Training Teachers to Use an Inquiry-Based Task Analysis to Teach Science to Students with Moderate and Severe Disabilities

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Abstract: Federal mandates as well as the National Science Education Standards call for science education for all students. IDEA (2004) and NCLB (2002) require access to and assessment of the general curriculum, including science. Although some research exists on teaching academics to students with significant disabilities, the research on teaching science is especially limited. The purpose of this investigation was to determine if teachers of students with moderate and severe intellectual disabilities could learn to use a task analysis for inquiry-based science instruction and if this training increased student responding. The findings of this study demonstrated a functional relationship between the inquiry-based science instruction training and teacher’s ability to instruct students with moderate and severe disabilities in science.

In 1983 the National Commission on Excellence in Education published *A Nation at Risk*, calling for reform in science education. The report claimed that the educational performance of American students in scientific areas was mediocre and would lead to competitors (e.g., Japan, South Korea, Germany) overtaking the United States’s dominance in scientific areas. Following the report, the American Association for the Advancement of Science (AAAS) began an initiative entitled *Project 2061: Science for all Americans* (1985). The purpose of the initiative was to develop a scientifically literate society by the year 2061. Both *A Nation at Risk* and *Project 2061: Science for all Americans* used inclusive terminology that called for the scientific education of all students. Similarly, when the National Research Council (NRC) published the National Science Education Standards (NSES) in 1996 the focus was “... science standards for all students... regardless of age, gender, cultural or ethnic background, disabilities, aspirations, or interest and motivation in science.” (NRC, 1996, p. 2)

Although these science initiatives targeted “all students,” there were few discussions of applications for students with severe intellectual disabilities until *No Child Left Behind* (NCLB, 2002) required the assessment of all students in science. To meet this requirement states could include students with significant cognitive disabilities in large scale testing through the use of alternate assessments, described by the U.S. Department of Education (2003) as “an assessment designed for the small number of students who are unable to participate in the State assessment even with appropriate accommodations (p. 3).” Although states have been required to develop science assessments, and by default teachers have needed to provide science instruction to prepare students for these assessments, there has been almost no research on teaching science to students with severe disabilities. A comprehensive literature review of science in...
struction for this population uncovered a limited number of studies (Courtade, Spooner, & Browder, 2007). Of the 11 studies that were discovered, eight dealt with concepts that related to only one content area of the National Science Education Content Standards (Content Standard F: Science in Personal and Social Perspectives). While these studies were designed to address daily living skills they had content that overlapped with science.

Although the number of studies that address some aspect of science is limited, they do offer guidance for developing effective instructional strategies. In general, these studies followed principles of applied behavior analysis methodology of operationalizing behavior, using procedures to promote and transfer stimulus control from teacher prompting to stimulus materials, and the use of feedback and reinforcement of correct responses (Alberto & Troutman, 2009). One common feature of several of the studies identified by Courtade et al. (2007) was the use of a task analysis to break skills down into the steps required to complete a response chain (e.g., Gast, Winterling, Wolery, & Farmer 1992; Marchand-Martella, Martella, Christensen, Agran, & Young 1992; Spooner, Stem, & Test, 1989).

None of the studies analyzed by Courtade et al. (2007) addressed one of the most fundamental aspects of science: the process of inquiry. The National Research Council asserts that “inquiry is 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).” Within the National Science Education Standards, inquiry is described as a critical component of a science program. Inquiry-based instruction requires more than hands-on activities. Students also learn to follow a problem solving process that can be applicable to the real world. Some research suggests that the use of an inquiry-based approach vs. a traditional science curriculum (i.e., one based on facts, laws, and theories with the secondary use of hands-on activities) reveals a positive impact on student performance criteria that includes achievement, process skills, analytic skills, related skills (e.g., reading, math), and other areas (e.g., creativity, logical thinking; Shymansky, Kyle, & Alport, 1983). Some research also suggests that students with mild disabilities may improve performance when taught with an inquiry method as compared to a more traditional textbook approach (Scruggs, Mastropieri, Bakken, & Brigham, 1995).

In contrast, there may be limitations to the use of an inquiry approach. The first is that many teachers do not have training to use this approach. Even science teachers within general education have expressed a lack of preparation for inquiry-based instruction (Roehrig & Luft, 2004). Second, some experts have questioned the whole premise of minimal guidance during instruction as being inconsistent with research on how students learn (Kirschner, Sweller, & Clark, 2006). Learners may need guidance until they have sufficiently high prior knowledge to self-direct their learning. Scruggs and Mastropieri (1995) also found that students with intellectual disabilities need “something more” than an inquiry-based instruction alone such as reductions in vocabulary demands, the use of graphic organizers, the use of multiple presentations, carefully structured questioning, familiarizing students with science materials, and guided coaching.

When students with moderate and severe intellectual disabilities participate in an inquiry process, this “something more” for an inquiry-based lesson may be instruction on each step of a task analysis. The questions that could be raised are whether this is still inquiry and what benefit this would have over the traditional task analysis of a specific daily living skill that includes some science. A task analytic approach would still be considered inquiry if the instruction contains the essential features of classroom inquiry. However, this variation involves less learner self-direction and more direction from the teacher and materials used (NRC, 2000). That is, students would be using strategies to derive some information about the materials to be explored, but would do so through interaction with the teacher. According to the National Research Council, the essential features of classroom inquiry include: (a) the learner engages in scientifically oriented questions, (b) the learner gives priority to evidence in respond-
ing to questions, (c) the learner formulates explanations from evidence, (d) the learner connects explanations to scientific knowledge, and (e) the learner communicates and justifies explanations. Each of these essential features can be simplified and defined as a task analysis for inquiry.

There are at least two advantages to using a task analysis of the process of inquiry versus of a specific daily living skill. First, an inquiry task analysis may have applicability across changing science content. That is, students may learn a generalized method for interacting with materials during a science lesson. Second, this generalized method can be used for science content that goes beyond daily living skills such as fossils, volcanoes, and chemical reactions. These broader topics are not only part of the general content standards that states are required to assess, but also may foster leisure interests (e.g., volcanoes), future career options (e.g., work in a lab or museum), or safety skills (e.g., avoiding mixing chemicals) for students with intellectual disabilities.

