TeenACE for Science: Using Multimedia Tools and Scaffolds to Support Writing

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Abstract

TeenACE for Science (TAS) is a writing intervention that combines components of Multimedia Technology, Universal Design for Learning (UDL), and Self-Regulated Strategy Development (SRSD) to help students develop expository writing skills in science. This developmental study examined the effect of the TAS intervention with two groups of culturally and linguistically diverse middle school students. Forty-six students in two classrooms that included general and special education students participated in a 12-week intervention during which they wrote multiple science reports. Students used the multimodal features of a productivity software (PowerPoint) to organize pictures and headings, take notes on a cognitive map, type in text, and record their voices narrating what they had written. This mixed methods study utilized pre-post tests and curriculum-based measures to examine quantitative changes. Qualitative measures included surveys and focus groups. Pre-post test results showed that students scored significantly higher on two *Woodcock Johnson III* subtests (Writing Fluency and Writing Samples) though no significant change was noted on the Editing subtest. Teachers rated the intervention as relevant, useful, and high quality; they reported continued use of the same protocol at a 1-year follow-up.

Key Words: expository writing, science, multimedia technology, universal design for learning, self-regulated strategy development

The ability to write effectively in a variety of genres involves a set of skills that students are expected to develop in the secondary school years. The National Assessment of Educational Progress (NAEP, 2011) Writing Framework described the characteristics of a skilled writer as one who could (a) develop and organize ideas, (b) use language for communicative purposes (persuade, explain, and convey experience), (c) use commonly available computer-based word-processing tools (editing, formatting, and text analysis), and (d) respond to on-demand requests for written responses. The Common Core State Standards English Language Arts (CCSS-ELA) specify that, from grades 6-12, students should demonstrate an increasing sophistication in language use and address increasingly demanding content and sources. The CCSS writing standards in the content areas highlight the need for students to address discipline-specific content, write a range of explanatory and informative texts, conduct research projects, and produce clear and coherent writing (CCSS Initiative, 2012); however, only 27% of 8th and 12th graders achieved proficiency in the most recent NAEP writing assessment (NAEP, 2011).

Many teachers face the challenge of teaching the processes of writing in the content areas to students entering middle school who do not possess the foundational writing skills. Students in a typical inclusion classroom have varied backgrounds and learning needs. These may include students receiving special education services, English language learners (ELLs), students who are culturally and linguistically diverse (CLD), and students who require additional supports to master the middle grades ELA and Science standards (National Science Foundation, 2009). In rural areas, teachers also may work in schools located in high poverty communities, work with students in multiple grade levels, have students with low incidence disabilities in their classrooms, and lack access to fiscal resources and specialists. Teachers would benefit from methods that provide additional supports to address a broad range of writing skills while concurrently developing student use of a structured writing process that produces more skilled and independent writers. Previous studies indicate that explicitly teaching writing strategies, planning, editing, goal-setting and note-taking produced significant positive impacts on writing quality (Gillespie & Graham, 2014; Hebert, Graham, Rigby-Wills, & Ganson, 2014; Kiuhara, O'Neill, Hawken, & Graham, 2012).

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This study describes the development and implementation of a writing project, TeenACE for Science, designed to address CCSS-ELA as well as Next Generation Science Standards (NGSS; 2015) standards in general education classrooms with diverse student populations. TeenACE for Science provides support and scaffolding for writing in the content area, focusing on the foundational processes of writing and connecting the processes with expository writing in science. The project addresses instruction for diverse learners in middle school classrooms, including students with disabilities as well as those who are CLD. The project provides opportunities to practice planning, organizing, drafting, editing, and revising in a structured way that is flexible and allows for varied levels of writing proficiency.

Developing lessons aligned with the CCSS-ELA and NGSS is an essential skill for teachers in planning, managing, and organizing instruction (Graham & Harris, 2013). The common core standards integrate language and literacy development with content-area knowledge and skill acquisition. For example, the CCSS-ELA (2012) standards for Grades 6-8 define the competencies students should have in "producing and publishing well-organized text appropriate to task and purpose by planning, drafting, revising, and collaborating with others" (p. 28). Students also must use writing to recall, organize, analyze, interpret, and build knowledge on content area topics. They must consider word choice, sentence structure, and conventions. The Science standards also emphasize the need for students to convey their meaning and intention, express key details and ideas, follow multi-step procedures when carrying out experiments, and compare and contrast the information gained from experiments and other sources. TeenACE for Science provides a model that teachers can use to meet these standards by integrating science content and a structured technology-based writing process.

For diverse students who need extra supports for literacy development, writing in science can pose challenges due to the specific and technical nature of the vocabulary and content of the science curriculum (Kiuhara et al., 2012; Powers & Stansfield, 2009). ELLs often need extra supports to build background and context for grade level science curriculum (Quinn, Lee, & Valdes, 2012). Students with literacy-related disabilities can benefit from instruction on how to generate and organize written text (Gillespie & Graham, 2014). TeenACE for Science includes these and other scaffolds and supports that take into consideration the academic language development needs of diverse students.

Rural Special Education Setting

The TeenACE for Science project was developed with teachers in rural school settings on a neighbor island in the state of Hawaii. With a population of about 7,500 people, the island center is one small town; most people live on rural homesteads and farms. Students are from CLD backgrounds, reflecting generations of immigration to the island. The population includes a majority (70%) of Native Hawaiian students, as well as individuals of Asian and mixed European backgrounds. Though most students are born in the United States, they speak non-standard English (Hawaiian Creole English). The students live in traditional and extended family settings, many of their parents and grandparents engaged in agriculture and fishing. Although the students are exposed to rich experiences of informal science, they are not as familiar with the academic and formal language of science. In rural classrooms where resources are limited, inclusion of students with special needs often is created naturally. Many students are not assessed or identified. In the two classrooms chosen for this study, each included students with identified special needs, 11% and 5% respectively.

TeenACE for Science

The TeenACE for Science (TAS) project was developed to address the CCSS Literacy in Science and NGSS standards, focusing specifically on the skills required to conduct research and write a quality report on a science topic. TeenACE for Science focused on *expository* writing, and was based on a similar project that targeted *narrative* writing skills. In the original project known as TeenACE Writing, high school students who were ELLs were given the task of writing a story with a set of pictures as prompts and using multimedia software (Dowrick & Yuen, 2006a). Using these pictures, students generated sentences and paragraphs, read and recorded their writing, listened and revised, and finally discussed their work with peers, teachers, and family members. The use of technology was a key component of the project. Using readily-available presentation software (e.g., Microsoft PowerPoint, Libre Office), students developed their projects on the computer in pairs or individually.

