Does the Use of Science Notebooks During Project Based Learning Improve Literacy?

Esther Dabagyan

California State University, Northridge
ABSTRACT

Standardized testing has become prevalent and punitive in education. Due to the great importance placed upon standardized tests in this country and in California, increasing attention has fallen upon English language learners (EL). EL students typically underperform on standardized tests. Schools that fail to meet standardized testing goals for many years face restructuring and staff replacement. Content teachers are asked to essentially teach both their subject matter and English to their EL students. The purpose of this study was to find out if science notebooks are an effective means of improving science literacy and English literacy among EL students and accomplishing this task. Two classes were studied where one was the treatment group and used science notebooks while the other was the control group and did not use the notebooks. Both groups of EL students were given pre and post tests. Two sources of data were collected from each class, pre/post tests and worksheets/notebooks. The study took place during a five and a half week long project-based unit. The findings showed that the class using then science notebooks improved in both science and English literacy greater than the class that did not use the notebooks. While difference between the two classes was not statistically significant, the results show that integrating writing into content areas other than English can be accomplished.
Chapter 1 Introduction

In 1983, the publication of A Nation at Risk revealed that the “average achievement of high school students on most standardized tests is now lower than 26 years ago when Sputnik was launched” (National Commission on Excellence in Education, 1983, Indicators of The Risk section, paragraph 1). Clearly, education was in trouble, and testing was viewed as the path towards a solution. In the United States, we have uniformly used standardized testing since 1930; however, at that time most students did not take more than three tests in their entire educational career (Perrone, 1991). In the early 20th century, standardized testing was used as a means to manage the rapidly growing number of students by sorting them into different educational tracks and using the results to determine whom to promote to the next grade level (Linn, 2001). Testing only became more prevalent as after the 1950’s. The National Commission on Excellence in Education also revealed that industry and military were forced to spend millions of dollars toward the remedial education of their employees in basic skills such as reading and writing. The shock of adults with subpar education highlighted the need to keep schools and teachers more accountable by employing a new battery of standardized tests (National Commission on Excellence in Education, 1983). Recently, Japan has also begun to implement the first nationwide standardized testing in 43 years in their primary and secondary schools as a means of improving their educational system (Shimbun, 2007). It seems that the testing pendulum is not going to swing the other direction anytime soon.

More recently, the enactment of the No Child Left Behind (NCLB) law by President Bush in 2002 paved the way for further testing and accountability in the form of penalization. In the name of economic growth, NCLB has dictated the following goal:
that all students are at a proficient level on state tests by the 2013-2014 school year. In order to reach this goal, NCLB has also mandated that all states develop their own tests and make “adequate yearly progress” (AYP). Once a school fails to achieve its AYP goals, it is classified as a Program Improvement (PI) school. As part of holding schools accountable, after only two years of failing to meet AYP scores, schools must allow their students to transfer to any school of their choice and be offered services such as tutoring. If a school does not meet its AYP goals for more than 3 years, it faces corrective action and can be restructured. Restructuring may include implementing new curriculum, replacing staff, appointing an outside expert to advise the school, changing the internal organization of the school and extending the school day or the school year. After the fifth year of failing to meet AYP goals, the school can face being converted into a charter school, having all or most of its staff replaced, being taken over by the state or having to hire a private managing contractor (U.S. Department of Education, 2003). With such punitive measures facing schools, doing poorly on standardized tests can truly hurt, yet in the last 5 years, from 2002 to 2007 little improvement has been made in the 8th grade national reading achievement scores (U.S Department of Education, 2008).

Because immigration into the United States has increased over the years, English language proficiency has become a major problem with regard to testing. From 2005 to 2006, legal immigration increased in the United States by 13 percent (Jefferys, 2007). However, illegal immigration, although hard to estimate, has risen much more. In fact, from 2000 to 2006, there has been an increase of 37 percent in illegal immigrants. The population of illegal immigrants has increased from approximately 8.5 million to 11.6 million (Hoefer, Rytina, & Campbell, 2007). As of 2003, “from a total of 48 million public school students, about 5 million students, or 10 percent, are English language
learners” (Abedi, 2007, p.3). The percentage of ELL students has doubled since 1992-1993 when it was only 5 percent (U.S. Department of Education, 2004). Many schools full of new immigrants who know little to no English struggle to meet their standardized testing goals. Even in 1983, the National Commission on Excellence in Education found that “about 13 percent of all 17-year-olds in the United States can be considered functionally illiterate. Functional illiteracy among minority youth may run as high as 40 percent” (Indicators of the Risk section, paragraph 1). In light of these stark statistics, standardized testing goals seem to be further out of reach, especially in states like California.

Many schools find it difficult to meet their standardized testing goals as shown by the more than two thousand schools in the Los Angeles Unified School District (LAUSD) that are in program improvement status due to NCLB (Wells, 2007). LAUSD is one of the two largest school districts in the United States; it is also in the state of California, which has one of the largest percentages of minority students in the nation (U.S. Department of Education, 2004). In LAUSD, teachers are constantly pressured by administrators, who are themselves pressured by state officials to improve test scores. Unlike the state of California as a whole, LAUSD did not meet its AYP goals in 2007. This was in large part due to their ELL population that had an English proficiency percentage of 21.2, just below the goal of 23 percent. Every other student subgroup met the AYP goal except ELL students and students with disabilities (California Department of Education, Policy and Evaluation Division, 2007). The large difference between the achievement of the total student population in LAUSD and the ELL population signifies that schools need help in addressing the needs of their ELL students.
Hill Middle School is located in the urban city of Hollywood, California. Historically, our school has had a very diverse population in terms of languages spoken at home. More than 17 languages are spoken by the student population, and currently our most common secondary language is Spanish. We also have a considerable Filipino population. Our minority population is the same as our ELL population. Hill is in its 4th year of Program Improvement status according to the NCLB guidelines. This year we have restructured our school into small learning communities. Hill’s ELL students do considerably worse (18.1 % proficient) on the English Language Arts state test when compared to the rest of our population (26.4% proficient) (California Department of Education, Policy and Evaluation Division, 2007). Our school has implemented many strategies to improve literacy in our students including writing across the curriculum and the analysis of student writing samples from all content areas. The ELL population also lags behind in math (18% proficient) when compared to the total population of Hill middle school (22.2 % proficient) (California Department of Education, Policy and Evaluation Division, 2007). ELL students need help in improving their skills in order to catch up with the rest of our student population. It is always challenging to teach ELL students, but it is also challenging for the ELL students themselves to take English-only tests that are often full of colloquialisms and content specific vocabulary. Due to the weight of this problem, content teachers are faced with a serious predicament: How do we teach our students both subject matter and literacy? This study will attempt to answer that question by investigating one method of improving literacy in a science classroom that has shown promise in elementary schools.