The purpose of this investigation was to determine if training teachers of students with moderate and severe intellectual disabilities in the use of a task analysis for inquiry-based instruction could be applied across science content. Further objectives of this study were to determine if training the teachers would increase students’ participation in an inquiry-based lesson.

The independent variable was an inquiry-based instructional training package based on reviews of research studies involving training staff who work with individuals with developmental disabilities (Demchak, 1987; Jahr, 1998). Demchak reviewed behavioral staff training in special education settings and compared antecedent, contingency management, and multi-faceted procedures. Antecedent procedures focus on training staff before the skills are to be applied. Antecedent procedures include instructions, modeling, and role-playing. Contingency management focuses on following certain staff behaviors with consequences. Feedback techniques (i.e., written, verbal, video, posted), performance lotteries, and monetary contingencies were all contingency management techniques. Most research has used multi-component procedures to change staff behaviors.

An antecedent strategy that Jahr (1998) found to be effective was modeling. Modeling is a procedure during which the supervisor demonstrates the correct procedures and then the staff member applies the same procedures to a specific individual. Like Demchak, Jahr found that modeling was most often used as part of a multi-component staff training intervention.

Kazdin, Kratochwill, and VandenBos (1986) propose the use of standardized manuals to train staff in research-based methods. They propose that manuals provide detailed, explicit guidelines that are cost effective, and can be updated based on new findings. One of the studies reviewed by Demchak (1987) included the use of a training manual as part of an effective multi-component training package (Reid et al., 1985). The use of the training manual combined with investigator feedback and praise, produced improved behaviors for both the teachers and students involved.

In the current study, a multi-component treatment package including a video model, role play, feedback, and a specific script (the task analysis) was used to train special education teachers to use an inquiry method. The task analysis was based on Magnusson and Palincsar’s (1995) phases of an inquiry-based approach that include: (a) engage, (b) investigate and describe relationships, (c) construct an explanation, and (d) report. Each phase was divided into specific steps for the teachers to use during instruction.

The primary research question was: What is the effect of a multi-component teacher training approach on teacher acquisition of steps to implement an inquiry based science lesson? The second research question examined the effect of this teacher training on generalization across content of the science lessons. A third research question was: What is the concurrent effect of teacher’s use of an inquiry-based lesson on student acquisition of inquiry skills needed to participate in science lessons? The final research question was: What is the effect of participation in inquiry-based science lessons on the concurrent effect of use of science terms?
Method

Participants and Setting

Teachers. Four teachers were recruited to participate in this investigation who met the following inclusion criteria: (a) teacher of a middle school class for students with moderate and severe intellectual disabilities (b) minimum of one year of teaching experience, (c) minimum of two students who met student eligibility criteria, (d) intent to continue teaching in his/her particular classroom for the remainder of the school year, and (e) agreed to teach science a minimum of three times per week. All teachers were female. Their ages ranged from 34 to 44. The teacher’s years of special education teaching experience ranged from 1½ to 13 years. All teachers had at least a Bachelors of Arts degree. Two teachers also had a Masters of Education degree. All teachers were licensed to teach special education, specifically students with intellectual disabilities.

Students. Each teacher recruited two of their students (n = 8 students) to participate in the investigation. Students were eligible for participation if they met the following selection criteria: (a) an IQ score that characterizes the student as having a moderate intellectual disability (40–55) or severe intellectual disability (25–39), (b) adequate vision and hearing to interact with the materials, (c) an ability to communicate verbally or with an augmentative communication system, (d) enrolled in grades 6–8, and (e) consistent attendance (absent less than two times per month). One student did not have a calculable IQ score but had been classified with moderate intellectual disabilities based on his developmental level. Student demographic information is presented in Table 1. All students were verbal and none were English Language Learners (ELL). For further information about student participants (see Table 1).

Setting. The study took place in a large, urban district located in the southeastern United States. The teachers were recruited from a pool of teachers in the school district’s Specialized Academic Curriculum (SAC) classrooms. Three of the SAC classrooms were located in inclusive public schools within the district. The remaining SAC classroom was housed at a public separate school. The SAC classrooms were designed for students with moderate to severe intellectual disabilities who need specialized adaptations to access the general curriculum. The SAC classrooms typically served eight students with one teacher and one paraprofessional. This investigation took place as part of the ongoing instructional program implemented by the teacher. All science instruction took place in the students’ special education classrooms and was conducted by the classroom teachers in a small group with the two target students. Some teachers also included other members of their class in the science lessons. The lessons were conducted with students seated or standing.

<table>
<thead>
<tr>
<th>Student</th>
<th>Age</th>
<th>Gender</th>
<th>Grade</th>
<th>Race</th>
<th>IQ</th>
<th>Verbal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
<td>F</td>
<td>7</td>
<td>AA</td>
<td>40 (WISC-III)</td>
<td>yes</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>M</td>
<td>7</td>
<td>C</td>
<td>40 (WISC-III)</td>
<td>yes</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>F</td>
<td>6</td>
<td>H</td>
<td>54 Leiter-R</td>
<td>yes</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>F</td>
<td>8</td>
<td>AA</td>
<td>35-49 FS verbal-46, nonverbal, 46-WISC-III</td>
<td>yes</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
<td>M</td>
<td>8</td>
<td>AA</td>
<td>41-LIPS-R</td>
<td>yes</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
<td>M</td>
<td>8</td>
<td>AA</td>
<td>49-LIPS-R</td>
<td>yes</td>
</tr>
<tr>
<td>7</td>
<td>13</td>
<td>F</td>
<td>8</td>
<td>AA</td>
<td>39-SBIS</td>
<td>yes</td>
</tr>
<tr>
<td>8</td>
<td>11</td>
<td>M</td>
<td>6</td>
<td>C</td>
<td>no IQ score (unable to calculate)</td>
<td>yes (1 to 2 word vocalizations)</td>
</tr>
</tbody>
</table>

AA = African American, C = Caucasian, H = Hispanic.
around a small instructional table (depending on what was needed to access the materials). The teacher stood behind or beside the table to demonstrate with the materials and provide students opportunities to respond.