Research on TeenACE for Writing

Studies on the TeenACE Writing strategy showed positive gains for students on measures of academic progress as well as engagement (Dowrick & Yuen, 2006b; Dowrick 2009; Rao, Dowrick, Yuen, & Boisvert, 2009). Between 2004 and 2008, researchers implemented TeenACE Writing programs for 8 to 12 weeks in schools located in communities with low rates of academic achievement, high rates of poverty, and a majority of ethnic and cultural groups (Dowrick & Yuen, 2006b). They reported large effect sizes (ES = .80) when participants in a TeenACE intervention group were compared with a Class-as-Usual group. Although initial numbers in this pilot study were small, subsequent efficacy study outcomes from the research on TeenACE found that teens were more motivated to write when using technology and made rapid gains in vocabulary, reading fluency, and comprehension (Dowrick, 2009). In a quasi-experimental study conducted with students receiving special education services in a rural high school setting (Rao et al., 2009), researchers found that TeenACE Writing resulted in statistically significant gains in writing outcomes measured on a rubric. The lower performing group of students in this study made the most gains between the first and last story written (out of five stories), appearing to benefit from the structured writing process. The classroom teacher who participated in this study described other benefits of this writing process for students, including an increased confidence in writing, more self-efficacy, and independence with writing tasks. Students were engaged by the technology-based writing environment and used the assistive features as intended. For example, students used the text-to-speech feature to listen to the words they typed on screen and were able to hear errors in their writing. They willingly edited and revised their text, which they did not often do when reading paper-based writing.

Multimedia Technology and Universal Design for Learning

Multimedia technology is an essential component of the TeenACE strategy, providing an environment in which students generate and present information. Multimedia software provides a creative environment for writing that can be a welcome alternative to traditional writing for students who struggle with literacy. For students who stare at a blank page of paper, unable to begin writing, the multimodal nature of digital media can provide essential scaffolds that help them to practice writing skills. Commonly used software, such as Microsoft PowerPoint, can be a powerful and engaging multimedia canvas for generating writing. PowerPoint (and similar presentation suites, such as Apple Keynote or Libre Office) can be used to combine text, photos, audio, and video.

Technology inherently has several "assistive" supports that can be useful for students with and without disabilities. For example, students who struggle with writing can benefit from keyboarding on the computer (Wanderman, 2008). Typed text can be clearer than handwritten text, it can be easily modified and edited, and it can be converted to audio, allowing students to hear what they have just typed. These supports are beneficial for many students, giving them multimodal ways to engage with text. Multimedia environments also allow text to be combined with visual elements. Struggling writers benefit from having visual prompts for writing. For example, the student who is unable to generate a sentence in the abstract may be able to write when given a photo and asked to describe specific elements.

The use of multimodal tools for generating writing is supported by the theory and practice of Universal Design for Learning (UDL). UDL is based on three main principles, providing multiple means of (a) representation, (b) action and expression, and (c) engagement (Center for Applied Special Technology, 2011), which are further defined by nine guidelines for providing flexible options within curriculum (Hall, Meyer, & and Rose, 2012). Technology and digital media provide natural avenues for meeting many UDL guidelines (Bryant, Rao, & Ok, 2014). Students can receive information in multiple formats, visually and aurally, through digital media. To provide options for expression, technology provides a range of creative possibilities. Students can compose information using photos and videos and organize and present information using various software. Students also are engaged when they are given the opportunity to use technology in the classroom and authentic tasks.

Self-Regulated Strategy Development

Self-Regulated Strategy Development (SRSD) is an evidence-based practice developed by Harris and Graham in 1996. Several meta-analyses of the research literature confirm the overall effectiveness of SRSD, citing high average weighted effect sizes (Graham & Harris, 2003; Graham & Perrin, 2006; Graham, 2006). TAS incorporates three of the major elements of the SRSD research. First, students are taught to carry out specific steps in the writing process, (e.g. outlining, researching, note-taking). Second, students are taught through cognitive modeling to develop self-regulatory procedures (e.g., use self-monitoring checklists, use self-assessment tools). Third, teachers use the six stages of SRSD instruction (i.e., Develop Background Knowledge, Discuss It, Model It, Memorize It, Support It, and Independent Performance) to increase students' independence, motivation, and self-efficacy. Teachers provide constructive feedback and encourage setting higher goals to mastery on individualized recursive writing projects. Although SRSD has been used with a variety of writing tasks, research on *expository* writing skills found improvements in quality, length, and completeness of writing, with results maintained over time (Lane et al., 2008; Lienemann & Reid, 2008).

The use of mnemonics is emphasized in the Memorize It step of the SRSD framework. We developed the POWER 8 mnemonic for TAS, adapting Culham's (2003) 6+1 traits to target eight writing skills and integrating that with Harris, Graham, Mason, and Friedlander's (2008) POWER mnemonic (i.e., pick a topic, organize, write a draft, evaluate, revise) to help students remember the steps in the writing process. The adapted POWER 8 traits include pick a topic, picture organization, outline, organize, write words, write sentences, evaluate and edit, revise and present. This POWER 8 mnemonic is one of the core parts of the TAS Process used as students develop and assess their work (on a POWER 8 rubric).

Purpose of the Study

The TeenACE for Science project was funded through a Steppingstones of Technology development grant by the Office of Special Education Programs. In the first 2 years, the research team developed the TAS protocols and implemented the project in three schools, two rural and one urban. In this article, we present the results of the pilot study in the two rural classrooms and discuss the implications of the TAS intervention in a rural setting. We conducted a mixed-methods study examining student outcomes, teacher implementation, and social validity of the project, guided by the following research questions:

1. Does TeenACE for Science improve student performance on standardized tests and curriculum-based measures of writing?
2. Does TeenACE for Science affect teacher and student perceptions of the writing process?
3. Do teachers, students and coaches regard TeenACE for Science as a relevant, useful, and high quality intervention?

Methods

Setting and Participants

Our participants were the teachers, educational coaches, and students in two middle school classrooms. Class 1 was a rural private school classroom with 26 students in Grades 5 to 8. Class 2 was a rural public school classroom with 20 students in Grade 7. Table 1 provides descriptions of the participants, including ethnicity, gender, language spoken at home, and eligibility for special education services. The majority of students (70 to 85 %) identified themselves as Hawaiian or Part-Hawaiian. Although most students (92 to 95%) reported speaking English at home, typically this included a local form of non-standard English or Hawaiian Creole English. Both schools were located in a community where 75% of the students qualified for the free/reduced-rate federal school lunch program. Table 2 presents a description of the teachers and coaches, including age, years of experience, gender, ethnicity, role, and educational level.

We trained classroom teachers and coaches during a 3-hr workshop at the beginning of the 12-week implementation. Project staff provided ongoing mentoring twice per week in the classroom during writing period throughout the intervention. Coaches were educational assistants, parent volunteers, high school students, or other members of the community and worked with students during and after school hours. Coaches could easily follow the TAS step-by-step protocol to assist students with writing, editing, revising, and publishing student work. Throughout the process, students evaluated their own writing skills and discussed their writing goals with coaches (and classroom teachers). This dialogue gave the students a variety of perspectives on the science content and the writing process.

Research Design

This study employed a mixed methods research design, combining quantitative and qualitative methods to address the research questions. For the quantitative analysis, we used a within person, pre- versus post-intervention comparison design to address the first research question about the effect of TAS on student writing outcomes. For the qualitative component of the study, we used teacher/student surveys and focus groups in a naturalistic case study design to collect data on the second and third research questions about student/teacher perceptions of the writing process and the social validity of TAS.