Purpose Statement
The purpose of this action research project is to assess the efficacy of using science notebooks during project-based learning. The science notebooks may improve science literacy as well as English proficiency. Science teachers frequently employ science notebooks and project-based learning in their classrooms.

My research questions are:

- Can the use of science notebooks improve English literacy?
- Can the use of science notebooks improve Science literacy?

If students are given the opportunity to write in an expository fashion during their content classes and reflect upon their own learning, they may be able to improve their science and English literacy.

**Importance of Study**

This study is important to any teacher who faces rigorous standardized testing of their ELL students. Teachers who have so-called “sheltered” classes, in which different levels of English learners are mixed in with students who are native English speakers, can implement the various techniques employed in this study to help close the language gap. Closing the language gap will also enable us to close the achievement gap between English language learners and fluent students. According to the statewide AYP report in 2006, the percentage of students who are proficient in English is 44.8; however, for ELL students, this number is only 24.8% (California Department of Education Policy and Evaluation Division, 2007). This study can also provide insights for teachers who may not have English language learners, but who have native English speakers who simply have a difficult time grasping the language of science. When students acquire one language, they often do so in the same manner as they have acquired another; acquiring scientific language is no different than acquiring a foreign language.
This study is of particular importance to me because of the demographics of my student population. For the past five years, aside from my honors science class, every other class I have had has been a sheltered class. These sheltered classes contain students of varying English proficiency levels, from four and above.

**Definition of Terms**

For the purposes of this study, the following terms are defined:

- Project-based learning (PBL) is defined as an inquiry based approach where students work in teams to explore real-world problems and create explanations to share what they have learned.

- English language learner (ELL) students are defined as students whose native or first language is not English. English learner (EL) and ELL are used interchangeably in this study.

- Language acquisition describes the process of learning a second language.

- Science literacy describes the understanding of scientific concepts contextually. In this study, science literacy is the understanding of a specific scientific concept.

- English literacy describes the ability of an individual student to express themselves through writing and speaking in grammatically correct English.
Chapter 2 Literature Review

In order to develop the proper context for this study, I will present three areas of literary review: The first area explores the nature of science literacy and the role that literacy plays in science. My first research question asked whether science notebooks can help improve science literacy. This portion of the literature review helped to solidify what science literacy is and how to measure it in a study.

The second area of my literacy review includes the extensive literature available regarding project based learning (PBL) and its use in science classrooms. My study was conducted during a PBL unit. My second research question asked whether science notebooks help improve English literacy. This portion of the review allowed me to better gauge the possible variables that may affect both science and English literacy aside from science notebooks.

The last portion of the literary review presents information available regarding science notebooks and how to effectively implement them in a classroom. I used the articles to construct a consistent reflection section and method in the science notebooks which the students used during the study.

The Role of Literacy in Science

Science literacy is very important in modern society. When science literacy is defined in a broad sense, it can include not only the understanding of key scientific concepts and principles but also the ability to apply scientific ways of thought to personal and social purposes (Rutherford & Ahlgren, 1991). Despite the significance of scientific knowledge in today’s world, American students lag behind; simply, Americans are not science-literate (Rutherford & Ahlgren, 1991). As educators, we are responsible for producing a scientifically literate population. According to Rivard and Straw (2000) the
goal of science literacy is that teachers create active learning environments where students can construct and understand science while conducting discussions within the class. Speaking is an important part of building scientific knowledge and thus scientific literacy is inextricably tied to literacy.

Norris and Phillips (2003) proposed that “scientific literacy ought to mean more than memorization of the vocabulary of science” (p. 225). They elaborated that literacy is fundamental to scientific literacy in that reading and writing are not only the instruments of science but without reading and writing, modern science could not exist (Norris & Phillips, 2003). Teachers cannot hope to address science literacy without addressing literacy itself. Rivard and Straw (2000) conducted a study regarding the effect of talking and writing on learning science. They illustrated that there are many benefits to writing in science class. These benefits included the personal connection that the student makes to the content and the connections the student can make within the content topics. Rivard and Straw (2000) concluded through their research that “peer discussion may be sufficient for the retention of facts and simple concepts, but may have to augmented by writing for the retention of more complex integrated knowledge” (p. 578). They showed that writing is a central component and can aid the retention of scientific literacy over time as long as students have some basic scientific ideas with which to begin (Rivard and Straw, 2000).

Project Based Learning

There is a significant amount of research published regarding project based learning (PBL). Sometimes referred to as kit-based science or guided-inquiry science, most research suggests that PBL is most effective in engaging children with authentic questions centered on a “big idea” (Amaral, Garrison & Kelntschy, 2002; Moje, Collazo,
Carrillo & Marx, 2000; Lynch, Kuipers, Pyke & Szesze, 2004). Descriptions of PBL typically have a strong correlation to the definition of inquiry-based science. Some common features include (a) posing questions; (b) planning investigations; (c) collaboration with peers and the community; (d) communicating results through written and oral formats; and (e) revising of previous thoughts based on on-going feedback (Diaz-Rico and Weed, 2002; Moje, Collazo, Carrillo & Marx, 2000). When PBL is applied in a science classroom, research has shown that the results can be positive. Students in the tenth and eleventh grades outperformed similar groups on a national science test after their teachers implemented PBL in their science classrooms (Schneider, Krajcik, Marx & Soloway, 2001). The students in the study by Schneider et al. (2001) attended a small alternative public high school and the results were statistically significant. According to research, PBL can facilitate greater success for students in science classes.