To introduce the research and middle school science concepts, a teacher workshop was held at a central office building located in the school district. The individual teacher trainings occurred in meeting spaces (e.g., conference rooms) at each teacher’s school.

Dependent Variables

Checklists for an inquiry based science lesson. The task analysis of inquiry instruction used in this research was called the Checklist for an Inquiry Based Science Lesson. A member of the research team was present for direct observations of the teachers implementing science lessons in their classrooms and used this checklist to score the task analysis. Each teacher’s performance was measured as the number of steps the teacher implemented correctly. To promote reliable data collection, the criteria for performance of each step was operationalized as shown in Table 2. Each teaching step could receive one of four codes. If the teacher completed a step independently and correctly, with no prompting, the step was marked with an “I.” If the teacher completed the step correctly after she was reminded by a member of the research team, the step was marked with a “P.” If the teacher attempted the step, but did not meet the criteria for performance, the step was marked with an “E.” If the teacher did not perform a step, the step was marked with an “O (see Table 2).”

Because this measure was developed by the first author, its reliability and validity were evaluated as part of this research. In this study interobserver agreement was established by piloting the instrument with the two observers who were trained to collect data for this study (a research associate and a doctoral student in special education). The first author provided each individual with Checklist for an Inquiry-based Science Lesson. The operational definitions and coding procedures were explained to each individual. The individuals were then asked to watch a videotaped inquiry-based science lesson that included a participant with severe disabilities and code the teacher’s use of the steps of the inquiry-based science lesson as defined for this investigation. The first author examined the results of the observation and modified the instrument as recommended by the two observers. The same two individuals were then asked to observe and code a second videotaped lesson. The interobserver agreement was above 85%; therefore, the operational definitions were accepted for use in the study.

In single subject research, the social validity of a measure also is means to support the appropriateness of the measure (Kazdin, 1977; Schwartz & Baer, 1991; Wolf, 1978). This was especially important in the current investigation to determine that the task analysis met the criteria for inquiry, but still targeted responses that would be meaningful for students with intellectual disabilities. The researcher asked an expert in science education, two science curriculum specialists, and an expert in the education of students with severe disabilities to review the task analysis and make suggested changes. The content specialists were asked whether it met the principles of inquiry and the special educator was asked to review the types of responses as appropriate and meaningful for the students. All agreed that the task analysis met the stated goals (inquiry; appropriate and meaningful responses) and had no revisions.

The data collected on the checklist were summarized as the number of steps correct for teaching. Interobserver agreement for the task analysis checklist was obtained by having a second observer (doctoral student) observe in the classrooms and independently score a subset (36%) of lessons. Coding of each step was compared for exact agreement and interobserver agreement was computed as agreements divided by total number of steps × 100%.

Generalization of inquiry across science content. The second research question examined the variation in science content taught by the teachers to determine if teachers generalized the inquiry approach across multiple contents in science. This dependent variable was measured by creating a code for each science content area identified in the National Science Education Standards (e.g., Physical Science, Earth & Space Science, Science & Technology), and then assigning the code for the
### TABLE 2
Steps in Task Analysis for Teachers and Criteria for Correct Completion of Steps

#### Phase A: Engagement

<table>
<thead>
<tr>
<th>Step</th>
<th>Correct Response</th>
<th>Incorrect Response</th>
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</thead>
<tbody>
<tr>
<td>1. Show the students a picture or material related to the science skill being taught&lt;br&gt;Correct Response: Shows the student a picture, picture symbol, or object related to the science skill</td>
<td>Incorrect Response: Discusses the skill being taught without showing a visual</td>
<td></td>
</tr>
<tr>
<td>2. Ask the students to tell you what the picture/material is&lt;br&gt;Correct response: Requests that a student tells what he/she thinks the picture/material is; if the student is not verbal, gives a choice of symbols for the student to use to make a comment; leads the student by asking questions</td>
<td>Incorrect response: Tells the student what the picture/material is; does not offer a student who is not verbal choices to make a comment; tells the student his/her identification is wrong</td>
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<tr>
<td>3. Ask the students what they think the picture/material does (what they know about it)&lt;br&gt;Correct response: Requests that a student tells what he/she thinks the picture/material does; if the student is not verbal, gives a choice of symbols for the student to use to make a comment; guides the student by asking questions</td>
<td>Incorrect response: Tells the student what the picture/material does; does not offer a student who is not verbal choices to make a comment; tells the student his/her identification is wrong</td>
<td></td>
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<tr>
<td>4. Ask the students what they would like to find out about the picture/material&lt;br&gt;Correct response: Requests that a student tells what he/she would like to know about the picture/materials; gives picture choices if necessary to elicit a response, guides the student by asking questions</td>
<td>Incorrect response: Responds for the student; does not provide choices if needed; discounts a student’s answer</td>
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</table>

#### Phase B: Investigate and Describe Relationships

<table>
<thead>
<tr>
<th>Step</th>
<th>Correct Response</th>
<th>Incorrect Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Ask students how they will gather information about the subject&lt;br&gt;Correct response: Requests that a student tells what he/she will find out more about the picture/materials; gives picture choices if necessary to elicit a response, guides the student by asking questions</td>
<td>Incorrect response: Responds for the student; does not provide choices if needed; discounts a student’s answer</td>
<td></td>
</tr>
<tr>
<td>6. Ask students to tell you what is the same (pattern)&lt;br&gt;Correct response: Guides students to observe patterns by pointing out characteristics to observe; gives choices of patterns if necessary</td>
<td>Incorrect: Points out the pattern immediately; does not guide students; does not give choices</td>
<td></td>
</tr>
<tr>
<td>7. Ask students to tell you what is different (pattern)&lt;br&gt;Correct response: Guides students to observe patterns by pointing out characteristics to observe; gives choices of patterns if necessary</td>
<td>Incorrect: Points out the pattern immediately; does not guide students; does not give choices</td>
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</table>