Development of TeenACE for Science Project

We used an iterative process to develop, refine, and field test the 12-week supplementary writing interventions as follows:

Phase 1: Developed TAS protocols based on prior TeenACE for Writing projects; incorporated additional strategies and assessments that addressed writing in Science.

Table 1

Description of the Participants in Class 1 and Class 2

Characteristic	Class 1 (n 26)	Class 2 (n 20)
Race Caucasian	2 (7.7%)	0 (0%)
African American	1 (3.8%)	0 (0%)
Filipino	0 (0%)	2 (10%)
Asian Races Except for Filipino	2 (7.7%)	0 (0%)
Hawaiian/Part Hawaiian	18 (69.2%)	17 (85%)
Pacific Islander	0	0
Multiple Races Except for Part Hawaiian	3 (11.5%)	1 (5%)
Language Spoken at Home English	24 (92.3%)	19 (95%)
English and Another Language	1 (3.8%)	0 (0%)
Language Other Than English	0 (0%)	1 (5%)
Gender Female	12 (46.2%)	12 (60%)
Male	14 (53.8%)	8 (40%)
Special needs	3 (11%)	1 (5%)

Note. Part-Hawaiian is a student of Hawaiian ancestry and mixed ethnicity

Phase 2: Identified Class 1, conducted universal screening, trained teachers and coaches, provided on going support, implemented TAS program, promoted "real-life" experiences for students to share science projects and writing with parents and community, and assessed student growth in writing with standardized and curriculum based measures; conducted surveys and focus groups at the end of each intervention.

Phase 3: Analyzed findings; revised and improved program interventions/protocols based on data from Class 1.

Phase 4: Repeated field tests in subsequent semesters at second site (Class 2).

Phase 5: Analyzed findings, developed training materials, planned future research, and disseminated information.

The TAS Writing Process

The TAS writing process follows a step-by-step procedure that provides students with a structure for researching, taking notes, writing, editing, revising, and publishing their work. The process can be used for a variety of typical science reports (e.g., sequential, compare/contrast, cause/effect), such as (a) descriptions of experiments, (b) factual topics, or (c) original research investigations using the scientific method. The process has five steps:

1. Prepare Instructional Materials
2. Students Research and Organize
3. Students Draft and Edit
4. Students Record and Listen
5. Evaluate and Monitor Progress

In steps 2-4, students are provided with various scaffolds to use during the writing process. Figure 1, the Quick Start Guide, summarizes the steps in the writing process and was based on Harris et al.'s (2008) POWER acronym (i.e., pick a topic, organize, write a draft, evaluate, revise).

Step 1. Planning and instructional materials. After developing a standards-based lesson plan, teachers create a set of 6 to 9 pictures with headings that outline the major sections of a science report (e.g., introduction, background, hypothesis, method). The set can be cut into individual pictures/headings and placed into a small plastic bag (see Figure 3). The teacher then prepares the POWER 8 materials and places these in a student folder that contains (a) a student checklist with the steps of the writing process, (b) a copy of the POWER 8 rubric, (c) the POWER 8 Curriculum-Based Measure (CBM) Assessment, and (d) the picture set. Finally, teachers introduce students to the POWER 8 writing process, the rubrics, and CBM assessment materials in their folders following the instructions in the teacher's guide.

Step 2. Students research, take notes, and organize information. Students are given the picture sets and asked to paste them into their template in an order that makes sense. They work individually or in pairs to research the topic and/or conduct an experiment. While they are doing this, they take brief notes on their organizers (cognitive maps) until they gather all the information needed to begin writing (see Figure 4).

Step 3. Draft and edit (Presentation software). Students are instructed to draft a paragraph under each picture heading and continue until a report with all the information is completed. If this is done with paper and pencil, the students type their work into the presentation

Table 2

Description of Teachers/Coaches in Class 1 and Class 2

	Age Range (Years Teaching)	Gender	Ethnicity	Position with School	Highest Degree
Class 1					
Teacher 1	60's (30)	F	Caucasian	Head of School	Professional Degree, Speech
Teacher 2	50's (20)	F	Caucasian	Principal	M. Ed.
Coach 1	30's (8)	M	Hawaiian/Part Hawaiian	Educational Assistant	High School Diploma
Coach 2	50's (30)	F	Caucasian	TAS Coach	B. Ed.
Class 2					
Teacher 1	40's (15)	F	Hawaiian/Part Hawaiian	Language Arts Teacher	B. Ed.
Teacher 2	40's (20)	F	Caucasian	Science Teacher	M. S.
Coach 1	30's (9)	F	Hawaiian/Part Hawaiian	Educational Assistant	Associates Degree

template on the computer. Students are encouraged to include scientific vocabulary, transitions, varying sentence structure, and the appropriate conventions of writing. The teacher can provide scaffolds or differentiate the assignment to meet student needs.

Step 4. Record and listen, revise, present. Once a student has completed the first draft, the student make an audio recording of what he or she has written, listen to it, and revise his or her writing, as needed. Students are encouraged to present their work to peers or other audiences in community as well as school settings, such as a science fair or symposium.

Step 5. Evaluate and monitor progress. Finally, using the POWER 8 Rubric and CBM Assessment, students evaluate their reports on each of the eight traits of writing, using a Likert scale of 1 to 5, and graph their progress (see Figure 5). Teachers use the same rubric to evaluate the student's work, meet with the student to discuss the ratings, and identify goals for improvement in subsequent reports.

An article describing each step of the process, as well as links to download the curriculum resources can be found at http://www.cec.sped.org/Publications/CEC-Journals/TEACHING-Exceptional-Children/TEC-Plus/Power-Assisted-Writing-for-Science-Developing-Expository-Writing-in-a-Multimedia-Environment. This article provides links to the curriculum resources (tools, rubrics, graphs, and UDL table) developed by the TAS project for teachers (Hitchcock & Rao, 2013).

Measures and Data Analysis

We conducted summative assessments with standardized tests pre- and post-intervention to determine whether TAS improved student outcomes in writing. We administered three writing subtests from the *Woodcock Johnson III NU Tests of Achievement* (Woodcock, McGrew, Mather, & Shrank, 2006): (a) Writing Fluency (e.g., formulating and writing simple sentences quickly), (b) Writing Samples (e.g., quality of expression, increasing length, level of vocabulary, grammatical complexity, level of concept abstraction), and (c) Editing (e.g. identifying/correcting mechanical errors or word usage). We used alternate forms of the WJIII before (Form A) and after (Form B) each field trial and analyzed for within group differences.

Formative assessments consisted of CBMs conducted at the completion of each science report (Fuchs, Fuchs, Hosp, & Jenkins, 2001). These CBMs generated ratings assigned by the teacher and student on the eight selected writing skills (i.e., topic clarity, organization, background research, use of a cognitive map, academic vocabulary, sentence structure, mechanics, presentation). Teachers and students used a 5-point Likert scale tied to a rubric for each of the eight writing skills. The rubric also was linked to the CCS-LA (CCSS Initiative, 2012).

We used a repeated measures ANOVA to analyze the improvements over time in primary writing outcomes, the WJ III tests, and CBMs during TAS implementation. Other data analysis included descriptive statistics on demographics and social validity ratings, visual analysis of graphs from student CBMs, fidelity of implementation with checklists designed for this research, qualitative analysis of pre/post surveys, and focus groups.

