Inclusive inquiry science using peer-mediated embedded instruction for students with moderate intellectual disability

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Abstract:

There has been limited research on the acquisition of grade-aligned science skills for students with moderate intellectual disability, with even more restriction on academic skills in inclusive settings. This study examined the effects of peer-mediated time-delay instruction to teach inquiry science and use of a knowledge chart to students with moderate intellectual disability in an inclusive setting. Six general education peers implemented an embedded constant time-delay procedure during three science units with 5 students with moderate intellectual disability. All 5 students increased the number of correct science responses across all science units. Three students required additional support by the special education teacher to reach mastery. In addition, all 6 peers were able to implement the intervention with high fidelity, while maintaining science grades at preintervention levels. High levels of social validity were reported.

Keywords: Special education | Science education | Intellectual disability | Instruction

Article:

Science education provides students with the opportunity to gain knowledge and wonder about the natural world. All students can benefit from learning information such as life cycles, the formation of the earth, and changing weather patterns. Another important rationale for teaching science to students with moderate/severe developmental disabilities is to provide access to the full educational opportunity. In one of the earliest articles on teaching science, Siegel-Causey, McMorris, McGowen, and Sands-Buss (1998) described how to include students with moderate/severe disabilities in general science classes in middle school. The authors discussed a four-step inclusion strategy incorporating planning, selecting classes, accommodating, and collaborating.

To date, there have been a limited number of studies on acquisition of science content for students with moderate/severe disabilities--and only a small subset of these targeted inclusive settings. In a comprehensive review of science content instruction for students with moderate/severe developmental disabilities, Spooner, Knight, Browder, Jimenez, and DiBiase (2011) found 17 studies; however, only 14 of these met criteria for evidence-based practice (Horner et al., 2005). Spooner et al.'s review provided support for using systematic instruction, such as task analysis and systematic prompting with feedback, to teach science content to students with severe disabilities. The challenge is that general science classes may not typically include systematic instructional strategies.

The National Science Education Standards (NSES; National Research Council, NRC, 1996) defines inquiry as "a set of interrelated processes by which scientists and students pose questions about the natural world and investigate phenomena; in doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models, and theories" (NRC, 1996, p. 214). Inquiry emphasizes an active process in which students are directed to make observations, pose questions, examine sources to see what they already know, plan investigations, use tools to gather data, propose predictions, and communicate results. According to the NSES, inquiry is a critical component of a science program, not just including hands-on activities but teaching a problem-solving process.

Distributed trial training has often been utilized to increase skill acquisition for students with moderate/severe developmental disabilities (Wolery, Anthony, Caldwell, Snyder, & Morgante, 2002). Different from massed trial training, distributed trial training can occur throughout a school day or lesson. When used in general education contexts the use of distributed trials is called embedded instruction (McDonnell, Johnson, & McQuivey, 2008). Numerous studies have examined the use of embedded instruction to teach specific skills to students with severe disabilities (Jameson, McDonnell, Johnson, Riesen, & Polychronis, 2007; McDonnell, Johnson, Polychronis, & Riesen, 2002; Wolery et al., 2002). For example, Johnson and McDonnell (2004) examined the effects of teacher-delivered embedded instruction in a general education elementary classroom on core content with three students with moderate intellectual disability. They found that embedded instruction was effective, and both general education teachers were able to implement the embedded instructional procedures with high fidelity.

In embedded instruction, students learn skills within the ongoing routine of a lesson or classroom setting. Typically, a teacher or paraprofessional presents material during natural opportunities. There is a growing research base in the area of using time delay to systematically present material to students through embedded instruction (Jameson et al., 2007; Johnson & McDonnell, 2004; Wolery, Anthony, Snyder, Werts, & Katzenmeyer, 1997). The use of time-delay procedures in the instruction of students with severe disabilities has been proven effective in the behavioral and academic arena of skills taught to this population (Browder, Ahlgrim-Delzell, Spooner, Mims, & Baker, 2009; Snell & Delano, 2011). Recent science research (Browder et al., 2010; Jimenez, Browder, & Courtade, 2009) has demonstrated the effectiveness of time delay on student academic outcomes.

Although embedding time-delay instruction in a general education class may be a powerful option for teaching science vocabulary and concepts, the need exists to determine if it can be combined with the inquiry learning typical of science. Several recent studies have demonstrated how to use directed inquiry with students with moderate/severe disabilities (Browder et al., 2010; Courtade, Browder, Spooner, & DiBiase, 2010; Jimenez et al., 2009). Jimenez et al. (2009) investigated the effect of self-directed learning to promote the generalization of science concepts across units of instruction. Using a constant time-delay procedure, students with moderate intellectual disability learned to self-direct the use of a knowledge chart (i.e., K = what do you Know?; W = What do you want to know; H = How will you find out?; L = what did you Learn; KWHL) across lessons and science units. Students increased the number of science questions answered correctly across lessons, as well as the self-directional use of the KWHL chart across lessons and units. Such findings suggest that students with moderate intellectual disability can learn an inquiry process; however, it is unclear whether students could acquire skills from the onset in the general science setting.

Embedded instruction might be an option to promote inclusive learning if the target skills include not only vocabulary but also inquiry responses (e.g., use of KWHL chart). One potential challenge in embedding this instruction is the amount of trials needed to ensure student progress (Wolery et al., 2002). Most of the research on constant time delay and embedded instruction has involved acquisition of two or more behaviors with at least five trials per behavior per lesson. If a general education teacher is required to embed this number of trials during science instruction, it could hinder promoting the student interaction and hands-on learning typical of an inquiry context. An alternative is to use peers to embed trials during science lessons while the general science teacher orchestrates the overall inquiry process. There is evidence to suggest that systematic instruction delivered by peers can be effective in teaching academic skills to students with moderate intellectual disability (McDonnell, Mathot-Buckher, Thorson, & Fister, 2001; Miracle, Collins, Schuster, & Grisham-Brown, 2001).

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The purpose of the current study was to examine the effects of peer-mediated embedded instruction using time delay on the number of correct science responses by target students with intellectual disability, and those students' use of a KWHL chart during inclusive inquiry science lessons. In addition, we examined the effect of the intervention on student social attitudes and the grade averages of the general education peers.

METHOD

PARTICIPANTS

After obtaining university and local school system Institutional Review Board approval, we selected participants using the following procedures.

Peer Tutors. We recruited six general education students to participate as peer tutors. One peer served as a substitute during the intervention, if another peer was absent from class. Students who participated in the study met the following inclusion criteria: (a) middle school student enrolled in a general education science course, (b) nomination by science teacher, (c) passing science course, (d) consistent attendance, (e) agreed to be trained and to work as a science peer during science lessons, and (f) met fidelity criteria in training. No prior experience as a peer mentor was expected of general education students, although experience was noted.

