# THE EFFECT OF TALK ALOUD PROBLEM SOLVING AND FREQUENCY BUILDING TO A PERFORMANCE CRITERION WITH A STUDENT AT-RISK FOR READING DISABILITIES: A CASE STUDY

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Learners at-risk for disabilities in the classroom often require explicit instruction and practice to master skills. Problem solving involves skills that students encounter in every subject area during the school day. The development of problem solving interventions such as Talk Aloud Problem Solving (TAPS) came from a need to help students with troublesome behaviors when solving problems and to increase feedback from experts. The present case study suggests that TAPS combined with frequency building to a performance criterion (FBPC) helped a fourth grade student at risk for reading disabilities acquire problem solving skills related to reading. The TAPS/FBPC included two stages in a combined intervention package, TAPS and FBPC. The student acquired the strategy through scripted lessons in the first stage, TAPS, followed by practice talking aloud with feedback in the second stage, FBPC, until he reached a fluency aim. The significance of the results and potential for future studies are discussed.

*Keywords*: Talk aloud problem solving, Frequency building, performance criterion, reading

Problem solving is a vital skill for every individual to master. Problems can range from an engineer troubleshooting mechanical issues with a hydraulic system to a student resolving analogies in elementary school. Problem solving is an important lifelong skill. Along with solving problems independently, an individual needs to communicate a solution to others. Once fluent in a variety of problem solving strategies, students can apply what they have learned to new and more complex skills. Attaining proficiency in the basic skills of problem solving becomes increasingly acute as skill level increases in difficulty.

Problem solving remains a term difficult to define and measure. An early and pragmatic attempt to define problem solving came from Skinner (1953). Skinner suggested problem solving included "any behavior, which through manipulation of variables, makes the appearance of a solution more probable" (p. 247). In other words, the person finds a solution to the problem at hand through an activity (i.e., behavior) that successfully leads to a resolution. Some problem solving skills that may occur in classrooms involve organizational and grouping strategies, visual imaging, self-monitoring, and engaging in covert intraverbal behavior (Palmer, 1991). A student solving problems attempts different methods until reinforcement occurs from the environment for his or her behavior through a correct answer or other means such as a teacher's praise for solving the problem. For example in a content area such as science, problem solving begins with the basic understanding of text or materials given. For comprehension, students decipher important details that will lead them to a logical solution of a reading problem. Using Skinner's definition, solving a problem can occur in any content area.

One academic content area in need of problem solving appears in reading. United States students are not achieving desired results with reading and content area goals. According to the 2017 National Assessment of Education Progress (NAEP) reading results for 4th grade, 32% of students fall below the "basic level," or partial mastery, in reading and only 31% reach a basic level of reading proficiency (National Center for Education Statistics, 2017). For the 8th grade 24% performed below basic level and 40% at a basic level. In addition to reading, student data available for science for 2015 in grade 8 demonstrated 32% of students not even meeting the basic level and only 34% meeting a basic level of knowledge (National Center for Education Statistics, 2015).

By fourth grade, students are expected to switch from mostly narrative text, to content area learning focused on expository text (i.e., text used to inform or describe). With the large number of students functioning at a basic to below basic level in both reading and science, the need for early and intense instruction appears significant. Students at-risk for, and with, learning disabilities present new challenges when reading expository text because of more complex text structure, conceptual density, level of complex vocabulary, and importance of prior knowledge (Saenz & Fuchs, 2002). There is a need for more research involving the complex process of reading, comprehending, and applying content in expository text in fields such as science.

One method that holds promise for developing problem solving involves requiring the student to talk aloud their thinking process while problem solving (Whimbey & Lochhead, 1999). Teachers using Talk Aloud Problem Solving or TAPS help learners break down individual problem activities into comprehensible components. Previous research in talking aloud in reading has demonstrated the importance of including explicit modeling and prompting with instruction (Baumann, Seifert-Kessell, & Jones, 1992; Bereiter & Bird, 1985). By making private verbal behavior public, the teacher readily identifies a student's instructional needs.