We gathered qualitative data to examine teacher and student perceptions of using this writing process (e.g., what they liked, what could be improved, whether they

Table 3

Changes over Time in Grade Equivalency Score (GE) on Standardized WJIII NU Writing Cluster and Subtests.

	Writing Subtest	Mean (SD) Pretest	Mean (SD) Posttest		p
Class 1	Written Expression Cluster	7.2 (2.44)	10.6 (4.59)	$F(1,25) = 39.96$	.000***
	Writing Fluency	6.1 (2.10)	9.5 (4.09)	$F(1,25) = 38.85$	.000***
	Writing Samples	9.3 (3.94)	11.1 (4.13)	$F(1,25) = 12.08$	.002**
	Editing	7.7 (3.25)	8.0 (3.09)	$F(1,25) = .31$	.585
Class 2	Written Expression Cluster	6.6 (2.54)	7.7 (2.71)	$F(1,19) = 3.16$	.091
	Writing Fluency	6.3 (2.16)	7.2 (2.89)	$F(1,25) = 4.48$	.048*
	Writing Samples	7.0 (3.32)	9.1 (3.20)	$F(1,25) = 9.61$	.006**
	Editing	6.0 (1.97)	6.6 (1.57)	$F(1,25) = 1.55$	.229

Note. *: $p < .05$ **: $p < .01$ ***: $p < .001$

recommend a friend use it). At the end of each field trial, data collection included individual written surveys administered to each participant and a follow-up focus group (recorded and transcribed) using the same questions. In addition, we asked survey participants to measure social validity (i.e., whether teachers, students, and coaches rated the intervention as relevant, useful, and high quality). We used a 5-point Likert scale where 1 was strongly disagree and 5 was strongly agree. We analyzed the qualitative data collected using the Constant Comparison Method (Dye, Schatz, Rosenberg & Coleman, 2000) with NVivo 10. Throughout the data set, we used codes or NVivo "nodes" to assign meaning to different parts of the text. We then grouped codes into eight "tree nodes:" (a) scaffolding, (b) technology, (c) reading, (d) vocabulary, (e) ELL, (f) other-centered (students), (g) reinforcing writing, and (h) self-reflection (teachers). We also analyzed transcripts from the focus groups and survey results in a three-pass read through to ensure for consistency between software and researcher analysis. Both analyses identified key issues, recurrent events, and activities; developed categories, compared incidents within each category, and identified the frequency, properties, and scope of the categories and subcategories; and identified relationships. The qualitative analysis provided an in-depth explanation of the whys and why nots and provided insight into the hows of the intervention and how TAS could be improved.

Implementation Fidelity

To determine if the TAS process was implemented with fidelity at the end of each field test, an independent observer completed a fidelity checklist. We calculated measures on the following aspects of implementation: (a) level of implementation (length, frequency, dosage), (b) program content coverage (the use of program protocols, existence of TeenACE characteristics), (c) setting, and (d) training and technical assistance received. The fidelity scores for both Class 1 and 2 were 100%. Minor variations in implementation included adjustments in time and technology work-arounds.

Respondents frequently cited time to spend on writing projects as a challenge in the public schools where, on average, each report required 2 to 4 weeks to complete. They also needed work-arounds to compensate for glitches in the technology. Although both classrooms used a commonly available software presentation program (i.e., Microsoft PowerPoint) on either PC or Mac computers, there were frequent challenges with the sound recording component. Sometimes the sound file would not play or simply disappear. One low-tech work-around was to have a peer read another student's text on each slide (including mistakes) to provide the same effect, namely that the student could hear, as well as see, what the student had written. Another work-around was to use the text-to-speech function in the software.

Group Size, Intervention Duration, and Intensity

The intervention for Class 1 was implemented during two 1-hr weekly writing blocks for 12 weeks. The intervention for Class 2 was implemented during four 45-min periods each week for 12 weeks. After subtracting time (15 min) in Class 2 spent on other activities, such as journal writing, the weekly dosage was consistent across classrooms (i.e., 2 hrs). Class 1 wrote 5 reports and Class 2, on the basis of teacher recommendations from Class 1, wrote 4. Students wrote reports on a variety of science topics, including an element from the periodic table, a chemistry experiment, a disease, a medical technology, invasive plants, organelles, and a variety of student-selected science research issues. We encouraged peer collaboration and mentoring during the research and revision stages of the writing process. We required individual work products on the first and last essay to provide a pre-post comparison of growth on the CBM measures. We targeted the six lowest scoring students at pre-test for extra support from the coach or teacher. The coach reviewed student progress in writing assignments for each student weekly and prioritized "coaching" time with those students who were identified as falling behind their peers. Typically, these were the same students that pre/post-test assessments, school assessments, and teachers identified as "low performing." Coaching students consisted of the asking of open-ended questions, note taking of student oral responses (if needed), redirection for inattention, and small group or one-to-one assistance. We faded these "supports" as students' ability to write independently increased.

Results

In this section, we summarize results from the quantitative and qualitative measures. First, we report the standardized measures (i.e., WJ III Tests), and CBMs, followed by the qualitative data collected from Class 1 and Class 2.

Standardized WJ III Tests

Class 1. We observed significant improvements in grade level scores on Writing Fluency, Writing Samples, and Written Expression, which is a cluster formed by Writing Fluency and Writing Samples tests, but not on Editing (See Figure 1). During the TAS implementation, students' grade level equivalency scores rose from 6.1 to 9.5 on Writing Fluency, 9.3 to 11.1 on Writing Samples, and 7.2 to 10.6 on the written language cluster Written Expression (See Table 3). In addition, students identified as struggling writers and needing extra support also made some progress but not as much as their general education peers.

Class 2. We observed significant improvements in grade level scores on the Writing Fluency and Writing Samples, with an average of 0.9 grades gain on Writing Fluency and 2.1 grade-level gains on Writing Samples; however, the improvement on the Editing test and the written language cluster Written Expression did not reach statistical significance (see Table 3).

Formative Assessment: POWER 8 CBM Assessments of Essays

In addition to the standardized battery tests, we obtained CBMs of students' science reports using a writing rubric (i.e., the POWER 8 rubric) from both students and teachers. A composite POWER 8 score is derived from the points assigned to eight traits of writing based on the rubric. The range of points was 1 to 5 for each trait and 8 to 40 for each report.

Class 1. We analyzed teacher-assessed POWER 8 rubric scores of the first and last essays written by students during the 12-week intervention using repeated measures GLM (general linear model). A total of 21 students had complete scores on two essays and were included in the analysis. The analysis showed a significant within-subjects effect of time, $F(1,20) = 50.76$, $P<.001$. Teachers gave significantly higher writing scores on students' last essay than their first essay. Means (and standards deviations) increased from 14.5 (4.38) to 25.0 (4.75).