#### Phase C: Construct Explanation

<table>
<thead>
<tr>
<th>Step</th>
<th>Correct Response</th>
<th>Incorrect Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Explain relevant accepted scientific knowledge&lt;br&gt;Correct response: Explains knowledge using pictures, symbols, etc.; knowledge is relevant and may help students explain what they have observed</td>
<td>Incorrect: Explains knowledge without showing a visual; knowledge is irrelevant to what students have observed; connection to explanations of what students have observed is cannot be discerned</td>
<td></td>
</tr>
</tbody>
</table>
concept taught during each science lesson (e.g., a lesson addressing the concept of properties of matter would be coded as Physical Science). The topics for each lesson, also, were submitted to a science curriculum specialist who coded the science standard for each lesson independently to check for interobserver agreement. At the end of data collection, the total number of lessons coded in each content standard for each teacher was added, divided by the total number of lessons coded for each teacher in all content standards, and multiplied by 100%. This number represented the percentage of lessons taught in each content standard. Interobserver agreement for coding content was computed by comparing for exact match codes and computing the number of agreements over total codes and multiplying by 100%.

Checklist for student acquisition of inquiry skills.
The third research question examined the students’ acquisition of inquiry skills during a science lesson as shown in Table 3. This dependent variable was a task analysis of student responding measured using the Checklist for Student Acquisition of Inquiry Skills. This assessment occurred during direct observations of the students participating in science lessons. In order to ensure reliable data collection, the criteria for performance of each step was operationalized. A member of the research team coded each step using one of four codes. If the student independently participated in the step, regardless of a correct or an incorrect answer, the step was marked with an “I.” If the student needed verbal, model, or physical prompt to participate the step, it was marked with a “P.” A step was considered prompted not only if the teacher reminded the student to perform the step, but also if a paraprofessional or another student did so. If the student did not participate in the step in any way, the step will be marked with an “N.” If a student was not given the opportunity to perform the step, an “N/O” was marked. If the student performed the step correctly, a / was added to the assigned code. If the step was performed incorrectly, a – was added to the assigned code. Steps 2, 3, and 4 were only assigned a / (gave an answer) or N because the students were being asked to provide individual answers that were not judged as right or wrong. Reliability and validity of this measure were determined using the same approach used for the Checklist for an Inquiry-based Science Lesson (see Table 3 for the 12 steps being measured, operational definitions, and examples).

Total of new science terms used. The fourth research question examined the students’ use
of science terms. This dependent variable was measured using a count of the number of times students used science terms taught in previous lessons correctly. The first author tallied the number of times terms were used during the science lessons they observed.
Teachers were asked to tally the number of times the terms were used by the students during any lessons that were not observed by a data collector and keep anecdotal records of the use of the terms by the students outside of a science lesson. The teachers were asked to record which term was used and the context in which the term was used.

<table>
<thead>
<tr>
<th>Student Steps</th>
<th>Example Lesson Steps 1. Magnetism</th>
<th>Examples of Correct Student Responses</th>
<th>Incorrect Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>B. Investigate &amp; Describe Relationships</td>
<td>5. Student tells how he/she will gather information about the subject (use of 5 senses)</td>
<td>1. Independently respond to the teacher’s request to tell how they would gather information to find out what they would like to know and were given verbal and picture choices to help them make decisions (e.g., ask the teacher, look in a book, experiment (try out) the materials)</td>
<td>5. Does not respond; responds with a sense that is incorrect-example-eating something that is not edible</td>
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<tr>
<td></td>
<td>2. Same as example 1</td>
<td>1. Independently provide a correct response to the teacher’s request to tell what was the same about the objects they were looking at</td>
<td>6. Does not respond; chooses dissimilar characteristics; chooses an incorrect pattern</td>
</tr>
<tr>
<td></td>
<td>6. Student tells what is the same (pattern)</td>
<td>1. Students were given some of the materials and asked to respond to what was the same about some of the objects (given verbal and picture choices; e.g., students were shown objects that were the same color or size)</td>
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</tr>
<tr>
<td></td>
<td>2. Students were asked to look at the two pieces of wood and respond to what was the same (given verbal and picture choices; e.g., they were both the same size, same color)</td>
<td>2. Independently provide a correct response to the teacher’s request to tell what was the same about the two pieces of wood they were looking at</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Student tells what is different (pattern)</td>
<td>1. Students were given some of the materials (i.e., 1 object made of wood, 1 object made of plastic; one object made of metal) and asked to respond to what was different about the objects (give verbal and picture choices)</td>
<td>7. Incorrect-Does not respond; chooses similar characteristics; chooses an incorrect pattern</td>
</tr>
<tr>
<td></td>
<td>2. Students were asked to look at the two pieces of wood and respond to what was different (given verbal and picture choices; e.g., one is on the floor; one is leaning on the shelving)</td>
<td>1. Independently provide a correct response to tell what was different about the objects they were looking at</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>2. Independently provide a correct response to the teacher’s request to tell what was different about the two pieces of wood they were looking at</td>
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</tbody>
</table>
### Experimental Design and Analysis

A multiple probe across participants single subject research design was used to evaluate the effect of the multi-component training on teacher’s use of the steps of inquiry-based science instruction and the concurrent effects on student participation in an inquiry lesson. A multiple probe design is a variation of a multiple baseline design in which data are

