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WRITING IN MATH AND SCIENCE CLASSES

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ABSTRACT

This qualitative research study examined the effects of writing in math and science classes. The science participants were a class of 17 fifth grade students. The math participants were a class of 19 fifth grade students. These math and science students participated in a variety of writing activities during class.

This study suggests that writing in math and science classes has many benefits for fifth grade students. Writing promotes student interest, creativity, and motivation. Writing in math and science classes increases students' understanding of the concepts and positively affects quiz and test scores. Student interaction increases as students continue to explain their ideas through writing, and these interactions show concrete understanding. Math and science writing shows students' misunderstandings and enables the teacher to reteach these necessary concepts.

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RESEARCHER STANCE

Reading and writing is something students need to do every day. As a fifth grade teacher, I always knew these were important activities for my students to be involved in throughout the day. When I actually sat down and reflected on the subjects I taught, I realized that for the last six years, most of the reading and writing occurred in language arts class.

Reading, actually, was a topic I was concerned about a few years ago. I watched my students, day after day, showing no motivation or excitement to participate in reading activities. I can remember during read-aloud time, the same one or two hands would go up to answer my questions. I began to count on these one or two students to keep the conversation going and to be models for the rest of the class. When we gathered in the reading area on carpet squares, there was not anticipation or interest. There were blank looks and wandering eyes, specifically looking at the time on the clock. Was it lunchtime yet? I became frustrated during a time I thought would be adventurous, exciting, and imaginative for my students.

So, two years ago in my first Moravian graduate class, I chose to do a mini-study researching the effects read-aloud would have on the students in my classroom. I read aloud to the students every day. I observed their participation and excitement during read-aloud time. The students also kept a reading response journal to answer questions and illustrate themes regarding the read-aloud text. By the end of the novel,

the students were excited about reading. Almost all of my students' hands were raised during our conversations, and every day, students asked if we would be reading aloud. There was a rush for carpet squares. Finally, I saw excitement in my students' eyes when reading was involved.

There was another positive result that I did not expect from this study. The more students wrote in their response journals, the better they comprehended the story. Why did that happen? Could writing allow for a deeper thinking and understanding because it forces you to put ideas into your own words? To me, this idea needed to be explored further. Freire (1970/2005) states, "On the contrary, reflection – true reflection – leads to action" (p. 66). I needed to reflect on the writing activities I did in the classroom.

Again, the first realization I had was that writing seemed to be saved for my language arts class. When I looked at the writing they completed during writer's workshop, I felt they could do better. Their writing was mostly acceptable, but not exceptional, and it seemed to me that writing experiences in other classes could improve their language arts writing. Writing is a big part of language arts class; however, should it not be included in other subject areas? Could that help improve the skills that they lack in their writer's workshop stories and enable them to make the stories better?

I began to reflect on what little writing I did in math class. Since the P.S.S.A. (Pennsylvania System of School Assessment) tests require

students to explain their math work in words, the other fifth grade teacher and I work with the students on answering math prompts. We stress that it is important for students to be able to solve the problem correctly, but it is even more important to use words to explain how they solved the problem. We tell the students that the people scoring the tests want to know every step in their thinking. We introduce t-charts and sentence starters. We practice once a week. Most of the time, the students are able to solve the problem using numbers, but they still struggle, especially with writing down what they already know that enables them to solve the problem in the first place. Thinking about how difficult this can be, I wondered if increasing the amount of time we write on a daily basis in math class would help.

With this idea in mind, I introduced math journals to my class. My goal was to have the students write in the journal several days a week during math class. Everything started out well. The students either responded to a prompt I gave them in class, or they wrote freely about what they were learning in math class. I collected and responded to the journals. I sometimes would score their answer using the P.S.S.A. testing rubric. About three weeks into using journals, they had already started to collect dust. I just did not make time, and the students never asked about them. I did not clearly state the purpose to the students, and it was not a high priority. At the end of the year, when they were passed out for the children to take home, a student asked why we had not used them more. As a teacher, I felt I did not do my job in this area, and I hoped I could do

better next year. Unfortunately, when next year came, I continued to just do math prompts to prepare for the P.S.S.A. tests because there was not time to include journals with everything else we had to accomplish during our one hour a day together. Therefore, I am unable to tell if using journals and prompts are helping the students understand the material and/or improve writing skills because they have not been consistent activities in my classroom.

When I reflect on science class and writing, I chuckle. We barely manage to fit science in three times a week due to other interruptions and activities, and when we do, it is hard to complete an experiment in the time we have together. My students are always writing during experiments, but the writing is mainly for observations. There usually is not time to write a conclusion or reflection on what happened because it is time to clean up. If we come back to it the next day, students will complain because they did not finish or they do not have enough information to do what is asked of them. With concepts that are extremely difficult to understand, writing seems like it could really help struggling students.

It is easy to say, "I'll do it tomorrow," or "There just is not enough time." I do not want to say that anymore. I need to require, force, myself to find time every day to incorporate writing in math and science classes for the benefit of my students. Even though I have tried math journals before, I plan to follow a stricter schedule to make sure my students are writing at least twice a week. I have chosen specific questions and prompts from the

math manual that I believe will enhance their learning and understanding. Furthermore, more writing will be incorporated in math class, and writing will be included weekly in science class, which has not occurred before in my classroom.

My personal and professional experience with writing, as well as the research I have done, has led me to my action research question ~ what are the observed and reported experiences when writing is integrated into math and science class?

LITERATURE REVIEW

Writing in Elementary School

Writing ability is developing in elementary school. Both writing and content improve when writing is integrated into the content. Science and mathematics, in particular, are subjects in which writing can be very valuable to students' understanding and success. Writing is not always thought of as fitting into these curricular areas, but writing in these areas can help the students process what they are learning and increase students' knowledge of particular concepts (Trisler & Cardiel, 2004).

Teachers may be hesitant, at first, to even think about incorporating writing in mathematics and science classes. In language arts class, there is time for writing because writing is part of the language arts domain, along with reading, speaking, and listening. However, in math and science classes, there are many concepts and ideas to teach. Not having enough time currently to cover all of the curricular objectives makes it difficult to think of incorporating another activity such as writing. However, the benefits of writing in math and science seem considerable. "As you incorporate more writing in these important content areas, you'll see an improvement in students' thinking" (Manning & Manning, 1996, p. 1).

Writing in Math

According to Burns (1995), writing in math class has two benefits. "It supports students' learning because in order to get their ideas on paper, children must organize, clarify, and reflect on their thinking" (Burns,

1995, p. 40). The second benefit is that students' papers are a valuable assessment resource for teachers to see what their students know and understand, as well as any misconceptions the students may have about the topic (Burns, 1995).

Math class has been seen as strictly a place where numbers are written, problems are solved, and solutions are discussed. However, this is changing. On standardized tests, students are now being asked to explain the solution to their math problems and how they got the solution, using their own words. In the classroom, including daily practice in which students solve a problem using numbers and words can help them when they are faced with these situations. Not only can it help students on standardized tests, but it can also assist them in making sense of the most currently learned math material. Being forced to explain a concept in his/her own words provides a higher level of thinking and enhances what the student will learn (Burns, 2004). According to Trisler and Cardiel (2004), "many students who struggle with math have problems with its language and concepts" (p. 2). They found that when the students explain their own solution, it forces them to think and communicate their thought process, which helps to improve their understanding. Agreeing with this position, Caballero (1995), stated, "If children were taught to explore by writing and reading in a math class, the children would recall better their experiences of the reading and writing" (p. 55).