Class 2. Similarly, both students and teachers evaluated the first and last science reports of the 12-week intervention using the TAS strategy based on the rubric POWER 8. We analyzed teacher-assessed POWER 8 rubric scores of the two reports using repeated measures GLM (General Linear Model). The analysis indicated a significant within-subjects effect of time, $F(1,16) = 25.747$, $P<.001$. The mean (and standard deviation) scores increased significantly from 14.8 (4.32) to 25.9 (7.91).

Qualitative Analysis: Teacher and Student Perceptions

We derived three themes from the analysis of qualitative data gathered through survey and focus groups. Teachers and students commented on the perceived benefits from (a)

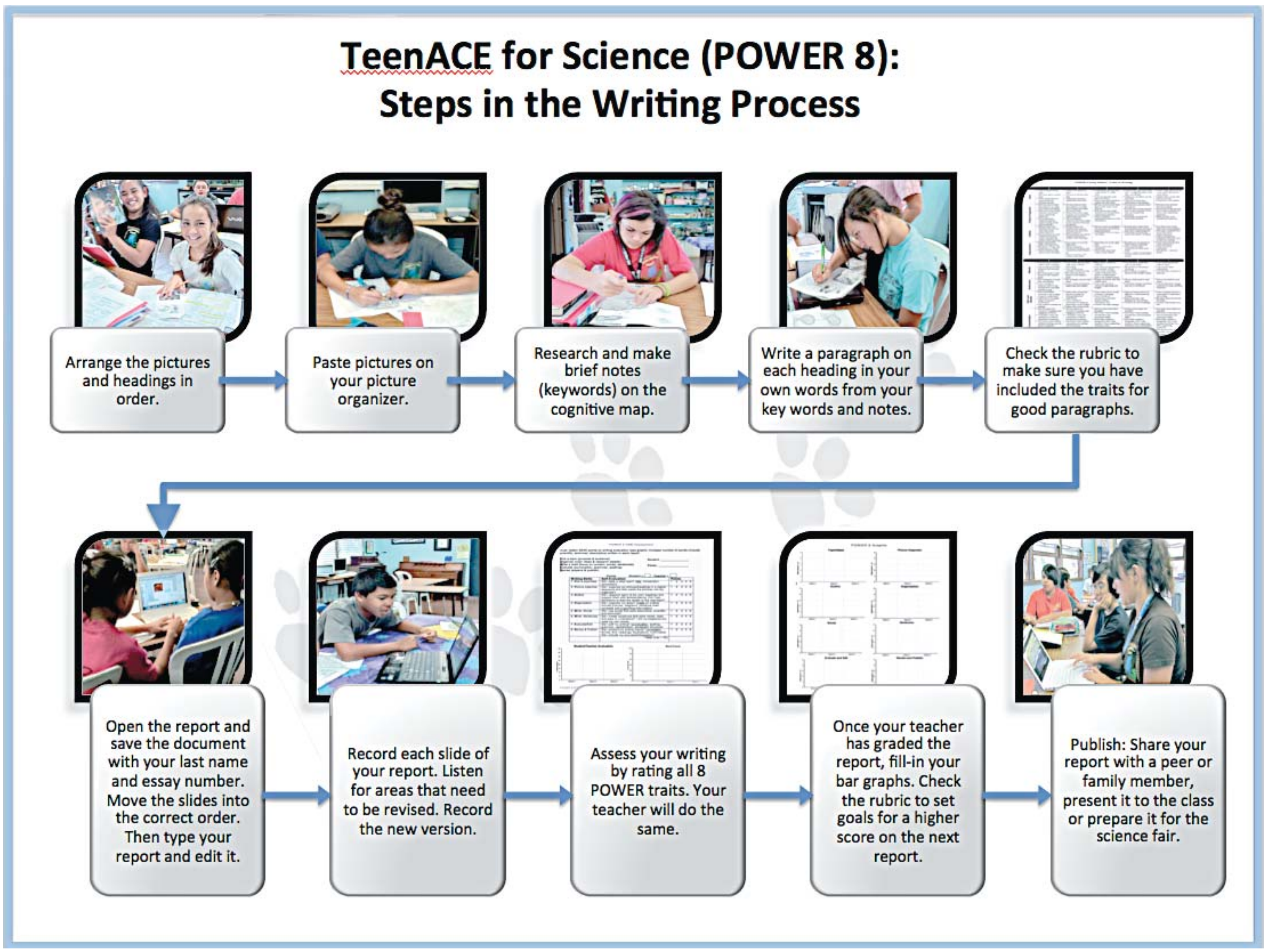

Figure 1. *Illustrates the steps in the TeenACE for Science writing process using computer technology and the POWER 8 tools (rubrics, CBM Assessment of the eight writing skills, and graphing chart to record progress toward mastery of each writing skill).*

the provision of supports and scaffolds, (b) targeted literacy development, and (c) fostering of collaboration and reflection. In this section, we elaborate on these three themes.

Provision of supports and scaffolds. The TAS process includes several scaffolds and supports that teachers and students identified as useful. The TAS process provided instruction on how to undertake writing a science report using an explicit structured approach. The process of developing their writing slide-by-slide and using the photos on each slide to generate writing in PowerPoint was helpful for those students who were often overwhelmed by the writing process when presented with a blank piece of paper. Students commented that, "PowerPoint pictures" (referring to the photos placed on each slide as prompts) were useful to "make ideas." One teacher remarked, "[I] have never used PowerPoint as a writing tool. TeenACE and PowerPoint are taking that whole [writing] experience and chunking, piece by piece. Then students wean themselves away from needing the chunking and move to Microsoft Word." The "chunking" of the writing process into individual slides rather than one long paper made the process more manageable for struggling writers.

Teachers observed that the use of technology engaged students and gave them experience using technology for productivity. Using PowerPoint as the medium for drafting their writing, students improved not only their writing skills but also their keyboarding skills. Teachers observed that students learned "how to find information they needed" using technology and "how to use the information they found to write better." Being able to write on the computer was an incentive for students, transforming the writing process to a digital, more motivating experience. Teachers reported that students were more confident drafting their ideas when using technology and that confidence appeared to extend to writing in other content areas.

Targeted literacy development. Although TAS focused on writing, teachers identified ways in which multiple literacy skills were supported through the process of TAS. The intervention promoted writing through reading, and, as students read their writing aloud or recorded themselves reading, they recognized when something did not sound right. Teachers reported that, as students heard what they wrote, they began to talk through edits and adjusted words and sentences on the page to reflect their spoken ideas.

Students noted that TAS helped them to improve vocabulary, develop ideas, and write better sentences and paragraphs. During focus groups, students talked about writing in terms of an introduction and conclusion, demonstrating their understanding of the structure of the science reports. When asked about their research, they readily used scientific terminology, such as *variabl*es and *hypotheses*. Teachers observed that students began to understand that writing is a multi-faceted process that includes researching content, organizing one's thoughts, and deciding how to present those to the reader.

The TAS process connected and reinforced writing across content areas. Prior to the intervention, teachers felt students were not making the connection between science and writing and were not generalizing skills. By pairing a content area (Science) and a skill-building course (Language Arts), teachers found their students were able to generalize learning through repetitive writing practice. One teacher reinforced the connection by simply posting identical lists of science terms in both classrooms and increased exposure to new vocabulary. Rather than explaining the writing criteria as a rubric, the Science teacher now keeps classroom binders with a variety of sample science reports that show "what good student writing looks like."

