The Effects of Using Interactive Student Notebooks and Specific Written Feedback on Seventh Grade Students' Science Process Skills

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Abstract

The purpose of this study was to determine whether the consistent use metacognitive strategies imbedded in an Interactive Student Notebook (ISN) would impact science process skills of 7th-grade students. In addition, this study explored whether specific teacher written feedback, provided to students in the ISN, further enhanced the use of ISNs and resulted in greater gains in students' science process skills.

A sample of convenience, 7th-grade students (n = 194) in two suburban middle schools in the northeastern United States was utilized for this study. Students participated for 15 weeks in one of three instructional programs: (a) a science instructional program using ISNs embedded with metacognitive strategies and specific written feedback (treatment), (b) a science instructional program using ISNs embedded with metacognitive strategies only (comparison), and (c) a traditional science program using regular classroom instructional practices (control). Students' science process skills were measured using Form A (pretest) and Form B (posttest) of the Diet Cola Test, and data were analyzed using an analysis of variance (ANOVA) and a multiple linear regression.

Results revealed a significant main effect for type of instruction. Students in the comparison group (n = 67, M = 10.75, SD = 3.53) scored significantly higher (p = .026, d = .47, moderate) than students in the control group (n = 66, M = 9.10, SD = 3.50) on mean posttest scores of Science Process Skills. There were no significant differences between the remaining groups. In addition, regression analysis suggested that the type of feedback that students received (Task-specific, Process-specific, or Metacognitive-specific) did not predict students' science process posttest scores. Implications for educators and researchers are suggested.

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Key words: science education, metacognition

Introduction

Teaching science involves teaching both content knowledge and science process skills through an inquiry-based instructional method (National Research Council [NRC], 2007). Research suggests that the United States has experienced a decline in student achievement in both of these areas (National Assessment of Educational Progress [NAEP], 2009), and the reasons for this phenomenon are varied. One reason may be due to the effort of school districts focusing on the development of effective instructional practices for reading, writing, and math high-stakes testing, leaving less time and support for science instruction (Michaels, Shouse, & Schweingruber, 2008). However, with the advent of mandated state science tests and science scores included in Adequate Yearly Progress (AYP) reporting, as well as the anticipated release of the Next Generation Science Standards (NGSS) (NRC, 2011), science education has become an area of renewed attention. Not only is science becoming "the cornerstone of 21st-century education" (Michaels et al., 2008, p. 2), it is also redefining how educators and students develop different ways of thinking about science education (Michaels et al., 2008).

Students benefit when learning how to utilize tools and strategies that will help them to become reflective learners. Utilizing metacognitive approaches during science instruction enables students to activate prior knowledge, understand what they are learning in the context of bigger ideas, and organize their knowledge to assist with the retrieval of content and ultimately transfer and application of processes (NRC, 2005). Interactive Student Notebooks (ISNs) are instructional tools that promote the application of metacognitive strategies, provide students with opportunities to record what they learn and to personalize their work in meaningful ways through reflection. The use of the ISN is one key strategy that may empower students to learn science processes.

Specific teacher feedback also enhances science learning when the feedback is related to how the student utilizes science process skills while performing a task or used to clarify misconceptions and redirect a student's learning (Marcarelli, 2010; Wist, 2006). Feedback that is timely, that clearly addresses the task at hand, and that is directly related to students' performance may be a powerful instructional tool (Hattie & Timperley, 2007; Marcarelli, 2010; Marzano, 2007; Siewert, 2011), especially when combined with metacognitive strategies. This study explored whether students' science process skills could be improved through the use of metacognitive strategies using ISNs with and without specific written teacher feedback.

Statement of the Problem

The need for effective science education in K-12 schools is critical in a global environment. Curriculum leaders search for the best resources, provide ongoing professional development, and support the classroom teacher by coaching and modeling instructional best practices (Michaels et al., 2008), and yet many districts are experiencing insufficient time to teach science in depth (Michaels et al., 2008).

Limited research exists on using metacognitive learning tools such as ISNs combined with specific teacher feedback to strengthen students' science process skills (Green, 2010; Wist, 2006). Green (2010) expressed the need for extended research that combined the use of ISNs and other specific instructional strategies that may benefit student learning. Wist (2006) pointed-out that although research does exist on traditional note-taking strategies, little or no research exists that examines the effect of ISNs on student learning.

Review of the Literature

The Link between Science Process Skills and Metacognition

A goal of science education is to teach students to… "use appropriate scientific processes and principles in making personal decisions" (NRC, 1996, p. 13). Scientific process involves promoting students' natural instincts for inquiry to ask questions, to find answers, and to explore the world around them (NRC, 1996). Educators frequently used the term *science process skills* to describe the process of doing science, and quite often the interpretation includes the practices of scientific thinking and/or critical thinking (Padilla, 1990). Embedding the basic process skills of observing, measuring, inferring, communicating, classifying, and predicting into inquiry-based instruction strengthens students' understanding of science concepts (Padilla, 1990, 2010). Students learn science process skills by actively participating in all steps of scientific practice and instruction (NRC, 2007).

Padilla (2010) discussed more advanced integrated science processes to the skills required by inquiry, including: engaging students with scientific questioning, designing procedures, emphasizing the importance of providing evidence, formulating explanations, making connections to scientific knowledge, and communicating and justifying explanations. Students are able to think like scientists when incorporating integrated science process skills which also promote problem solving and critical thinking (Padilla, 2010).

The NRC has recently redefined scientific processes and practices to include "scientific and engineering practices" (NRC, 2011, p. 41) to better reflect the practices of professional scientists and engineers. Scientific and engineering practices are built upon science process skills and are integrated into both inquiry and design. The scientific and engineering practices are:

1. Asking questions (for science) and defining problems (for engineering).
2. Developing and using models.
3. Planning and carrying out investigations.
4. Analyzing and interpreting data.
5. Using mathematics and computational thinking.
6. Constructing explanations (for science) and designing solutions (for engineering).
7. Engaging in argument from evidence.
8. Obtaining, evaluating, and communicating information. (NRC, 2011, p. 42)

As science education evolves, so do the practices that help students to gain a deeper understanding of the concepts. "A focus on practices (in the plural) avoids the mistaken impression that there is one distinctive approach common to all science—a single 'scientific method' " (NRC, 2011, p. 48). In the current study, the researcher has continued to reference science process skills with the understanding that they are now part of the overarching concept of scientific practices.