There are however contradictory studies in the effectiveness of project based learning for students who struggle with the English language. Moje, Collazo, Carrillo and Marx (2000) argued that in order for project based learning to be effective for English language learners, a greater care must be used to merge discourse within the activity. They found that PBL is especially difficult for EL students that are acquiring English in an everyday context, and also being are asked to interpret their PBL discourse in a scientific context (Moje et al., 2000). Simply, learning English and also learning scientific English can be a large burden on EL students. Lynch, Kuipers, Pyke and Szesze (2004) found that within a diverse group of 1500 eighth grade students, the EL students were the only subgroup that did not benefit from a PBL unit in measurements on
scientific achievement tests. The PBL unit in the study included the use of science notebooks as most PBL lessons usually do include some sort of writing.

Amaral, Garrison & Kelntschy (2002) found that EL students increased their achievement in not only science, but math, reading and writing over a 4 year period of participating in PBL. The study was very structured in that the teachers received over 100 hours of professional development to implement a highly rated PBL curriculum that was specifically geared towards EL students. Teachers were also trained how to develop writing skills in science notebooks. Often, the PBL units were introduced in the students’ native language.

In a study conducted by Hug, Krajcik and Marx (2005), a student population 60% below grade level on state-mandated achievement tests could nonetheless make strong and meaningful connections from their own lives to the curriculum when taught through PBL. The students repeatedly related their projects to real life experiences and the central driving question of the unit. The students discussed the ideas behind the central question and included scientific terminology and concepts. The personal connection was found to be one of the most important factors in not only language acquisition, but also the building of content knowledge. PBL has high discourse content, encouraging students to engage in conversations about what they are learning. While this does place a difficult demand on EL students, when the project is exciting and relevant, students want to talk. Often times, these conversations and other means of communication (writing reports, oral presentations) need additional scaffolding from the teacher for EL students to gain true depth of knowledge. The wide spectrum of PBL effectiveness is largely dependant on implementation and project type. Not all PBL will benefit EL students and the research points to mixed results.
Almost all the research publications concerning PBL suggested that students utilize some sort of science notebook to keep track of their progress during the unit. These notebooks usually involve a lot of writing for the student and thus can help develop not only science literacy but literacy itself. Ruiz-Primo, Li and Shavelson (2002) defined science notebooks as a “compilation of entries… that provide a partial record of the instruction experiences a students had in her or his classroom for a certain period of time” (p.2). There is little to no quantitative research that measures the effects of science notebooks on test scores and student achievement. However, many guides and recommendations exist on the topic of how to prepare and use science notebooks in the classroom.

Gilbert and Kotelman (2005) stated that students must practice writing in order to learn how to write and that science notebooks offer them various forms of writing, such as procedural, narrative, descriptive and labeling. By enhancing student communication, science notebooks can help develop EL language acquisition. Gilbert and Kotelman (2005) also outlined some of the other benefits to using science notebooks, such as writing for thinking and allowing teachers access to students’ thinking, differentiated learning support and fostering collaboration. They explored the Tucson (AZ) Unified school district that has implemented science notebooks in combination with PBL and has found that their ELL population was “especially benefiting” (Gilbert & Kotelman, 2005, p. 31). Unfortunately, Gilbert and Kotelman (2005) did not present any quantitative data.

Klentschy (2005) had discovered through research at the Valle Imperial Project in Science that the six essential sections of a science notebook are question/problem/purpose, prediction, planning, observation/data/claims-evidence, what
have you learned, and next steps/new questions. Each section requires modeling by the teachers and clear rubrics regarding the quality of entries into the notebook. Klentschy (2005) has found that science notebooks empower students to take ownership of their own learning and develop their own personal meaning and ideas about the world surrounding them.

Other types of science notebooks exist, such as science journals and interactive science notebooks (Chesbro, 2006). They are less clearly defined or are not meant to support the inquiry process that takes place during PBL. The most effective method of employing science notebooks is to allow the student to follow the investigative process in their notebook in a clear method as outlined by Klentschy (2005) and Nesbit, Hargrove, Harrelson and Maxey (2004).

**Summary**

According to the literature cited earlier, science literacy and English literacy are closely intertwined. Students were expected to contextually explain scientific content to represent their scientific literacy. Student had clearly defined sections in their science notebooks to accommodate the process of PBL and allow them to seamlessly integrate their English language skills with the science content. As the literature recommended, opportunities for discourse among cooperative groups and opportunity for reflection was given to students during the study.
Chapter 3 Methodology

Participants

The study took place at Hill Middle School in Hollywood, California. Hill is a public school located in an urban community where 97% percent of the students qualify for the free lunch program. It is part of the Los Angeles Unified School District (LAUSD) and more specifically is part of local district four. It is in the middle of a mixed neighborhood where some parts are full of gang activity and other parts are slowly becoming gentrified. Many students know about, experience on a daily basis or are associated with gang activity. The school itself lies within a community that includes television and movie studios.

Hill is a multi-track school. It has three tracks and thus has students on its campus at all times of the year. The three tracks are titled A, B and C tracks. All students in the study were B track students. B track is unique because it is the only track that has its two month vacations in the middle of the semesters. The study included two groups of eighth grade students that were studying physical science during the first semester. Both groups were taught by me. The first class, (using only worksheets) class W, contained 23 students of which 21 participated in the study. The second class (using science notebooks), class N, contained 18 students of which 16 participated in the study. The EL levels of the students are shown in Figure 3.1 for each class. Most of the level 4 students were in the class W. Most of the students (74%) were 14 years of age in the class using worksheets (class W) and that was also the case of the class using notebooks (class N) where 82% were of 14 years of age.
Figure 3.1. EL level demographics bar graph

EL level 4 is the most advanced level of EL students and indicates that those students are current taking English as a second language (ESL) course. In general there are 2 types of ESL courses, levels 1 and 2 are usually grouped together and levels 3 and 4 are grouped together. Students who are classified as “preparing for re-designation” have passed their ESL level 3/4 course but have not met other criteria to be reclassified or re-designated into mainstream English classes. The reclassification criteria include a score of 3 and above on the California English language development test and a basic level and above on the California Standards Test in English language arts. These groups of students are enrolled in a “sheltered” English course and sometimes a “developing readers and writers” (DRW) course to help them prepare for re-designation.