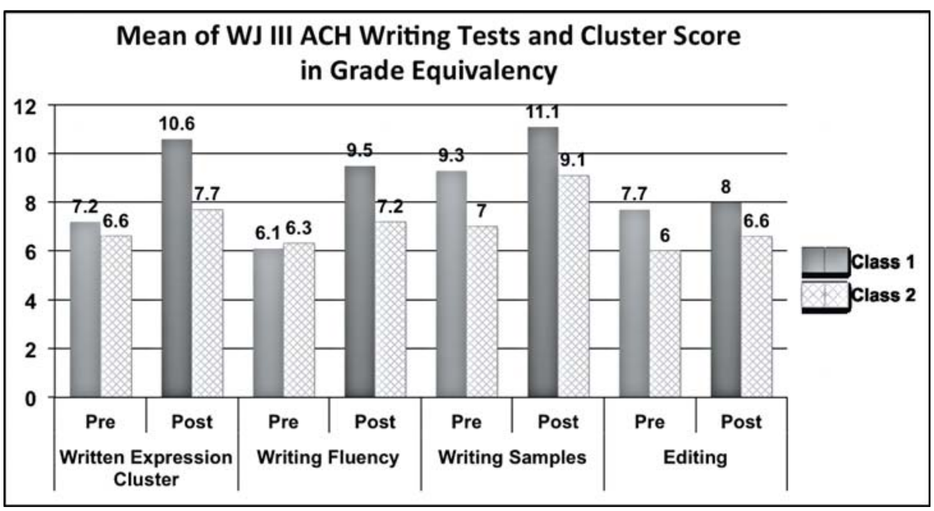

Figure 2. *Illustrates pre-post standardized test measures of writing using three subtests from the Woodcock-Johnson Test of Academic Achievement, 3rd Edition, Normative Update. Class means are presented in grade equivalency form for each subtest. We used Form A at pre-test and Form B at post-test.*

Interaction and collaboration. This process-based approach to writing appeared to support students who are ELLs and are in the earlier stages of language development than their peers. One student stated that TAS "improved our second language [English]." Students said they learned about what they could write while conducting and sharing their research. Teachers encouraged ELL students to get feedback on drafts and rewarded students for turning in additional drafts for improved scores. A Language Arts teacher summarized the benefits she saw by saying that TAS "enabled ELL students to succeed!"

As part of the TAS process, teachers organized students into writing teams, and students had to learn how to work together. While students gave mixed reviews about writing in teams, one student was positive, "when we worked with a partner, [they] do some of the work." Teachers observed that students "formed little cohorts to help themselves be successful." The group writing process also promoted more opportunities for feedback between students, as well as teachers. Students said they learned how to "give more constructive criticism," and teachers said students were generally more "helpful to others." Students appeared to become more aware of the audience in the process of reflecting on the writing of others, as well as on their own writing. Students were enthusiastic about being able to present their thoughts in this multi-modal format and noted that writing in this way made the end product "easier for the audience" because "you record your voice which made it 'less boring.'"

Social Validity

The results of the teacher/coach surveys and focus groups indicated that teachers rated the social validity of the project highly (Likert Scale 5 = strongly agree). Means (with standard deviations in parentheses) were 4.6 (.44) for relevance (i.e., helpful with research and writing skills), 4.7 (.30) for usefulness (i.e., easy to understand, can use it on other projects/content areas), and 4.7 (.51) for high quality (i.e., improved organization, writing, and presentation skills). Another aspect of social validity emerged from the teacher focus groups. Teachers felt the TeenACE for Science process allowed them to, "see what each student's writing needs were" and provided "information that allowed me to focus my instruction." TeenACE for Science provided a structure that allowed teachers and students to be on the same page where expectations and learning became more consistent.

In addition to improved writing skills, 79.9% of students achieved mastery (defined as a quiz score of 60% or better) on teacher-made science tests. A follow-up with Class 1 and 2 one year later found that the teachers continued to use the writing process. One teacher applied it to projects in another content area (i.e., social studies).

Discussion

In this section, we describe the key facets of the TAS project that contributed to the improvement of student writing skills. We describe how specific components of this intervention package supported the writing process, connections to the ways in which SRSD and UDL play a part in the instructional process, and how this process addresses some of the challenges of teaching in rural settings.

Writing Score Gains

We noted significant improvements on the WJIII on both the Writing Fluency and Writing Samples subtests for Class 1 (in a small rural school with multiple grade levels) and Class 2 (a rural grade 7 classroom in a Title 1 school). Though the lack of a control group does not allow us to attribute writing score gains to the process alone, the progress made in writing skills exceeded the typical gains in writing made by students in an 8 to 12 week school session (Hitchcock, Wynne, & Dowrick, 2009). In addition, teachers reported that, by the end of the intervention, students were able to generate sentences more quickly than they had at the beginning; they also were able to develop more varied and complex sentences when constructing written responses. Notably, there was no improvement in editing skills, suggesting that additional instruction was needed to teach these mechanical skills.

Students showed improvement on eight writing skills on CBMs, particularly on students' ability to outline, organize, use better word choices, and, finally, to evaluate, edit, and revise their writing. Ratings by the students and teachers for reports written at the end of the project were significantly higher on all skills when compared with ratings on reports written at the beginning of the intervention. Explicit instruction and reflection on these components of writing appeared to help students improve their writing skills and teachers individualize instruction (differentiate), and meet students' diverse needs in general education classrooms.

Structured Writing Process

The scaffolds and structured writing process of TAS provided explicit instruction and combined content-area skills in science with process-based skills of writing. Teacher and student comments highlighted the importance of several of the SRSD components integrated into this intervention. In alignment with Step 1 of the SRSD process

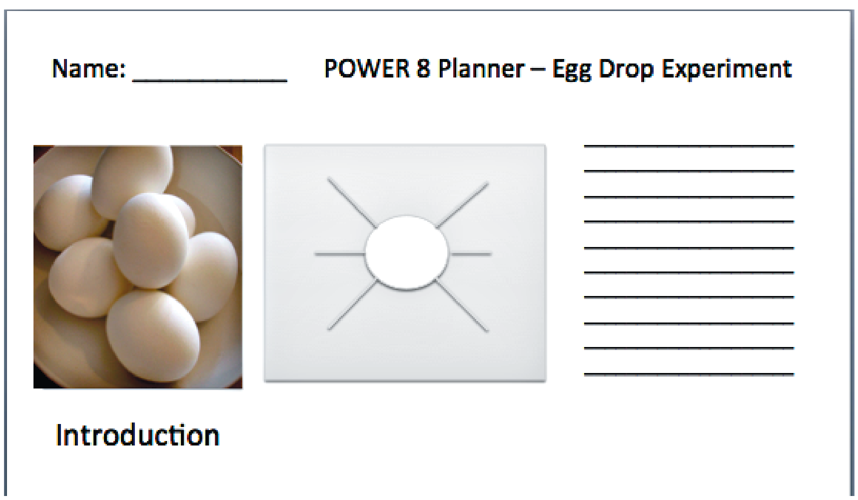

Figure 3. *Illustrates Step 1. The teacher prepares the instructional materials for the lesson. The example here shows a picture set (with headings) for an "Egg Drop" experiment and a template (planner) for the presentation software.*

(Develop Background Knowledge), students outlined, researched, and made notes using the cognitive map tool to prepare for their science writing assignments. Stages 2 and 3 of the SRSD process (Discuss It and Model It) were built into the TAS intervention through the collaborative dialogues, self-assessment, and sharing of each others' projects as students developed writing skills. Step 4 of the SRSD process (Memorize It) was addressed through the use of the POWER 8 mnemonic. In addition, students internalized the steps in the writing process simply by practicing writing multiple reports using the same steps, which had been made clear and explicit through the TAS intervention. TAS introduced an iterative writing process that included group, peer, and one-on-one discussions about writing, in alignment with SRSD Step 5 (Support It). Gains in writing scores and student and teacher comments supported the usefulness of these explicit and scaffolded steps for integrating instruction in science and writing.