<table>
<thead>
<tr>
<th>TABLE 3 (Continued)</th>
<th>Example Lesson Steps 1. Magnetism</th>
<th>Examples of Correct Student Responses</th>
<th>Incorrect Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Steps</td>
<td>Lesson 2. Simple Machines</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Inclined Plane Lesson)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Construct Explanation</td>
<td>8. Student touches or looks at the information being shown</td>
<td>1. Students pointed to or read with the teacher as she read sentences about a science concept to the students (e.g., Magnets stick to most metals. This paper clip is metal. The magnet will stick to it.)</td>
<td>1. Touches sentence or reads sentence with teacher as she reads it</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Students pointed to or read with the teacher as she read sentences about a science concept to the students (e.g., A ramp is a simple machine. Simple machines make work easier. It is easier to push an object up a ramp than to lift it up.)</td>
<td>2. Same as example 1.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9. Student provides an explanation (prediction)</td>
<td>1. Independently make a prediction or answer a prediction question based on the science concept (e.g., This pencil is made of wood. Will the magnet stick to it? Yes or no?)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>9. Does not provide an explanation; chooses an explanation that is not relevant to the previously provided information</td>
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<tr>
<td></td>
<td></td>
<td>2. Using the same concept, students made a prediction about whether it is easier to lift something or push it up a ramp (e.g., I need to get this crate on top of the book shelf. It will be easier to use the ramp than to lift it up)</td>
<td>2. Independently make a prediction or answer a prediction question based on the science concept (e.g., I need to get this crate on top of the book shelf. Will it be easier to use the ramp than to lift it up? Yes or no?)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>10. Does not respond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10. Student participates in testing explanation</td>
<td>1. Independently participate by physically manipulating the objects or directing partners to</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Independently participate by physically manipulating the objects or directing partners to</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Students participated attempting to lift the crate and push the crate up the ramp</td>
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collected intermittently in order to estimate trends and patterns in the data within and between tiers (Horner & Baer, 1978; Kennedy, 2005). Specifically, “probes” (observations of science lessons) were conducted for all teachers and students prior to each teacher and student pair entering intervention. Ongoing data were collected once the teacher entered intervention.

**Procedure**

**Pre-baseline.** Because teachers of students with moderate and severe intellectual disabilities may receive little to no exposure to science instruction, all teachers received a one day workshop that included a general overview of science from the first author and science curriculum experts prior to the beginning of data collection. Each special education teacher was asked to invite a general education science teacher to the workshop with them. Specifically, the inservice consisted of information on five topics: (a) Science and Students with Significant Disabilities (the first author described why the re-

<table>
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<th>TABLE 3 (Continued)</th>
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<tr>
<td><strong>Example Lesson Steps</strong></td>
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<tr>
<td><strong>1. Magnetism</strong></td>
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<td><strong>2. Simple Machines</strong> (Inclined Plane Lesson)</td>
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<tr>
<td><strong>Student Steps</strong></td>
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<tr>
<td>1. Students answered questions or reported information about what they discovered during the experiment (i.e., What the magnet stuck to?)</td>
</tr>
<tr>
<td>2. Students answered questions or reported information about what they discovered during the experiment (i.e., It was easier to push the crate up the ramp.)</td>
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<tr>
<td>12. Student answers questions about the information</td>
</tr>
<tr>
<td>1. Students responded to questions about the science concept (i.e., A ramp is a simple machine. It is easier to push an object up a ramp than to lift it up.)</td>
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search was being done and what is known about teaching science to students with significant disabilities), (b) Middle School Science Content Overview (two school district science curriculum personnel gave an overview of middle school science content, including state science standards and core concepts that are addressed in grades 6–8), (c) How Do We Get There? Strategies for Accessing the General Curriculum (the first author provided strategies such as adaptations and modifications, systematic instructional procedures, the use of functional activities and the use of technology), (d) Extending State Standards (a doctoral student gave specific examples of how to design grade-level appropriate science activities based on state standards), and (e) Planning Lessons (the special education and general education teachers worked together to adapted lesson plans to meet the needs of students with severe disabilities). Providing this general information prior to baseline was important to determine whether the individual teacher training package was needed.

Baseline. During baseline, teachers were asked to teach a science lesson they had developed. No instruction was given to the teachers about the content, structure, or delivery of the lesson other than the general information they received in the pre-baseline workshop. Data on the four teachers and the eight students were collected using the task analysis for the teacher (Checklist for an Inquiry-based Science Lesson) and the student (Checklist for Student Acquisition of Inquiry Skills). As described, the first author and two observers collected all data through direct observation in the classrooms. No feedback was given to the teachers after the lessons. Baseline data were collected on each of the teacher and student pairs three times. The data were graphed and visually inspected.

Intervention. When the baseline was found to be stable for a teacher and student pair, that teacher received a 4-hour training session from the first author. The training took place in a one-on-one context between the teacher and the first author at the teacher’s school in a private setting (e.g., tutoring room, empty office). The intervention was a multi-component training program that included: (a) a fidelity checklist that the researcher followed to ensure each teacher received all the same training components, (b) a training manual, (c) verbal explanation of the contents of the training manual, (d) a videotaped model of an inquiry based science lesson in which a student with severe disabilities was being instructed, and (e) an opportunity to develop a science lesson for which the first author modeled the components and gave feedback.

During the individual teacher training session, the researcher first played the videotaped science lesson and gave the teacher a guided notes handout to help her identify the steps of the inquiry instruction. Next, the researcher did a verbal presentation of the training manual which the teacher followed in her own copy. The manual was based on the Professional Development Standards from the National Science Education Standards (NRC, 1996), research related to teaching inquiry (Germann, Aram, & Burke, 1996; Keys & Kennedy, 1999; Palincsar, Anderson, & David, 1993), and research related to staff training (Demchak, 1987). The manual was 30 pages and included: (a) an overview of inquiry-based science instruction, (b) a rationale for the use of inquiry based instruction for general education students and students with disabilities, (c) general education science lessons demonstrating plans for an inquiry based lesson, (d) steps included in the adapted inquiry process (task analysis), (e) examples for each step of the task analysis, (f) sample lessons applying the task analysis to specific science content for students with moderate and severe disabilities, (g) ideas for choosing a first lesson, (h) ideas for individualizing lessons for each student (e.g., assistive technology), and (i) a lesson planning form (the task analysis with space to fill in specific materials and activities for each step).