Materials

The students studied one PBL immersion unit during this study. The unit was titled “What Makes Things Float?” and explored the topics of density and buoyancy. The first class (class W) did not use science notebooks as described by Klentschy (2005) while the second class (class N) did use science notebooks during the unit of study. Science notebooks were used daily to document events, use vocabulary and to reflect at
the end of the period. The PBL unit was designed and implemented by the Los Angeles Unified School District, in conjunction with an organization called SCALE (System-wide Change for All Learners and Educators). SCALE is a national network of more than 50 working groups of educators and researchers focused on improving mathematics and science teaching and learning at all levels. SCALE is currently working with four major urban school districts (Denver Public Schools, Los Angeles Unified School District, Madison Metropolitan School District, and Providence (RI) Public Schools), and three universities (University of Wisconsin-Madison, California State University, Dominguez Hills and California State University, Northridge). The unit took about six weeks to implement and began with a core question presented to the students. The core question throughout the unit was “What makes things float?” Following the core question, students were shown various discrepant events and asked to generate their own questions related to the topic. Of those questions, several were chosen and pursued. The questions generated by each class were distilled into essential questions the class must investigate in order to understand what makes things float. Because the unit contains a set of hands on activities that must be done in a specific order, the instructor chose the order of the student generated questions to fit the next activity. As a culminating task, students were given the opportunity to share their conclusions and reflections through their science notebooks (class N) or their worksheets for those in class W. Students in class W were provided with worksheets to reflect each day on their activities and lessons.

When science notebooks were not used, students were asked to simply fill out handouts and complete writing assignments as needed. The handouts were uniform in both classes; and students who used science notebooks simply glued or stapled those handouts into their notebooks. This was the only difference between class W and class N.
Examples of these activity handouts or worksheets can be found in appendices A and B. Pre-tests and post-tests were given to both classes before and after the unit using the same questions about the unit of study. The tests contained five open ended questions and a copy can be found in appendix C. Both class used the same format to reflect on lessons as shown in appendix D.

*Procedures*

Classes W and N began the density and buoyancy unit in November of 2007 after learning about forces and motion. The unit lasted approximately five and a half weeks. Class W did not use scientific notebooks while Class N did. The science notebooks were collected at the end of the unit. The worksheets that Class W completed were collected on a weekly basis, checked and handed back at the conclusion of the unit. All papers regarding the density and buoyancy unit were collected from Class W students at the end of the unit. Both classes were taught how to use the notebooks at the beginning of the school year and already had experience using them. Class W was asked to stop using their notebooks for the duration of the PBL unit. The unit began with a pre-test for both groups. These tests were collected and evaluated for scientific and English language literacy.

After the pre-test, several discrepant events were set-up for the students to observe and interact with. From these observations, students were asked to generate questions, first individually and then collaboratively, about the central theme. The classes discussed which questions were possible to investigate, which were not and why. From a class list of testable questions, several questions were revised, and trends were observed in similar questions. These questions were documented in the science notebooks or on a
Does the Use worksheet and also on a class poster. The questions were displayed and referred to throughout the unit as the guiding reason for the rest of the investigations.

Students worked in groups of three to four. The groups were selected by the instructor to be heterogeneous according to ability level; however they were homogenous in gender as much as possible. Each class then began to investigate the questions generated by the class. The instructor chose the order of the questions that would be investigated. At the end of each day, students from Class W were asked to reflect on a worksheet about any conclusions they had reached or how they needed to modify their procedure. Class N students were asked to go through the same process but to use their science notebooks instead.

Whenever new vocabulary was introduced, all the students were asked to write down their own definitions. All new vocabulary works were displayed on a word wall at the front of the classroom. At the conclusion of the unit the students took the post-test and the same five students from each class were interviewed again. The post-test contained the exact same five open ended questions as the pre-test. Student notebooks from class N and packet of student worksheets from class W were collected at the end of the unit and coded for use of key terms, explanation styles, completeness and sentence structure.

Analysis

The data was organized into two sets: the coded science notebooks or worksheets, and the coded pre- and post-tests. Science notebooks and worksheets were coded for English literacy and Science literacy. The results were tabulated and analyzed for patterns and trends within student subgroups in the two classes. The pre- and post-tests were graded for accuracy and also coded for the same elements as the science notebooks, and
worksheets. The results were graphed for each class and for each research question. As mentioned earlier, EL level 4 students were primarily in the class that did not use notebooks (class W).

Following the analysis of each set of data, they were compared to one another using inductive analysis. Classes were followed across two sets of data where patterns regarding language growth and science literacy were identified. T-tests were conducted to see the statistical relevance of the difference in improvement between class W and class N.
Chapter 4 Findings

To answer my research questions, two sources of data were analyzed. The first source of data was the pre and post tests. The second source of data was the worksheets and notebooks. My two research questions were:

- Can the use of science notebooks during project based learning improve English literacy?
- Can the use of science notebooks during project based learning improve Science literacy?

**Coding Method for English Literacy**

To answer the first question, data was gathered from notebooks, worksheets, pre-tests and post-tests. All the data was in the form of written responses to various questions, including those that asked students to describe specific scientific knowledge and those that simply asked them to reflect on their experiences in class. The written responses were coded for English literacy and assigned point values according to the scale in figure 4.1. Some codes were valued at positive one or two and others were valued at negative one. The positive and negative values correspond to strong and weak English literacy skills respectfully. A score of zero indicated that the student had just as many correctly stated sentences as they had mistakes, thus they are of medium level of English literacy when compared to their classmates. If the student did not respond to a question, no points were given or taken away.