Clear Expectations and Goal Setting

The TeenACE for Science project provided a shared definition and an organized process that teachers and students appreciated. The project provided structure that allowed teachers and students to have similar expectations and explicit incremental goals. During the writing assessment with the POWER 8 rubric, teachers and students evaluated and discussed their writing, referencing the eight traits of writing. Teachers provided exemplars and models of expected outcomes. Using the POWER 8 self-assessments and checklists incorporated the cognitive modeling (Step 2) in SRSD. Repeatedly using the self-assessments helped the students internalize the process, check their progress, know what the next step was, and ultimately helped them become independent writers, an important skill in rural schools with small staff. By making the components of the writing process explicit and providing structure for various tasks associated with writing, students began to develop a deeper understanding of how to approach and progress through the stages of writing from brainstorming to organization to drafting and editing.

Teachers stated that students benefited from peer collaboration, learning how to work together and provide constructive criticism. The project provided opportunities for students to practice writing skills in their science and language arts classrooms, making clear connections that the writing process was relevant across different subjects. In addition to developing writing skills, students took ownership during the writing process; as stated succinctly by one student, "[we] write our own." Because their written products were shared, students gave consideration to who their audience was and became more aware of the audience for their writing. These outcomes support the CCSS anchor standards, especially the three standards under Production and Distribution of Writing, which address using clear and organized writing appropriate to a task, strengthening writing through revising and editing as necessary, and using technology to produce, publish, and collaborate on writing (CCSS Initiative, 2012).

Constructing with Multimedia

Using technology as part of the writing process provided multimodal supports and a tool for organizing writing. The use of technology provided several supports aligned to specific UDL guidelines and their related checkpoints (http://www.udlcenter.org/aboutudl/udlguidelines). Composing sentences on presentation software slides with pictures and headings was an effective strategy that "chunked" the writing task; for some students, the writing process was made more manageable through the use of pictures as prompts for generating words and sentences. From the PowerPoint slides, students cut and pasted their compositions into a word processing document. This aligned with several UDL guidelines and their corresponding checkpoints (e.g., Checkpoint 5.3—Build fluency with graduated levels of support for practice and performance and Checkpoint 6.3—Facilitate managing information and resources.)

The multimodal option of listening to the text they typed provided both support and engagement for students. Students enjoyed recording their words and replaying the audio clips. In addition to the authenticity of reading one's own words, students benefited from hearing what their writing sounded like and used this auditory feedback to help them edit their words. Students noticed sentences that were not correctly constructed when they heard the audio feedback although they may not have recognized the awkward or incorrect portions when re-reading the sentence. These uses of technology were consistent with UDL Checkpoint 5.2 (Using multiple tools for construction and composition) and Checkpoint 8.4 (Increase mastery-oriented feedback.)

Students enjoyed being able to use computers as part of the project. They appreciated the option to write in a different way and to integrate some creativity into their production. The multimedia environment allowed students to make creative choices and integrate their own personalities into the projects. This is consistent with UDL Checkpoint 7.1 (Optimize individual choice and autonomy) and UDL Checkpoint 7.2 (Optimize relevance, value and authenticity). Incorporating multimedia technology also provided Step 3 of the SRSD process and increased students' motivation and self-efficacy. Students began to see themselves as competent writers.

Lessons from Pilot Project Implementation

One purpose of this study was to determine which aspects of the project teachers and students valued and which aspects of the project could be adjusted to suit classroom needs and conditions. Initially, the plan was to have students use the TeenACE for Science process to write five reports. Prompted by student requests, teachers reduced the number of writing assignments per 12-week semester to three reports. Students

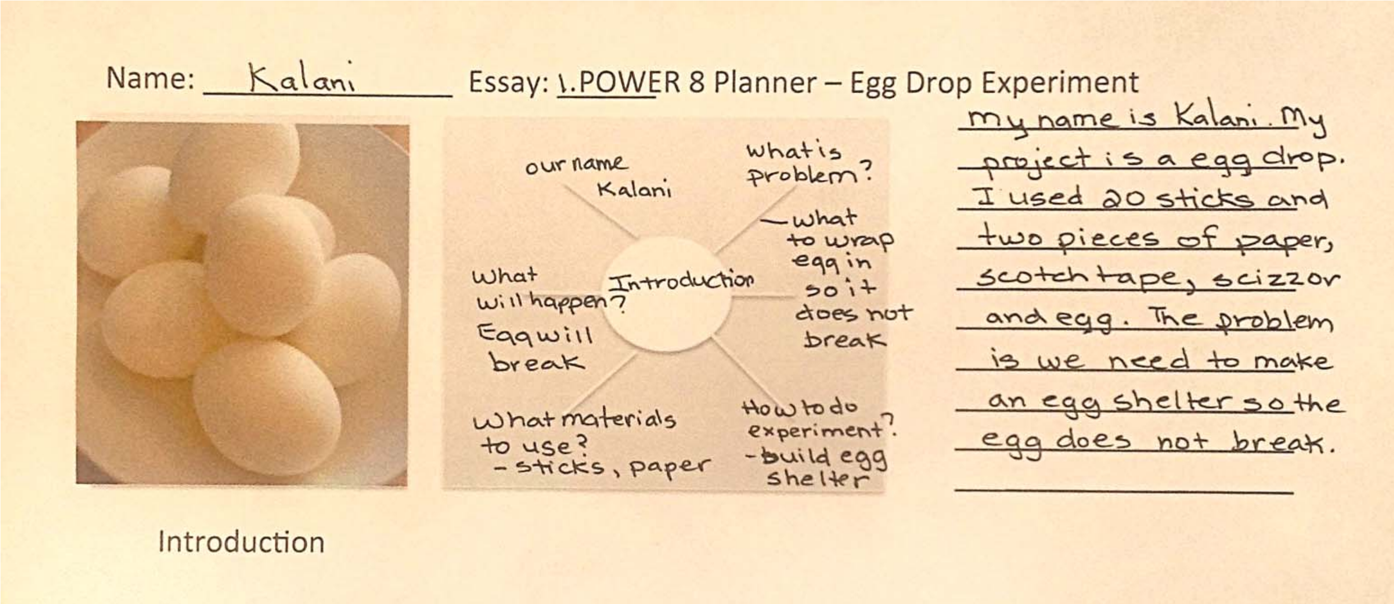

Figure 4. *Illustrates Steps 2 and 3. In Step 2, students research and organize using the POWER 8 planner and sequence photos and take notes on a cognitive map. In Step 3, students write a first draft of a paragraph that goes with each heading (e.g., Introduction, Materials).*

were able to develop their reports and achieve more depth with more time and fewer reports. Once students started using this structured process, science teachers in both schools began integrating more writing into their classes, and students became more independent.