TAPS is recognized within the advanced science community, specifically chemistry, as an intervention to continue investigating within content instruction (Bodner & Herron, 2002). TAPS became useful for practitioners when used for instruction to teach problem solving, reasoning and analytical thinking skills to students of different skill levels with and without disabilities (Robbins, 2011). For students without disabilities, a broader intervention with think alouds using pairs was successfully implemented (e.g., effects in problem solving performance or learning experience for students) with older students (Holzer & Anduret, 2000; Jeon, Huffman, Noh, 2005; Johnson & Chung, 1999; Kani & Shahrill, 2015; Pate & Miller, 2011; Pate, Wardlow, & Johnson, 2014; Pate & Young, 2014; Pestel, 1993; Tingle & Good, 1990). The use of TAPS in science provides an explicit, replicable intervention to help guide students in advanced problem solving.

Research in older grades has established the need for this intervention, but more exploration is required with younger students and lower level content. Working with a student with a disability, a recent five-phase study evaluated the effect of TAPS on the analytical thinking skills of an 11 year old girl with autism (Ferris & Fabrizio, 2009). Highlights of the findings were: 1) two minute timings were preferable to one minute apparently because the student had more time to talk aloud and solve problems; 2) multiple timed practice trials produced better learning than only one timed practiced trial; and 3) TAPS required that the private problem solving behaviors become vocal and thus remediable through explicit instruction and practice.

The study by Ferris and Fabrizio (2009) suggested that frequency building leading to behavioral fluency could work for others with similar characteristics. Frequency building refers to a process of practice that involves the timed repetition of a behavior (a practice trial) and immediate performance feedback following the practice trial (Kubina & Yurich, 2012). Behavioral fluency marks the end goal. Namely, frequency building is completed when the student reaches a criterion or a quantitative marker called a performance standard. As an example, a performance standard for basic multiplication facts is 80-120 digits written correctly in one minute (Lin & Kubina, 2005; Lin, Kubina & Shimamune, 2011). A large body of research shows certain associated critical learning outcomes occur when a performance standard (i.e., behavioral fluency) is achieved: long-term retention, endurance or resistance to fatigue, and application or the ability to apply element skill(s) to a more complex compound skill (Binder, 1996).

Adding frequency building to a performance criterion (FBPC), which leads to behavioral fluency for an intervention such as TAPS, has the potential to positively impact students with or at-risk for learning disabilities who need help reading expository text and solving problems. TAPS/FBPC represents an intervention which makes public the private subaudible vocalizations that do or do not occur with problem solving. Teaching and then practicing, or FBPC may directly impact those struggling with content dense text such as science readings.

With problem solving, discerning fluent performance that demonstrates acquisition and proficiency has yet to be studied widely. Proficiency or fluency defined in terms of a measurable standard (i.e., performance standard) would lead to a clear marker indicating when students have truly mastered a problem solving strategy. The current case study was designed to clarify parameters that are indicative of a proficient skill (i.e., behavioral fluency) and techniques that may help students reach high levels of performance. Stated differently, placing sentences into a logical order may be a core skill in reading comprehension where students learn the relationships between sentences and content within sentences. The ability to perform the ordering task actively and accurately demonstrates an understanding of relationships between sentences and how the paragraphs are constructed (Whimbey & Lochhead, 1999). For students struggling in the general education classroom with science content, navigating expository text and demonstrating a logical understanding of the text seems critical.

Combining research in talking aloud with behavioral fluency techniques in the TAPS/FBPC intervention package, the current case study explores the skills needed to achieve fluent problem solving. The study seeks to understand the development of good problem solving and what separates a strong student from a struggling student in the general education science classroom. The case study focused on the question: Does instruction in TAPS/FBPC improve performance on a problem solving skill using science text?

## Method

### Participant

The procedure for locating the student included first asking teachers and a school psychologist to nominate any students who struggled with test-taking skills and reading comprehension. The experimenter confirmed with the teacher that the nominated student did not receive instruction similar to the study objectives and obtained parental permission. Next, the nominated student was assessed and demonstrated the ability to read grade level passages above 100 correct words per minute (CWPM) with less than five incorrect words per minute (IWPM) on AIMSweb (2002) curriculum based measures in reading. The fluency criterion established that the student read above the 25$^{th}$ percentile for grade four in the spring of their school year (Hasbrouck & Tindal, 2006).