Writing in math also enables teachers to see “what they understand, how they approach ideas, what misconceptions they harbor, and how they feel about what they’re discovering” (Burns, 1995, p. 40). Johnson (1997) agreed when she reported that when students write about mathematical concepts, it can give teachers valuable insights into students’ understanding of math. This feedback can provide teachers with useful springboards for extending lessons, reinforcing ideas, and reteaching concepts (Burns, 2004). The teacher will be able to tell if the students do not understand a concept, and it will allow for the teacher to lead small or large group reteaching sessions. The students’ writing responses could also be a signal to the teacher that some students need enrichment in a particular concept.

“Many of us have been taught to believe that every piece of writing we do must conform to all the rules of grammar and syntax” (Burton, 1985, p. 41). Teachers think that all of students’ writing must have perfect spelling and punctuation. These rules “are suspended when free writing or other information, or ‘private’, writing is done” (Burton, 1985, p. 41). I, too, believe that when writing in math, it is important for teachers to emphasize, and for students to understand, that the writing is not about placing punctuation marks in the correct spot or having complete sentences throughout the paragraph. Free and informal writing is about the content. It is about putting your thoughts into words, as if to explain it to someone just learning the subject. With this understanding, students

will hopefully feel free to fully express themselves because they are not obsessed with the mechanics of the writing. For this study, the main goal for writing in math is for students to put numbers into words and gain a better understanding of the mathematical concepts. This is important for the students to know so they will focus on the math explanation rather than the spelling and completing a perfect sentence.

Writing in Science

Combining science and writing can motivate students to learn (Bower, 1993). Science was a powerful motivator in Bower's (1993) daily writing workshop. Bower (1993) surrounded the students with picture books and materials so students could observe, experiment, and research. She made time for students to observe, experiment, and write, and she established a link to literature, which caused the students to develop writing skills and scientific knowledge. Once students are motivated, they are more likely to show an interest to learn the material.

Researcher Dickinson (1996) says that science and writing processes are similar, and they both help learners construct understandings. Dickinson (1996) goes on to say that when students are able to choose their own words to talk about what they are learning, they will be able to sort through and clarify their ideas. In science class, writing is very important and sometimes overlooked. Science is based on experiments and sometimes, teachers and students get so excited about the actual "doing" of the experiment that they forget how important it is to

be writing things down. "Writing is almost a necessity for the scientist, as it becomes a means for recording investigations, for organising one's thinking and a way to reflect" (Hudson, 2000, p. 35). Fortner (1990) feels opportunities for writing projects in science should be actively sought out by teachers and used in order to increase students' observation skills and help them express themselves. Similar to math, writing is an important part of teaching and learning science. According to Kepler (1998), writing enables children to communicate their observations and ideas and also reinforces their understanding of key concepts in science.

Mason and Boscolo (2000) conducted a study on the effects of writing in science class with 34 students in fourth grade. These students were split into two groups. One group was an "experimental group in which the writing activity in the service of learning took place in science class" (p. 203). The second group was a control group, and the students in this group did not participate in writing activities. Both groups were involved in the same observations and experiments, as well as discussions about the same information. These two groups were taught by two different teachers, but these teachers had very similar attributes and met regularly to plan their lessons.

The teachers started with activating prior knowledge. After completing a questionnaire, the results showed that there was no significant difference between the two groups of students. Throughout the study, the experimental group participated in writing activities to record

and communicate their own ideas. The control group did not. At the end of the study, the researchers found significant difference among the two groups. The first question the researchers studied “was to see whether fourth graders could use writing-to-learn as a tool to express and compare ideas, reflect and reason on them in the process of scientific understanding” (p. 221). They found that writing allowed the experimental group of students to express their current conceptions about scientific ideas in a form they could look at and think about. They could revise and change their ideas through this writing. “The second research question asked whether the use of writing in the service of learning improved understanding of the new topic which implied conceptual change” (Mason & Boscolo, 2000, p. 221). The data showed that writing significantly contributed to a better understanding of the topic of study. “The findings show that in the experimental group the students reached a better understanding of the target concept” (Mason & Boscolo, 2000, p. 199).

“Science must be integrated into the writing curriculum and writing into the science curriculum. Students can enjoy not only the excitement of discovery, but also the pride that comes from being able to communicate what they know” (Yockey, 2001, p. 41).

Classroom Techniques

There are several activities that can be incorporated into the classroom, which will increase the amount of time spent on writing during math and science classes.

Journaling

Most teachers have used journals for some part of their teaching. Journals are typically seen as a language arts activity, in which the students respond to a prompt or free write; however, journals can be used in math class and for more than just writing out math problems. Journals can be utilized in science class as well in order to make experiments more meaningful and connected.

For teachers who do not regularly keep math journals with their classes, it is one of the best ways to introduce writing in math class (Burns & Silbey, 2001). Math journals can be used at any point during the class. Students can keep notes and practice in them. At the end of math class, students could describe what they did, what they learned, and what they do not understand. Teachers should then read the students' entries and at times write a response (Manning & Manning, 1996). Using them in this capacity allows students to examine and express their ideas, and allows teachers to evaluate their progress, strengths, and needs (Burns & Silbey, 2001).

Math journals can help students keep continuous records of what they do in class (Burns, 1995). As Burton (1985) adds, journals in math are a permanent record of what is happening in class. It is continuous and allows students to flip back and reread what has been done previously in class. Also, as questions and misunderstandings are answered and

corrected, students can feel satisfaction as they read back in their journals.

Koirala (2002) conducted a study to explore the ways math journals influence the teaching and learning of mathematics. Approximately 200 prospective elementary teachers, enrolled in a required university math course, participated in this study. The students monitored their thinking through weekly math journals. In their journals, they either answered a specific question or responded to a scenario given by the teacher, or they reflected on a particular mathematical concept. The researcher read the journals and responded to them throughout the course. He analyzed the writing – what were students' responses in a particular week's journal, and how did journals help students for their growth of mathematical understanding. Koirala (2002) found that when students were given open topics, more than 80% chose to express their beliefs about math. They were asked to demonstrate their mathematical understanding, but this understanding was not noted, and these entries were brief and did not show higher-order thinking skills. On specific journal entries, the students' mathematical understanding was clearer and more evident. The responses made it clear to the researcher that many students never had the opportunity to learn about math in a meaningful way. Instead, they were taught the rules and accepted them, without question. In conclusion, Koirala (2002) found that "math journals not only help instructors in understanding students' feelings, likes, and dislikes about classes, but

also help students to demonstrate their mathematical thinking processes and understanding” (p. 2). Even though the participants in this study were adults, it shows how important it is to provide writing opportunities in math. Students will benefit from explaining what they are thinking, and it is interesting to think about what the difference might be between fifth-grade students’ responses to open-ended versus specific journal prompts. This study may cause teachers to begin their math journals with more specific prompts before asking students to demonstrate their understanding on their own.