All six peers were 11 years old, in sixth grade, and were members of the same general education science class; five were female and one male. Although three of the six students had prior experience as a peer mentor (i.e., after-school program, summer camp, physical education in elementary school), none had experience as a peer mentor in an academic classroom.

Students With Disabilities. We recruited five students who received special education services to participate in this investigation. Students who participated in the study met the following inclusion criteria: (a) identified as having a moderate/severe intellectual disability (IQ 55 or below), (b) clear response mode (e.g., point to pictures), (c) able to identify 20 or more picture symbols, (d) able to identify 10 or more sight words, (e) enrolled in a middle grade (6-8), and (f) consistent attendance (absent fewer than two times per month). The special education teacher nominated the students based on these criteria. We verified the student characteristics by reviewing school cumulative records. Table 1 lists relevant characteristics of the students with moderate intellectual disability included in this study.

Teachers. One general education science teacher participated in the study. We selected the teacher based on the following inclusion criteria: (a) middle school science teacher, (b) uses inquiry to teach science lessons and is willing to commit to using inquiry two to three times per week, (c) uses cooperative base groups, and (d) willing to help facilitate inclusive education with five students with moderate intellectual disability.

One special education teacher also participated in the study. We selected the teacher based on the following inclusion criteria: (a) middle school teacher serving students with moderate intellectual disability, and (b) willing and able to provide massed trials of science vocabulary training to students after inclusive lessons as needed.

Table 1. Characteristics of Students

Student	Age	Gender	Grade	IQ	Disability	Response Mode
Mary	14	Female	7	40 (WISC IV)	ID Mod	Verbal
Jade	11	Female	7	34 (DAS)	ID Mod	Verbal
Devin	13	Male	7	55 (UNIT)	ID Mod	Verbal

Derek	11	Male	6	53 (Stanford-Binet)	ID Mod	Verbal
Brett	11	Male	6	49 (DAS)	ID Mod	Verbal

Note. WISC IV =Wechsler Intelligence Test for Children, Fourth Edition; DAS = Differential Abilities Scale; UNIT = Universal Nonverbal Intelligence Test; Stanford-Binet = Stanford-Binet Intelligence Scales; ID Mod = moderate intellectual disability.

SETTING

The teachers and students were drawn from a middle school in a large, urban school district in the Southeast United States. We recruited the participants from one classroom which served students with moderate to severe intellectual disability. Although the students received ongoing science instruction in their special education class, this study was their first experience with learning new science content daily in a general education science class.

This investigation took place in a general education science classroom setting. The student/teacher ratio in the general education science classroom was 26:1. The science teacher had 6 years experience teaching secondary science; the year of this study was her first year teaching science within the school district, and also the first year she had used the district's prescribed science curriculum. The teacher's procedure for teaching inquiry science, which received a rating of 4 on a 5-point scale ("above average example of inquiry") by a science content expert, was:

1. Students and teacher read a passage from their textbook.

2. Teacher introduces the lesson for the day, asking what students know about a given topic (using the KWHL chart). Students respond verbally. Teacher prompts students' thinking to generate more ideas.

3. Teacher asks class what they would like to know about the topic, using the KWHL chart. Students respond verbally. Teacher prompts students' thinking to generate more ideas.

4. Teacher asks class how they might find out more information using the KWHL chart. Students respond verbally; teacher prompts students' thinking to generate more ideas.

5. Cooperative learning groups of four to five students either participate in experiment or activity online (cyber-experiment using an interactive whiteboard) or investigate using hands-on materials.

6. Students report their answers by completing a worksheet, filling in data on a chart, or verbally telling the teacher what they saw. Teacher prompts students' thinking to generate more results or deeper understanding of what they experienced.

7. Teacher asks students what they learned from the experience (usually, students repeat what they wrote on their worksheet).

8. Teacher directs thinking to the topic that will be covered in the next class session.

The classroom was set up with six large rectangular tables, and groups of four to five students sat around each. Four to five students without disabilities and one student with a disability sat at five of the six tables (cooperative base groups).

To train the general education students on the peer-mediated instructional method, we held a 1-hr training workshop in a small room within the school media center. We assessed students during baseline and probe sessions within the general education classroom for acquisition of the KWHL chart. We also conducted assessments of science vocabulary and concept statement acquisition for baseline and probe sessions at a small table within the special education classroom, with additional in vivo probes within the general education classroom.

MATERIALS

KWHL Chart. We used a KWHL chart to train and assess students' self-monitoring of the inquiry process during the science lesson. Each student with disabilities received a new KWHL chart for each lesson, and the science teacher used a poster-size copy of the chart on the whiteboard for the entire general science class.

Vocabulary. For the students with disabilities, the first author typed the science vocabulary words using a word processor, printed and glued the words onto a 3x5 index card, then laminated them for durability. Similarly, the first author created science picture symbols (e.g., a rollercoaster moving down a track to symbolize kinetic energy) using the Internet and computer software. She printed the symbols and placed them on index cards, then laminated for durability. For generalization, the first author created three science picture symbols for each vocabulary word (e.g., kinetic energy: rollercoaster, runner, motorcycle). A response board with Velcro allowed peers to change the order of the vocabulary cards during instructional trials.

Concept Statements. Using picture-symbol computer software, the first author placed concept statements (e.g., kinetic energy is the energy of motion) on card stock paper and laminated them for durability. She also placed a small piece of Velcro on the empty space in the statement to allow students to place the vocabulary word that completed the statement.

DEPENDENT VARIABLES

Student Science Responses. We conducted student assessment probes after each inquiry science lesson (two-three times per week) implemented in the inclusive science classroom with a general education peer, measuring each student's performance by the number of independent correct responses. Student responses included two science words, two science pictures, two science word/picture matches (i.e., technology, energy, kinetic energy, potential energy, continents, tectonic plates), and two concept statements per unit. Science responses were drawn from the unit of instruction being taught in the general education science classroom, using the state's sixth-grade science text. A university-level science content expert validated that each vocabulary word and concept statement were valid content aligned to the unit of instruction being taught.