As part of training, teachers were instructed on how to use the system of least prompts procedure to promote student responding on each step of the task analysis. The system of least prompts was chosen based on evidence of its effectiveness with students with severe disabilities who are learning chained tasks (Demchak, 1990). Teachers were instructed to move through the following prompts if the student was not responding to a question or request: (a) verbal, (b) model, and (c) physical guidance. The first author also noted the importance of praising correct responses and
responding to errors by interrupting them and giving the next level of prompting.

After the manual and information on using the system of least prompts was reviewed, the teacher used the planning form to create a lesson and then role played it with the first author. The first author gave feedback on any steps omitted and on the use of prompting and feedback. Following the individual training, the first author or other observers would also give feedback on any steps omitted and the use of prompting and feedback during the classroom observations in intervention by meeting with the teacher briefly at the end of the lesson. During intervention, the observers also gave prompts during the lesson if the teacher overlooked a step or began to respond for the student (e.g., by saying “What does Monica know about the material?” or “I wonder who knows what’s the same?”).

Procedural Fidelity

In order to strengthen the ability to demonstrate a functional relationship between the independent and dependent variables and to provide reliable training across teachers, treatment integrity (Billingsley, White, & Munson, 1980) was measured using a checklist of each component (verbal explanation of inquiry instruction and rationale for use, videotape example, strategies for adapting inquiry-based instruction and science content for students with severe intellectual disabilities, planning, implementation, feedback). A second member of the research team attended two of the four individual teacher sessions and measured the treatment integrity for teacher training. Because the focus of this study was teacher behavior change, the Checklist for an Inquiry-based Science Lesson served as the treatment integrity checklist for the student’s intervention.

Social validity. A threat to validity in an educational intervention is that the outcomes may not be of practical significance to key stakeholders (Wolf, 1978). To address this threat, a survey was sent to the students’ parents to determine if they perceived science instruction to be important for their children. Also, surveys were conducted with the teachers in the study to determine if the variables being measured were socially important and if it was feasible to instruct this student population using inquiry-based methods. A second survey was given to the teachers to determine they perceived the intervention itself to be socially valid.

Results

Lesson Implementation

Each teacher began implementing the science lessons within three days of the individualized intervention training. All lessons took place in the special education classrooms the students regularly attended. Lessons lasted approximately 20–30 minutes. Lessons were taught in small groups that ranged from 2–6 students. Each teacher taught 2–3 science lessons per week.

Fidelity for Researcher’s Training of the Teachers

Procedural fidelity for the researcher’s training of the teachers was monitored for pre-baseline training as well as the individual teacher training (intervention). Fidelity for the pre-baseline workshop was monitored by the two trained observers. Fidelity of the individual teacher trainings was monitored by one of the trained observers. Procedural fidelity for the pre-baseline workshop was 100%. Procedural fidelity for the individual teacher trainings had a mean of 93.43%.

Interobserver Agreement

Interobserver agreement on 6 of the 13 (46.2%) probes taken during the baseline period using the Checklist for an Inquiry-based Science Lesson (teacher data) ranged from 92%–100% with a mean of 96%. Interobserver agreement on 16 of 48 (33.33%) probes taken after intervention using the Checklist for an Inquiry-based Science Lesson (teacher data) ranged from 83%–100% with a mean of 97.43%.

Interobserver agreement on 6 of the 13 (46.2%) probes taken during the baseline period using the Checklist for Student Acquisition of Inquiry Skills (student data) ranged from 92%–100% with a mean of 96.67%. Interobserver agreement on 16 of 48 (33.33%) probes taken after intervention using the Checklist for Student
Acquisition of Inquiry Skills (student data) ranged from 83%–100% with a mean of 93.89%. When interobserver agreement fell below 85%, the data collectors were retrained on the data collection procedures and operational definitions by the first author.

Observers noted the concept of each lesson being taught by the teachers. Fifty-six lessons were coded by the first author (content area of 5 lessons was missing) and the science content expert. Of the 21 different concepts taught (concepts were taught multiple times by multiple teachers), the first author and science content expert agreed on the content area for 18 of the concepts (86%). The first author mistakenly identified three concepts (i.e., gravity as an Earth Science concept, simple machines and work as Physical Science concepts). The science content expert corrected the misconceptions (i.e., gravity is a Physical Science concept; simple machines and work are Science and Technology concepts).

Effect of Training Teachers in Inquiry-based Instruction on Science Lessons

Figure 1 presents the number of steps on the Checklist for an Inquiry-based Science Lesson each teacher performed correctly. For all four teachers, there was a change in level and trend after the training in inquiry-based science instruction. Maintenance probes were only taken with Teacher 2 because the school year came to an end before more probes could be taken.

Teacher 1. During baseline, Teacher 1’s scores ranged from 2 to 3 lesson components correct. Her post-intervention scores ranged from 7 to 12 with a majority of the scores (75%) at 10 or higher (criteria for teacher performance was set at 10 or above). The last two data points show a decelerating trend that may have been related to her personal circumstances. Teacher 1 had to drop from the study because of a death in her immediate family.

Teacher 2. During baseline, Teacher 2’s scores ranged from 3 to 4 steps of the lesson correct. Her post-intervention scores ranged from 10 to 12 with a majority of the scores (75%) at 10 or higher. Two maintenance probes were conducted. Teacher 2 scored 11 on both maintenance probes.

Teacher 3. During baseline, Teacher 3’s scores ranged from 3 to 4 steps of the lesson correct. Her score during the baseline probes ranged from 4 to 5 steps correct. An additional probe was conducted because the teacher’s performance showed some acceleration after the first teacher’s intervention. Teacher 3 performed 3 steps correct during the additional probe. Her post-intervention scores ranged from 10 to 12 with a majority of the scores (88%) at 12.