Waywood (1992) conducted a four-year study involving approximately 500 students in seventh through eleventh grade. The teachers of these students used journals as an instrument of math instruction. Students wrote in the journals at different points during math class. Waywood (2002) found that students’ journal writing could be described as recount, summary, or dialogue. Recount mode is reporting what happened. Summarizing is using knowledge and integrating it with what is already known. Dialogue is an interaction between a number of ideas. Waywood (2002) found “in journals that different students organize their learning differently” (p. 36). Waywood (2002) also concluded that “Experience has shown that journals are more effective when implemented at the level of the school curriculum than at the classroom level” (p. 36). Students need to see journal writing as part of their normal mathematics day, not as an extra, supplemental activity. From the

teacher's point of view, using the journal as a teaching and learning tool brings elements of instruction into focus. Finally, Waywood (2002) found that "journal writing enhances students' mathematics learning" (p. 40).

Jaus (1990) believes that students in second grade through eighth grade should be required to keep science journals. He goes on to say that these journals should include labeled drawings, class notes, lists of observations, answers to questions, and any other important piece of information. When students keep science journals, "they participate in the science process and develop necessary writing skills that should be part of every student's education" (Jaus, 1990, p. 31).

Science journals can come in all different shapes and sizes. Kepler (1998) discusses shared science journals and before-during-after journals. A shared science journal is one journal kept for the entire classroom which focuses on one subject. A before-during-after journal is kept by each student, and they write their hypotheses (before), observations (during), and conclusions (after) from a science experiment (Kepler, 1998).

Notebook writing is very similar to journal writing. Writing in notebooks generally consists of an on-going discussion or topic, rather than writing little segments about different topics and prompts, as found in journals. Baxter, Bass, and Glasser (2001) conducted a study to see how teachers facilitated notebook writing in their classrooms. Eighty-three students in three fifth-grade classrooms in two schools in an urban district were studied. During science investigations, students were expected to

document ideas and conclusions in their notebooks. Teachers collected the notebooks and examined them based on features of inquiry. It was found that notebook writing in science is an important tool for observing, hypothesizing, and assisting thinking, reasoning, and problem solving during a science inquiry. According to Baxter, Bass, and Glasser (2001), when used correctly, notebooks can encourage student inquiry and knowledge development.

Journals are not something that should be hidden in the language arts classroom. There are many benefits from incorporating them in math and science classes. "The journal is not the end product, but instead it functions as a tool for facilitating children's thinking by serving as a resource for the creation of a final product" (Shepardson & Britsch, 1997, p. 14).

Prompts

Prompts can be used to start journal writing. They can also be a separate writing piece altogether, given at the end of a chapter or unit to wrap-up the topic of study. They could be given to review material that was learned earlier in the year and also in preparation for standardized testing.

Choice is important for students; however, asking them specific questions or to explain a specific topic is also important, depending on the teacher's objective. Prompts are valuable to introduce students to writing in math and science.

Prompts can be more than phrases, sentence starters, or questions. Prompts can simply be a list of key words relating to a specific topic. Students select key words and then use these words to write sentences and paragraphs. “The key-word process helps children learn not only how to write, but also what they are writing about” (Yockey, 2001, p. 36). Using these key words to write intelligent paragraphs about certain topics show that students are beginning to formulate an understanding of the concepts. By writing about these key concepts, the information sticks with the student, which is what every teacher wants to happen.

According to the “Write Now” approach, giving open-ended prompts at the beginning of math and science classes gets students focused and can give them a chance to think about and explain the previous day’s lesson. After students have completed the open-ended prompt, students volunteer their answers, which gives them a chance to reread their writing and articulate their thinking (Ryan & Rillero, 1996). Also, with this approach, teachers can see if students understood the material from each lesson.

Learning Logs

Bristor (1994) conducted a five-year study to look at the effects of an integrated curriculum strategy on the achievement, attitudes, and self-confidence of fourth and fifth grade students. The experimental science/reading group received in-depth instruction in science and reading, including hands-on activities, writing, and discussion. Trade

books, other print materials, and visual technology materials were also used to enhance comprehension of the science text. The control group received regular basal reading and science instruction separately. During the first two years, the experimental group obtained significantly greater levels of achievement in reading and science as compared to the control group.

Several science reading and writing activities caused this achievement. Activities which caused achievement included paraphrasing/summarizing science learning, applying science to real life, and group experience stories. Another cause of this achievement was the use of learning logs. Learning logs are another medium for writing ideas and thoughts. Learning logs can be used in a variety of ways. Students can write predictions, write observations, write conclusions, state what was learned after a lesson, describe favorite experiments, and write summary paragraphs using main ideas from class. As a result, the children in this study are writing more.

Finding Time

One major concern many teachers have is how to fit all of these writing activities into the daily routine. Fortner (1990) believes that the challenges of a crowded curriculum and a day that is not long enough can be tackled at the same time by combining language arts with science. A teacher could then “fit two subjects into the curriculum space and time requirement of one” (p. 34). Therefore, if looked at in this way, teachers

can combine many language arts skills with math and science skills without it being an added requirement that needs to be accomplished in the school day.

Writing could occur in the beginning, middle, or end of math and science class, depending on the topic and purpose. Using journals in the beginning of class can introduce a new topic or can review a topic previously learned. This is beneficial to teachers because students are engaged and on task as soon as they walk into the classroom (Ryan & Rillero, 1996). This will help tough transition times and maximize the time spent on the important learning task for that day.

Some teachers might ask children to write at the end of class to describe what they learned, what they do not understand, or what questions they still have (Burns & Silbey, 2001). This enables teachers to assess themselves at the end of a lesson and know where to go with the lesson during the next class.

Writing in math and science could take as much or as little time as the teacher wants to devote to these activities during the day.

Summary

Writing activities provide opportunities for students to take an active role in their learning. Writing alone does not guarantee learning will take place. "Rather, writing to learn requires that students and teachers take an active role in making the writing process apparent, purposeful, and relevant" (Baxter, Bass, & Glasser, 2001, p. 139).

Whether writing in the form of journals, prompts, or learning logs, the writing is beneficial for the students. Manning and Manning (1996) stated the following:

The major purpose of writing in math and science is to help students clarify and extend their knowledge in these subject areas. Students elaborate their knowledge and clarify for themselves what they know as they express their thoughts about writing. (p. 1)

RESEARCH DESIGN AND METHODOLOGY

Setting

The elementary school, built in 1999, is a K-5 school with approximately 275 students. Nestled in a small borough in Northeast Pennsylvania, the school's families are middle to low class. The majority of students walk to school, but there are two buses that bring students as well. There are two classrooms of each grade, with the exception that this year there are three 5th grades.

My fifth grade classroom is on the third floor. In the classroom, the desks are either set up in a U-formation or in groups of 5-6 desks. There is a reading-writing area in the back corner of the classroom. This area consists of open space in which students can sit on carpet squares. There is a large table to work on, and this area is surrounded by a library of books, reading and writing posters, and a writing process bulletin board. The writing process can also be seen on pencil posters in the front of the classroom.