Metacognition

Dewey (1910) theorized that one way to teach this type of thinking is through reflection; reflection, he suggested, is iterative and an integral part of learning: "Reflection involves not simply a sequence of ideas, but a consequence - a consecutive ordering in such a way that each determines the next as its proper outcome, while in turn leans back on its predecessors" (p. 3). Reflection makes meaning out of what was learned and then evokes new thinking from the new knowledge (Dewey, 1910). Bruner (1960) described three phases involved with the act of learning: acquisition of new information, learning transformation, and evaluation. Bruner's learning phases are not only similar to the iterative cycle of thought processes as described by Dewey (1910) but also to the process of metacognition. Metacognitive regulation occurs with the evaluation of the new information in terms of how the person knows to apply it to tasks and/or actions (Flavell, 1976).

Metacognitive knowledge is the understanding of what one knows, does not know, and wants to know, along with the understanding of how to perform a task to direct one's learning (Flavell, 1979; 1987). Zimmerman (2002) suggested that self-regulation is not a performance skill but "rather it is the self-directive process by which learners transform their mental abilities into academic skills" (p. 65). Metacognition has since been further defined to include knowing how to reflect, analyze, draw conclusions, and apply one's knowing to solve problems, make decisions, and process information (Brown & Palinscar, 1987; Flavell, 1979; Pintrich, 2002; Zimmerman, 2002). Both Flavell (1979) and Pintrich (2002) discussed how metacognition may be categorized into knowledge of cognition and control or regulation of knowledge. Cognitive knowledge may not be that different from metacognitive knowledge (Flavell, 1979; Livingston, 1997), but the difference is in how the knowledge is used. The actions of comprehension, memorization, and written work are supported when one monitors cognitive activities such as problem-solving, understanding reading materials, and writing effectively.

Metacognitive strategies may be related to problem-solving skills. Bergin et al. (2009) collected data using the Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994) to measure declarative, procedural, and conditional knowledge, with an additional component to measure areas of regulation (management, monitoring, evaluation, etc). Results suggested the existence of two major components of metacognition: knowledge of cognition and regulation of cognition together explained 30.6% of the variation in students' problem-solving scores (16.4% for regulation and 14.1% for knowledge), indicating that student participants who chose a better decision to the problem could "better discriminate among the various components of metacognition" (p. 98). Bergin et al. (2009) concluded that teachers need to incorporate everyday problem-solving into instructional practices by devising strategies to help students acquire and develop knowledge of the metacognitive skills of cognition and regulation. Strategies, they suggested, should include instruction that focuses participants' attention on learning tasks and strategies. Bergin et al. (2009) further suggested that benefits of incorporating metacognitive strategies into curriculum would theoretically increase students' abilities to make decisions and solve problems, abilities which are closely related to integrated science process skills.

Specific Written Teacher Feedback

Specific teacher feedback is a response made to students, either verbally or non-verbally, that references a specific task, the process of a task, the student's self-regulation, and/or the student as a person (Brookhart, 2008). Teacher feedback can be provided in various forms. Feedback may be immediately given using verbal feedback or it may be delayed using a written form (Brookhart, 2008; Butler & Nesbit, 2008; Siewert, 2011). For feedback to be effective and improve student learning, it should be provided continuously (Butler & Nesbit, 2008; Hattie, 1992). Corrective and constructive feedback may be used to redirect a student's understanding of a concept, clear misconceptions, prod for more details, or simply to affirm progress (Brookhart, 2008). Researchers (Waxman & Walberg, 1991) have reported that corrective feedback informs instructional practices, causing teachers to re-teach the material in new or various ways; and when the reinforcement through feedback is clear and timely, it can affect student learning by suggesting how to improve next time.

Feedback, when delivered in a timely fashion (Brookhart, 2008; Gilbert & Kotelman, 2003; Marzano, 2007; Siewert, 2011; Waxman & Walberg, 1991), can be a powerful formative assessment tool for teachers and a learning tool for students, especially when the focus is directed toward a task, the processing of the task, and/or evidence of student self-reflection (Brookhart, 2008; Hattie, 1992; Hattie & Timperley, 2008). Siewert (2011) conducted research to determine whether lack of written feedback from the teacher affected fifth grade students' abilities to learn or to transfer information. A second goal of the study was to determine whether written teacher feedback would affect the self-esteem of students with learning disabilities or their general education peers. Results indicated that written feedback on writing conventions and corrected mistakes decreased errors in writing from 61% to 26% for students in general education and gifted students. Results for special education students indicated a greater improvement than other students, with a decrease of errors in terms of writing conventions and corrected mistakes from 80% to 33% in errors (Siewert, 2011). Siewert (2011) suggested that verbal feedback is quick and easy and, at times, is all that is needed to correct oral reading and to provide confirmation of correct or thoughtful responses. In contrast, written feedback is not as immediate, but it may serve as a more concrete model to correct students' responses and provide teachers with the means to comment positively on academic expectations (Siewert, 2011).

The timing of feedback is also critical (Siewert, 2011). Written feedback is considered delayed feedback, allowing time for the student to forget incorrect responses or misconceptions and use the teacher's corrective or supportive responses to improve or validate student work. Siewert (2011) concluded that a major implication of this study is that students need to receive both verbal and written feedback that is informative, specific, and positive.

The effectiveness of feedback varies by the timing, amount, type (written or verbal) and by the audience (Brookhart, 2008). Brookhart (2008) described the concept of *audience* as an individual student, group of students, or an entire class. Feedback to the entire class happens when the teacher assesses class work, discovers multiple student misunderstandings, and then uses feedback to inform a lesson or re-teach if necessary. Individual feedback is most effective when communicating specific information to a student on his or her own performance (Brookhart, 2008). Waxman and Walberg (1991) suggested that specific teacher feedback, or corrective feedback, may have a somewhat higher effect with disciplines that require a conceptual understanding of concepts that does not come with memorization.

Written specific teacher feedback can stimulate student thinking if the feedback regularly focuses on the *task* itself (Task-specific) or the *process of doing the task* (Process-specific) (Butler & Nesbit, 2008; Marzano et al., 2001). However, feedback that continually focuses on the mechanical aspects of the task or process instead of the metacognitive aspects of learning such as the interpretation and understanding may not be as effective at moving students forward with mastering integrated science processes (Butler & Nesbit, 2008; Butler & Winne, 1995; Marzano et al., 2001).

Interactive Student Notebooks

Interactive Student Notebooks (ISNs) are instructional tools that provide students with an opportunity to record what they are learning and to personalize their work in a meaningful way through reflection and interpretation (Chesbro, 2008; Shapiro, 2010: Waldman & Crippen, 2009; Young, 2003). ISNs originated in the 1970s by a California teacher, Lee Swenson, with collaboration from his social studies colleagues. The ISN was later adopted and adapted by the Teacher's Curriculum Institute (TCI) as part of the *History Alive*© Program (Teachers' Curriculum Institute, 2012). ISNs have been used in many classrooms across the country during social studies instruction and recently have expanded into other disciplines such as math and science.