The lead author and two research graduate students served as data collectors. We showed each student three flash cards with either the science vocabulary word or picture and asked them to "find [kinetic energy]." To establish a generalization measure of the science vocabulary picture symbols, we rotated the pictures symbols used for each vocabulary word (e.g., kinetic energy/Picture 1, kinetic energy/Picture 2, kinetic energy/Picture 3). To assess the science vocabulary word/picture match, we showed students three pictures and asked them to match the word to the picture. We also rotated the three picture symbols used for the vocabulary term for this portion of the assessment as well. To assess the concept statement, we showed the student the concept statement with a word missing. When presented with three vocabulary words, the student needed to place the missing vocabulary word (e.g., "Can you find the word that completes this statement? -- is the energy of motion."). The data collector waited 5 s for the student to respond to each question then coded each response as either independent correct or incorrect/no response.

We took an in vivo probe for each student at least once during each unit of instruction, consisting of the first peer-delivered trial for each science response (i.e., Word 1, Word 2, Picture 1, Picture 2, Picture/Word Match 1, Picture/Word Math, Concept Statement 1, Concept Statement 2). We recorded data as independent correct or incorrect/no response.

KWHL Chart Responses. We also examined the use of a KWHL chart to self-monitor science behaviors during an inquiry lesson. Although we measured this dependent variable during baseline, during intervention the KWHL responses were measured in vivo by general education peers on number of KWHL steps initiated independently during an inquiry science lesson. The peers recorded each step of the KWHL process during daily instruction as an independent correct or incorrect response, and then peers tallied the sum (e.g., 3/4 steps completed).

Student Attitudes. We measured students' attitudes prior to and after being involved in a peer-mediated learning experience using a one-page survey with six questions (rated on a five-point Likert scale). The validity of the instrument was evaluated by a special education expert with experience in using peer supports with students with disabilities.

The general education peers took this survey at the beginning of the peer training workshops. We gave the same assessment to the students with moderate intellectual disability, modifying it as needed to meet student communication needs (i.e., read aloud: student pointed to answer). We also asked all students to complete the same assessment postintervention.

In addition to the student/peer attitude survey, after the intervention was complete, the general education peers participated in a 25-min focus group. We asked reflection questions (adapted from Carter, Cushing, & Kennedy, 2009) regarding their perception of the intervention, working with a student with a disability, and science inclusion. We recorded and reported responses as anecdotal notes to accompany the student/peer attitude survey. Responses also served as a student social validity measure. Anecdotal notes for each question were reviewed by a second observer for consensus.

Finally, we measured the general education students' science grade averages prior to and after being involved in this peer-mediated learning experience by collecting a pre/post science grade average. The general education teacher provided the last five grades in science, based on a 100-point scale; we added each grade together and divided by 5 to gain an average science grade.

Teacher Feasibility. Following the intervention, both the general education and special education teachers involved in the study completed a six-question survey regarding their likelihood in continuing this intervention in the future, willingness to share the strategies with co-workers, and overall perceptions of the intervention. There was room at the bottom of the survey for additional comments.

EXPERIMENTAL DESIGN AND ANALYSIS

We used a single-subject design to demonstrate a functional relationship between peer-mediated embedded instruction and the primary dependent variable (i.e., student acquisition of science responses). Specifically, the design was a multiple probe across three science units with between participant replications for the five students who receive the peer-mediated embedded instruction (Gast, 2010; Horner& Baer, 1978). During baseline, the three units' science responses were probed for each student at a minimum of three sessions or until data were consistent for three sessions. Following baseline, instruction began on Unit 1 for all five students. Students received embedded instruction by peers for a minimum of six inquiry lessons. Prior to a student moving from Unit 1 to Unit 2 responses, the student had to show mastery of two out of eight science responses for two consecutive sessions. Once a student was ready to move to Unit 2, the student was probed on Unit 2 and Unit 3 responses. After a minimum of six lessons had been taught in Unit 2, and a minimum of two unit science responses mastered, Unit 3 was probed. Unit 3 tasks were then taught for a minimum of six lessons. The special education teacher taught unlearned science responses from previous units during booster training sessions in the special education classroom after inquiry lessons, using three massed trial sessions per science response. Booster sessions continued until mastery of that unit's science responses. Mastery of science responses was demonstrated after two consecutive assessment sessions where students correctly identified six out of eight responses. Maintenance probes of previous unit tasks were conducted every three sessions, allowing students to demonstrate mastery of previously unlearned tasks, as well as show maintenance of learned tasks.

Additionally, we evaluated the target students' generalization of the KWHL chart across lessons and units of science instruction. The KWHL responses were graphed separately from the other responses as these may generalize across all six lessons, and across all three units early in instruction.

PROCEDURE

General Education Peer Training Workshop. Using guidelines from Carter and Kennedy (2006), this study included four core components of peer support interventions: (a) select students, (b) train peers, (c) implement peer-delivered support, and (d) provide adult monitoring. After baseline and before intervention, during one 1-hr workshop, we trained peers to (a) embed a minimum of three learning trials per each science response (two science words, two science pictures, two word/picture matches, two concept statements) using constant time delay, and (b) embed trials to self-monitor science behaviors using a KWHL chart. The training was delivered using a PowerPoint presentation with slides embedded to allow for questions, answers, examples, and guided practice. During the training peers practiced the constant time-delay procedure using sample materials used during the intervention. Peers used a checklist to self-monitor trials given to students, checking off each trial as they embedded it during the lesson. We assessed peers' procedural fidelity during the training on implementation of the time-delay procedure and use of the self-monitoring checklist. Our target for the time-delay procedure was 85% accuracy; five of the six peers met 100% fidelity after three trials, with one peer at 88%. Because this peer's fidelity was the lowest, he served as a substitute peer if another peer was absent or dropped out of the study.

Baseline and Ongoing Probes. During baseline, the lead author served as the primary data collector. Interobserver agreement (IOA) was taken on one of the three baseline sessions by one graduate assistant. Students were individually assessed on all science responses for each of the three units of instruction during each baseline probe (six vocabulary words, six vocabulary picture symbols, six vocabulary word/picture matches, six concept statements). We collected baseline data at least once on all three of the vocabulary picture symbols for each science term. All baseline probes followed the same procedures described in the Student Science Responses section. We provided no feedback to students during baseline probes, and graphed and visually inspected data after each session. Once students entered intervention, we followed this same procedure to conduct ongoing probes of student performance.

We established a baseline of student's ability to use a KWHL chart within the inclusive science classroom over three sessions prior to intervention (during Unit 1) or until consistent data were collected. We placed the KWHL chart in front of each student on the table, and directed them to use the KWHL chart during the inquiry lesson. We collected baseline data for all three sessions and followed this same procedure for ongoing probes during intervention.

General education peers took the student/ peer attitude survey during the peer training session, and students with moderate intellectual disability took the same assessment (with modifications) prior to intervention. We asked all students to complete the same assessment postintervention.

