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Technology-Aided Instruction and Intervention in Teaching Students With Autism to Make Inferences

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Abstract

Inferential readings skills are necessary in ensuring that students with autism spectrum disorders (ASD) are successful in the general education curriculum. These skills provide a foundation for reading comprehension across content areas. Technology-aided instruction and intervention (TAII) has the potential to address these reading deficits, by presenting content in an interactive format. Using an adapted alternating treatment design (ATD), the present study compared the impact of the TinyTap app, videos, and traditional graphic organizers to improve the inferential reading skills of two middle school students with ASD. Replication of the most effective intervention occurred, and maintenance data were collected. The results suggested that the TinyTap treatment condition was the most functionally effective in increasing inferential reading skills. From the research, there are a number of implications moving forward for both practitioners and future researchers examining the impact of TAII on academic skills.

Keywords

autism spectrum disorders, educational evidence-based practices, literacy

The Individuals with Disabilities Education Improvement Act (IDEIA, 2004) mandates that students with disabilities, including students with an autism spectrum disorder (ASD), have access to the general education curriculum. According to the National Council on Disability (2018), effective inclusive practices and instruction lead students with disabilities to be more successful academically, as well as socially and behaviorally. A key component to success in the general education environment is reading comprehension skills, which are an area that is of great challenge for many students with ASD (Nation & Norbury, 2005). According to Perfetti et al. (2008), three components that are essential for developing reading comprehension include (a) sensitivity to story structure, (b) inference making, and (c) comprehension-monitoring. As a foundational skill, the ability to make inferences from text is a prerequisite for reading comprehension and higher-order thinking and is critical across the curriculum, including English language arts, science, and social studies (Marzano, 2010). Drawing inferences from text is present in the Common Core State Standards (CCSS) English Language Arts Standards, in both middle school and high school (CCSS.ELA-LITERACY.RL.6.1; CCSS.ELA-LITERACY.RL.7.1; CCSS.ELA-LITERACY.RL.8.1; CCSS.ELA-LITERACY.RL.9-10.1; CCSS.ELA-LITERACY.RL.11-12.1). For students with ASD, inferences can be particularly challenging due to the need to understand information that is implied or not directly stated. For this reason, more research is needed to support academic skills for students with ASD.

Technology-aided instruction and intervention (TAII), previously known as computer-aided instruction and speech-generating devices, has the potential to address these inferential reading deficits for this population. The core feature of TAII is the usage of technology in the instruction or intervention. According to the CSESA Technology Group, technology is defined as "an electronic item/equipment, application, or virtual network that is used to intentionally increase, maintain, and/or improve daily living, work/productivity, and recreation/ leisure capabilities of adolescents with autism spectrum disorders" (as cited in Odom et al., 2015, p. 3806). Such technologies may include speech-generating devices, smartphones, tablets, computer-assisted instructional programs, and virtual networks (Odom, 2013). The National Professional Development Center on Autism Spectrum Disorders (NPDC) identifies TAII as an evidence-based practice that may be utilized by a variety of professionals to

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Table 1. Descriptive Information on Participating Students.

Participant	Age	WISC-IV	WJ III-broad reading	WJ III-broad written language	SPM-social participation
1	13.5	—	81	72	56
2	12.5	109	82	76	—

Note. The assessment data are standard scores and were used to qualify each student for special education services. WISC-IV = *Wechsler Intelligence Scale for Children–Fourth Edition Full Scale IQ* (Wechsler, 2003); WJ III = *Woodcock–Johnson Tests of Achievement III* (Woodcock et al., 2001); SPM = Sensory Processing Measure (Parham et al., 2010). The assessment data are standard scores and were used to qualify each student for special education services.

effectively address social, communication, behavior, joint attention, cognitive, school-readiness, academic, motor, adaptive, and vocational skills of preschool students to young adults with autism.