The potential participant's current reading level was screened using readings and criteria established by the experimenter. The student needed to retell five or less independent clauses (includes a subject and verb and is a complete thought) per passage in one minute. Selection procedures also required the participant to remain below the frequency aims on grade level retells established in previous research studies (i.e., fluency goal was 10 correct retells per minute) (Culler, 2010).

One 4$^{th}$ grade male Caucasian student labeled at-risk for reading failure, Jerry, met the selection criteria. At-risk was defined within the school district as students not responding to Tier 2 interventions in the Response to Intervention (RTI) program. When tested for grade level reading fluency, Jerry read 118 CWPM with one IWPM on passage one and 124 WCPM with zero IWPM on passage two. When tested on his retell ability he produced five correct and one-half incorrect retells on passage one and five correct and one and one-half incorrect retells on passage two. Jerry's performance made him eligible for the current study.

### Setting

The case study took place in a rural elementary school in the northeastern United States. As the only elementary school in the district, the building was adjacent to the district's one high school. The total enrollment of the elementary school during the case study was 566 students. The elementary school was majority Caucasian with an enrollment of 553 students. Minorities totaled 8 students during the same year with five students unidentified. A total of approximately 21% of the student population received special education services. During the length of the study, approximately 45% of the student population received reduced-price/free lunch.

The experimental procedures took place in the school building where the experimenter could find alternative quiet spaces to work one-on-one with the student. The spaces included empty classrooms and an empty hallway when classrooms were unavailable. The student received one-to-one instruction outside of the general education setting.

### Dependent Variable

The dependent variable problems involved silently reading a paper with sets of four sentences from a science text and placing each sentence in the most logical order in a two-minute timed session. The dependent measures included correct sequence of sentence (CSS) and incorrect sequence of sentence (ISS). To complete the problems the student read each sentence and wrote his selected order in front of the sentence. The sentences chosen to create the problems were taken from science textbooks used in fourth grade classrooms (Banks et al., 2001; Hacket et al., 2008; Heil et. al., 1994; and Sciencesaurus, 2002). The student was provided with enough sentences to work for the entire two minutes, never repeating any of the problems already completed/read. The experimenter read through textbooks and located sets of four sentences, the first sentence started the paragraph and the remaining sentences were contained within the same paragraph. When choosing sentences, the experimenter looked for transition words, noun phrases, or cues such as events in a sequence (e.g., (1) Migration is a natural behavior for an organism. (2) It does not need to be learned. (3) Another type of natural behavior that helps an animal survive is hibernation. (4) Hibernation is a state of inactivity that occurs in some animals when outside temperatures are cold). After the sentences were selected, the experimenter randomized the order. The student was only exposed to the set of sentences one time. Three to four sets of sentences were on each page, with more pages available if needed. Two people independent to the experiment, a student in undergraduate studies and an adult with a graduate degree in science, checked the problems. The problems completed incorrectly or found to be confusing to the independent problem checkers were thrown out.

Jerry completed each paper and was provided another if he completed all of the available problems. To complete the problems, he numbered the sentences one through four in the space provided. The numbered responses were scored as either correct or incorrect based on the order given by the textbooks.

### Independent Variable

The Talk Aloud Problem Solving (TAPS)/ Frequency Building to a Performance Criterion (FBPC) intervention was the independent variable. The experimenter broke down the intervention into two stages based on skills required to problem solve while talking aloud (Whimbey & Lochhead, 1999). The first stage, TAPS, involved formatted lessons having an "expert" or proficient learner model at least twice and then guiding the student through the process of placing sentences into a logical order while talking aloud through scripted lessons (explicit instruction lessons available at request to first author). The systematic and explicit instruction leads the student through models, guided practice and independent practice (Archer & Hughes, 2011). Following several explicit models and guided practice, the student or learner began the process of talking aloud with feedback from the experimenter. The goal of the scripted lessons and feedback was to build the students ability to provide explanations about their problem solving behavior. All of the intervention sessions were audio taped to later transcribe information about student performance and calculate reliability and procedural integrity.

The second stage of the TAPS/FBPC was frequency building to a performance criterion where the experimenter set up a practice routine for more intense feedback. First, the student talked aloud for two minutes and next, received one minute of feedback (e.g., about what was done well and what areas to improve for the next practice). The two step practice routine was repeated one additional time. The first talk aloud prior to feedback was used as the measure for the independent variable for decision making. Following two practices with feedback, the dependent measure was given to the student. Feedback consisted of at least one statement describing what the student was doing well and one statement for something to improve. This stage was completed when the student was able to produce the exit criterion for three consecutive days.