Additionally, after the intervention, peers participated in a 25-min focus group where we asked them questions regarding student perception of the intervention, working with a student with a disability, and science inclusion. Finally, we collected a measure of students' science grade averages, by asking the general education teacher for the last five grades prior to the intervention and postintervention.

Intervention. When the student response and KWHL baseline was found to be stable for all five students, peer-mediated embedded inquiry teaching sessions began. The intervention included (a) peer-mediated science response training using time delay embedded within an inclusive inquiry science lesson, and (b) peer-mediated embedded instruction on the use of a KWHL chart within an inclusive science lesson.

The intervention began in the general education science classroom. The general education teacher provided inquiry science instruction to the entire class of students. Prior to baseline, the general education teacher and special education teacher met with the lead author during a planning session (i.e., time selected by teacher) for a 20-min consultation of what the science teacher was expected to do. After this brief training, the general education teacher conducted science lessons as usual, ensuring that the lesson included an opportunity for students to use the KWHL chart. The teacher was prepared to prompt students, by pointing to the chart and directing the class's attention to its components (e.g., "Let's see what we know about the material," pointing to the K). Although the teacher typically followed this pattern for her class, we asked her to do so with daily consistency, including pointing to the chart to be sure students had dear KWHL learning trials.

Peers embedded the constant time-delay procedure to teach the use of the KWHL chart as the general science teacher led the class to fill in their charts. Using a zero-second delay, peers pointed to a section of the chart when the science teacher gave the direction to the full class (e.g., "What did you learn? Find your L column"), and asked the student with disabilities to do the same. After 2 days with no delay in prompting, peers delayed their prompt to 5 s, allowing students to self-monitor use of the KWHL chart with natural classroom prompts. If the student did not point to the section of the chart after 5 s, the peer modeled pointing to the appropriate section and reminded the student to ask for help if they did not know what to do.

Students were placed into learning groups of four to five students, with each group including one student with moderate intellectual disability and one trained peer. Within the natural context of the inquiry science lesson, peers embedded the designated number of teaching trials using a constant time-delay procedure for the science vocabulary and concept statements related to the lesson. For the first 2 days, the general education peers embedded three learning trials of each science response (e.g., "What word completes this concept statement: -- is the energy of motion? Kinetic energy is the energy of motion.") at a zero-second delay. On subsequent days, the general education peer embedded three learning trials of each science response at a 4-s delay, using the appropriate error correction procedures. Additionally, the general education peers embedded teaching trials using the same time delay procedure (zero delay for 2 days, then 4-s delay for subsequent days) on the use of the KWHL to self-monitor science behaviors. The general education peers self-monitored embedding teaching trials by using a checklist, which eliminated the chance of them forgetting to embed the teaching trial or waiting until the end of the lesson to embed all teaching trials (mass-trial training). The lead author observed all teaching trials and provided additional support to peer mentors as needed (e.g., additional training trials on time-delay procedure, behavioral support).

We collected a generalization measure throughout the intervention, providing peers with one of three picture symbols for each vocabulary word to present to the target students during each teaching session. The lead author recorded which picture symbol was used during all testing probes to demonstrate generalization of the science vocabulary across picture symbols.

Additional Support. If the pace of learning was not sufficient for students to keep pace with the changing content of the general science class, students were provided additional trials to learn the science vocabulary and concept statements by the special education teacher in their special education classroom. The special education teacher followed the exact same time-delay procedure as the peers, except using a massed trial format, until the student met the mastery criteria.

RESULTS

PROCEDURAL FIDELITY AND RELIABILITY

The first author used a detailed checklist to collect procedural fidelity of peer-implementation of the embedded time-delay procedure during inquiry science lessons. The checklist included the 28 steps for using time delay for the KWHL chart, vocabulary, and concept statements formed. Procedural fidelity was taken on an average of 29% of sessions across all peers. Fidelity scores ranged from 79% to 100%, with a mean score of 96.3%. IOA for this peer procedural fidelity (taken three times) was 100%. Additionally, second observers (doctoral-level graduate assistants) evaluated 48% of all baseline data collected and 64% of all ongoing probes collected. IOA was 100% for all baseline and ongoing probes observed.

STUDENT ACHIEVEMENT

All of the target students increased their number of independent correct responses for the eight science vocabulary words, pictures, word/picture match, and concept statements from baseline to intervention, across all units:

* Mary. Unit 1: Technology and Energy, baseline, M = 2, range 1-4; intervention, M = 5.8, range 3-8. Unit 2: Kinetic and Potential Energy, baseline, M = 1.8, range 1-3; intervention, M = 5.5, range 2-7. Unit 3: Continents and Tectonic Plates, baseline, M = 3.2, range 2-5; intervention, M = 5.75, range 4-8 (see Figure 1).

* Jade. Unit 1: Technology and Energy, baseline, M = 2, range 2-3; intervention, M = 7.8, range 7-8. Unit 2: Kinetic and Potential Energy, baseline, M = 1.75, range 1-2; intervention, M = 6, range 3-8. Unit 3: Continents and Tectonic Plates, baseline, M = 2; intervention, M = 6.5, range 5-8 (see Figure 2).

* Devin. Unit 1: Technology and Energy, baseline, M = 2.7, range 2-4; intervention, M = 7.7, range 6-8. Unit 2: Kinetic and Potential Energy, baseline, M = 3.5, range 3-4; intervention, M = 7.5, range 7-8. Unit 3: Continents and Tectonic Plates, baseline, M = 5, range 3-7; intervention, M = 7.3, range 6-8 (see Figure 3).

* Derek. Unit 1: Technology and Energy, baseline, M = 4.8, range 2-6; intervention, M = 8. Unit 2: Kinetic and Potential Energy, baseline, M = 3.6, range 3-6; intervention, M = 8. Unit 3: Continents and Tectonic Plates, baseline, M = 3.5, range 3-5; intervention, M = 8 (see Figure 4).

* Brett. Unit 1: Technology and Energy, baseline, M = 1.7, range 1-2; intervention, M = 6.9, range 5-8. Unit 2: Kinetic and Potential Energy, baseline, M = 1, range 0-3; intervention, M = 4.8, range 2-8. Unit 3: Continents and Tectonic Plates, baseline, M = 3.2, range 3-4; intervention, M = 5.3, range 4-6 (see Figure 5).