Participants

The science participants are a heterogeneous class of fifth grade students. There are 17 students in the fifth grade science class. There are 6 boys and 11 girls, and they range in age from 10 to 12 years old. Some students receive free and reduced lunch. There is one student who receives speech services and three students who receive Title I remedial reading assistance. One student has a Learning Support Individualized

Education Plan (IEP), and I have one Level 2 English as a Second Language (ESL) student. One student moved into my science class halfway through the study.

The math participants are a heterogeneous class of fifth grade students. There are 20 students in the fifth grade math class. There are 13 boys and 7 girls, and they range in age from 9 to 12 years old. Some students receive free and reduced lunch. There are 9 gifted students. One of the gifted students is in fourth grade, but accelerated in math. One student has a 504 Education Plan, and one student moved into my math class two-thirds of the way through the study.

Procedure

My first step in the research process was to inform my building principal of my study and gain her written consent (see Appendix A).

I then submitted an application to Moravian College's Human Subjects Internal Review Board (HSRIB). This board reviewed my application to ensure that the study was to be conducted in an ethical manner that protects human subjects. The research proposal was accepted before the research had begun (see Appendix B).

Once I was approved to begin my study, I sent permission slips home with the students in my math and science classes (see Appendix C).

Once I received the signed slips, I introduced the study to my students. During the next math and science class, my students joined me in our read-aloud area, and I told them my research question and what

they could expect to happen in the next few months. Then, they completed a survey, which asked about their ideas and opinions with regard to writing in school (see Appendix D). I read these surveys and used them to understand my students' writing backgrounds.

To begin the study, my math students were given a composition book to use as their math journal. For each chapter in math, they wrote in their journals at least two times. Many times they answered a question or explained a concept relating to the subject matter they were learning about in math (see Appendix E). Other times, they were given an open-ended learning log prompt to write open and honestly about (see Appendix F). Generally, the first question or concept came early in the chapter, and the second question or concept dealt with the end of the chapter. Students completed these journals at different times during the lesson, depending on how the question, concept, or prompt related to the lesson of the day.

They were instructed to write as much as they could about the topic. I then read their journals and responded with regard to correctness and the written explanation. I offered suggestions and ideas to improve their explanations, and if they got an incorrect answer, I went back and retaught the topic.

Finally, in math, the students took a survey that was given halfway through the study (see Appendix G). This survey provided me with the

students' thoughts and feelings at that time and enabled me to reflect on the current writing activities.

In Science, there were a variety of writing activities. To begin, they created journal entries using a set of designated key-words (see Appendix H). They were instructed to write sentences or paragraphs using these key-words. I read their key-word paragraphs and responded to their understanding and writing by offering suggestions and reteaching, when necessary.

The writing activities in Science became more creative. After our study of ecosystems, the students completed an exit slip, which asked them to name and describe their favorite ecosystem (see Appendix I). During our study of symbiosis, the students created two imaginary creatures and illustrated a symbiotic relationship between the two. They then wrote a letter from one creature to the other, using their knowledge of this relationship (see Appendix J). Next, the students completed two science journal prompts. First, they were given a picture of an animal and instructed to use as many science words as they could to write a story about this animal. Then, after learning about biomes and completing a homework assignment, the students completed a journal the next day which asked them to explain what they learned about biomes (see Appendix K). As the students learned about endangered animals, they chose an endangered animal and created a poster with information to convince others to help save it (see Appendix L). Finally, the students

were given a biome mission. They had to research and compile information that they then wrote in note-form for their classmates (see Appendix M).

Throughout my study, observation was an important facet. I observed the students when they were writing and participating in class (see Appendix N). I looked for increased participation and more concrete answers during class discussions. I observed them on a daily basis.

Data Collection

In order to triangulate my data, I used participant observations, surveys, and student work.

I observed my students' writing and participation during class. Connelly and Clandinin (1988) believe that participant observation is one of the most useful tools for reflection. The focus of participant observation is on the participation. The teacher must be involved in the activity that is being observed, which is easy for teachers to do. I typed all of my participant observations, and my observations included what I saw, as well as my reflections, which I bracketed. These data were kept in my field log.

I gave the students a survey to fill out before and after the study. "A survey or questionnaire gives you a broad base for understanding your students' ideas in regard to your research question, a profile out of which a more specific study may take shape" (MacLean & Mohr, 1999, p. 41). I began with a survey for this reason. I wanted to see what my students' views were about writing in math and science prior to beginning the study.

As I continued to read the research about surveys, I found interesting advice. “Our advice with surveys is to view them like the photographs . . . – useful snapshots of a moment in time that must be pieced together with other data to get a true picture of what is happening in your classroom” (Hubbard & Power, 2003, p. 65).

Throughout the study, students completed a variety of writing activities in math and science. I collected their written work. “Student work may be the centerpiece of your data, helping you to understand and interpret all the rest” (MacLean & Mohr, 1999, p. 47).

Trustworthiness Statement

After I was approved by the HSIRB (Human Subjects Internal Review Board), and I received the signed permission slips, I introduced the study to my students. I explained the purpose and details of the research, as well as an overview of what the students would be doing with regard to this study.

I made the students aware that any of the work that I collected would be used to help me in the research and help them understand the material. The work would not count as a grade for their report card.

I explained to the students that everything they did would be kept confidential. What they said and wrote in private would remain private. Their thoughts would not be used against them.

I informed the students that any work used in my paper would not have their real names on it. Every student would have a pseudonym, and

they would not be able to know what their pseudonym was at any point. I either used this pseudonym or did not use the name at all in my paper.

The students were informed that they had the right to withdraw from the study at any time. “Students need to know that they may withdraw from the study at any time without fear of negative consequences” (Holly, Arhar, & Kasten, 2005, p. 177). If students withdraw, they must still do the work, but their data will not be used in the study.

According to Arhar, Holly, and Kasten (2001) another way to ensure trustworthiness is to triangulate the data collected. Triangulation is accomplished by “using multiple sources of data, multiple methods even multiple theories” (p. 207). In my study, I collected student work in the form of journals and creative writing activities. I also kept an observation log with my participant observations and reflections. I graded math and science tests and quizzes. Finally, I conducted surveys about writing in math and science class.

I continued to build trust in my classroom and encouraged open communication with my students, the parents, and my colleagues. I made sure I listened to all points of view. I discussed my research with my colleagues. I asked for my students’ opinions and ideas with relation to what we were doing.

I consulted with my research support group during our class meeting times. They provided objective and valuable feedback, making me consider and reconsider my research findings. These group meetings

also made me continue to reflect on what I was doing in the classroom so that I was as honest and accurate as possible.

Biases

I know that I am coming into this study with several biases. First of all, I am very optimistic that my students will make great gains and benefit incredibly from writing in math and science. I know that when I write, it helps me remember the material that has just been introduced. It is hard for me to see that anything else will happen because I have experienced it. However, I know I have very low writers. Will they benefit when they struggle simply writing a sentence? Will they become even more frustrated and learn less? I need to be aware that writing in math and science will not ensure success for every student.

Secondly, writing, as I am incorporating it, is a fairly non-traditional method, especially in math. I think back to my education, and my friends and I did not have learning logs or journals for math or science. We never had to explain what we were thinking for state tests. I, as well as most of my classmates, did well in school. We graduated from high school and went to great colleges. We are very successful people with good jobs. If it worked for us, should it not work for the students today? While I know research supports new methods to increase student understanding, I think back to those days. During this study, I need to be open to activities that are different from what I am used to from my educational experiences as a student.