According to Odom (2013), Knight et al. (2013), Hedges and AFIRM Team (2017), and Barton et al. (2017), research on technology-based interventions is steadily growing. However, there is currently more literature targeting social, communication, behavioral, and school-readiness skills, as opposed to academic skills. Articles examining TAII and the impact on academic skills primarily focus on task completion (Mechling & Savidge, 2011) and self-monitoring (Cihak et al., 2010; Soares et al., 2009). In addition, research that does focus on academic skills targets vocabulary acquisition (Moore & Calvert, 2000) and spelling (Stromer et al., 1996), with limited focus on inferencing and reading comprehension skills, especially in middle school (Hedges & AFIRM Team, 2017).

Therefore, the purpose of the study was to extend the present research literature on addressing reading skills, and particularly, inferential reading skills of students with ASD due to its importance in academic areas. Furthermore, the study aims to add to the literature on the impact of TAII in regard to academic skills by specifically examining TinyTap (2019). TinyTap is a social platform application (app) in which educators create and share interactive lessons and educational games. Within the targeted school setting, school system, and other surrounding school systems, TinyTap was being utilized for academic instruction, with limited research on the impact of the app on student performance when compared with past efforts to teach inferential reading skills. Therefore, the following questions were addressed in the research:

1. What were the comparative effects of TinyTap, videos, and graphic organizer treatment conditions on the inferential reading skills of students with ASD as measured by immediate posttests?
2. What were the students' opinions of the TinyTap, videos, and graphic organizer instructional strategies?
3. To what extent did any improvements in inferential reading maintain 2 weeks following the conclusion of the study?

Method

Participants

Two male, middle-school participants who met the criteria for ASD according to the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; *DSM-IV*; American Psychiatric Association, 1994) were selected for the study. Both participants were in the seventh grade and had individualized education programs (IEPs) and received no related services, such as occupational therapy, physical therapy, speech and language therapy, and/or adapted physical education. Observations, conferencing with the classroom teachers, and past assessment data indicated that these students needed help with inferential reasoning skills. Within an inclusive English language arts classroom, both participants were observed having difficulties with specific comprehensive reading assessment questions that required inferential reasoning (i.e., how and why questions). Additional assessment scores were collected from participants' administrative records, which are identified in Table 1.

Setting

The study took place within a comprehensive middle school located in a public school system on the east coast of the United States. The participants were students in multiple inclusive classroom settings within the general education environment. Each classroom contained 29 students with one general education teacher and one instructional assistant.

A special education teacher was also present during the participant's mathematics and English language arts classes. The educators within the classrooms used both whole-group and small-group teaching procedures to target specific academic skills.

The second author, a special education teacher, was the interventionist and delivered the intervention one on one to each participant. Participant training on the treatment conditions and intervention phase probes were conducted in a separate, intervention classroom. Probes conducted in the baseline phase and replication phase were completed in the participants' general education classroom. Maintenance

phase probes were conducted in the participants' classrooms and also in the intervention classroom.

Independent Variables

TinyTap. The second author created and embedded a visual support representing two key sources of information for inferencing, which included considering background knowledge and text clues. The visual support was subsequently followed by another visual (i.e., photograph, cartoon, drawing) that prompted the participants to practice making inferences using the aforementioned key sources. Using an interactive sorting feature from TinyTap, participants were then prompted to sort six sources of information based on whether they were considered to be background knowledge or text clues. An iPad was utilized to present the created material on the TinyTap app for the participants.

Videos. An educational video was created and shown on a computer to instruct participants on how to make inferences from a visual. In the video treatment condition, participants were first provided with a visual support that was different from the TinyTap treatment condition. The visual included a definition of inferences and a process visual showing that background knowledge of participants and information gained or learned leads to making inferences. A visual was then shown in the video and participants were prompted to make an inference. Participants were then shown an example of background knowledge and text clues that would lead to an inference.

Graphic organizer. The graphic organizer treatment condition involved the usage of traditional instructional strategies. Participants were provided with verbal instructions and a paper graphic organizer prompting participants to identify background knowledge and text clues to make inferences. The graphic organizer included a series of three boxes. The first two columns were labeled as *background knowledge* and *text clues*, which were connected with a plus sign. The third box was labeled *inferences* and was connected with an equal sign.