Figure 1. Mary's Number of Correct Science Responses Across Units 1–3

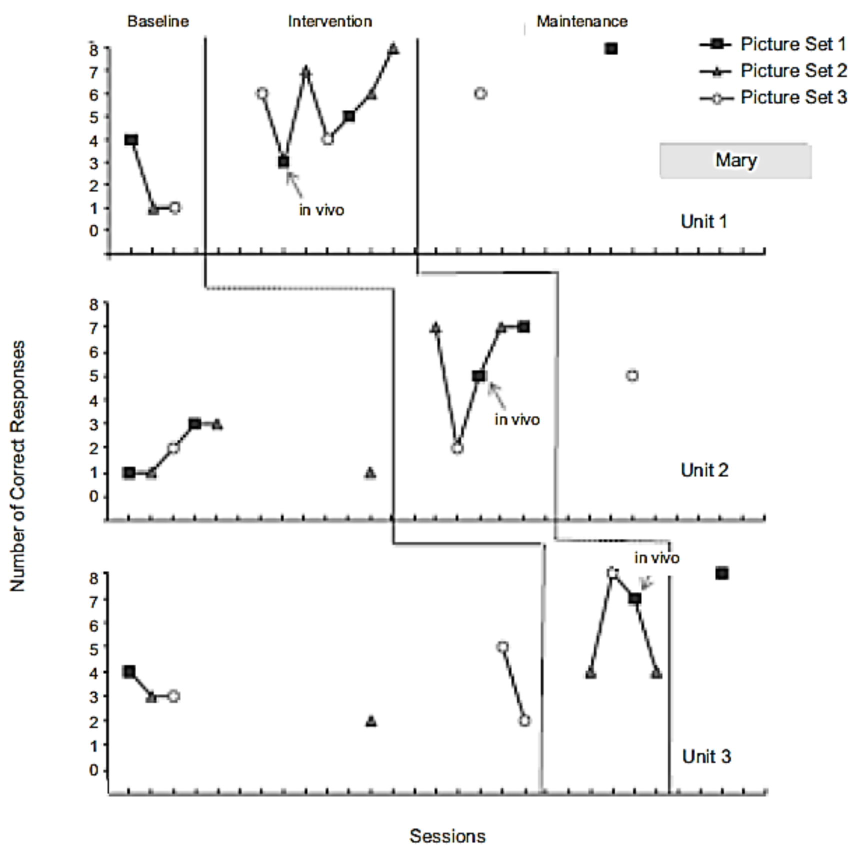


Figure 2. Jade's Number of Correct Science Responses Across Units 1–3

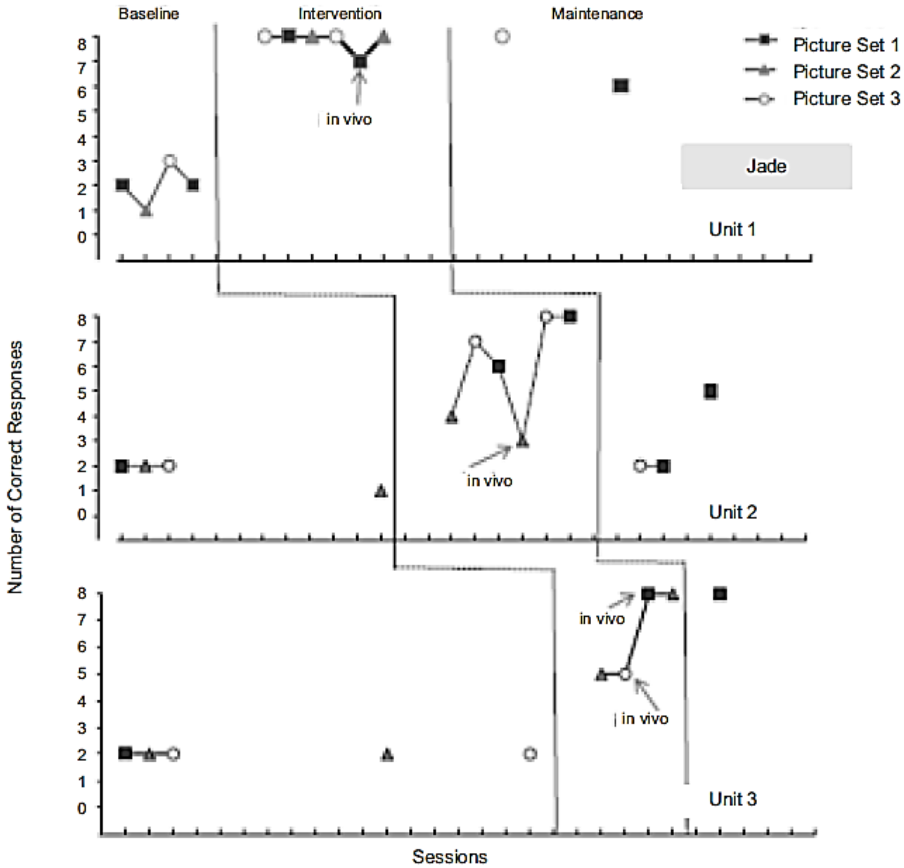


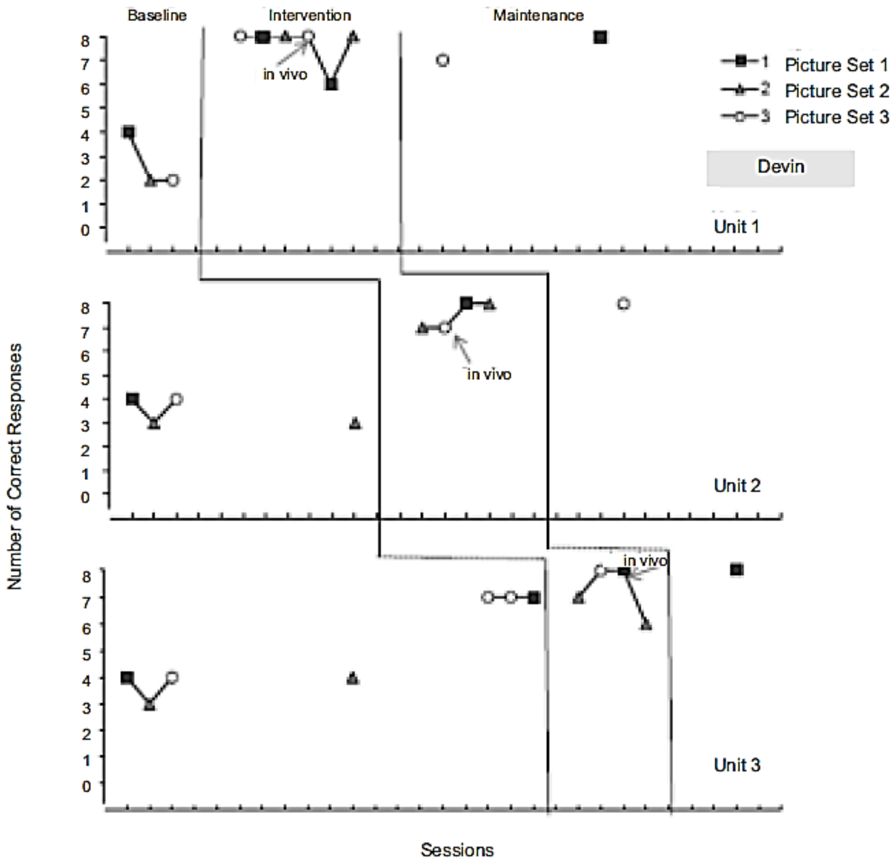
Figure 6 indicates the mean number of correct responses students had on the KWHL chart in baseline and intervention. All students had higher mean responses in intervention.