ISNs are spiral notebooks or composition books that are organized into two parts: the right side contains input and the left side contains students' output (Chesbro, 2008; Waldman & Crippen, 2009; Young, 2003). Input (right side) consists of information received through teacher lectures, notes, lab sheets, and information obtained from text. The output (left side) consists of students' interpretation and/or reflections through nonlinguistic representations, a metacognitive instructional strategy that is underused (Marzano et al., 2001), such as labeled graphs, charts, drawings, and/or writing to show understanding of what was learned (Glynn & Muth, 1994; Green, 2010; Maracelli, 2010). The left side of the ISN belongs to the student and offers the student the opportunity to further scientific understanding with a section in which to make connections and extensions based on the knowledge and understanding of the content that was learned. The left side helps students to make sense of the investigation, allows them to think about the lab they just performed, and enables them to reflect and organize their thoughts. Butler and Nesbit (2008) stated "Writing to make sense of investigations involves students in the process of constructing knowledge" (p. 137). Conceptual illustrations drawn by the student also provide the teacher with visual evidence of student learning, along with another means for teachers to assess misconceptions and or inaccuracies (Fisher & Frey, 2007; Shapiro, 2010). "Students can express their interpretations and reactions to the content through original and creative ideas" (Wist, 2006, p.14).

Shepardson and Britsch (1997) suggested that science notebooks…"enable teachers to assess the domains of conceptual understanding, factual and procedural knowledge, science processes, and attitudes" (p. 46-47). ISNs provide a medium for teachers to conduct ongoing formative assessments that guide instructional practices and lesson development enhancing reflective practices of both the teacher and student. Glynn and Muth (1994) support the need for more writing of explanations in science. As a tool to further develop strategies that promote the application of metacognitive skills, the use of the ISN is one key approach that may empower students to communicate science learning processes and incorporate science process skills. Butler and Nesbit (2008) have suggested that ISNs are designed to build upon process skills.

Green (2010) conducted research to determine if the use of ISNs during math and science instruction significantly affected fifth grade students' achievement scores. Participants (n = 42) in this study were fifth grade students in a large urban inner-city middle school district with a total student population in the middle school (grades 5 to 8) of 645. Using a quasi-experimental pretest/posttest design, Green (2010) utilized two methods of instruction. The treatment group (n = 17) was instructed in mathematics and science with the use of an ISN, and the control group (n = 27) was instructed through traditional note-taking methods. Math and science achievement were measured using standardized assessments from the district's adopted textbook as pre- and post-unit tests. Teacher participants were provided two 18-week unit plans: one for math and one for science, with critical points identified by the researcher so that all students received the same information. Results suggested that the use of the ISN alone was not a statistically significant predictor of math posttest scores, $p = .064$. However, it is important to mention the fact that Green (2010) measured content knowledge and not process skills. The researcher made the recommendation that future studies should identify a specific set of activities with the use of ISNs to increase student achievement, and that teacher participants are trained more extensively in the use of the ISN. The current research attempts to build upon this finding and, adding in the element of specific written teacher feedback, determine if the use of metacognitive strategies delivered through an ISN may be an effective way to teach science process skills.

Methodology

This quasi-experimental, pretest, posttest research examined the impact of a metacognitive science program combined with written specific teacher feedback on students' science process skills. This intervention was delivered through the vehicle of ISNs. Classes were randomly assigned to three types of instructional programs: (a) metacognitive strategies plus written specific feedback (treatment) delivered through an ISN; (b) metacognitive strategies only (comparison) delivered through an ISN; and (c) traditional classrooms using neither approach. Using a systematic approach the researcher investigated the following quantitative research questions:

1. Is there a significant difference in Science Process Skills between 7th-grade students who participate in a metacognitive instructional program using ISNs and specific teacher written feedback (treatment), those using metacognitive instructional strategies using ISNs only (comparison), and those who participate in a traditional instructional program (control)?
2. To what extent and in what manner does the Type of Feedback (Feedback - task, Feedback - process, Feedback - metacognitive) predict students' Science Process Skills as measured by the Earthworm Test Form B of the DCT?

The researcher hypothesized that there would be a significant difference in posttest scores and that the type of feedback would predict students' science process skills.

In addition, mixed methods were utilized to triangulate quantitative with qualitative data. A Convergent Parallel Model (Creswell & Plano-Clark, 2007) was used "to obtain different but complementary data on the same topic" (p. 62). Qualitative and quantitative data were collected separately at the same time and were then merged.

Description of the Setting and Sample

This study included a sample of convenience consisting of 7th–grade students from two middle schools located in a suburban school district in the northeast (population approximately 34,500). The district serves approximately 1,612 students in grades six through eight (CSDE, 2010) with a total student population of 6,974. The breakdown of ethnicity in the district includes: 82.8% White, 6.0% Asian American, 4.7% Black, and 6.3% Hispanic students (CSDE, 2010). Approximately 4.7% of students come from homes where English is not the primary language (CSDE, 2010). This suburban community has 11 schools: 6 elementary schools, 2 middle schools, 1 high school, 1 bio-technology institute, and 1 pre-school (CSDE, 2010). The average household income for the district is approximately $97,614 (Onboard Informatics, 2010).

Six seventh grade science teachers on separate teams and approximately 550 seventh grade students from two middle schools were invited to participate. A total of three teachers on separate teams and students (*n* = 194) from 13 classrooms participated in the study. Each teacher was certified in the content area of science with a moderate level of teaching experience (6 – 11 years), as presented in the Teacher Participant Demographics' table below (Table 1).

Table 1

Teacher Participant Demographics

Teacher Identification	Gender	Years Teaching	Years in Current District	Degrees - Certification
1	Female	6	6	BS: Education: Liberal Studies (Biology and Psychology) MS: Science Education: Biology
2	Female	9	9	BS: Biology (Marine Science/Psychology) MS: Secondary Education: Science
3	Female	11	11	BS: Biology (with certification 7-12) MS: Biology MA: School Counseling

The researcher utilized a random assignment of intact classrooms to conditions. Gall et al. (2007) suggest that when using two schools in the same district, the possibility of threats may exist if each teacher participant teaches in only one condition. To minimize this limitation, the researcher made the decision to randomly assign at least one classroom from each teacher to each of the three conditions. As a result, each teacher taught in all three conditions: treatment, comparison, and control.

A total of 194 seventh grade students from three middle schools participated in the study: 102 female participants and 92 male participants were included in this sample of convenience. Male and female participants were more equally represented in the treatment and control groups; however, there were more females (n = 41) than males (n = 28) in the comparison group (Table 2).