Presentation of conditions. A single treatment condition was implemented within approximately 20 min. The presentation of treatment conditions occurred in a block rotation (i.e., ABC, BCA, CAB, ACB, BAC, CBA) using a random letter sequence generator on successive days, 5 days a week for 15 weeks. To minimize the effects of potentially confounding variables and the possibility of carryover and sequencing effects, the scheduling of treatment conditions was counterbalanced (i.e., each set of three-block rotations began with a different treatment condition).

The time in which the treatment was implemented rotated daily to avoid the participant missing the same subject area each day. Participants were typically pulled at the beginning of class so that the missed work was minimal and only included the warm-ups given daily in each class. A general education teacher, special education teacher, and/or paraprofessional provided targeted assistance to support the participant in understanding the concepts that were missed in class.

A distinctive discriminative stimulus was used to provide a signal immediately preceding each treatment condition. To provide a clear indication to the participant which treatment condition was in effect, the teacher stated, "We are going to use TinyTap," "We are going to use videos," and "We are going to use a graphic organizer." After each prompt was given, the treatment condition was presented to each participant. Given the single verbal prompt, participants were able to complete each condition with no additional directions provided.

Dependent Variable

A representative sample of equally leveled reading passages accompanied by four questions requiring inferential reading skills was developed. Participants read a different passage that was equivalent in difficulty for each of the baseline phase probes, each of the treatment conditions, and each of the maintenance phase probes. Another educator examined the reading passages and inferential reading probes to ensure that the passages were equally leveled according to Lexile reading levels and that the questions were equally difficult. Immediately following a treatment condition, participants were prompted to read a passage presented and to answer four multiple-choice questions presented on the other side of the printed passage.

During the probes, the participants were not provided with prompts, hints, or additional instruction by the special education teacher and were not allowed to refer to the implemented treatment condition. The probe was conducted in approximately 10 min and a timer was set and placed beside the participant. After 10 min, the probe was concluded.

Answer keys were created and listed the correct answers to the inferential reading questions for each reading passage. A response was counted as correct if the participant identified the correct multiple-choice response. Unanswered or unclear or partially answered items were scored as incorrect. The number of correct responses was divided by the total number of questions to calculate the participants' percentages of correct inferential reading questions for each session. The criterion for acquisition performance of each participant was correctly responding to the inferential reading questions with 100% accuracy for three consecutive sessions. The treatment condition to first achieve this criterion and demonstrate the greatest fractionation or differentiation compared with the other two treatment conditions was then replicated.

Experimental Design

An adapted alternating treatments design (ATD; Barlow & Hayes, 1979; Cooper et al., 1987; Ledford & Gast, 2018) was used to examine the differential effects of TinyTap, videos, and graphic organizers on each participant's inferential reading skills. Using this design, experimental control is demonstrated through fractionation between data points. Fractionation is a component of visual analysis for an ATD and examines the vertical separation between the data points for one intervention from the data points of the other interventions being compared (Alberto & Troutman, 2009). Greater fractionation indicates that the treatments are differently effective. Specific to this study, experimental control was established when participants demonstrated increased inferential reading skill performance with one of the three treatment conditions. Furthermore, experimental control may be inferred between the treatment conditions by counterbalancing and the discriminability of each treatment by participants through instructions. A functional relation may be further demonstrated if the effective intervention is replicated in isolation in a third phase.

Procedures

Baseline phase. The classroom educator conducted five baseline probes by prompting the participant to read a passage presented on paper and to answer four multiple-choice questions presented on the other side of the printed passage. The probe was conducted in approximately 10 min, with the probe discontinuing after 10 min of unresponsiveness. Additional correction, instruction, or reinforcement did not occur during this phase of the study.

Intervention phase. Following the baseline phase and prior to conducting the intervention phase, participants were trained on how to navigate and utilize the three targeted treatment conditions. Modeling was used to demonstrate to each of the participants how they would use TinyTap, videos, and graphic organizers to make inferences. The training took approximately 15 min for each treatment condition. No further detail was needed during the intervention phase after the original training. Subsequent intervention phase probes were conducted in approximately 20 min.