SOCIAL VALIDITY

Students and peers responded to a survey regarding their attitudes toward peer-mediated instruction, pre- and postintervention. The survey contained six questions and used a five-point Likert scale (i.e., SA = strongly agree, A = agree, N= not sure, D = disagree, SD = strongly disagree). In order to determine a numerical range, we assigned values to each of the points (i.e., 5 = strongly agree, 1 = strongly disagree). There was an increase in mean scores of general education peer surveys from preintervention (M = 3.2) to postintervention (M = 4.6), as well as an increase in the mean scores of the students with moderate intellectual disability (M = 3.5 to M = 4.7, respectively).

Following the intervention, the six general education peers participated in a 25-min focus group. We transcribed student responses and a second observer collected IOA on the number of comments made, recorded, and accuracy of transcription; IOA was reported at 100%. Students indicated that they wanted to continue to use peer-mediated instruction strategies with other students with disabilities, across context and content. Peers enjoyed the process and felt that they benefited both socially and academically from the experience.

Figure 3. Devin's Number of Correct Science Responses Across Units 1–3



Following the intervention, the general education and special education teachers involved in the study completed a feasibility survey. This survey also contained six questions and Likert scale response (i.e., 5 = strongly agree, 1 = strongly disagree). There was space for additional comments at the bottom of the survey. Both teachers agreed that the intervention was socially important, successful, and feasible.

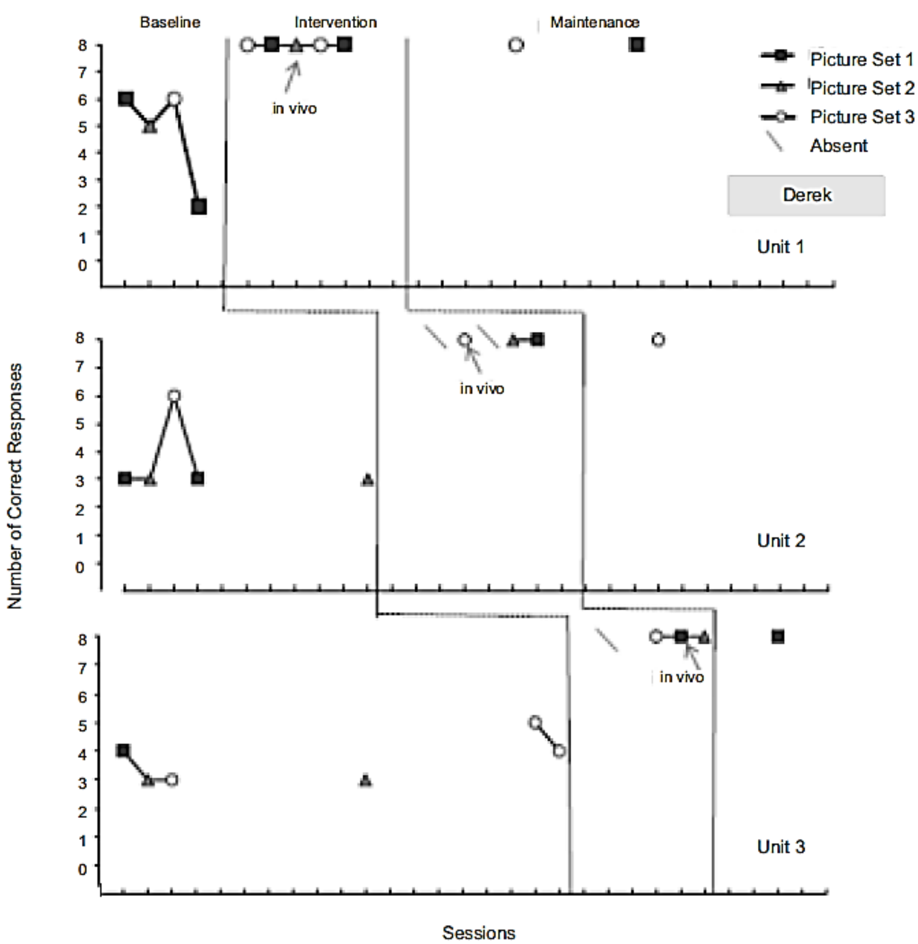
Finally, all six peers' science grade average remained steady based on their science grade average prior to the beginning of the study (M= 81%), and their grade average postintervention (M = 84.7%). Two of the general education peers demonstrated higher science letter-grade averages (i.e., pre 72% to post 82%, pre 79% to post 86%) after intervention.

DISCUSSION

In this study there was an overall functional relationship between the peer-mediated embedded time-delay instruction and the number of correct student science responses. Data from all five students indicated that the intervention had a positive effect on students' science vocabulary and concept knowledge.

One important component of the intervention was the embedded time-delay procedure. McDonnell et al. (2002) taught paraeducators to embed time-delay trials for four students with moderate disabilities to read and define academic sight words within the context of an inclusive setting. In the current study, general education peers rather than paraeducators learned to embed trials for students with moderate intellectual disability to identify science sight words, picture symbols, match words to picture symbols, and concept statements. McDonnell et al. found that paraeducators were able to embed trials using systematic instruction at a high-fidelity level, leading to the acquisition of sight words and definitions by all four students. Similarly in this study, peers were able to effectively embed trials using systematic instruction (i.e., time-delay) within an inclusive classroom, leading to the acquisition of science vocabulary and concept statements for all five target students.

Figure 4. Derek's Number of Correct Science Responses Across Units 1-3



Other researchers have trained peers to use time delay or had peers provide instructional support, more general than time delay, within inclusive classrooms. For example, Carter, Sisco, Melekoglu, and Kurkowski (2007) examined the effectiveness of peer support interventions (e.g., verbal prompts, inviting students to participate in small-group activities, positive feedback) to improve social and academic outcomes for high school students with moderate disability in core academic classrooms. Carter et al. considered students to be academically engaged when they were actively involved in or attending to the materials being used during the lesson (e.g., asking questions, attending to teacher, looking at class-related materials). This study extends the literature by showing peers can teach specific academic content in inclusive settings.