At my school, I teach the higher-level math students, which I love because I love math. My love of math is a bias because I expect my students to love math and for math to be as natural for them as it is for me. Loving math, my students should be able to express their ideas and answers in a specific way. I will find it hard to understand why a student cannot explain his/her math work in his/her own words. To me, it is easy because math comes naturally to me. However, I have to be sure not to frustrate my students and instead guide them to analyze their thinking.

Finally, as a child, I loved to write. I wrote mysteries and stories with chapters. My best friend and I had dreams of publishing a story we had written. Even today, I have an interest in writing a children's book. I wish I had more time to write for pleasure. Currently, I know I have students who dislike writing. I need to understand this and be ready to deal with this situation. How will I be able to motivate them? I need to be aware of these feelings and thoughts throughout my research study.

MY STORY

The first day of a new school year is a day filled with excitement and nervousness. Students and teachers are worried about meeting each other, many times expecting the worst but hoping for the best. Students and teachers are also excited about the journey they are about to begin – the learning and activities that are going to take place throughout the next school year.

I have felt these emotions on the first day of school for the last six years. This year was not any different, except that I was even more excited. I was about to take my students on a journey.

During the summer prior to this school year, my study was approved by Moravian College's Human Subjects Internal Review Board (HSIRB). This board cleared the activities I wanted to implement in my classroom. The only requirements to be completed were getting permission from my principal and my students' parents.

My principal approved my study at the beginning of the school year. During the second week of school, I met with my science students in our reading area of the classroom. I explained my study and their role in it. We discussed activities that may be done, as well as the use of pseudonyms and the privacy of their work. I told them to expect writing in science at least one time each week, since I only see them three times a week. When I was done speaking, I looked carefully at them. They were all

staring at me, and I did not get the impression that they were overly excited about being a part of a research study.

I was a little upset and nervous about explaining this study to my math students after seeing how my science students reacted. I remembered that Dewey (1997) said, "As I have emphasized more than once, the road of the new education is not an easier one to follow than the old road but a more strenuous and difficult one" (p. 90). So, I began the discussion with my math students in the same, excited way. I told them that we would be writing in math at least twice during each chapter. This time, the students were more excited. They were smiling and asking questions. They especially became interested when I discussed the use of pseudonyms because they wanted to pick their fake name. After realizing they would not be able to pick their name, they were still smiling and talking about the study.

After talking to all of the students, I sent the permission slips home on the Thursday of the second week of school. They were all returned by Friday of that same week. All of my students were participating, except for one of my science students. With these permission slips, I was able to start.

The first activity I did was a survey. I wanted to see what students thought about writing and when they remember writing in school to get some baseline information. So, instead of completing the morning journal, my students answered questions about writing.

When I read the surveys that evening, all of the students agreed that they had written in math, science, library, and language arts. All but two students said they wrote in social studies, which made me wonder what experiences in social studies these two students were thinking about because I would think they would write often in this class. The students agreed that writing did not occur in physical education, art, and music classes, which did not surprise me and made me wonder if teachers of art, music, and physical education are aware of the benefits of their students writing in class.

To answer the last question, "Do you think, by writing about new concepts and skills, you understand the material better," most of the students wrote, "Yes" and then repeated the question. For example, Andrew wrote, "Yes, by writing about a new concept and skill in your own words, you'll understand that concept or skill better." Only one student answered without including any words from the question, and this student seemed to understand the question and answer honestly. Erin wrote, "Yes, I do, because if write it in your own words you understand it." The answers to this question made me wonder if I had worded the question differently, they would have answered differently because it was almost like they knew the right answer was "yes."

There were a few other comments from this survey that stood out to me. Several students answered question one, what they like about writing, by saying that they like to be able to express themselves and write

about what they want. The majority of students said that in math, they had to find the answer and then write about it, or answer a prompt in words. In science, students referred to writing only during experiments.

By doing this survey, I realized that students were familiar with writing in math, but not as often or as varied as we were going to do this year. Also, I saw that science writing occurred only during experiments, and throughout the next year, they would be writing in many more creative ways during science class.

Math Writing

Getting to Know My Math Students

The first type of writing activity we did during math time was journal writing. The students used composition books for their math writing. I allowed them to decorate the cover, and I gave them a sticker for the front so we could distinguish these journals from the vocabulary books. I felt this activity gave the students ownership of these journals.

Their instructions when writing in the journal were to write the date, and they could either copy the question or statement, or they could restate the question or statement in the first sentence of their answer. I shared with the students that I wanted them to write as much as they felt was necessary. There were not a correct number of sentences or words. The question or statement was always posted on the whiteboard, and the students knew where to look for it.

For the first two journal prompts, the students were serious and really took their time to think about the answer. These students wrote for at least five minutes, and they started right away. They wrote quickly, as if they had a lot to say and were excited to share it. I constantly moved around the room to encourage them and look over their shoulders.

After these first few journal writing assignments, I felt like I had a better understanding of who my math students were. By reading their writing, which included their math understandings and thoughts, I got to know my students, the majority of whom I had never met before. Therefore, I was very excited that I had started this in the beginning of the year, and I already felt like I would know my math students better this year than ever before because of these writing activities.

Early on, one student stood out to me because he had just moved to our school. His name was Bill. During journal writing, Bill was always done first. The first time this happened, I resisted the urge to go over and check it right away. I was thinking that he did not do a thorough job because he was done so quickly. When I did get a chance to look at what he wrote, I saw that his answer showed that he understood the concepts and concluded he was just a fast writer. I knew he was a gifted student, and I learned from his writing that he was one of my brightest math students. He showed me through his writing that he could problem-solve and think on a higher level than many other students. Jeven also showed a high level of understanding and creativity through his writing. He, too, is

a gifted student. On the other hand, Doug, another gifted student, disappointed me with his first entry. He wrote one sentence, and it really did not show a clear understanding of the concept.

Something else I learned through these first few journal prompts was that students were going to need some instruction in order to maximize the effect of the journals. I read the journals after each writing assignment and then wrote comments regarding their answer and writing. I returned the journals so the students could get feedback. However, not everyone looked at what I wrote. One student, Maria, did, and she answered my questions correctly, causing her to rethink what she learned and correct it. Joseph also looked at his journal and actually used what he had written to help him with his homework. These two students experienced success when they responded to my questions, and I knew I had to talk to the rest of the class about reading and responding to my comments. Once I did this, Robert looked back and began feverishly answering one of my questions. Vygotsky (1978) reminds us that “What a child can do with assistance today she will be able to do by herself tomorrow” (p. 87). So, instead of thinking to myself that this was hopeless, I thought that the students need help right now and soon will be successful on their own.

The third writing prompt began to show differences among the students. Three students did not finish, and this made it clear to me that time was going to be a factor. The time it took students to complete these

entries varied from 3 minutes to 15 minutes. Monica, one of the last students to finish, sat at her desk and looked into space. It was hard to tell if she was daydreaming or thinking. Another of the three students decided to read his book instead of completing the prompt. Frank needed prompting every time we did journal, as did Joseph, although he seemed to need more reassurance that he was doing things correctly. Aaron forgot to do the prompt, and he did not seem too excited about writing in math. Robert and Doug (again) were done quickly. Jeremy, however, wanted to do more, so he also drew a graph using the information from the prompt. Differences among my students when they were writing were becoming obvious.