Table 2
Gender Demographics for Treatment, Comparison, and Control Groups

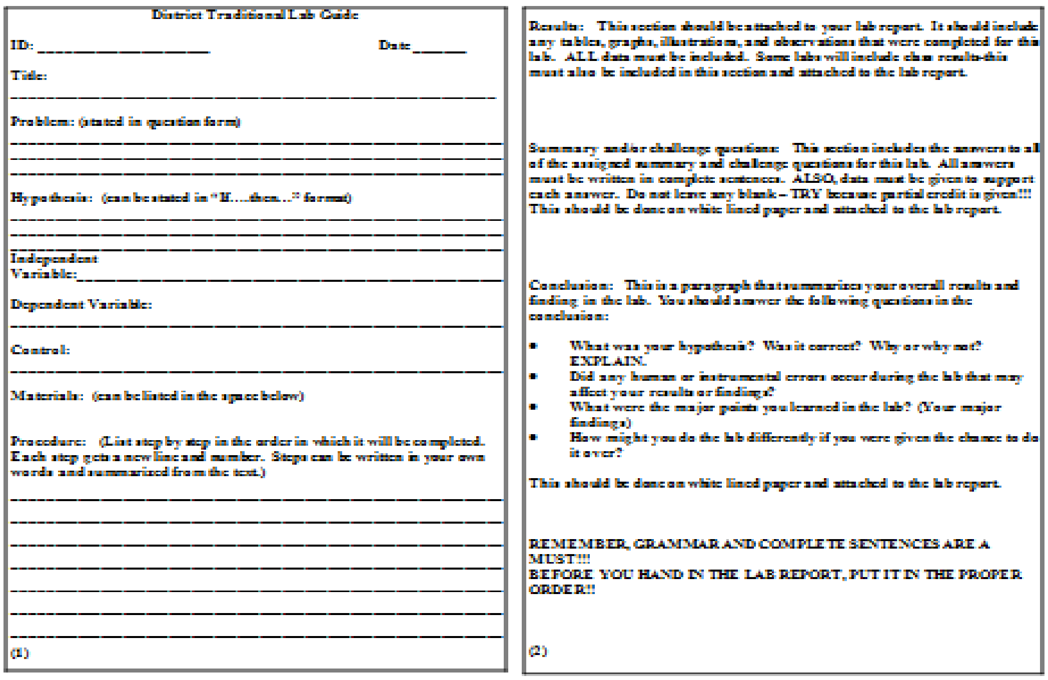
Gender	Percent - Treatment (n = 55)	Percent - Comparison (n = 69)	Percent - Control (n = 70)
Male	50.9	40.6	48.6
Female	49.1	59.4	51.4
Total	100.0	100.0	100.0

Intervention

Prior to the 15-week intervention, the researcher conducted 15-minute interviews with each teacher participant prior to the training and implementation of the intervention using the Concerns-Based Adoption Model (CBAM) Levels of Use (LoU) of an Innovation (Hall et al., 2006; SEDL, 2006). The LoU structured interview model was utilized to determine teachers' current use or knowledge of using specific teacher written feedback as defined by the current study. The researcher also provided professional development on the use of metacognitive strategies in ISNs and how to provide different types of specific written feedback: task-specific, process-specific, and metacognitive-specific. During the workshop, the researcher guided the teachers through the organization and use of an ISN, and provided them with a training-workshop binder containing copies of the set-up materials, presentation slides, lab activity logs, and resources on metacognition and critical thinking strategies along with additional background information on notebooking and feedback.

Pretests were administered by the researcher in each classroom over a 2-day period. The researcher provided support and coaching to teachers throughout the duration of the study through emails, phone conversations, before and after school visits, and planned meeting times. During the intervention, the researcher met with the teachers to collect samples of student work, to provide examples and discussion on the type of specific feedback, and to guide the development of the left side of the notebook. The researcher scheduled one 20-minute meeting per month with each teacher participant; in addition, the researcher scheduled two 1-hour work meetings to further discuss the implementation of specific written feedback using samples of student work from the ISNs. Classroom visits, lasting approximately 10 minutes per visit, were conducted by the researcher at least once per month to observe the students working in the ISNs. At no time did the researcher provide instruction to the students on the use of the ISN. Ongoing communication with the teacher participants was had through interschool office mail, and email as presented in the email audit log.

All groups performed the same six lab investigations using a uniform district science lab guide. Teachers in the all conditions taught the same core content, and students in all groups used the same PowerPoints developed by the teachers and science lab packets to learn the material. Teachers in the control group used a traditional lab guide (Figure 1).


District Traditional Lab Guide

ID: ____________ Date ______

Title:

Problem: (stated in question form)

Hypothesis: (can be stated in "If….then…" format)

Independent Variable:

Dependent Variable:

Control:

Materials: (can be listed in the space below)

Procedure: (List step by step in the order in which it will be completed. Each step gets a new line and number. Steps can be written in your own words and summarized from the text.)

(1)

Results: This section should be attached to your lab report. It should include any tables, graphs, illustrations, and observations that were completed for this lab. ALL data must be included. Some labs will include class results-this must also be included in this section and attached to the lab report.

Summary and/or challenge questions: This section includes the answers to all of the assigned summary and challenge questions for this lab. All answers must be written in complete sentences. ALSO, data must be given to support each answer. Do not leave any blank – TRY because partial credit is given!!! This should be done on white lined paper and attached to the lab report.

Conclusion: This is a paragraph that summarizes your overall results and finding in the lab. You should answer the following questions in the conclusion:

- What was your hypothesis? Was it correct? Why or why not? EXPLAIN.
- Did any human or instrumental errors occur during the lab that may affect your results or findings?
- What were the major points you learned in the lab? (Your major findings)
- How might you do the lab differently if you were given the chance to do it over?

This should be done on white lined paper and attached to the lab report.

REMEMBER, GRAMMAR AND COMPLETE SENTENCES ARE A MUST!!!
BEFORE YOU HAND IN THE LAB REPORT, PUT IT IN THE PROPER ORDER!!

(2)

Figure 1. *Traditional Lab Guide Used by Students in the Control Group.*

Students in the comparison group used the same guide; however, they glued these lab guides into the ISNs on the right side and then proceeded to interpret their understandings on the left side (Figure 2).

<table>
<tr><th>Left side of notebook:</th><th>Right side of notebook:</th></tr>
<tr><td>Interpretation:

Conceptual Diagram

Reflection:

Connection:

Extension:

I noticed that…

This made me wonder if…</td><td>Lab Title: ______________________________
PRE LAB
Safety rules addressed:
____
____
Purpose/Problem (research question)
____
____
Why is this important? (relevancy)
____
Prior knowledge and background information:
____
____
State your hypothesis – (What are you claiming?)
____
____
Independent Variable: ______________________
Dependent Variable: _______________________
Control: _______________________________
LAB:
<u>List materials:</u>

<u>Procedures:</u>
Define specific vocabulary or terms you will use…
How will you measure?
How many trials will you perform? Why?
Record observations

<u>Data presentation:</u>
Choose how you will represent your data collection/evidence: data table, graph, etc.