Figure 5. Brett's Number of Correct Science Responses Across Units 1–3

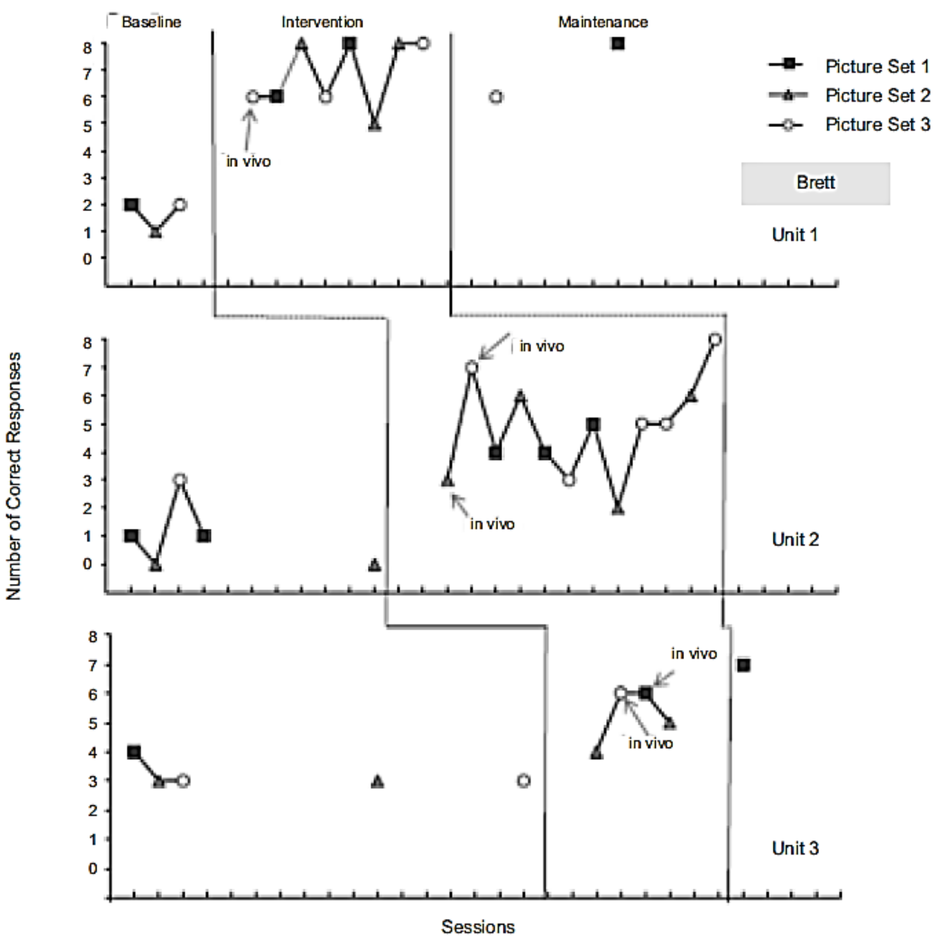
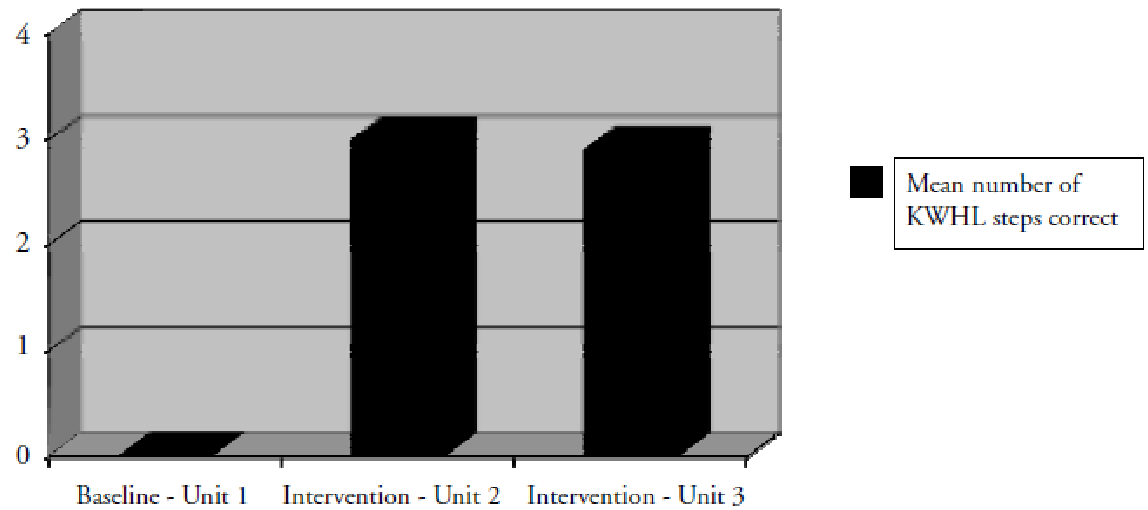


Figure 6. Mean Number of Independent Correct Responses on Use of KWHL Chart During Baseline and Intervention for All Students



One other study also has shown that peers can embed constant time-delay trials in inclusive classrooms. Jameson, McDonnell, Polychronis, and Riesen (2008) trained general education peers to use embedded constant time delay within a general education classroom (i.e., health, arts and crafts class). Students with moderate/severe intellectual disability learned content-specific vocabulary (e.g., lungs, stomach; kiln, glaze). The study (Jameson et al., 2008) demonstrated that peer tutors could be trained to implement embedded instruction using a time-delay procedure with high levels of procedural fidelity, resulting in skill mastery for all three students with disabilities. This study extends the work of Jameson et al. by showing peers can teach additional grade-level aligned content in core subject areas (i.e., science), resulting in student skill mastery across science units.

This study not only adds to the prior literature on using embedded instruction; it also provides a unique demonstration that this instruction can complement an inquiry-focused science lesson. The students with disabilities were able to participate fully in the hands-on science activities while learning the science vocabulary and concepts and keeping pace with the general class format of using a KWHL chart. Student outcome data indicate a positive relationship between the peer-mediated embedded time-delay instruction and the number of correct student responses. Because the embedded instruction of the KWHL responses only had AB phases, no causal inference can be made that this learning was due to the peer intervention. In future replications, introducing one student at a time to the peer support for the KWHL responding (e.g., multiple probe across participants design) might strengthen the demonstration of the embedded KWHL instruction.

