes task. This shows a 29% decrease in the reliance of the research facilitator to prompt the learner to use technology. Edwin demonstrated greater independence overall with the correct and independent completion of the functional/vocational tasks with the use of the AR condition in comparison to the VS condition. Although only two data points have been collected so far for each condition, these preliminary results are promising and begin to demonstrate greater independence in the completion of the functional tasks with a vocational focus.

Limitations

Although the preliminary investigation proposed by this study in an area with limited research opened up an investigation into AR supports for vocational skills, there were still many significant limitations that impacted the completion of this study. One of the greatest limitations was caused due the COVID-19 pandemic. The study and its completion was severely impacted by the pandemic. Initial data collection for baseline began back in October 2020. However, baseline was interrupted by an adaptive pause taken by the school which paused in-person learning through the end of the year. Student attendance was also affected due to quarantine policies and procedures caused by a student displaying COVID-like symptoms. Due to limited in-person student attendance, the number of sessions were limited spread out over the course of the school year.
Additionally, although the preliminary results are promising upon completion of the study, there were several limitations to this study. First, the study only collected intervention data on one participant. The results would have been strengthened if the original methods and procedures were implemented with a larger number of research participants. Also, the research results would have been strengthened with an extended baseline phase was conducted for the generalization intervention. This would have continued to establish a low level of student performance in the correct and independent completion of the two vocational tasks in the generalization setting and using the generalization materials. Although this would have been preferable, a low-level of student performance was still established between the three data points collected with the intervention setting and materials and one data point collected with the generalization setting and materials.

With continued data completion efforts beyond the submission date for this paper, the results of the study will be strengthened and will hopefully demonstrate an increased correct and independent completion of the vocational skills with the use of the low-tech and high-tech supports. The expected results of this study will demonstrate a greater acquisition rate of the correct and independent completion of the vocational skill with the use of the augmented reality supports versus the picture supports.

**Implications for Future Research**

This study proposes the implementation of an augmented reality intervention to teach the correct and independent completion of vocational/daily living skills in individuals with autism and/or intellectual and developmental disabilities in comparison to standard low-tech visual, picture supports. Research being conducted in this area is relatively new
and emerging, and there are several implications for future research and investigation. Further research is needed in the realm of generalizing these skills among alternate settings, especially community-based and employment settings. In this study, due to the controlled settings utilized in the school building to conduct data collection sessions as well as limitations to travel into the community, the student only used the augmented reality video supports within the school. A further investigation into using AR in real-world employment and community-based settings would make the applicability of these skills more vast and far reaching for individuals with disabilities in their lives post-secondary.

Augmented Reality technology can be used in many ways for interventions beyond vocational/daily living skills. Hopefully, with additional research and investigation, augmented reality video supports can become more common and effective intervention supports for promoting independency skills among individuals with autism and other developmental disabilities.
References