**Figure 4.1. English Literacy Codes**

<table>
<thead>
<tr>
<th>Description</th>
<th>No Response</th>
<th>Simple Complete Sentences</th>
<th>Complex Complete Sentences</th>
<th>Incomplete Sentences/Run-ons</th>
<th>Words out of context/order</th>
<th>Article problems</th>
<th>Verb problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>nr</td>
<td>ss</td>
<td>cs</td>
<td>is</td>
<td>woo</td>
<td>ap</td>
<td>vp</td>
</tr>
<tr>
<td>Points</td>
<td>none</td>
<td>1</td>
<td>2</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
</tr>
</tbody>
</table>
This is a sample of a simple complete sentence from student 267 as written in their notebook; "The yellow cube floats and the brown cube floats.” This is a complex complete sentence from the same student; “The sold + silver blocks sink because they have more density.” This is an example of an incomplete or run-on sentence from student 210, “It will be in the middle because when the ball gets that big it will have a lot of volume and but the cotton ball is going to get a little heavy because it absorbs water and it makes it sink.” This is an example of a sentence that has a verb problem and a word out of context (used incorrectly) from student 248, “What make a object float is the light of an object also because the water is pushing up the object” (emphasis added). The previous sentence also has an article problem where a is used instead of an. Students’ English literacy scores were obtained by averaging the values of each question in a particular assignment as shown in Table 4.1.

Table 4.1
Sample from Class W: Post-test English Lit. Scores

<table>
<thead>
<tr>
<th>Student ID</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>106</td>
<td>2</td>
<td>-1</td>
<td>2</td>
<td>-1</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>142</td>
<td>1</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
<td>-0.2</td>
</tr>
<tr>
<td>140</td>
<td>-1</td>
<td>2</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
<td>0</td>
</tr>
<tr>
<td>126</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
<td>-0.2</td>
</tr>
<tr>
<td>104</td>
<td>1</td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
<td>0</td>
</tr>
<tr>
<td>165</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>1</td>
<td>-1</td>
<td>-0.6</td>
</tr>
<tr>
<td>171</td>
<td>3</td>
<td>-1</td>
<td>2</td>
<td>-1</td>
<td>-1</td>
<td>0.4</td>
</tr>
<tr>
<td>138</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>121</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>0</td>
<td>-1</td>
<td>-0.8</td>
</tr>
<tr>
<td>191</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>-1</td>
<td>1.2</td>
</tr>
<tr>
<td>195</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>153</td>
<td>2</td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>174</td>
<td>2</td>
<td>2</td>
<td>-1</td>
<td>1</td>
<td>0</td>
<td>0.8</td>
</tr>
</tbody>
</table>
The columns that are titled Q1, Q2, etc., refer to question 1, question 2, etc., in the test.

After each student was given an average English literacy score, class averages were tabulated from those scores. With regards to science notebooks and worksheets, each student had three scores for those assignments, one score from the beginning of the unit, one from the end of the unit and the last is the difference between the beginning and the end as shown in Table 4.2. Shaded boxes indicate missing worksheets or pages from notebooks. Missing worksheets or pages were not given a zero, but were left out of the score tabulation process. If a particular student did not have a beginning or end score, the change in those scores was not computed for that individual student. A t-test was done with the individual student scores. For the notebook and the worksheet assignments, each class had an average English score for the beginning of the unit, and the end of the unit.

The beginning and end scores were compared to one another for indication of improvement in English literacy.

Table 4.2
Class N: Sample Notebook English Scores: Beginning vs. End

<table>
<thead>
<tr>
<th>ID</th>
<th>English Prof. Beginning: 1.1 Observations</th>
<th>Class N: Beg. English Ave. Score</th>
<th>End: 3.1 REAPS: P</th>
<th>Reflection: Class N: End English Ave. Score</th>
<th>Class N: Change in English Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>212</td>
<td>-1,1</td>
<td>0</td>
<td>-1</td>
<td>Nr</td>
<td>-1</td>
</tr>
<tr>
<td>225</td>
<td>1</td>
<td>1</td>
<td>-1</td>
<td>Nr</td>
<td>2</td>
</tr>
<tr>
<td>242</td>
<td>-1,-1,1</td>
<td>-0.33</td>
<td>nr</td>
<td>1</td>
<td>1.33</td>
</tr>
<tr>
<td>241</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>297</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>240</td>
<td>-1,1</td>
<td>0</td>
<td>-1</td>
<td>-1</td>
<td>-1.00</td>
</tr>
<tr>
<td>210</td>
<td>-1,1</td>
<td>0</td>
<td>2</td>
<td>1,-1</td>
<td>0.67</td>
</tr>
<tr>
<td>220</td>
<td>-1,-1,-1</td>
<td>-1</td>
<td>1,-1</td>
<td>0</td>
<td>1.00</td>
</tr>
<tr>
<td>231</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>214</td>
<td>-1,1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>267</td>
<td>1</td>
<td>1</td>
<td>-1</td>
<td>2</td>
<td>-0.50</td>
</tr>
</tbody>
</table>
English Literacy Findings

The average English literacy score for both assignments increased for both class N and class W as shown in Figure 4.2. When the change between the beginning and the end scores are tabulated, class N shows an overall greater improvement in English literacy than class W. The greatest improvements are evidenced from class N’s notebooks as shown in Table 4.3 which shows the average change in student English literacy scores.

Figure 4.2 English Literacy Scores for Classes N and W

<table>
<thead>
<tr>
<th></th>
<th>Beginning</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Pre/Post Score: Class N</td>
<td>0.08</td>
<td>0.4</td>
</tr>
<tr>
<td>Average Notebook Score: Class N</td>
<td>0.06</td>
<td>0.27</td>
</tr>
<tr>
<td>Average Pre/Post Score: Class W</td>
<td>0.00</td>
<td>0.19</td>
</tr>
<tr>
<td>Average Worksheet Score: Class W</td>
<td>0.27</td>
<td>0.16</td>
</tr>
</tbody>
</table>

A one tailed t-test was conducted to see whether the change in the English literacy scores were statistically significant between the two classes in the pre/posts tests. The results indicated that they were not statistically significant (p=0.36). The difference between the
Table 4.3
Change in Average English Literacy Score

<table>
<thead>
<tr>
<th></th>
<th>Class N: Average Change in English Score</th>
<th>Class W: Average Change in English Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre/Post Tests</td>
<td>0.29</td>
<td>0.19</td>
</tr>
<tr>
<td>Notebooks/Worksheets</td>
<td>0.33</td>
<td>0.19</td>
</tr>
<tr>
<td>Average</td>
<td>0.31</td>
<td>0.19</td>
</tr>
</tbody>
</table>

classes for the notebooks and worksheets were also not statistically significant (p=0.36).

