Title: Using an Argument-Based Inquiry Approach to Learn Science: Year 1 Results of the Science Writing Heuristic (SWH)

Author(s): Mary Grace Villanueva, Brian Hand, William Therrien and Jonte Taylor;
University of Iowa
Background / Context:

Current efforts in science education highlight the need for writing to learn strategies in science classrooms (Yore, Bisanz, & Hand, 2003). These strategies recognize the value of having students articulate their understandings in different ways as a means to construct a richer conceptual framework of science knowledge. Importantly, these strategies are based on incorporating authentic writing tasks which extend students’ needs to engage with the demands of science, rather than seeing writing as note-taking, fill-in-the-blank, or complete-the-sentence type of exercises (Prain & Hand, 1996). Writing to learn tasks incorporate the need for students to access canonical science knowledge and engage the nature of science, and their epistemologies and reasoning strategies as a framework to build understanding (Hand, Prain, Lawrence, & Yore, 1999). The SWH is an example of this type of writing activity.

The SWH approach was developed by Hand and Keys (1999) as a means to explore the idea of trying to build a framework that would link inquiry, argumentation, and an emphasis on language. The SWH approach consists of a framework to guide activities as well as metacognitive support to prompt student reasoning about data. The SWH provides learners with a heuristic template to guide science activity and reasoning in writing. Further, the SWH provides teachers with a template of suggested strategies to enhance learning from laboratory activities. As a whole, the activities and metacognitive scaffolds seek to provide authentic meaning-making opportunities for learners.

A template for student thinking prompts learners to generate questions, claims, and evidence for claims. It also prompts them to compare their laboratory findings with others, including their peers and information in the textbook, Internet, or other sources. The template also prompts students to reflect on how their own ideas have changed during the experience of the laboratory activity. The SWH can be understood as an alternative format for laboratory reports, as well as an enhancement of learning possibilities of this science genre. Students are expected to respond to prompts eliciting questioning, knowledge claims, evidence, description of data and observations, and methods, and to reflect on changes to their own thinking.

Purpose / Objective / Research Question / Focus of Study:

The aims of the project are centered on a 2 year field trial of the SWH approach with students in grades 4-6. Building on the results obtained from the quasi-experimental designs used in previous research, this project tests the efficacy of the SWH approach with an experimental design using a random assignment of buildings to treatment and control groups. The project seeks to examine the efficacy of the SWH approach by tracking the following:

1. Grade 4 - 6 students’ performance on the ITBS Science test across the 2 years of the field trials. This will include subscale scores on science content and science inquiry skills.
2. Grade 5 students’ performance on the Cornell Critical Thinking skills test each year
3. The quality of teachers’ implementation of the SWH approach and the impact on student performance on the ITBS Science scores.
As the random field trial is nearing the completion of the first year, our current study seeks to report on the results generated from the students’ ITBS scores and Critical Thinking Skills tests. A preliminary examination of SWH teachers’ initial year of implementation will also be presented. The following questions will be used to guide the progress report of the random field trial:

- **Research Question 1**: After Year 1 of implementation, does SWH treatment result in higher mean student outcomes, compared to control, for each grade level?

- **Research Question 2**: After Year 1 of implementation, does SWH treatment result in higher mean student outcomes, compared to control, for all students in all grade levels combined?

**Setting:**

The study is conducted in Iowa and involves the school districts and the local Area Education Agency (AEA) as the coordinator for the districts within the region. An AEA’s function is to provide the local school districts with their professional development needs, media resources, and school leadership support where needed. The AEAs that will be involved with this project are the Loess Hills AEA, which provides services to 34 school districts and Keystone AEA which provides services to 25 school districts. These AEAs were recruited for participation due to the success of previous collaboration efforts between the AEA and the University of Iowa. Particular schools have been selected based on need (e.g., % of students on free and reduced lunch, % of students who are at-risk learners, % of ethnically diverse students) and their interest in SWH program implementation. The student population is drawn from a range of different economic situations, including designated rural poverty areas and urban settings.

Because of concern of bleed-over between classrooms and the desire to track students over a two year period, school buildings are the unit of assignment. School buildings have been assigned at random to treatment or control groups within school districts, with each district serving as a natural block to control for potentially confounding effects in comparing between treatment and control schools attributable to differences of district-level size, socioeconomic patterns (measured by free and reduced lunch participation and other SES measures available for all districts), governance structures, policy regimes, and the like.