The exit criterion of the study was established by collecting data from two high school students with an established high performance in science (i.e., Advanced Placement science). To enhance procedural integrity and reliability for future studies, this additional measure allowed the experimenter to measure student mastery of the intervention (i.e., what was being taught). Prior to this case study, no measure was available to determine what a fluent performance looked like. To determine an expert or fluent performance, data were collected by asking the two high school students to talk aloud for two minutes while solving similar problems. The students were able to produce at least 16 statements supporting their decisions in problem solving. Therefore, students exiting the intervention were expected to talk aloud about 16 statements.

Three categories emerged from statements in talking aloud while problem solving. The three categories were rereading, talk alouds about cues, and talk alouds about order. Rereading was considered talking aloud with point-to-point correspondence to the text. Half credit for the independent variable count was also given if the student reread part of the sentence (e.g., providing part but not complete repetition). Talk alouds about cues (i.e., signal allowing student to solve problem or helping them get to the answer) were any talk aloud that used parts of the sentences and words to explain the order or sentences chosen (e.g., this sentence should go last because it elaborates about the other sentences). Talk alouds about order were considered any sentence that was about order without any explanation (e.g., this sentence goes first). The student moved into the second stage of the intervention after producing eight talk alouds about cues for three consecutive school days. The first author decided on eight because this demonstrated enough accuracy through lessons to move on to practice with performance feedback (i.e., student was able to participate in the systematic practice routine without struggling). Sixteen talk alouds about cues were the goal for the student to exit the intervention. Talk alouds about cues were identified as the statements helping the student get to the answer, common in expert learners. The additional talk aloud measure ensured the student received enough instruction and feedback to acquire the skill taught during the intervention.

### Design

The quasi-experimental design was an AB design (Gast, 2010). The AB design requires repeated measurement and a stable baseline. The AB design does have several threats to external validity and results should be interpreted as tentative (i.e., cannot offer a functional relation). An AB design was selected to show possible effects. The case study is a first attempt at systematically implementating the TAPS/FBPC. Jerry entered the intervention phase after demonstrating a stable baseline showing a decreasing trend in CSS and/or increasing trend in ISS.

### Procedural Integrity

An independent observer listened to 30% of the audio recorded intervention sessions for the independent variable. The exact, scripted lessons were provided for first stage in TAPS/FBPC. For the second stage, the observer worked off a task analyzed set of steps of the procedures delivered for the TAPS intervention. The procedural integrity was 100% for 30% of the independent variable. To check the lessons in talking aloud, the observer checked off the parts of the lesson to ensure that the instructor covered each component. The observer timed FBPC to ensure that the experimenter followed the desired timelines. If the student or experimenter were finishing a sentence they were allowed to go over the one minute (e.g., the sentence was last because [timer goes off] it starts with lastly).

### Scoring Agreement

The dependent variable was the percent match between the student's answers and answers presented in an answer key prepared by the experimenter. The answer key had the sentences with the answers entered in the appropriate spaces along with the sentences written in paragraph form underneath the answers. The observer independently went through 30% of randomly selected probes. A total agreement formula was used for calculation: the number of agreements (smaller total) divided by the total number of agreements and disagreements (larger total, multiplied by 100 (Johnston & Pennypacker, 2009). The scoring of the dependent variable was calculated at 99% agreement in scoring.

The independent measure of talking aloud was scored to determine different talk aloud frequencies during lessons. Talk aloud frequencies were used for decision making, making correct scoring a priority. The independent observer was trained until the experimenter and scorer reached 100% agreement on scoring procedures. The talk alouds about cues (i.e., the measure that determined the student entered the next stage or completed the study) were focused on in re-scoring. The experimenter randomly selected 30% of the talk aloud transcriptions demonstrating 87% agreement.

### Procedures

**Baseline.** During baseline, Jerry was given the dependent variable, two-minute timed trials placing sentences from expository science text into logical order. He answered the questions silently on five separate days with the opportunity to continue answering as many problems as possible in the time limit (i.e., because this was a frequency measure, Jerry was asked to complete as many as he could in two minutes). Once a stable baseline was demonstrated (i.e., determined with at least five data points), the student began the intervention (i.e., TAPS/FBPC).