Coding Method for Science Literacy

The responses from notebooks and worksheets were categorized into beginning and end portions of the unit of study. Two to three responses were chosen from the very first page of the unit and two responses were chosen from the end of the unit. The responses were individually coded according to whether students reached an understanding of the target concept, were approaching understanding of the target concept or had a misconception and thus little understanding of the target concept. The codes were given values similarly to the English literacy scores as shown in Table 4.4.

Table 4.4
Science Literacy Codes and Scores

<table>
<thead>
<tr>
<th>Description</th>
<th>No Response</th>
<th>Misconception</th>
<th>Approaching</th>
<th>Target Concept</th>
<th>Response Doesn't answer Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>nr</td>
<td>m</td>
<td>A</td>
<td>tc</td>
<td>daq</td>
</tr>
<tr>
<td>Value</td>
<td>none</td>
<td>-1</td>
<td>0</td>
<td>1</td>
<td>none</td>
</tr>
</tbody>
</table>

This is an example of a misconception, “What make objects sink is the volume inside of an object” from student 142. This is an example of an approaching concept from student 106, “The volume of water will go up because you would put more weight on the water and the object will sink and the water will go up.” The student understands that the water will rise when an object is placed in it, but makes no mention of key terms such as
Does the Use     26

displacement. Student 138 writes in his post-test “If you have a little density, it will float”
showing that the target concept was understood by them.

The science literacy codes and scores can be seen in Table 4.5 for class W where
each student is given a score that indicates whether they understood the target concept or
not. Their scores are averaged per section, i.e. for the beginning worksheets and for the
ending worksheets. The shaded boxes indicate that the student did not turn in those
worksheets or pages. A change in the science literacy score could only be calculated if
the student had a beginning score and an ending score. Responses that were classified as

Table 4.5
Class W: Science Literacy Scores for Worksheets

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>106</td>
<td>0</td>
<td>-1</td>
<td>-0.5</td>
<td>nr</td>
<td>-1</td>
<td>-1</td>
<td>-0.5</td>
</tr>
<tr>
<td>142</td>
<td>0</td>
<td>daq</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>140</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>126</td>
<td>0</td>
<td>daq</td>
<td>0</td>
<td>0</td>
<td>-1</td>
<td>-0.5</td>
<td>-0.5</td>
</tr>
<tr>
<td>104</td>
<td>daq</td>
<td>daq</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>165</td>
<td>daq</td>
<td>-1</td>
<td>daq</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>171</td>
<td>daq</td>
<td>daq</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
</tr>
<tr>
<td>138</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>121</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>191</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>195</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>153</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>174</td>
<td>daq</td>
<td>-1</td>
<td>-1 nr</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>117</td>
<td>daq</td>
<td>daq</td>
<td>daq</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>113</td>
<td>daq</td>
<td>nr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>109</td>
<td>nr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>154</td>
<td>0</td>
<td>-1</td>
<td>-0.5</td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>101</td>
<td>0</td>
<td>-1</td>
<td>-0.5</td>
<td>0</td>
<td>1</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>122</td>
<td>0</td>
<td>daq</td>
<td>0</td>
<td>-1</td>
<td>0</td>
<td>-0.5</td>
<td>-0.5</td>
</tr>
<tr>
<td>116</td>
<td>0</td>
<td>-1</td>
<td>-0.5</td>
<td>daq</td>
<td>nr</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>
“daq” indicate that the student did not answer the question. Responses coded as “nr” indicate that there was no response at all. The tabulated average scores were not impacted by daq or nr codes because they were not given a value. The beginning scores as well as the end scores were averaged for each class. This was done twice, the first time for the scoring of the worksheets/notebooks and the second time for the pre/post tests. The change in the average science literacy score for each student was used to run a one tailed t-test comparing the students in class W with those in class N. Two t-tests were done, one to compare the worksheet/notebook scores and another to compare the pre/post test scores from the two classes. Aside from the average science literacy scores, the actual codes themselves were used in tracking the number of misconceptions, approaching concepts and target concepts.

*Science Literacy Findings*

After analyzing the science literacy scores from notebooks, worksheets and the pre/post tests, both classes W and N show improvement in science literacy. In Figure 4.3 it is evident that while the results from the pre and post-tests are different from those of the worksheets and notebooks, they both show improvement. When the change between the beginning and ending scores are calculated for each student and averaged as shown in Table 4.6, class N shows greater improvement in science literacy than class W. The greatest improvement in science literacy was evidenced in class N’s notebooks. The one tailed t-test was conducted to see if the change in science scores in class N were significantly different from those in class W. The t-test results showed that neither the pre/post tests nor the notebooks/worksheets were significantly different from one another (p=0.38 and 0.11 respectfully).
Does the Use of Notebooks and Worksheets影响科学素养的提高

**Figure 4.3. Science Literacy in Class N vs. Class W**

![Graph showing the comparison of science literacy between Class N and Class W](image)

**Table 4.6 Class N vs W: Change in the Science Score**

<table>
<thead>
<tr>
<th></th>
<th>Class N Average Change in Science Score</th>
<th>Class W Average Change in Science Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre/Post Tests</td>
<td>0.39</td>
<td>0.46</td>
</tr>
<tr>
<td>Notebooks/Worksheets</td>
<td>0.69</td>
<td>0.28</td>
</tr>
<tr>
<td>Average</td>
<td>0.54</td>
<td>0.37</td>
</tr>
</tbody>
</table>

The number of total responses in pre and post tests in each class were also tracked and categorized in Figure 4.4. This figure shows that both classes experienced a decrease in the number of misconceptions and an increase in the number of target concepts in the pre/post tests. The category titled “not applicable” tracks the number of responses that either did not answer the question or did not respond at all. The notebooks and worksheets were analyzed similarly and they showed slightly different results between
Figure 4.4 Pre and Post Test Scores for Classes N and W

The classes. Class W showed an increase in the number of misconceptions and a decrease in approaching concepts. Figure 4.4 shows that the greater increase in the percentage of the target concept responses (16% on tests) was in class N. However, figure 4.5 shows that the greater increase in the percentage of target concept responses (27% in worksheets) were in class W. The number of responses does not directly correlate to the number of students; therefore multiple responses have originated from the same student.