<u>Results:</u> Explain your findings (analysis)

<u>Conclusion:</u> (evidence based on your data) What would you change if you did this lab over?</td></tr>
</table>

Figure 2. *Example of an opened ISN used with the comparison group.*

Students in the treatment group used the same lab guide and input/output system. In addition, they also were provided specific written teacher feedback based on either the task they had just completed, the process of the task, or the metacognitive reflection itself (Figure 3).

<table>
<tr><td colspan="3">Left side of notebook:</td><td>Right side of notebook:</td></tr>
<tr><td></td><td colspan="2">Teacher Feedback</td><td rowspan="4">Lab Title:
PRE LAB
Safety rules addressed:
____
Purpose/Problem (research question)
____
____
Why is this important? (relevancy)
____
Prior knowledge and background information:
____
____
State your hypothesis – (What are you claiming?)
____
____
Independent Variable: _______________________
Dependent Variable: ________________________
Control: ___________________________________
LAB:
<u>List materials:</u>

<u>Procedures:</u>
Define specific vocabulary or terms you will use…
How will you measure?
How many trials will you perform? Why?
Record observations

<u>Data presentation:</u>
Choose how you will represent your data collection/evidence: data table, graph, etc.

<u>Results:</u> Explain your findings (analysis)

<u>Conclusion:</u> (evidence based on your data) What would you change if you did this lab over?</td></tr>
<tr><td></td><td>Performance</td><td>Think about</td></tr>
<tr><td rowspan="2">Interpretation:

Conceptual Diagram

Reflection:

Connection:

Extension:

I noticed that…

This made me wonder if…</td><td>The Task / The Process ↓</td><td></td></tr>
<tr><td>↑ Metacognitive Strategies</td><td></td></tr>
</table>

Figure 3. *Example of an opened ISN used with the treatment group.*

An example of a completed lab guide for a student in the treatment group is provided in Figure 4.

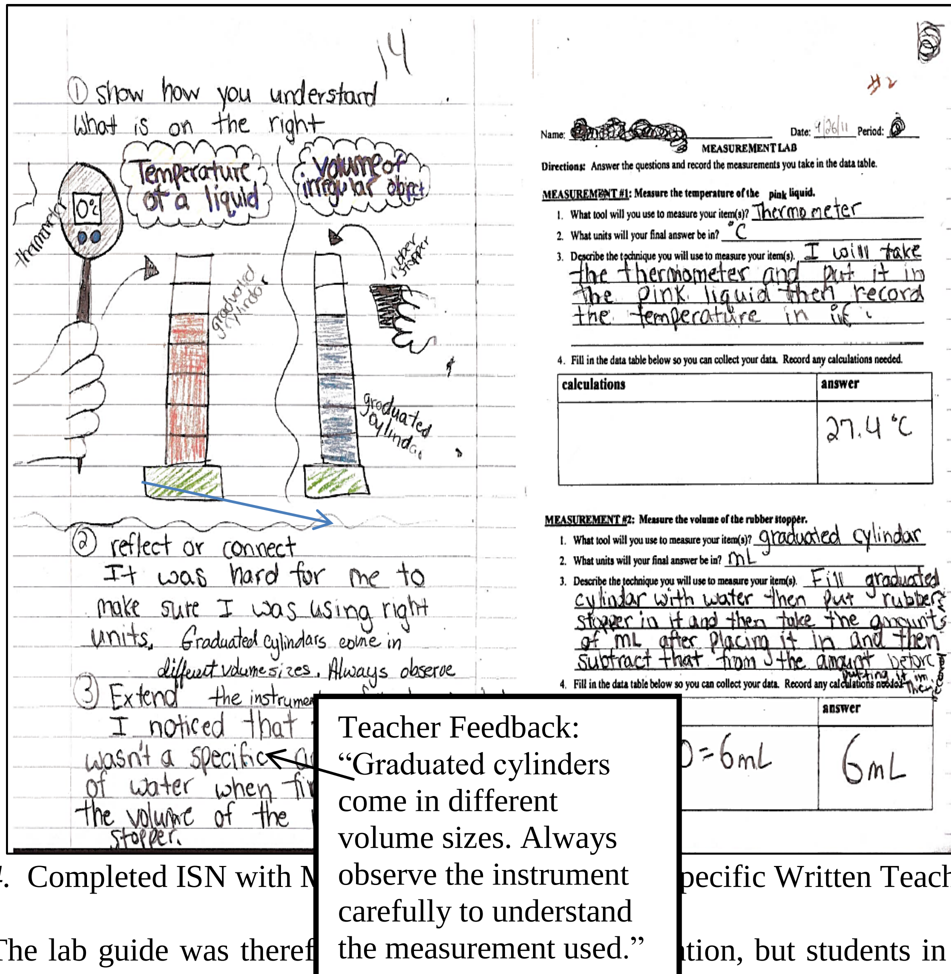


Figure 4. Completed ISN with M[...]pecific Written Teacher Feedback.

The lab guide was theref[...]tion, but students in the treatment and comparison groups also worked on the left side (output) where they applied interpretations, reflections, and/or other metacognitive learning strategies that were directly related to the lab. In addition, students in the *treatment group* only received specific written teacher feedback on their work. To ensure fidelity of procedures, teacher participants maintained a teacher log to track the date and title of the every science lab for all three groups.

The researcher also collected a total of 45 ISNs as samples from the treatment to document the amount of specific written feedback provided by the teachers. Teacher participants systematically collected the ISNs at the end of each class period on designated days and sent the ISNs to the school office to be picked up by the researcher. At the end of the 15-week intervention period, the researcher administered posttests in each classroom.

Instrumentation

Pre- and posttests. The Diet Cola Test (DCT) (Fowler, 1990) instrument was used in the current study to measure students' science process skills. Validity and reliability of the DCT have been previously established (Adams & Callahan, 1995; Fowler, 1990). Form A of the DCT (Fowler, 1990; Appendix B) was designed as an open-ended assessment that directs students to apply their knowledge to design an experiment based on one question: "How would you do a fair test of this question: Are bees attracted to diet cola?" Form B, The Earthworm Test (Adams & Callahan, 1995), asks students to design a fair test of the question, "Are earthworms attracted to light?" In the current study, Form A was used to measure students' pretest scores and Form B was used to measure students' posttest scores.