In future iterations of this project, we will reinforce how the rubric can be used as a discussion tool with students, providing a starting point to target skills for improvement and to set incremental individualized goals. By using the rubric to set goals, teachers have a structured way to address the range of skills that students have, promoting differentiation and providing varied levels of challenge appropriate for each student.

Limitations and Future Research

Limitations of this pilot development study are the relatively small number of participants, and lack of a control group. Implementing the TAS process with a larger number of classrooms using randomized treatment and control groups in an efficacy study is a recommendation for future research. Defining participant characteristics, such as ELL and disability status, to gain an understanding of the efficacy of the intervention across diverse student groups would be helpful to determine which students benefit most. Examining potential differences between groups, and potential variations in length and intervention also would be important variables to consider.

This pilot project provided valuable information for us to finalize the development of the TAS protocols and strengthen future iterations of the project. For example, the teacher in Class 2 developed models of reports that received high (5), medium (3), and low (1) ratings on the rubric to provide exemplars for her students. As the measures of the Editing subtest of the WJIII NU showed little or no growth after the intervention, instruction in the mechanics of writing is recommended to improve these skills and further support the writing process. In addition, a critical pre-requisite skill when researching and preparing to write about topics in the content area of science is reading. Including interventions that explicitly teach vocabulary, reading fluency, and oral language skills through peer-assisted or cooperative learning methods, as well as note-taking strategies, also are highly recommended to support the writing process (Connor, Alberto, Compton, & O'Connor, 2014; Hebert et al., 2014).

Implications for Practice

The ability to write a well-researched and cohesive science report that demonstrates content knowledge is a valuable skill that students need for higher education and future careers; however, students often are expected to meet the increasingly stringent standards in the common core without instruction or scaffolds to support the writing process. TeenACE for Science provides structure and a process that combines elements from multimedia technology, UDL, and SRSD to assist struggling writers as well as their general education peers. This combination of established evidence-based practices in special education with flexible options, scaffolding, and technology appear to hold promise for teaching diverse students in today's rural settings.

Table 2. Power 8 Rubric

	5	4	3
Pick a Topic	▪ I am an expert on my topic. ▪ The main idea is crystal clear. ▪ I have details that are unusual and not everyone knows.	▪ I know a lot about my topic. ▪ It's easy to tell the main idea. ▪ I have great details to explain the main idea.	▪ I understand the topic but could narrow it a little more. ▪ I can tell what the main idea is all about. ▪ I have some good details to explain the main idea.
Picture Organizer	▪ All nine pictures have been glued in an order that is fluid and logical. ▪ Each picture has a topic sentence and at least seven supporting sentences. ▪ The transitional sentences lead the reader fluently to the next paragraph.	▪ All nine pictures have been glued in an order that is logical and helps the story to flow. ▪ Each picture has a topic sentence and at least five supporting sentences. ▪ The transitional sentences alert the reader to the content of the next paragraph.	▪ All nine pictures have been glued in the order I have selected. ▪ Each picture has a topic sentence and at least three supporting sentences. ▪ I have included a transitional sentence to the next picture.

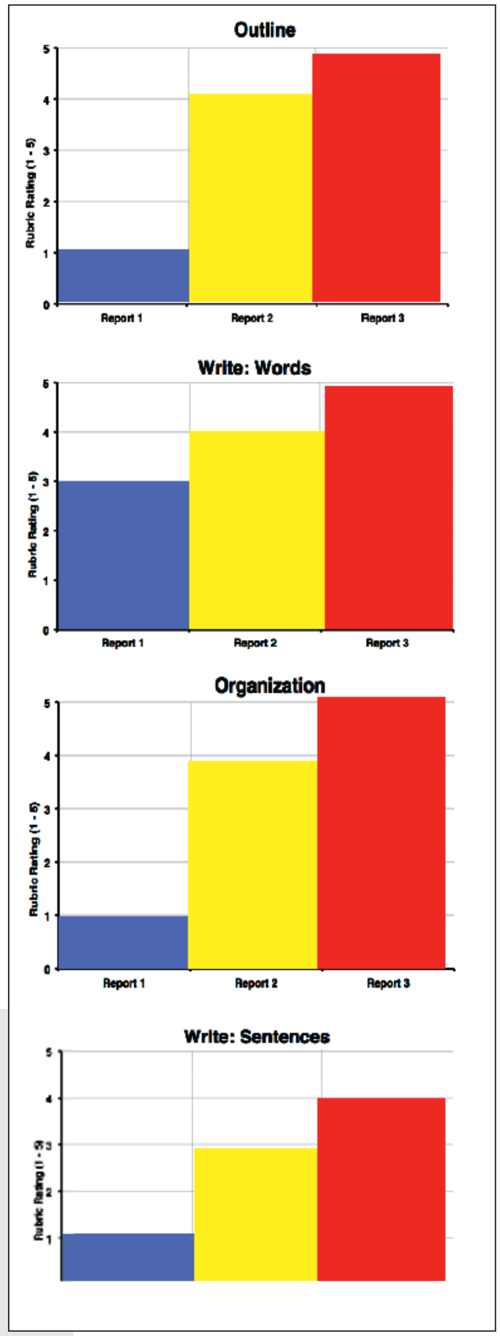

Figure 5. *In Step 5, students evaluate and monitor progress using the POWER 8 rubric, the POWER 8 CBM Assessment, and self-graphing tools as illustrated by these examples.*

POWER 8 CBM Assessment

Goal: obtain 35/40 points on writing evaluation (see graph); increase number of words (scientific, technical, descriptive) for each report.

Pick a topic (purpose and audience)
Organize (main ideas and research details)
Write a draft (focus on content, words, sentences)
Evaluate (punctuation, grammar, spelling)
Revise (expand and publish)

Student: ______________

Essay: ______________

Points: Student = ◯ Teacher = ☐

Writing skills		Student evaluation	Teacher evaluation
Pick a topic/idea	Did I state a clear *topic*? (title, introduction, conclusion)	1 2 3 4 5	1 2 3 4 5
Picture organizer	Did I organize my pictures/headings in a logical sequence and then paste the pictures into my organizer?	1 2 3 4 5	1 2 3 4 5
Outline	Did I research each of the main headings and support them with facts/evidence. Did I use transitions to lead the reader to the next topic?	1 2 3 4 5	1 2 3 4 5
Organization	Did I *organize* my ideas? (make an outline, include pictures, diagrams, introduce main concepts and supporting information)	1 2 3 4 5	1 2 3 4 5

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