TinyTap. Once seated at a table or desk within the classroom, the educator stated to the participant, "We are going to use TinyTap." With the TinyTap app open to the inferential reading interactive lesson, the educator placed the iPad in front of the participant. The participant independently completed the interactive lesson, which included dragging and sorting background knowledge and text clues based on a visual presented. Once the participant had completed the interactive lesson, a probe was immediately implemented.

Videos. The educator began the treatment condition with the statement, "We are going to use videos." With the video already available on the screen, the participant independently viewed the video. The participant was permitted to view the video only once. Once the video was complete, a probe was immediately implemented.

Graphic organizer. The participant sat at a table or desk within the classroom. The educator stated to the participant, "We are going to use graphic organizers." The educator placed a worksheet in front of the participant. After the participant read and completed the worksheet, a probe was immediately implemented.

Off-task protocol. For all three treatment conditions, there was a consistent procedure to address off-task behaviors exhibited by participants. If the participant averted his eyes from the intervention or selected another app, program, or went to complete another task, the educator provided a verbal prompt to remind the participant to view the intervention. If the participant continued for an additional 3 s or if this occurred a second time, a gestural prompt was used, along with a verbal prompt to look at the intervention. After a third occasion or continuation of the behavior, the treatment condition was concluded and was implemented again the following day.

Maintenance. Two weeks following the replication phase, participants were probed for an additional seven times. The procedures for collecting maintenance data mirrored the procedures for the baseline phase.

Social Validity

At the conclusion of the study, participants were individually asked which treatment condition was preferable. Participants were also asked what aspects of the selected intervention were positive. The participants were also asked whether there were any additional comments about the interventions. All participants were able to verbally articulate the answer to these questions.

Reliability

Interobserver agreement (IOA). Another educator independently scored 40% of the inferential reading comprehension questions across all phases and all three treatment conditions for each of the participants. Mean IOA was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%.

Fidelity of implementation (FOI). All sessions for all participants were observed by a second educator for the purposes of collecting FOI data. The observing educator used a procedural