LIMITATIONS

Several limitations must be considered when analyzing results related to the current study. First, the small number of participants limits the generality of the findings of the study. When considered with the overall literature on peer-mediated instruction or embedded instruction, the current study adds to the overall evidence on using both of these strategies to teach science to students with moderate and severe intellectual disability. There is currently only one other study on the use of peer-mediated embedded instruction conducted in inclusive education with students with severe disabilities (Jameson et al., 2008).

A second limitation of the study is the format used for measuring comprehension of science terms and concept statements. During assessment sessions, students were asked to identify the answer (e.g., What picture shows kinetic energy?) from an array of three responses. For each question asked, the field of responses included one correct response and two incorrect responses (distracter options). Students had a 33% chance of selecting a correct response at random. One possible solution to this limitation would be to increase the number of response options to four, reducing the likelihood of students selecting the correct response by chance to 25%. Some students may be able to generate a verbal response by defining the term or stating the concept statement.

A third limitation of the study is that the embedded instruction was not used alone, but combined with special education teacher instruction for three of the five students to keep pace with the changing content of the general science class. When interpreting results, it is important to note that although some students may benefit from peer-mediated embedded systematic instruction alone, others may require supplemental intensive 1:1 support from a special education teacher or some other form of additional support (e.g., computer-delivered practice trials) to meet mastery criteria. One reason that this supplemental special instruction may have been needed was the amount of content targeted for student learning and the pace of this specific class. For each topic, the students with disabilities needed to learn two vocabulary words, pictures and concepts, along with learning to use the KWHL chart, in 6 or fewer days before the content changed. If this had been a co-taught class or other well-established inclusive context, it may have been feasible for the special education teacher, the peer, or a paraeducator to supplement the peers' embedded instruction with some 1:1 massed trial instruction in the general science class during other class times (e.g., while other students wrote out answers to questions in the text). Also, we did not take fidelity on the general science teacher's adherence to the inquiry format nor provide overall input on how the teacher conducted these lessons. Although the teacher did provide the key opportunities needed for the students to use their KWHL chart, it may be that joint planning for each lesson could create more opportunities for students to learn the science concepts in this context.

A final limitation of the study was Devin's growth during baseline probes for Unit 3. It was indeterminable how he acquired the new Unit 3 vocabulary prior to the intervention. Devin had not received instruction on this content within his special education class, nor the general education classroom, prior to the intervention and he could not communicate how he mastered the content. As mentioned, it was possible to select the correct answers due to a 33% chance, but unlikely to be shown consistently because the baseline probe sessions were repeated over days and picture symbols (generalization). Possibly, Devin's experiences in Unit 1 and 2 provided him with an interest in science and some strategies to glean information from other external sources (e.g., television or Internet).

SUGGESTIONS FOR FUTURE RESEARCH

In this study, general education peers were able to implement with high fidelity embedded time-delay instruction with students with severe intellectual disability. In addition, the outcomes suggest that students with severe disabilities were able to acquire new science content across units of instruction that directly aligned with the general education curriculum. In order for this method of instruction to become an evidence-based practice (per Homer et al., 2005), further research using the same intervention must be conducted. The intervention should be replicated at least three more times, with at least one more different researcher in one or more locations. It also is important that the intervention be studied with different aged students in order to determine if the intervention can be used with different school-aged populations. Future research is needed to determine if the embedded instruction could be modified to be effective in helping keep pace with the rapidly changing content without supplemental massed trial instruction. Further, this study was conducted in an inclusive science classroom. In order to make the results of the intervention stronger, future research should investigate the effects of peer-mediated embedded instruction in other core content areas (e.g., math, social studies).

Another recommendation is to expand the overall research in academics for this population, especially in inclusive settings. There is limited research in the areas of reading, mathematics, and science for students with severe developmental disabilities, although that research base is growing (e.g., Browder et al., 2010; Spooner et al., 2011). This growing research demonstrates how to create meaningful extensions to the general curriculum and how to teach this academic content. Replication in inclusive settings is needed in all academic areas to demonstrate how to use these methods in the typical milieu of a general classroom. As this study demonstrates, these inclusive applications raise new issues such as keeping pace with rapidly changing content and finding ways to embed the systematic instruction trials. A third recommendation is to continue research in the area of inquiry science for students with severe disabilities. The NRC (1996) has recommended inquiry-based instruction as a method to teach science; as more students with severe disabilities participate in inclusive science classrooms, techniques for students to participate and self-direct their own learning need to be explored. The use of a KWHL chart may provide students with a graphic organizer that allows them to be part of cooperative learning groups, demonstrate attention to the lesson, and record information gained. Only one other study currently exists in which students with severe disabilities (Jimenez et al., 2009) have used a KWHL chart in an inclusive science classroom. More research is needed to extend the use of this chart to record student knowledge.

A final suggestion is to determine the long-term impact of peer-mediated embedded instruction on peers involved in the implementation of the strategy. Although there was no effect on students' science grade averages and participants reported only positive attitudes, future research is needed to determine the length at which peers should be expected to participate in such supports. General education students participated in this intervention for approximately 9 weeks. It is unknown if attitudes or grades would have been negatively impacted had the study lasted longer. It is possible that peers could take turns providing supports to students with severe disabilities in the inclusive classroom, allowing more peers to participate with less pressure on one peer for long periods of time.

IMPLICATIONS FOR PRACTICE

General education and special education teachers who are teaching students with disabilities in inclusive classrooms can gain a method of instruction from this study. Although this is only the second study to use both peer-mediation and embedded instruction in the inclusive classroom, positive results from both studies indicate a promising research-based practice. In this study, peers helped students learn vocabulary and key concepts of the science lessons. This same strategy might be applied to concepts in other content areas (e.g., social studies). The students with disabilities also learned to use a KWHL chart. Once students are familiar with this type of chart, they may also use this format for taking notes in other areas (e.g., KWHL charts are often used in language arts). One of the challenges of the current study was the rapidly changing content of the general education setting. Although some target students did keep pace, others needed additional special education tutoring. In applying this intervention, teachers need to be cautious about relying solely on peer-delivered instruction. Additional evaluation also may be needed to determine if this strategy would work in high school classes or some types of middle school classes where the pacing of content is even more rapid. Although the peers in this study liked being tutors and were able to maintain their own grades while doing so, educators also need to monitor the ongoing impact on peers who serve as tutors.

The results of this investigation show that general education peers are able to successfully embed systematic instruction during the naturally occurring inquiry science lesson, resulting in the academic learning of students with moderate intellectual disability. Further, when students with moderate intellectual disability are included in general education science, academic gains can be made in grade-aligned, core content.

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