Prior to the intervention, the researcher assessed students' science process skills using Form A of the DCT (Fowler, 1990). Pretests were scored using the Fowler Science Process Skills Assessment Pretest/Posttest Scoring Sheet (Fowler, 1990). Each pretest was scored by the researcher and one of two science team leaders from both middle schools who did not instruct 7th-grade students. After 15 weeks of intervention, students were administered Form B, The Earthworm Test (ET), of the DCT (Adams & Callahan, 1995). The researcher collected these posttests and scored them with the assistance of the same two science team leaders using the Fowler Science Process Skills Assessment Pretest/Posttest Scoring Sheet (Fowler, 1990). Again, each form was rated by two scorers, and raters' scores were correlated for evidence of inter-rater reliability.

Both tests were scored using a checklist of 15 specific items that address science process skills and each item was awarded 1 or 2 points if the item was incorporated into the students' design, hence, ratings of 0, 1, and 2 were applied (Adams & Callahan, 1995; Fowler, 1990). A range of 0-30 points was therefore possible for either the pretest or posttest. Higher scores meant that students had demonstrated greater mastery of the item. Items included but were not limited to the following: plans to practice safety; states a problem or a question; plans to repeat testing and tells reason; and plans to control variables.

The Concerns-Based Adoption Model (CBAM) Levels of Use (LoU) of an Innovation. The CBAM-LoU (Hall et al., 2006) measures use or nonuse of an innovation on eight levels: (a) Nonuse, (b) Orientation, (c) Preparation, (d) Mechanical Use, (e) Routine, (f) Refinement, (g) Integration, and (h) Renewal. Each of the eight levels is rated along seven categories: (a) Knowledge, (b) Acquiring Information, (c) Sharing, (d) Assessing, (e) Planning, (f) Status Reporting, and (g) Performing. The LoU Manual (SEDL, 2006) provides operational definitions for all levels and categories.

The researcher used the LoU in the current study to measure the three teacher participants' levels of use of specific written feedback as defined by this current study. The researcher referred to The Basic Interview Protocol, The LoU Rating Sheet, and the Guidelines for Rating LoU Categories for this process (Hall et al., 2006; SEDL, 2006). Validity and reliability has been established for the LoU (Hall et al., 2006; SEDL, 2006); Cronbach's alpha coefficient is .98.

*Sample of ISNs from students in the treatment group***.**Teacher participants were asked to provide specific written feedback to student participants in the treatment group which was specifically related to the interpretations and reflections they made on the left-side, output page, of the ISN after each lab. The researcher systematically collected 45 ISNs from the treatment group at various points during the study for fidelity of implementation and to document the type and frequency of feedback incidents recorded in the notebooks. To assure equality among the schools, the researcher requested that at least six lab activities were to be conducted during the study (for all groups). This would afford students in the comparison and treatment groups several opportunities to apply metacognitive strategies in the form of interpretations, either written or in conceptual form, and reflections, through connections or extensions, to their work. After each lab, teachers would apply written feedback in the ISNs to student participants in the treatment group.

Data Analysis

Data were collected and organized using Microsoft EXCEL 2010 (Microsoft Office®, 2010) and then entered into the statistical package SPSS v. 15 (IBM, 2006) for further analysis. For research question one, data were analyzed using a one-way analysis of variance (ANOVA) on posttest Form B scores. The independent variable was the type of instructional program (treatment, comparison, or control). Pretest data were collected to use as a covariate if necessary, and the dependent variable was the mean score from each group on the pretest Form A of the DCT.

For research question two, data were collected from 45 student ISNs in the treatment group. Each item of feedback was counted and categorized according to the type of feedback: Task-specific, Process-specific, or Metacognitive-specific. Each specific written feedback incident recorded in the ISNs was documented by type and frequency, and validated by another researcher in the field of educational psychology.

Data were then entered in SPSS and analyzed using a multiple linear regression. The three predictor variables were the variables containing the amount of each type of specific feedback (Feedback-Task-specific, Feedback-Process-specific, and Feedback-Metacognitive specific process-specific), and the criterion variable was students' mean science process skill scores (posttest).

Results

Research Question One

Descriptive statistics were computed for the pretest and posttest scores for the treatment, comparison, and control groups and are presented in Tables 3 and 4 below.

Table 3
Descriptive Statistics for Total Pretest Scores on Form A of the Diet Cola Test by Condition

Pretest	*n*	Minimum	Maximum	Mean	Standard Deviation
Control Group	69	2.00	18.00	8.97	4.04
Comparison Group	66	2.00	17.00	9.60	3.44
Treatment Group	53	1.00	16.00	8.58	3.36
Overall	188	1.00	18.00	9.09	3.66

Table 4
Descriptive Statistics for Total Posttest Scores on Form B of the Diet Cola Test by Condition

Posttest	*n*	Minimum	Maximum	Mean	Standard Deviation
Control Group	66	3.00	19.00	9.10	3.50
Comparison Group	67	2.00	19.00	10.75	3.53
Treatment Group	53	2.00	17.00	9.68	3.83
Overall	186	2.00	19.00	9.86	3.66

For research question one, the researcher first ran an ANOVA on the *pretes*t mean scores on Form A of the DCT (Fowler, 1990) to evaluate if the means were equal prior to the intervention. Results of the ANOVA for the pretest scores indicate that there were no statistically significant differences on the mean pretest scores between the three groups $F(2, 185) = 1.203$, $p = .303$, prior to the intervention. See Table 5 for results of the pretest ANOVA.

Table 5
ANOVA Results for Mean Pre-test Scores for Form A of the Diet Cola Test

Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Science Process Skills	32.07	2	16.04	1.20	.303	.01

Testing the Assumptions for Pretest Scores

Meyers et al., (2006) suggest that there are three assumptions that must be met before the researcher can perform an ANOVA. These assumptions include: (a) independence of observations, (b) normality of the dependent variable, and (c) equal variances across groups. The researcher tested for each assumption as follows.

The independence of observations assumption was tested by ensuring that no students participated in more than one group. The normal distribution of the pretest variable was assured by performing a normality test which revealed that skewness (.136) and kurtosis (-.740) were within the recommended limits of ±1.00 (Meyers et al., 2006). In addition, the researcher examined a histogram of the scores for normality (see Figure 12). Meyers et al. (2006)

suggested that a histogram be used as a graphic representation when showing the distribution or the relationship of the frequency count of a continuous variable such as pretest scores. The researcher used SPSS v. 15 (IBM, 2006) to generate the histogram from the data entry.