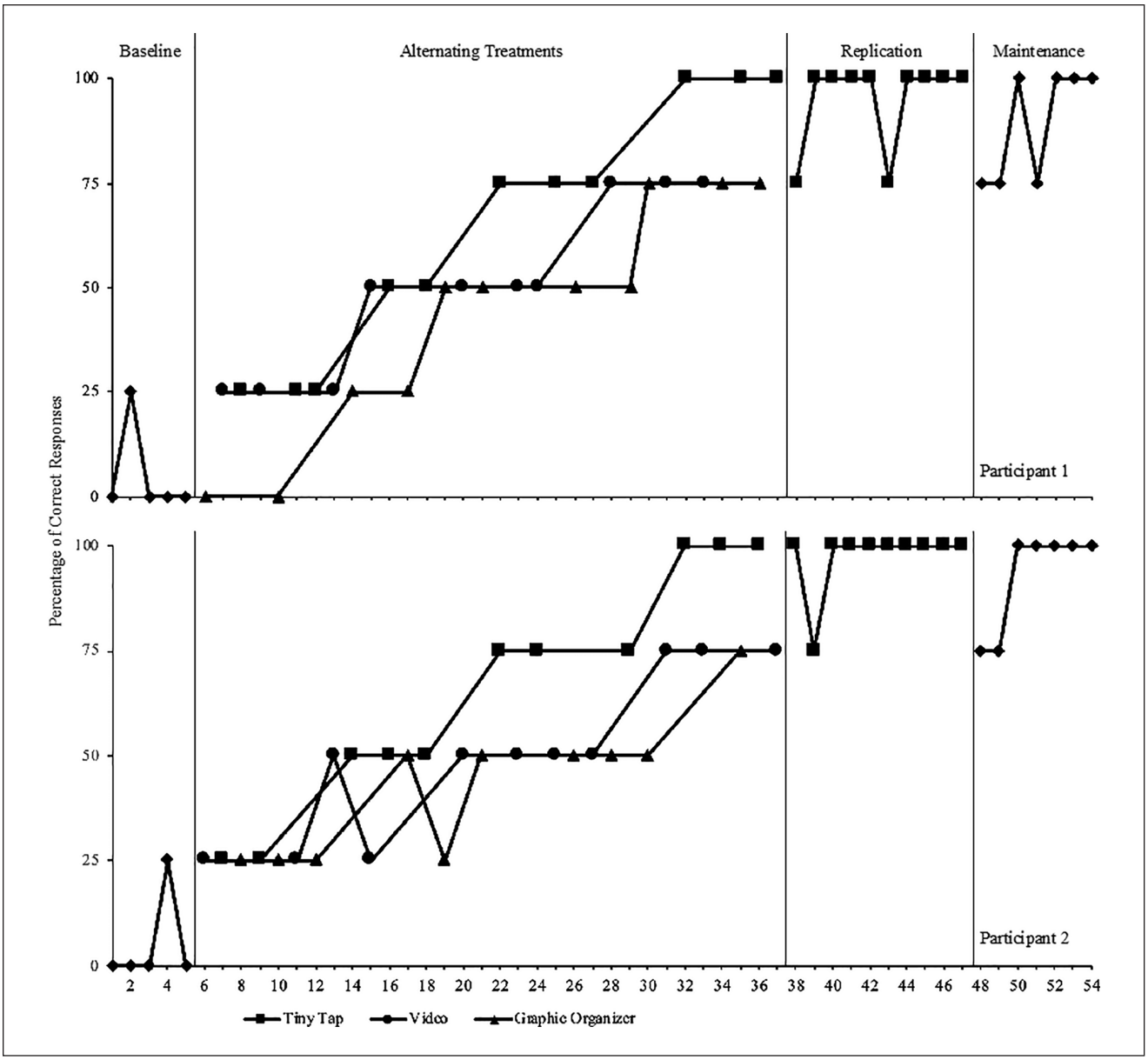

Figure 1. Performance data for all participants.

checklist while watching each session. FOI was calculated by totaling the number of steps completed, dividing by the total number of steps necessary, and multiplying it by 100%.

Results

Participant Results

The results of the study, including the data collected in the baseline, intervention, replication, and maintenance phases, are represented in Figure 1. The results indicate that the TinyTap treatment condition was the most effective in improving inferential reading skills for both Participants 1 and 2. With a visual analysis of the baseline phase, both participants were able to answer one of the four questions correctly in one instance. In all other baseline phase probes, participants were unable to answer any questions correctly.

Participant 1. The mean percentage of correct responses using the TinyTap treatment conditions was 63.64% after 11 probes (range = 25%–100%). The mean percentage of correct responses using the video treatment conditions was 50.00% after 10 probes (range = 25%–75%). The mean percentage of correct responses using the graphic organizer treatment conditions was 43.18% after 11 probes (range = 0%–75%). By visual inspection of the graph and when

compared with either or both of the other intervention conditions, clear fractionization of data for the TinyTap condition was indicated during all probes. Therefore, the use of TinyTap was determined to be more effective than the video and graphic organizer conditions. When replicated, the performance of Participant 1 with TinyTap improved to a mean of 95%. The mean number of inferential reading questions in the maintenance phase was 89.29%.

Participant 2. The mean percentage of correct responses using the TinyTap treatment conditions was 65.91% after 11 probes (range = 25%–100%). The mean percentage of correct responses using the video treatment conditions was 50.00% after 11 probes (range = 25%–75%). The mean percentage of correct responses using the graphic organizer treatment conditions was 42.50% after 10 probes (range = 25%–75%). Following a visual analysis of the graphed data and when compared with both of the other intervention conditions, there was limited differentiation between the three treatment conditions in the beginning of the intervention phase. However, clear fractionation of data for the TinyTap condition was indicated in seven of the probes. Therefore, the use of TinyTap was determined to be more effective than the video and graphic organizer conditions. When replicated, the performance of Participant 2 with TinyTap improved to a mean of 97.5%. The mean number of inferential reading questions in the maintenance phase was 92.86%.