**Talk aloud problem solving.** During TAPS, 10-15 minute lessons following an explicit instruction format were followed by a two-minute, one problem, timed talk aloud trial (i.e., used to measure mastery of the intervention). During the talk aloud trial, the student was asked to explain aloud how he came up with his answers until the timer went off. After the two-minute timed talk aloud, the dependent variable was measured.

**Frequency building to a performance criterion.** Once Jerry demonstrated accuracy (8 talk alouds about cues for three consecutive days) with the problem solving skills, he moved on to the second stage of the independent variable. To demonstrate accuracy, Jerry was required to talk aloud about cues eight times within two minutes. The next stage was FBPC. During FBPC the goal was to become fluent at talking aloud about how to place sentences in a logical order. Jerry read through two-minute timed talk aloud problem (i.e., with one problem containing four sentences) and placed the sentences in order while talking aloud. Following the timed talk aloud, the experimenter gave Jerry one minute of feedback. He then practiced the same prompt again, applying the feedback from the experimenter. After the second practice, he received one minute of feedback again. The dependent variable was administered once he was given feedback for the second time. A criterion was established from "expert" learners (i.e., two high school students taking Advanced Placement or AP courses in science) that required him to reach 16 talk alouds about cues to exit the study.

## Results

### Rationale for Standard Celeration Chart

All results from the experiment are presented in a graphical and tabular format. Standard Celeration Charts (SCC) segments are displayed in Figure 1. The SCC is a ratio chart that shows successive calendar days along the horizontal axis and count per minute frequencies on the vertical axis. Displaying data in real time allowed the experimenter to show the behavior change picture that occurred while accounting for days missed or when the student was unavailable for participation. The SCC allows for consistent displays of data across participants along with an ability to quantify important aspects of behavioral data such as celeration or the speed and progress of learning (discussed below).

The Standard Celeration Chart is a conservative representation of data change that enables experimenters and teachers to use change measures like celeration, Improvement Index (I.I.), and frequency and celeration multipliers. Celeration describes how significant the student's behavior changes over time, and the direction of the behavior change. For example, a x2.0 celeration means the student's behavior is doubling per week. To compare two data points, such as the last one in baseline and the first in the intervention, the frequency multiplier allows experimenters to accurately depict the immediacy of change upon introduction of a variable. Frequency multipliers also quantify the relationship between two frequencies. The value is calculated by determining the multiplicative factor the first frequency data point must change in order to get to the second frequency data point (Pennypacker, Guitierrez, & Lindsley, 2003). In other words the frequency multiplier provides a way to analyze the immediacy of impact between conditions, a condition necessary for single case experimental designs (Kratochwill et al., 2012).

Another important metric, the Improvement Index (I.I.), shows the degree of progress improvement. I.I. is calculated by taking concurrent celerations for corrects and incorrects and combining them into a ratio (Kubina 2018). I.I. was calculated in order to quantify the accuracy of student learning taking into account both deceleration and acceleration data. The I.I. values were compared against published significance criteria (Kubina & Yurich, 2012). The correct responses are labeled with dots and the incorrect responses are labeled with X's in agreement with SCC conventions. Celeration multipliers, or celeration turns, represent the change in learning between phases (i.e., with a minimum of 5-7 data points in each phase) quantifying how the learning changes (Kubina & Yurich, 2012). The celeration multiplier is calculated by comparing the celerations for corrects in one phase between the celeration for corrects in the following phase (i.e., with the same procedure for incorrects).

### Correct and Incorrect Sequence of Sentences

**Jerry**. Figure 1 displays Jerry's results across baseline along with the TAPS/FBPC. Across the five data points in baseline, Jerry's learning worsened. His correct and incorrect responses diverged from the first data point demonstrating increasingly inaccurate learning. In baseline, Jerry's correct sequence of sentences or CSS decelerated with a celeration of ÷8.2 [5 days]. Incorrect sequences of sentences or ISS increased with a celeration of x7.4 [5 days], indicating rapid growth. The Improvement Index (I.I.) across baseline came to ÷60.5 [5 days]. I.I. indicated a substantial deterioration of progress over time and led to the decision to start Jerry with the independent variable.