Figure 4.5 Notebook and Worksheet Scores for Classes N and W
Chapter 5 Discussion

Overview of Study

The purpose of this study was to find out if science notebooks are an effective means of improving science literacy and English literacy. This topic is of special importance to me because the majority of my students are English language learners who perform poorly on state-wide standardized tests. Science literacy was measured by the students’ ability to accurately articulate target concepts about the unit. English literacy was measured by the students’ ability to write well without major grammatical mistakes. Two sources of data were collected from each class that participated in the study. Class W was the control group and used worksheets instead of notebooks. Thus, class W’s two sources of data were the worksheets and pre/post tests. Class N, the treatment group, used science notebooks and their two sources of data were the notebooks and the pre/post tests. Each class was evaluated for an improvement in their English literacy skills and their science literacy skills.

The two sources of data consisted of open ended questions and answers that were coded. The worksheets were collected weekly and the notebooks were collected at the end of the unit. The pre-test was given prior to the start of the unit and the post-test was given immediately after the unit. The pre and post tests were identical. All work was evaluated based on how students wrote and thought at the beginning of the unit in comparison to the end of the unit, thus key pages from the notebooks and the worksheets were chosen based upon chronological sequence.

Summary of Findings

My findings indicate that both classes improved their English literacy skills, but that class N improved their literacy score slightly more (+0.31) than class W (+ 0.19).
While the difference between the two classes was not statistically significant for either the pre/post tests or the worksheet/notebooks, many students made gains in their ability to construct complex sentences in a scientific context.

My findings show that both classes improved their science literacy skills. There was a larger increase in the percentage of students that learned the target concept in class W while at the same time; they showed an increase in the number of misconceptions in their worksheets. However, when all data was taken into consideration (decrease in misconceptions as well as an increase in the target concept), class N improved slightly more (+0.54) than class W (+0.37) as evidenced by the average change in science literacy scores in table 4.6. The difference in science literacy between class N and class W was not statistically significant.

Conclusions and Recommendations

The results indicated that the use of science notebooks marginally help the students develop their English literacy and their science literacy skills. This difference, however small and statistically insignificant, suggests that despite the fact that the curriculum was completely the same; students were able to improve their skills simply by keeping all their worksheets in a science notebook. Both classes were taught the same project based unit and both classes used the same worksheets. The only difference was that class N glued or stapled their worksheets into their science notebooks and kept them the entire duration of the unit while worksheets were collected every week. The results imply that allowing students to have continuity and ownership of content in a written form can develop two skills at the same time; English and science.

On the other hand, removing the continuity of science notebooks can have adverse effects. Class W showed conflicting data between their tests and their worksheets
by displaying an increase in misconceptions in their worksheets but a decrease in their tests. Class N consistently displayed a decrease in the number of misconceptions during the study. This suggests that the notebooks served almost as reference material for the students and they were able to utilize them to reflect on their own learning and perhaps not repeat their previous mistakes. The students in class W did not have this option because their worksheets were collected every week. The only opportunity they had to reflect upon the entire unit was prior to the post-test when all their worksheets were handed back. This implies that the decrease in the post-test misconceptions in class W can be credited to the availability of all their worksheets.

The study showed that allowing students sufficient reflection opportunities and the availability of those reflections throughout a unit of study can improve content skills as well as English literacy skills. This study used the most conservative interpretation of science notebook implementation and thus the control group varied very little with respect to the treatment group. This implies that either the notebooks made the majority of the impact or that there was another group of variables that influenced class N in a positive manner.

I will continue to implement science notebooks in all my classes with a greater attention to proper curriculum alignment. The results show that whether the teacher implements science notebooks or not, students can benefit from being given ample opportunity to write, and reflect in a continuous and chronological manner which the PBL unit provided. Students may be unable to retain information and correct misconceptions partly due to the fragmented nature of class work and science notebooks can battle this problem. I recommend that teachers develop a formal structure for
Does the Use

implementing science notebooks and include time everyday for students to reflect
meaningfully in their notebooks.

**Limitations of Study**

While both sets of data show that class N improved more than class W, class N contained students who began at a higher EL level. The fact that the majority of the students in class W were lower in their English literacy skills at the start of the unit could have attributed to the greater improvement in class N. This study may not apply to native English speakers of which only one was present in this study. Every student in my study but one was an English language learner. As a result of the lower English proficiency level of class W, answers to reflection questions were reviewed at times as a class and may have skewed some of the results regarding science literacy in their favor.

The two classes were not equal in size or in gender distribution which also could have affected the results. The sample size was very small and the students involved in the study were from a very specific demographic. My students were frequently absent and thus many assignments were not completed that resulted in missing notebook pages or worksheets. One student in particular was absent weeks and thus had to be excluded from the study. Several other students were excluded from the study because they failed to return an informed consent form. Two additional students were excluded from the study because their parents did not wish them to participate. All of the above factors greatly reduced my sample size and thus my data was hampered.

This study may also not apply to students in a more traditional class setting that does not utilize project based learning. The curriculum implemented during the study was based on guided inquiry within a project based learning setting. This structure allowed students more time with their colleagues and also with their own thoughts. Students in a
more traditional classroom where lectures are more common may not have enough time to reflect on their own learning and write those thoughts down.

The study could be expanded in a number of ways starting with building a curriculum around a structured method of using scientific notebooks. In this study, the science notebooks were adapted to an existing project based curriculum. Future studies can focus on the reverse where the curriculum is adapted to the structure of a formal science notebook. This will focus the study on the science notebook itself rather than the curriculum.

The study should also be increased in length of time. Ideally, the study should be carried out over several units where the two groups can experience both treatments at least on two separate occasions. Both groups should be at the same EL level eliminating advantages due to English ability level. Expanding the length of the study would also allow the researcher to test for long term knowledge retention. If science notebooks truly hold their power in providing continuity, this benefit can be shown more clearly in a long term study. The longer format would also allow data collection at more than just instances in time. In this study, only the beginning and end of the unit was used for data and had the entire notebook been evaluated, additional conclusions could have been made.