Reliability

The average calculated interrater reliability was 100%. The average calculated FOI was 98% (range = 93.1%–100%) for the treatment sessions across all participants.

Social Validity

Participants were asked to indicate which treatment condition they preferred and to provide a rationale for their decision. Participant 1 stated that he preferred the TinyTap intervention. He liked how he could work independently and indicated that TinyTap was easier for him to comprehend. He also stated that he wished other teachers would do activities like these. Participant 2 indicated that he liked both the TinyTap and the video intervention condition. He enjoyed viewing the videos and found the TinyTap to be enjoyable. Participant 2 shared that he prefers to learn when there are visuals similar to the interventions explored and would like more of these interventions used in other classes.

Discussion

The purpose of the study was the examine the comparative effects of TinyTap, videos, and graphic organizers on the inferential reading skills of students with ASD. Using an ATD, the use of the TinyTap treatment condition was determined to be most functionally effective in increasing inferential reading skills. Moreover, results suggest that TinyTap was the more efficient intervention, as all participants reached the criterion for acquisition before the other comparison interventions. When TinyTap was used in isolation in the replication phase, participants' performance remained consistent and continued to reach the criterion for acquisition performance (e.g., 100% accuracy for three consecutive sessions). This indicates that there is a functional relationship between TinyTap and inferential reading skills (Alberto & Troutman, 2009). Individual differences did occur. The fractionation is more prominent for Participant 1, whereas Participant 2's performance with all three treatment conditions was more intertwined in the probes conducted in the beginning of the intervention phase.

These findings support the present research literature by empirically validating the use of TAII to improve academic skills for students with ASD and further extend the research by demonstrating the impact of TAII on inferential reading skills on the performance of students in middle school (Barton et al., 2017; Hedges & AFIRM Team, 2017; Knight et al., 2013; Odom, 2013).

Strengths and Limitations of the Research

The study aimed to compare three interventions to determine which one is most effective. During the intervention phase, the presentation of treatment conditions occurred in a block rotation. To minimize the effects of potential confounding variables, and the possibility of carryover and sequencing effects, the scheduling of treatment conditions was counterbalanced. Such procedures increase the validity of the results of the study.

However, limitations may affect the results and interpretation of the study. As there were only two participants enrolled in the study, it is difficult to determine whether these results are externally valid for other participants and academic contexts. The treatment conditions were implemented one to one and the implementation of the intervention and the same results may not be yielded in small- or large-group instruction. Furthermore, the use of ATD may be more consistent with an AB design, with limited experimental control and lack of a controlled set of instructions in the baseline phase. Ledford and Gast (2018) do state that the use of the baseline phase is optional but recommended and that the baseline does aid in presenting the participants' performance prior to the interventions and the need for intervention. Continuing the baseline along with the intervention conditions would further strengthen the study.

Implications for Research and Practice

Future research is necessary to replicate and verify the results of the study and to investigate the impact of these

treatment conditions with a larger sample of students with ASD.

Furthermore, additional research should examine whether the interventions can feasibly be implemented in small- and large-group instruction and yield the same positive results. Future research applying more experimental control to examine the impact of TAII on academic skills for students with ASD is needed, as well as research targeting students in middle-school and high-school education (Barton et al., 2017; Hedges & AFIRM Team, 2017; Knight et al., 2013; Odom, 2013).

The results of the study have positive implications for both students and practitioners.

Inferential reading skills are essential and are the foundation for reading comprehension. For practitioners, the development of appropriate instructional strategies and the integration of instructional technology for students with ASD is vital when considering and addressing the needs of middle-school students. In addition, student preferences may play a significant role when deciding which interventions to select. According to McNeish et al. (1992), students are more likely to be successful when engaging in preferred academic tasks. Therefore, completing a preference assessment may be important for educators when selecting interventions. Educators may use TinyTap or other instructional technologies and make modifications to the procedures to reflect the instructional needs, goals, and resources available. Other academic areas may also be considered when replicating or modifying the study.

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