During the TAPS/FBPC, lessons and practice talking aloud resulted in overall change in direction for Jerry's correct and incorrect celerations. The CSS accelerated x1.3 [25 days] and ISS decelerated ÷1.65 [25 days]. Upon entering the intervention, Jerry's correct performance frequency jumped up x2.9 and incorrects jumped down ÷1.4. The I.I. during TAPS/FBPC changed to x2.15 [25 days] demonstrating a substantial accuracy improvement. The celeration multiplier indicated substantial changes in learning between phases with a turn up of x10.7 for corrects and a turn down of ÷12.2 for incorrects.

## Discussion

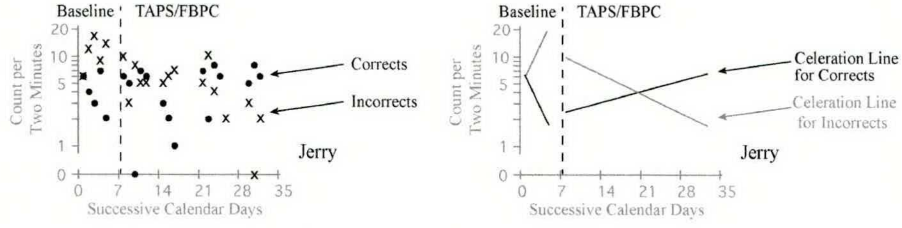
The present study is the first to systematically explore the effects of a TAPS/FBPC with a student at-risk for failure in reading. The experimenter targeted a basic problem solving skill of placing sentences in a logical order using general education content. The data collected from the current study begin to build an empirically based procedure for creating a replicable problem solving model. The task of placing sentences in a logical order starts to examine the language used in expository science text and the student's awareness of sentence structure within different texts. Fourth grade students are beginning to read for content understanding and are asked to solve problems that may be complicated by being unaware of cues provided by the text. Fourth grade students begin to build their content knowledge, and this study explores the start of an elementary student's introduction to language in science and the ways they problem solve to make sense of what they read.

With the experimental case study, Jerry's data clearly demonstrated an inability to progress during baseline with rapidly growing incorrect and decelerating corrects. His I.I. value of ÷60.5 indicates a poor condition of progress (Kubina & Yurich, 2012). The deteriorating baseline performance over five days established a need for Jerry to begin the intervention TAPS/FBPC.

Upon introduction of the TAPS/FBPC, Jerry demonstrated immediate improvement. Jerry's correct performance had an immediate, impressive jump up in frequency by x2.9. Additionally, his incorrects jumped down by ÷1.4. An immediate and abrupt change of the data upon application of an intervention provides evidence the independent variable had an effect (Kratochwill et al., 2012). Jerry's data visually and quantitatively show a positive, sudden impact for both correct and incorrect responses.

Beyond the first day of instruction, Jerry's performance continued to improve during the intervention. His celeration demonstrated a significant improvement in comparison to

**Figure 1. Jerry's Correct and Incorrect Sequence of Sentences**




Change Measures

Baseline Celeration
Corrects ÷8.2 [5 days]
Incorrects x7.4 [5 days]
Baseline I.I.
÷60.5 [5 days]

TAPS Intervention Celeration
Corrects x1.3 [25 days]
Incorrects ÷1.65 [25 days]
TAPS Intervention I.I.
x2.15 [25 days]

Frequency Multiplier
Corrects x2.9
Incorrects ÷1.4
Celeration Multiplier
Corrects x10.7
Incorrects x12.2

baseline. Jerry's improving performance included clear improvement in accuracy along with significant changes in learning as indicated by the celeration multiplier (i.e., x10.7 for corrects and ÷12.2 for incorrects). Quantifying data to demonstrate both immediate and ongoing improvements from the Talk Aloud Problem Solving Intervention shows promise for student outcomes and begins to explore a replicable procedure to study further.