Writing Variety Sparks Interest

Even though the majority of students were performing successfully on the writing prompts, I decided to vary the writing by doing an exit slip with a learning log prompt. The students were extremely excited about the idea that they had to finish the sentence on the exit slip in order to leave the class. One student said, "I'm going to stay here all day long." They became obsessed with this idea and had to be encouraged to start writing. Some students proceeded to fill it out quickly because they were allowed to work on the homework when they finished. This different activity sparked more interest, and I decided to add more of these different activities. I also saw that, when given as a list of tasks, the students may not put in full effort depending on what the following task was.

I continued assigning different writing activities. Even though the students answered the next prompt in their journals, the prompt required students to use higher-level problem-solving skills, which was unlike any we had done so far. It was harder than the previous writing activities, but in my opinion, it also seemed more fun because it was more creative and different. Five of the students answered it correctly. These students, as well as the ones who did not answer it correctly, took time to explain their thought process, although some were hard to follow. Maria, however, struggled, and after two days of working on it, did not have an answer. Frank said he finished it, but really did not. This was not surprising as he continued to not completely answer the writing prompts in his journal.

Another activity that sparked interest in my math students was creating their own math prompt that they wanted a peer to answer. Writing began quickly, and once they were given a new prompt, the students started answering it right away. It did not take much time, and the conversations I heard about this activity included, "That was fun," and "My question was too easy."

Instruction Adjustment

There were several times throughout the math writing when I read the journals later in the day, and I realized that many of the students had the incorrect answer. This enabled me to reteach the concept the next day and go over the correct answer. This also caused me to question the pacing. Were we going too fast?

Students' Perspectives on Writing in Math

Approximately halfway through the study, I surveyed my math students. When they came into class, I asked them to complete six questions regarding writing in math class. The first thing the students were asked to do was complete the sentence, "Writing in math is," and many of their answers are represented in the following pastiche (see Figure 1).

Writing in math is...

...important to me because it helps me understand things better.

...hard because you have to explain everything.

...a good way to learn how to do something in math.

...really fun!

...*fun because it is easier to me because sometimes people's words get mixed up.*

...makes me think and understand the problem better.

...fun because we get to
do the problems
that hurt your brain and
really stump you.

...helpful because it helps you understand if you write it in
your own words.

...can help your brain remember things better.

...important but explaining everything is mind-
numbing.

...easy because I could answer all the questions and hard because I don't know how to explain it really good.

Figure 1. Pastiche using student responses on a writing survey.

All but one student felt that writing in math was positive. Doug, on the other hand, said that writing in math was not fun because he did not like writing, except with numbers, and he did not like math very much. He did say in his survey, though, that writing in math was helpful because it helps you understand. He sees the value but just does not like doing it. Similarly, Frank said writing was helpful and easy because he could answer all the questions, but hard because he did not know how to explain it really well. Also, Robert wrote that writing was hard because you had to explain everything like you were saying it to someone who did not even know what math was. This information made their actions during writing time clearer to me. The three of these boys are gifted and find it easier to just solve the problem, and they then struggle with being required to explain how they did it. This made me realize how extremely important writing in math is especially for these smart, but struggling, writers.

Susan likes math and writing. In her survey, she said math writing is helpful because it makes her think and understand the problem better.

Several students felt that writing in math would help them later in life, in the real world. Three students liked writing in math because it was easier to express themselves, and they were not worried about being wrong because I was the only one reading it.

Bill wrote that writing in math is easy because “we’re used to it.”

This was a good sign that writing in math class was becoming more natural for some students.

Writing + Math = Connection

The students answered a journal question or prompt every day in Language Arts class. I collected Susan’s journal, and as I was reading it, I stopped on her October 14 entry. The students had a free topic, which meant they were able to write about anything. Susan, who had already mentioned that she likes to write, chose to write about writing in math. The poem shows Susan’s thoughts and feelings from her entry (see Figure 2). Susan chose to write about math in her journal when she could have chosen any topic. This energized me to continue using a variety of writing activities in math.

Math Today

Today in L.A. we can write about anything,
I want to write about math,
I can, can't I?
It says the topic is free.

So, I'm going to write about math,
It's on my mind,
We're having a test today,
And I want to do my best.

I like to write,
And we're writing in math,
So it fits,
That I am writing about it today.

Tenth, hundredth, thousandth,
Place value, comparing numbers,
Equivalent decimals, ordering,
Writing it in all kinds of forms.

I studied.
I am ready.
I am good at math.
I'm wishing I get them right.

Figure 2. Poem describing Susan's thoughts about math and writing.

Math Writing Seems to Lead to Interesting Discussions

The students were given the following information: A science book has information about the planets in the solar system. It includes the planets' diameters, temperatures, and distances from the sun. Would these data about planets be expressed as exact numbers or estimates? Why?

Everyone started right away and wrote quickly. When I told them time was up, some students were still frantically writing to make sure all of their thoughts were included. I asked them to share their answer with a partner, and if their answers differed from each other, they needed to persuade their partner to go with their choice and then decide on one final answer. Jeven and Monica's discussion was particularly interesting. Monica had the correct answer, and she was trying to defend her answer to Jeven. Jeven, however, always has a hard time being wrong, and I was afraid he was going to have a meltdown, as he often does when he does not understand something. He did not have a meltdown, though. Monica's explanation persuaded him to change his answer, and although he was not happy about it, because he said, "Yeah, I guess you're right," he did change his answer.

After this partner discussion, eight other students changed their answer of "exact" to the correct answer, "estimate", because of this dialogue. Some students were still hesitant, though, that "exact" was correct. I asked Erin to share her answer because it precisely said why the

answer could not be “exact”. She said, “If a planet was made of gas, we can’t measure the diameter, and no one can get close to the sun so we don’t know the exact distance.”

When I read the journals later in the day, the students who had the incorrect answer were still able to explain their thoughts and back up their answer.

Seeing the benefit of group discussion, the students’ next task was to compare their unit review answers with a neighbor. I was not expecting this activity to go well because students seemed disoriented and not on-task. Before they could begin, many had to go back to homeroom to get forgotten materials, and students spent a lot of time trying to find their homework, open their books, and get organized.

Because I was not expecting much, I had planned to stop this activity after I completed other housekeeping tasks, but what I observed while standing in the front of the classroom during this time made me continue the activity for 10 extra minutes.

When I brought the students’ attention to me, I asked them why I had stood in the same spot for the last 10 minutes. Maria answered that it was because I could hear what each group was talking about. I concurred, and told them that I heard amazing things – that I had goosebumps! This made them smile. I told them several examples of what I had heard. I heard Jeremy tell Madison that the decimals had to be lined up. Hannah told Aaron that six minus one is five. Monica and Eric were trying to

explain to Andrew and Ben why Tuesday was the answer to a problem-solving question. Terry was trying to figure out what he did wrong when Robert leaned over to look at Terry's work in order to help him. All of the students who were confused or had questions responded with "Oh!" after their peer explained the problem to them. I saw great teamwork. The students continued to smile at this comment.