**Population / Participants / Subjects:**

Across 48 elementary schools, the participants of the project include Grades 4 to 6 students ($n_{\text{treatment}}=1359; n_{\text{control}}=1040$) and their science teachers ($n_{\text{treatment}}=52; n_{\text{control}}=38$). The majority of students are Caucasian, yet there is a growing population of Hispanic and African-American students in several school districts. Despite race, many of the students are from low socioeconomic backgrounds. Students with disabilities as identified by Individualized Education Plans (IEP) comprise 12% of the sample population.

**Intervention / Program / Practice:**

Over the course of the academic year, science teachers engaged in 10 days of professional development opportunities such as workshops (summer + 1 each semester), planning sessions,
professional community meetings, and onsite support. The control cohort continued with their traditional methods of instruction. While we will report on Year 1, the design of the PD will be repeated in Year 2.

During the SWH professional development, all treatment teachers:
- Experienced learning science using the SWH approach, so as to understand what it means to be a learner using this approach;
- Prepared at least one unit of work using the NSF developed support material, in conjunction with the teacher trainers;
- Examined the necessary matrix of required teaching practices in order to build understanding of the needed pedagogy (Chapter 9 of Question, Claims and Evidence – Heinemann)

During Year 1 treatment, teachers embedded the science argument and used the SWH approach as a framework to guide science inquiry activities, as well as metacognitive support, to prompt student reasoning about data. The students from the treatment group were encouraged to set their own investigative agenda for laboratory work by framing questions, propose methods to address these questions, and carry out appropriate investigations. Students were also encouraged to engage in discussion whereby their personal explanations and observations were tested against the perceptions and contributions of other students in the class. Additionally, students were asked to make explicit and defensible connections between questions, observations, data, claims, and evidence.

Research Design:

The study uses a block-randomized design with schools randomly assigned to the treatment and control condition within districts. While this current study will report on Year 1, the full evaluation will be implemented for two years in 48 elementary schools (24 treatment; 24 control).

During Year 1, schools assigned to the treatment condition used the SWH approach in their science instruction. Treatment teachers received seven days of professional development during the summer and three days during the school year. Twenty percent of all instructional sessions have been videotaped and 10% of the taped sessions has been stratified by month, teacher, and study condition and then randomly selected for viewing and coding. Teachers in the control condition teach the standard science curriculum in place at the school without the Science Writing Heuristic approach.

Data Collection and Analysis:

Students’ ITBS scores, Critical Thinking Skills test results (grade 5 only) and teachers’ videotape of implementation will be used to measure student outcomes and the efficacy of the SWH approach. To date, grades 4 – 6 students’ ITBS data from 2009 and 2010 have been collected and a database has been developed for analysis. The Cornell Critical Thinking Skills pre-test was administered at the beginning of the school year and the post-test is currently in progress.
Additionally, teachers’ fall video tapes have been collected and a database has been developed. Teachers’ are currently in the process of videotaping and submitting their videos.

To measure the fidelity of implementation by the treatment teachers, we will use a program developed instrument of classroom practices and the Reformed Teacher Observation Protocol (RTOP), which was developed by the Evaluation Facilitation Group of the Arizona Collaborative for Excellence in the Preparation of Teachers (Sawada et al., 2000). Estimated reliability for the RTOP has been previously reported as Cronbach’s α = 0.954 (Sawada et al., 2000). It is important to note that the results from this alignment task indicated that 13 RTOP descriptors focused on related SWH major skill areas. The abridged version of the protocol has 13 questions divided into 3 categories of student voice, elements of argument, and teacher’s role. The internal reliability estimates calculated for these collapsed categories using RTOP scores from videotaped lessons are as follows: student voice α = .982, elements of argument α = .977 and teacher’s role α = .985 (Martin & Hand, in press).

Findings / Results:

The process of the ITBS collection has been ongoing throughout the year, depending on when the school buildings administer the test. In Iowa, each school district administers the test independent of each other. To counter this, a Grade Equivalent Growth (GEG) score has been calculated for each individual. The GEG score describes a student’s location on an achievement continuum identifying student performance in grade level and months. Grade equivalents scores are appropriate for measuring individual students’ developmental status at the time of the test and students’ cognitive growth from one year to the next. Initial analysis of student performance will be conducted during Year 2.

A comprehensive analysis and discussion of the ITBS, Critical Thinking Skills test and teacher implementation results for Year 1 will be available after the completion of the data collection.

Conclusions:

The data generated and findings presented will be used to inform the recommendations and conclusions of the study.
Appendix A. References