Previous research in talking aloud or thinking aloud in reading has demonstrated the importance of including explicit modeling and prompting with instruction (Baumann, Seifert-Kessell, & Jones, 1992; Bereiter & Bird, 1985). The present research suggests that when explicit procedures are paired with frequency building to a performance criterion, a struggling student can demonstrate talk aloud levels similar to students who were successful at problem solving (i.e., approximately 16 talk alouds about cues in the sentences). A rich history of literature shows extended practice can lead to "improvement in performance by an order of magnitude, along with a huge reduction in the range of interindividual differences" (Hunt, 2006, p. 31). Thus, the present experiment systematically extends the research base showing practice, specifically frequency building to a performance criterion, with a targeted problem solving skill with science content leads to a significant improvement.

TAPS/FBPC offers a number of advantages in classroom use. The independent measure of talking aloud, for instance, showed a level of sensitivity that was helpful in determining how much learning took place. Using a sensitive measure such as frequency, or count, demonstrates a time saving and efficient way to quantify the most powerful interventions for individual students. Daily frequency measurement allows teachers to collect a large amount of data that leads to a clearer picture of behavior change (Kubina & Yurich, 2012). Instruction using scripted lessons and a simple practice procedure can be implemented easily into a small group setting for students who demonstrate a need for additional instruction.

All content areas involve problem solving, but not all areas have measures of proficiency (e.g., digits per minute in mathematics). There is a large amount of literature aimed at students acquiring different reading skills (NRC; Snow, Burns, & Griffin, 1998), but a lack of data-driven techniques to help them establish proficiency in higher order skills such as problem solving. Providing science teachers with a timed quantity can lead to informative decision-making across students. More information for problem solving in different science contexts would prove useful. For example, in math it is recommended that students who are struggling are given explicit instruction and provided with opportunities to talk through the decisions they make and the steps they take (National Mathematics Advisory Panel, 2008). By simply talking aloud, the teacher has data that will identify the area the student is struggling. Students in science class learning about evolution can demonstrate the use of several strategies while performing a task and receive immediate feedback on their performance.

Other fields have explored the possibility of TAPS in the teaching and learning of content specific to their field. TAPS with partners was used for examining the troubleshooting ability of university level aviation technician students (Johnson & Chung, 1999), high school chemistry problem solving (Jeon et al., 2005; Tingle & Good, 1990), high school science (Pestel, 1993) and math instruction (Kani & Shahrill, 2015), college power equipment course (Pate, Wardlow, & Johnson, 2014; Pate & Young, 2014), secondary level agriculture and industrial technology course (Pate & Miller, 2011), and combining learning techniques in mechanics with a multimedia component (Holzer & Anduret, 2000). The use of TAPS in science provides an explicit, replicable intervention to help guide students in advanced problem solving.

TAPS is recognized in the chemistry community as a worthwhile intervention to continue exploring (Bodner & Herron, 2002). Studies using TAPS for older students helped guide misunderstandings, develop recognition of skills, and allow students to solve problems with immediate feedback. Not only do students receive corrective feedback, but they also display correct use of problem solving strategies and acquisition of skills for the teacher to directly observe. A guided approach with immediate feedback is as important in solving equations in chemistry as it is for students solving problems using expository text after years of reading narrative text. Whatever type of expository text students encounter they have one thing in common, the goal is to correctly solve the problem of comprehending the meaning of sentences. The present study includes concepts such as minerals seen in chemistry, to motion and forces addressed in advanced physics. The positive aspects of TAPS/FBPC should begin in earlier grades and help students become more fluent in preparation for more complex skills as they continue through school. Problem solving in science begins with a basic understanding of the text and content and continues on to more complex skills.

**Future Directions and Limitations**

The TAPS/FBPC in the present experimental case study shows promise in content areas that involve problem solving. With this promise comes the need to explore the TAPS/FBPC intervention with continued scrutiny and experimental rigor. The current case study requires replication to further examine the functional relation. Systematic replication for future studies should vary age groups and ability levels to examine if the present intervention produces similar results for classroom teachers and students in different settings. The TAPS/FBPC was conducted with a student at-risk for a disability and would be beneficial if conducted with students with learning disabilities or other disability categories.

Varied content and skill levels are needed to examine instructional needs and scaffolding required to use TAPS/FBPC successfully. Different ages and skills levels will provide expectations that are useful for classroom teachers. The current study also demonstrated the need for more field-tested probes to eliminate possible confounds existing within the difficulty of text and prior knowledge. More probes will also need to be created to develop a truly random selection of materials.

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