It makes sense to me that having the experience of writing explanations may have made it easier for the students to help and talk to each other about math.

Increased Participation and Thoughtful Explanations

A third discussion that was valuable occurred during the middle of the algebra chapter. I asked the students to share anything they had learned about expressions. Maria started by saying, "It only uses numbers." I looked at her, and she rethought this, and added "and it can have variables"! Madison gave an example of an expression using cookies. Bill said that an expression was a math phrase. I complimented him because that was the core of the concept! Eric said it was showing a problem and its value. Their answers were well stated and explained.

I then asked the students how they would solve the following problem: $12 + n = 15$. Robert raised his hand, told us the answer, and what he did to find the answer. I asked him why he solved the problem in this way. He could not explain his math process using words, and someone else had to explain what to do. This experience coupled with a

journal discussion changed Robert's attitudes about writing in math. The journal discussion focused on why the students should answer the questions that I ask them. I observed Robert feverishly looking back and answering my questions. After these experiences during math class, Robert began to show a different side of himself in class. Something just "clicked" for Robert because he began to participate more and was able to explain his math answers using words. Although it was not easy for him, he was finally putting forth all of his effort and working hard to become a better math student.

Real-Life Connections

I asked the students to free-write in their journal. They could write about anything dealing with math, and they only had to write a few sentences. As they began writing, I noticed they were not stopping. They all wrote more than a few sentences. What they wrote was amazing as well. Many students wrote about how they used math in their real life during the past weekend. Others wrote about their excitement to start algebra. Doug wrote a poem about math, but he included his negative view about math, including "subtraction sucks." When I wrote in his journal that he should change the word, he responded and chose "super." This surprised me, and as I would find out later, he started to write more and show a greater interest during class.

Journal Creativity Continues to Lead to Student Interest

I continued to see when creativity was involved, students were excited to write. Robert and Doug were becoming the last students to finish, instead of the first, as in the beginning of the year. Their answers and responses were now correct and explained thoroughly. Robert's written responses were improving, and Doug was really thinking and taking his time. The following layered story shows Doug's journey to this point in the school year (see Figure 3).

Layered Story

Doug

Math is not my favorite subject. I can solve problems correctly, but I do not like to write about it. Here we go. Ten minutes after nine, and it is time to go to math class. What is she going to make us do today? Whew, no journal prompt today, but she sure is asking us a lot of questions.

Another day has passed, and I just know today is the day. Yes, I'm right! The journal prompt is written on the board. Great. Ok, let's make this as painless as possible. I can answer this question in one sentence, and then I'm done. I can read my book. Did it! One sentence! Wow, I'm good. How long can I do this for?

Uh-oh, she wrote a note to me about my writing yesterday. It says that I should write more. Ok, two sentences. I can do that.

Uh-oh, she wrote another note. I disappointed her with what I wrote. Boy, I don't want to do that. I need to try. From this point forward, I'm going to really think about the question and write more to show that I really understand what is going on! I am a smart boy and in the gifted program. I need to show her that I can do this. I can't wait for the next journal!

Me

I love math! I hope all of my students are fond of math, especially since I have the high math group. They should all love it. I'm about to start a great math writing study with them. They will be so excited. They are coming in now for math. There isn't a journal prompt today because there isn't time, but I'm

going to ask them a lot of questions to make sure they understand the material. Ok, that went well. Tomorrow, we will do a journal prompt.

Here they come again! Here we go! Why isn't Doug writing? Why is he staring into space and not starting? Oh, and now he's done? He's already reading his book. I wonder what he wrote. I'll check after class.

Wow, he only wrote one sentence, and it's not that good. It doesn't really show a deep understanding, and he's a bright boy. Maybe, it will change. Maybe he's having a rough day.

No, today's no different. He still won't write. I need to make him aware of this by writing a note in his journal.

Oh, he's reading it. Now, he's writing. Success! He's done early again. Why isn't he taking this seriously? Is his home-life impeding his academics? I know he is dealing with a lot of issues outside of school. I'm going to write to him again because I don't like the word he used in his poem.

He's reading it again today. Now, he's writing. He's still writing. Wow, he's still writing. Finally, he's taking it seriously. I'm anxious to read it.

Yes! He's getting it. He's showing me what he knows! Go Doug!

Figure 3. Layered story about writing in math from Doug's point of view and my point of view.

Change Over Time

By the beginning of December, students were taking ownership of their writing and looking back at my comments, without my reminders.

Students were still taking the writing seriously and would write for several minutes. A few were incorporating ideas from class discussions and

practice into their journals. For example, Susan and Erin created a t-chart and began their explanations with "because I already know," both ideas

coming from P.S.S.A. practice. The fifth grade teachers had been teaching the students how to answer math prompts for these standardized tests.

On the tests, students are required to answer several math open-ended prompts, and we recommended two strategies to the students. One

strategy was to use a t-chart to differentiate their math work from their

written explanation. The other strategy was to begin their written explanation with the words, “because I already know.” Beginning with this statement would force the students to write down any mental math they were using to solve the problem. Susan and Erin remembered these two strategies and implemented them in their math journals.

Student Interview Shows Writing Progress

I asked the students to reflect back to September and the beginning of journal writing. I asked them if it has become easier, harder, or the same to answer prompts. The following pastiche shows some answers (see Figure 4).

I also asked the students if they felt that writing helped them understand the material, and everyone shook their head yes. At this point, students may have agreed with Freire (1997/2005), “Dialogue is thus an existential necessity” (p. 88).

Journal writing progress...

It depends on the problem. Some are easy. Some are hard.

Easier – familiar with material that we're writing about.

Same – we do the journals after we learn the subject.

Depends on the problems. This is good because of jobs later in life.

Depends on the problem. We keep going over the material so we know it.

Same – problems are harder but writing is easier.

Easier – we're getting better writing in math. It doesn't take so long to write our answers any more, and we can explain it better.

It was harder in the beginning to explain my work, but now it is easier. The comments you write are helping us to know what to fix and what we did wrong.

Figure 4. Pastiche showing students' opinions about writing in math class.

Robert's response in his reflection was truly exciting. I could see his progress and increased interest in math writing. The following vignette shows Robert's story.

Vignette

Robert

I know the answer! Pick me! Call on me! I know it! Yes! The answer is 54. What? How did I get that? Well, I don't know. I just did it in my head. What did I do in my head? Wow, that's really hard to explain. You ask me to do this in my journal too. You ask me a question and then I have to explain my answer. That is hard. I only write a few sentences in my journal. Oh, you noticed. But, I'm really smart. I'm in the gifted program. I still have to be able to explain, huh? Great, I'm in trouble. I better start practicing. I will participate more in class in order to help me with this.

I know the answer! Pick me! Call on me! I know it, and I can explain it, or at least, I'll try!

Figure 5. Vignette showing Robert's journey with math and writing.

Writing Effects in Assessments

Following the first two journal entries for the first chapter, the students took a 20-question quiz. The lowest score was an 84%B. Everyone earned either an A or B.

This pattern continued on every quiz and test. Students completed at least two writing activities and then would take an assessment. Students earned As and Bs, and on at least one quiz and one test, which was 40 questions, the lowest score was a 90%, which is a very high B.