Teacher 4. During baseline, Teacher 4’s scores ranged from 1 to 3 steps of the lesson correct. Teacher 4’s scores during baseline and the probe phases indicated a stable trend and level. Her post-intervention scores ranged from 7 to 12 with a majority of the scores (75%) at 10 or higher.

Effects of Training Teachers on Generalization across Content Area

All four teachers generalized the use of the inquiry-based task analysis across three or more areas. Lessons were taught that addressed concepts in Physical Science, Life Science, Earth and Space Science, and Science and Technology. No lessons were taught that addressed concepts in the areas of Science in Personal and Social Perspectives or History and Nature of Science. All four teachers taught lessons in Physical Science. Lessons taught that represented this content area included concepts such as magnetism, gravity, force, friction, motion, speed, and density. All four teachers also taught lessons in Life Science. Lessons taught that represented this content area included concepts such as plants and plant cells, parts of the human body, the respiratory system, cells, and heredity. Three of the four teachers taught lessons in Earth and Space Science. Lessons taught that represented this content area included concepts such as earth’s crust, volcanoes, shadows/sunlight, day/night, and gravity. Teacher 2 taught two lessons in Science and Technology. The lesson concepts coded as Science and Technology included simple machines and work. No lessons were coded as content areas F (Science in Personal and Social Perspectives) or G (History and Nature of Science).
Figure 1. Teacher's number of steps of task analysis correctly implemented during science lesson.
Effects of Inquiry-based Science Instruction on Students' Acquisition of Inquiry Skills

Figures 2 and 3 summarize the number of inquiry responses made by the students. For clarity of presentation, one student from each teacher’s classroom is presented in each graph (e.g., Monica and Kyle both received instruction from Teacher 1). There was a change in level and trend after the training in inquiry-based science instruction for all eight students. Baseline scores ranged from 1 to 3 lesson components correct. Post-intervention scores ranged from 3 to 12, with a majority of the scores in classes 2, 3 at 9 (75%) or higher. Both students in class 1 had to discontinue participation in the study when their teacher requested to be removed due to a death in the family. Two maintenance probes were conducted in class 2. Valerie scored 10 and 11 on the probes and Charlotte scored 9 and 10 on the probes indicating an ability to maintain the high skill acquisition over time (see Figures 2 and 3).

Students’ Use of Science Terms

Only one teacher (Teacher 2) reported student’s use of a new term (“skull”) outside of a lesson. During observed lessons, students with Teacher 2 also initiated use of newly introduced terms (metal, magnet, dense, liquid, solid, and dissolved). There were no other observations of student initiation of science terms.

Social Validity Results

Following the intervention, a parent survey was sent to the parent/guardian of each student involved in the study that used a 5-point Likert scale (i.e., 5=strongly agree, 1=strongly disagree). Only three of the eight (38%) parents/guardians returned the survey and responses ranged from 4–5 (see Table 4). Although the return rate was low, the survey was not sent out again because the school year ended. Similarly, a validity survey was sent to the teachers involved in the study. The survey contained seven questions which could be answered using a 6-point Likert scale (i.e., 6=I agree, 1=I disagree). Three open ended questions were also included: (1) What was the most helpful component of the training; (2) Least helpful; and (3) Suggestions for improving/changing training for future studies. All four of the teachers (100%) returned the survey. Scores for each of the seven questions ranged from 5–6. Examples of comments to the open ended questions included: Learning the task analysis in order to teach all the components of an inquiry lesson was the most helpful; more sample lessons & more time for planning with regular educators.

The teachers also were sent a feasibility survey. The survey contained seven questions which could be answered using a 5-point Likert scale (i.e., 5=strongly agree, 1=strongly disagree). All four of the teachers (100%) returned the survey. Scores for each of the seven questions ranged from 5–6. Examples of additional comments included: I appreciate being involved in this grant. It has made me more aware of how to teach science that would be most beneficial to my students. The more I conduct inquiry science lesson plans, the more comfortable I feel; Planning for inquiry lessons is time consuming.

Discussion

The purpose of this investigation was to determine if teachers of students with moderate and severe intellectual disabilities could learn to teach the process of inquiry using a task analysis. A further objective of this study was to determine if training the teachers would increase students’ participation in inquiry science lessons. The findings of this study demonstrated a functional relationship between the multi-component teacher training package (videotape, manual, application, role play, in vivo feedback) and teacher’s ability to instruct students with moderate and severe intellectual disabilities in the steps of inquiry. The teachers generalized the task analytic instruction across science content areas. All students increased the number of responses to participate in an inquiry lesson and one student used a science term outside the lesson and in another instance students initiated use of the terms in the science lesson. Finally, social validity measures indicated a high degree of teacher satisfaction with the intervention and its intended outcomes. Parent response rate was low, but those who responded were satisfied with the intervention.
Figure 2. Number of inquiry skills completed independently by the students during inquiry lesson (Students 1, 3, 5, 7).
Figure 3. Number of inquiry skills completed independently by the students during inquiry lesson (Students 2, 4, 6, 8).
Although an inquiry-based approach to instruction may be new for some teachers, especially those who were trained primarily to work with students with severe disabilities, professional development can be an effective way to build this capacity. In contrast, this professional development may need to be more intensive than the typical group workshop. In the current study, the general training in science and the process of inquiry did not result in teachers using steps of inquiry during baseline. Literature reviews of staff training conducted by Demchak (1987) and Jahr (1998) have found that multi-component training procedures that involve modeling, role play, and feedback are effective. A critical component of the training in the current study may have been the use of a videotape model in which the teachers could see a student with a severe intellectual disabilities using inquiry. It also was important for the teachers to have the opportunity to practice creating an inquiry lesson and role-play its use. The teachers also received in vivo feedback on their application of the inquiry-based task analysis. Other research on staff training has found benefits for giving teachers immediate feedback during classroom instruction (e.g., Demchak, Kontos, & Neisworth, 1992).