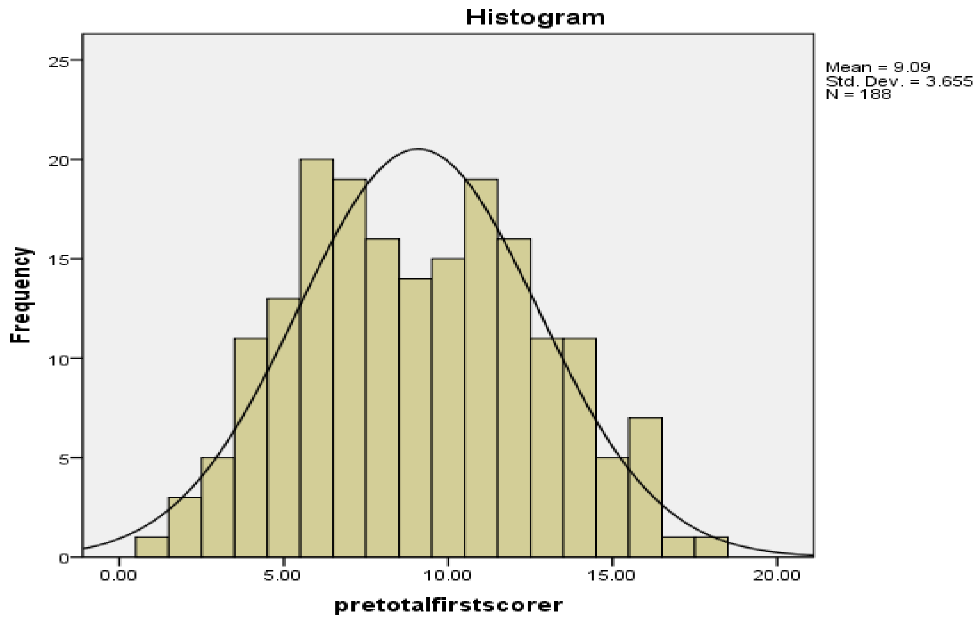


Figure 12. Histogram of the mean pretest scores from Form A of the DCT (Fowler, 1990).

In an ANOVA, the homoscedasticity assumption is referred to as homogeneity of variances "in which it is assumed that equal variances of the dependent measure are observed across the levels of the independent variables" Meyers et al., 2006, p. 70). Homogeneity of variances was tested using the Levene's Test of Equal Variances. The Levene's Test indicated that variance of the data did not differ significantly at the .05 alpha level (p = .104) across the levels of the independent variable (Meyers et al., 2006). After performing all assumption tests, the pretest data were considered fit for analysis.

Meyers et al. (2006) suggest that a covariate be used when groups are unequal on the dependent variable at the start of an intervention. Because mean pretest scores did not differ significantly across groups, it was not necessary to use the pretest scores as a covariate. Results of the ANOVA on the posttest scores indicated that there was a significant main effect for type of instructional program $F(2, 183) = 3.523$, $p = .032$, partial eta squared effect size = .04, trivial (Table 6). Students in the comparison group (n = 67, M = 10.75, SD = 3.53) scored significantly higher (p = .026, d = .47, moderate) than students in the control group (n = 66, M = 9.10, SD = 3.50) on Science Process Skills. There were no significant differences between the remaining groups: the control (M = 9.10, SD = 3.50) and the treatment group (M = 9.68, SD = 3.83) or the comparison (M = 10.75, SD = 3.53) and treatment groups (M = 9.68, SD = 3.83).

Table 6
ANOVA Results for Mean Posttest Scores for Form B (ET) of the Diet Cola Test

Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Science Process Skills	91.87	2	45.94	3.52	.032	.04

Research Question Two

A multiple linear regression model was used to analyze the data for this research question. This model was used to determine whether the three predictor variables (Feedback: Task-specific, Feedback: Process-specific, or Feedback: Metacognitive-specific) received by a student in the treatment group, explained variation in the criterion variable, students' Integrated Science Process Skills.

These items of specific feedback were coded into one of three feedback categories: (a) Task-specific (*n* = 102), (b) Process-specific (*n* = 70), and (c) Metacognitive-specific (*n* = 137). The categories were content validated by an expert in the field of educational psychology. The data indicated that metacognitive feedback (44%) and task feedback (33%) accounted for 77% of the total amount of specific written teacher feedback; feedback items related to the process of the task (23%) accounted for the least amount applied (see Figure 5).

Percentage of Specific Written Feedback Incidents Per Type

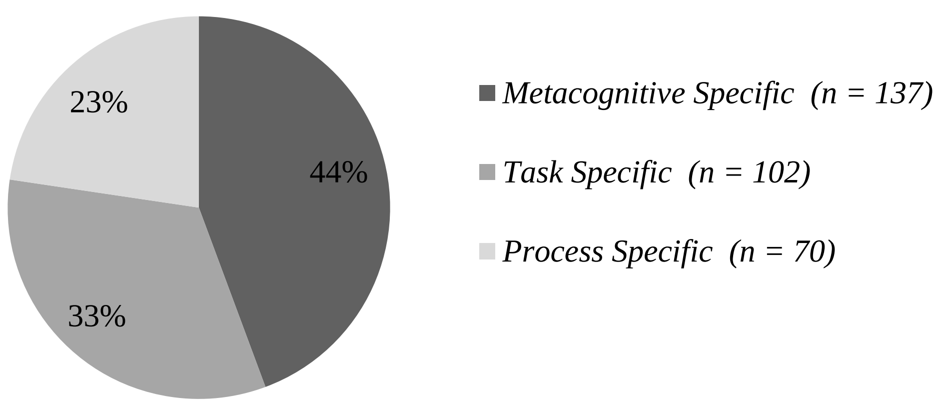


Figure 5. Type of Specific Written Feedback Provided to the Treatment Group.

Results. The results of the regression analysis are presented in Tables 7, 8, and 9 below.

Table 7
Means, Standard Deviations, and Pearson Product-moment Correlations for Variables Used in Regression Model for Research Question Two

Variable		M	SD	1	2	3	4
1	Posttest Scores	9.63	3.83	1.0			
2	Feedback on Task	2.26	1.35	.314	1.0		
3	Feedback on Process	1.47	1.37	.093	-.105	1.0	.
4	Feedback on Metacognition	3.28	1.69	.027	-.147	.497	1.0

Table 8
Multiple Linear Regression Model for Research Question Two

Model	Sum of Squares	Df	Mean Squares	F	Sig.
Regression	70.84	3	23.61	1.69	.185

Table 9
Predictors of the Mean Scores on the Feedback Regression Model

	B	SEB	Β
(Constant)	6.905	1.700	
Task Feedback	.936	.433	.329
Process Feedback	.333	.486	.119
Metacognitive Feedback	.037	.395	.016

The regression model was not significant $F(3, 39) = 1.69$, $p = .185$. Together, the variables in the model explained 4.7% of the variation in students' posttest scores, indicating that Specific Written Feedback did not significantly predict the mean posttest scores for students' Science Process Skills.