Future research on science notebooks can also focus on tracking the grades and standardized scores of the students in all core subject areas to show correlation between English literacy and content literacy. Different types of science notebooks can and should be tested to see if the format of science notebooks affects improvement in English and science literacy. Science notebooks are a very flexible student and teacher tool; however a more formalized structure may yield more significant results. In addition, it would be
interesting to see if the results hold up in a classroom that does not have EL learner students.

This study would not have been possible without the generous cooperation and help of my colleague Bonnie Anderson who spent many hours revising worksheets with me to incorporate student reflections into every lesson and science notebook. I would also like to thank my cohort professors and colleagues at CSUN without whose support I would not have stayed the course. Finally, a special thanks to my husband for putting up with many hundreds of hours of sheer silence and outbursts of frustration.
References


http://www.cse.ucla.edu/CRESST/Reports/TECH559.PDF.


### Directions:

**Observations:** Make observations about the puzzle on your table. Watch what is happening and write everything you see.

**Questions:** After completing your observations, write down 2-3 questions about the puzzles you have observed. Base your questions on your observations.

---

### Observations

<table>
<thead>
<tr>
<th>Puzzle #1 Cubes</th>
<th>1)</th>
<th>2)</th>
<th>3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puzzle #2 Vials</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
<tr>
<td>Puzzle #3 Soda Cans</td>
<td>1)</td>
<td>2)</td>
<td>3)</td>
</tr>
</tbody>
</table>

### R.E.A.P.S. Questions

- **R** What pair of floating/sinking objects were you most curious about?
- **E** What other floating/sinking objects have you observed in your everyday life?
- **A** What measurements did you find your self looking at in all three of the puzzles?
- **P** What do you think is important to notice to predict if something will float or not?
- **S** What did you think about today that you had not thought about before?
Background:
Can you recall a time when you dropped an ice cube into a glass of water or soda and had the glass overflow? Maybe you’ve filled a sink with water to do dishes and had it nearly overflow when you added the dishes. The water that was pushed out of the way when you added the ice cube to your drink or the dishes to the full sink is called displaced water.

Purpose: What causes the water to be displaced?

Hypothesis: If I measure the _________________ of an object, I will be able to predict how much water will be displaced when the object is fully submerged in a liquid.

1. How would the amount of displaced water be different if the object was only partially submerged?

_______________________________________________________________________________________

_______________________________________________________________________________________

2. Work with your group to write a procedure in the space below describing how you will test your hypothesis and answer the questions being asked. Plan carefully. How will you measure ACCURATELY how much water an object displaces? Imagine this situation and how you could collect and measure the water that overflows:

A tub of water is filed to the brim with water. As soon as any objet touches the side, some water spills over the side. Once the object is in the water and settles down, some amount of water has overflowed. That is the displaced water, the water you want to measure! How can you measure it?

Think about how to carefully collect and measure the overflow, EVEN IF IT IS A TINY AMOUNT. How have you measured the volume of liquids before? Plan with your group the procedure you will use.
3. Use your procedure to collect evidence and measurements for the following Experiments A, B and C. For each experiment, make cube combinations, measure their mass, calculate their volume and use your procedure to measure the amount of displaced water. Record your data in the chart below.

**Experiment A:**
Combination 1: Combine the copper cube with the aluminum cube
Combination 2: Combine the brass cube with three nylon cubes

**Experiment B:**
Combination 3: Combine the copper cube with the aluminum cube
Combination 4: Combine two nylon cubes

**Experiment C:**
Combination 5: Combine two pine cubes with 2 oak cubes
Record how much of Combination 5 is below the surface of the water.

<table>
<thead>
<tr>
<th>Experiment A</th>
<th>Experiment B</th>
<th>Experiment C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combo. 1</td>
<td>Combo. 2</td>
<td>Combo. 3</td>
</tr>
<tr>
<td>Combination 1</td>
<td>Combination 2</td>
<td>Combination 4</td>
</tr>
<tr>
<td>Calculated Volume of object (mL)</td>
<td>Measured Volume of displaced water (mL)</td>
<td>Mass of object (g)</td>
</tr>
<tr>
<td>Partially Submerged?</td>
<td>Other Observations</td>
<td></td>
</tr>
</tbody>
</table>

4. In Experiment **A**, which measurement and observations were close to the same for both Cube Combinations 1 and 2? Which were different?

____________________________________________________________________________________________
____________________________________________________________________________________________

5. In Experiment **B**, which observations and measurements were close to the same for both Cube Combinations 3 and 4?

____________________________________________________________________________________________
____________________________________________________________________________________________
6. In Experiment C, what determined whether the Cube Combination would sink or float?
______________________________________________________________________________________________
______________________________________________________________________________________________

7. Which combination in Experiments A and B were similar to the Cube Combination in Experiment C? Explain all the similarities that you observed.
______________________________________________________________________________________________
______________________________________________________________________________________________
______________________________________________________________________________________________
______________________________________________________________________________________________

8. Think about what the evidence you collected tells you about displacement. What can you measure to predict how much water is displaced when an object is placed in a liquid?
______________________________________________________________________________________________
______________________________________________________________________________________________

9. Does it make a difference in how much water is pushed out of the way if the object is fully or partially submerged? Why?
______________________________________________________________________________________________

**REAPS Questions (Conclusion)**

R: What determines how much water an object displaces?
______________________________________________________________________________________________

E: If an object is floating or partially submerged, what volume of water does it displace?
______________________________________________________________________________________________

A: When would it be logical to measure volume with the displacement method rather than direct measurement such as length multiplied with width, multiplied with height?
______________________________________________________________________________________________

P: What do you predict will happen to the amount of displaced liquid if you use liquid oil or orange juice instead of water?
______________________________________________________________________________________________

S: What decisions and changes did you make that helped you make more accurate measurements for the displaced water?
______________________________________________________________________________________________
Appendix C

Density and Buoyancy Pre and Post Test Questions

Please answer in complete sentences and do your best:


3. If you had a cotton ball the size of a bus, would it still float? Why or why not?

4. What happens to the volume of water in a glass if you put an object into it?

5. Is there a way to make a large piece of iron metal float? How?
<table>
<thead>
<tr>
<th>What did we do in this lesson?</th>
<th>What evidence did we collect?</th>
<th>Big idea(s) that I took away from the lesson?</th>
<th>How would you use that evidence to make a prediction?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>