Another aspect of the training that may have made it effective for the teachers was that although an inquiry-based approach was new, the use of task analytic instruction was not. Task analytic instruction has been shown to be effective with a wide range of domestic and community living, safety, and academic skills for students with significant intellectual disabilities (e.g., fire safety (Bannerman, Sheldon, & Sherman, 1991), first aid (Spooner et al., 1989), and communicating being lost in the community (Taber, Alberto, Hughes, & Seltzer, 2002)). One of the advantages of training in this “generic” task analysis for inquiry is that teachers gained a template that could be used for a wide variety of science content. In this study, teachers planned and implemented the inquiry-based task analysis in four areas of science (Physical Science, Earth and Space Science, Life Science, and Science and Technology). Previous research focusing on teaching science to students with moderate and severe disabilities was mainly focused in one content standard (Science in Personal and Social Perspectives, Courtade et al., 2007; Spooner, DiBiase, & Courtade-Little, 2006). Giving teachers a generalizable method for instruction provides a tool for accessing the varied content of science. In this study, the students’ acquisition of the inquiry responses reflected generalized responding across different materials. That is, not only did the teachers generalize the inquiry instruction across materials, so did the students.

The limitation of this generic task analysis approach is that that students learned to engage with science materials, but it is unclear whether they learned science concepts per say. As described in the results, only a few of the students began to initiate use of the science terms. For example, McDonnell, Johnson, Polychronis, and Riesen (2002) embedded time delay instruction in the context of a general education setting to teach vocabulary including some science terms. Students might also need to practice generalizing the vocabulary in daily living activities. For example, the students might have noted that they can “conserve” water not letting the water run continuously as they wash their hands or how the rain caused “erosion” on the athletic field.

### Table 4

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<tr>
<th>Item</th>
<th>Mean</th>
<th>Range</th>
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<tr>
<td>1. I think it is important for my son/daughter to learn science skills.</td>
<td>4.33</td>
<td>4-5</td>
</tr>
<tr>
<td>2. My son/daughter should receive science instruction on a daily basis.</td>
<td>4.00</td>
<td>3-5</td>
</tr>
<tr>
<td>3. It is important to me that my son/daughter is instructed in science as recommended by the National Science Education Standards.</td>
<td>4.33</td>
<td>4-5</td>
</tr>
<tr>
<td>4. My son/daughter has expressed interest in the science skills he/she is learning.</td>
<td>4.33</td>
<td>4-5</td>
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Because science instruction is a new direction in education for students with severe disabilities, ongoing discussion is needed about the outcomes proposed and achieved. One possible goal would be increased access to the educational opportunity of science content. Students in the current study did not have regularly scheduled science lessons prior to the implementation of this study, but had three lessons per week once intervention began. In the following school year, science instruction became a school system and state requirement for this population to prepare for upcoming NCLB-related assessments. This study provided an early model for how to structure this instruction to build on long standing principles of task analytic instruction. In contrast, one of the three parents who returned the social validation survey was “not sure” about the importance of his/her child receiving science instruction. The need exists to articulate clearer outcomes for science learning for this population beyond simple access.

One such outcome might be for students to acquire the skills involved in an inquiry process. Students in the current study were learning to focus their attention on novel materials, compare and contrast them (“What is the same/different?”), make predictions, and draw conclusions. The generalization of these skills across a variety of materials was an important outcome. In contrast, what future research and practice should target is the generalization of these skills to non-instructional contexts. For example, could the student be taught to apply these skills in visiting a museum, going on a nature hike, setting up job parts, and so on?

For this to occur, teachers might need additional training in teaching this generalization. In this study, there were some “not sure” responses from the teachers about their confidence in using inquiry. Similarly general educators trained to use inquiry in their classrooms have sometimes expressed a lack of confidence (Keys & Kennedy, 1999; Roehrig & Luft, 2004). Two teachers indicated that the more they conducted the lesson, the more “comfortable/confident” they felt. Similarly, teachers may have needed training, practice, and possibly a planning template to prepare for teaching students to generalize the inquiry skills across contexts.

Although this study focused primarily on the process of inquiry, the goal of students with moderate and severe intellectual disabilities mastering science concepts may be a topic for future research. One option might be to teach students to recognize science terms as sight vocabulary and then apply this vocabulary to perform an activity. For example, Browder and Minarovic (2000) taught supported employees to recognize job words and use them to follow a job schedule. Students might learn a term like “erosion” and then use a model to demonstrate how this occurs or find an example in a community setting.

Besides access to science curricula, learning inquiry, and mastering science concepts, a fourth goal of science education might be increased opportunity to learn in general education science classes. Some studies have shown that students with severe intellectual disabilities and their peers without disabilities can benefit from inclusion in general education settings (Cushing & Kennedy, 1997; Kennedy, Cushing, & Itkonen, 1997; Kennedy & Itkonen, 1994). Future researchers may want to try combining instruction in inquiry with the embedded trials demonstrated by McDonnell et al. (2002) to create an adaptation of the current intervention with utility within general education science classes.

Summary and Recommendations for Future Research

This study was the first to train teachers to use a form of inquiry with students with moderate and severe intellectual disabilities. The task analysis the teachers used was applicable across science content and promoted student responding. One limitation of the current study to address in future replications is that students’ performance was constrained by the teachers’ skill in following the task analysis. There were no baseline data showing how students may have responded to a teacher experienced in inquiry prior to receiving instruction. In contrast, student data showed gradual vs. immediate change once intervention began; indicating the change in student
data was not simply an artifact of the teachers offering opportunities. To prevent this limitation, future studies should include a baseline for students conducted by a teacher experienced in inquiry who creates the opportunity for all steps of the task analysis to be performed. Future research may also give more consideration to inquiry as an independent variable.

For example, if students master the steps of inquiry are they able to gain information on a new topic with minimal teacher guidance? Do they generalize communication skills gained during inquiry to other contexts? Future research may also want to consider how to promote student’s acquisition of concepts within inquiry. For example, can students learn a concept like chemical reactions and apply it across materials and contexts?

References


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