Discussion

The purpose of this study was to determine whether the consistent use of metacognitive strategies imbedded in an Interactive Student Notebook impacted the science process skills of students in grade seven. In addition, this study explored whether specific teacher written feedback, provided to students in the ISN, further enhanced the use of ISNs and resulted in greater gains in students' science process skills.

Findings from the current research demonstrated that using the ISN with metacognitive strategies embedded (but without specific written teacher feedback) impacted students' science process skills over traditional science instruction. These findings support a raft of research on the effectiveness of metacognitive regulation in instruction (e.g., Flavell, 1976; Padilla, 2010; Palinscar & Brown, 1987; Zimmerman, 2002). The majority of sampled student participants believed that using metacognitive strategies gave them a better understanding of science concepts that were taught. This finding is also consistent with research by Bruner (1960) and Padilla (2010) that suggests that, as with using integrated science process skills, learning happens in various phases of transformation from receiving knowledge to synthesizing and applying knowledge. These students may be further empowered if they are allowed to choose to interpret their understanding through a variety of conceptual drawings and written expressions.

This finding also implies that metacognitive learning strategies, along with other best instructional practices, should be provided to both pre-service teachers in their training to complete certification requirements and to classroom teachers through ongoing professional development. Curriculum coordinators, teaching coaches, administrators, and higher-education coordinators may develop and make available courses, workshops, and training opportunities for classroom teachers. Classroom teachers may instruct students through modeling strategies and providing examples that help them to express their thoughts and reflections in a variety of ways such as through graphic organizers, conceptual drawings, or writings to support learning and a better understanding of the concepts.

Further research is also warranted to explore the use of the ISN to promote their effectiveness as vehicles for other instructional strategies. The majority of sampled students believed the use of the ISN as an instructional tool facilitated their learning in that it improved their organization and provided them with one vehicle to use for science lab investigations, interpretations, and reflections which assisted them with their learning. These findings support research on the use of an ISN to as an instructional tool to promote learning strategies (e.g., Chesbro, 2008; Maracelli, 2010; Marzano et al., 2001; Wist, 2006; Young, 2003). Future studies may investigate how to best structure or use ISNs in ways other than prescribed in the current study perhaps with use in language or reading, for example. In addition, researchers may investigate how allowing student choice in the type of activity in the ISN may influence teacher instructional practices and a student's ability to better understand concepts and perform well.

Another interesting finding from the study indicated that the type of specific written feedback (task, process or, metacognitive) did not predict students' science process skills. Lack of science instructional time is a recurring issue for teachers as they are required to deliver the rigorous demands of district and national standards along with other managerial requirements. Teachers may feel stressed that they do not have time to provide feedback to students, especially when teaching multiple lab classes. A variety of feedback is important to student learning; however, the teachers in this study preferred verbal feedback. One teacher stated, "Yes, comments were read by students and used to improve learning." However, two of the three teachers believed the process was time consuming. Results of the student survey suggested that a small portion (21.43%) of responses indicated that specific written teacher feedback was not helpful or was unnecessary to students. Students responded that all directions were already clear and if they wrote a clear response then feedback would not be necessary; or that feedback was not helpful because they usually received feedback after they completed the lab not before it.

For feedback to be effective, improve student learning, and be a powerful formative assessment tool for teachers, it should be provided continuously (Butler & Nesbit, 2008; Hattie, 1992) and in a timely fashion (Brookhart, 2008; Gilbert & Kotelman, 2005; Marzano, 2007; Siewert, 2011; Waxman & Walberg, 1991). Further research is warranted on how to structure teachers' time and how to train them so that they are able to provide necessary and timely written teacher feedback with consideration for students to also be able to read, respond, and use ongoing feedback to impact their learning.

The researcher cannot speculate as to why the treatment group with feedback did not score significantly higher than the other groups; however, further study may warrant investigating if student responses differ when knowing that teachers will be commenting on their work. For example, would students demonstrate sufficient understanding alone or would they expand their thinking through reflection and creativity? Also, because the comparison group contained more female than male student participants, future researchers may wish to determine whether gender differences and maturation of females versus males may have an impact on metacognitive learning development.

This study did not explore student academic achievement on science content, but rather investigated interventions to improve students understanding of concepts as demonstrated through the use of science process skills. Further research may warrant investigation on whether the use of the ISN with the application of metacognitive learning strategies improves students' science achievement.

Limitations of the Study

At times, the intervention that is utilized by a treatment group may appear to be highly effective, causing members of other groups to want to follow the same instruction (Gall et al., 2007). The teacher participants in this current study taught in all three conditions. This posed a moderate threat. The treatment and comparison groups utilized a science notebook and metacognitive strategies that were not used with the control group. Although the teachers taught in all three conditions, they were comfortable with their own traditional teaching experiences and practices that were used with the control group. To partially address this threat, the researcher assured the teacher participants that the intervention could expand to include the control group once the study was completed. Also, the researcher assured the building administrators that workshops would be provided to all grade level teachers upon completion of the study. The researcher maintained ongoing communication with teacher participants and instructed them to document using a teacher log to ensure fidelity of implementation.

Conclusion

The application of metacognitive learning strategies by students, such as linguistic and non-linguistic interpretations of their understanding of an investigation, along with reflections and extensions of the students' knowledge, with the use of an interactive student notebook

(ISN) as an instructional tool appeared to impact the science process skills of 7th-grade students. Qualitative findings indicated that students liked using the ISN for science labs and believed that it benefitted their learning of science process skills. Teachers and students also believed that using the ISNs was helpful to students' learning because of the application of metacognitive strategies.

Although specific feedback may be an empowering tool for teachers to utilize, the findings of the current study indicated that the amount and type of feedback (feedback on the task, on the process of performing the task, and/or on metacognitive strategies) did not predict science process skills. Qualitative findings indicated that students in the treatment group believed that feedback encouraged them to put forth more effort in their work and to improve their own learning; however, teachers perceived specific written feedback to be difficult and time-consuming as compared to verbal feedback which they believed was quick and in-the-moment.

The researcher began this study with the idea that the ISN as an instructional tool would solely impact students' science process skills through use during science instruction. What emerged from this current study was that asking students to think and demonstrate what they know about what they learned through the application of metacognitive learning strategies, empowered them to think, reflect, and apply their knowledge to the processes of conducting science investigations. The metacognitive strategies embedded with the use of the ISN, as an instructional tool or a vehicle to organize their thoughts, were key to the impact made on the science process skills of the 7th-grade students in this study.

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