At the end of the first marking period, all students in my math class had an A average.

I hoped these high scores were because of the journal writing, but I knew I also had the top math group, and the earlier graphing chapters tended to be the easiest for fifth grades. "Students' academic achievement represents intellectual growth and the ability to produce knowledge" (Ladson-Billings, in Delpit & Dowdy, 2002, p. 111). However, this pattern continued throughout the entire study. At the end of the second marking period, one student earned a B average, and all the other students earned an A average.

Science Writing

Key-Word Paragraphs Shows Key Understandings

To begin writing in science, I started with key-word writing, as Yockey (2001) tried in her study. I wrote five words relating to the water cycle, our current topic of study, on the board. These words were the key

concepts from our first lesson. As I reread Yockey's (2001) study, I decided I wanted to time the students. In math, I had quickly found that time was a constant factor, and I thought if I gave them five minutes to free write and include as many of the five words as possible, it would be quick and successful. They were all writing and eager to do the activity. However, I quickly realized that many students do not do well with timed activities. Tyler was trying to reread what he had written but felt rushed because of the time. Mike looked frustrated with his hand on his head. He was a struggling writer from what I had seen so far this year. When I told the students that time was up, several groaned. Because I sensed frustration, I asked the students what they thought about the time limit. They were very honest. Several of the students said they focused more on the time, and according to Debbie, "I am stressing"! She was not alone because several students felt stressed out because they could not finish or reread their work. A few students were not worried about the time and had finished, but not many. I gave them about seven more minutes, and several students still did not finish.

I was not sure what to expect from the students' paragraphs because we had not written in science this year, especially not the type I had asked them to do. I was happily surprised when I did read them. Several students simply defined the words. Most of the definitions were accurate; however, some students had inaccurate information that I would need to discuss with them. Thus, this paragraph showed me which

students had mastery of the factual information and which students needed reteaching. Kyla, an unenthusiastic writer normally, created a personal story using the words, and Victoria expressed her positive thoughts about the subject matter. Bridgette, a new student to this country and the English language, was only able to write one sentence. Now, due to the timing, I was unable to do this activity before the science quiz, and therefore I was unable to catch the misconceptions before the assessment. The average quiz score was 83.6%. Students who had inaccuracies in their key-word paragraph also seemed to do poorly on the quiz.

The next key-word paragraph was done before any assessments so I could catch any misunderstandings. The words this time related to ecosystems, our current topic of study. Jordan, like last time, had incorrect information. Tyler and Erin showed mastery of factual knowledge. Teresa was creative with her paragraph because she wrote it like a story, giving examples and using all of the words. Bridgette wrote six sentences this time, although she shared how difficult and confusing science was for her. At least she was trying. Again, Kyla created a story and showed that she understood all of the terms. After I read all of the paragraphs, I sat down with the students who had errors and helped them understand the material. The average quiz score this time was 88.9%, which showed an increase from the previous quiz.

Writing Variety Sparks Interest in Science, too

To add a fun, creative writing activity, the students filled out an exit slip at the end of the science lesson in order to leave the classroom and go to their special class. The slip asked them to name their favorite ecosystem and explain why it is their favorite. Shocking to me, since we had spent some time studying ecosystems, several students stared blankly in the air, and after I read their writing, I realized that the majority of students did not remember the names of the ecosystems. Therefore, I decided to do another creative writing activity that would help them learn about and remember ecosystems.

During the next class, we listed the seven ecosystems. I told the students to choose their favorite one. Immediately, there was discussion, smiles, and excitement in the room. Once they chose their favorite ecosystem, I instructed them to research and gather certain information, and then create a poem using this information. They immediately began working. There was obvious excitement, and every student was engaged in research. They were all on-task, and when I told them our time was up, I could not get them to stop writing. I asked the students what their thoughts were about this activity, and Erin remarked, "We worked so quickly because we got to pick what we wanted to write about, and we were more interested. The poems were wonderful (see Figures 6-9). Many students chose an acrostic to display their information, and all information was accurate. Later, I looked at every student's quiz to see how they

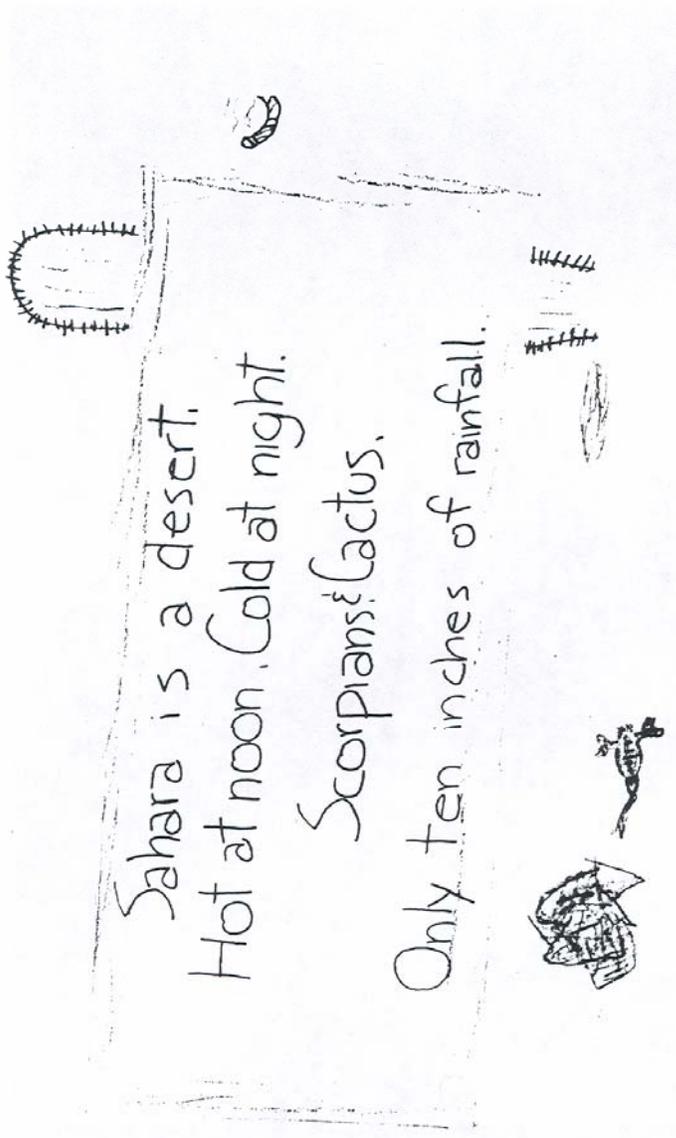


Figure 6. Susan's poem about the desert ecosystem.

Tundra white and dull
Winters there are cold and dry
But summers are wet

Arctic fox and hare
Whales and rams live together
Wolves and grizzly bears

Snow, Snow, Snow, Snow, Snow
That is what it is about

Tundra area



Figure 7. Erin's poem about the tundra ecosystem.

Coastal ecosystems can be divided into swampan and marshes, they both inhabit different animals.



Other kinds of coastal ecosystems are the Bog and the everglades.



All over the world there are coastal ecosystems.



Soft muddy bottoms where plants take their roots.



There is no same climate that coastal ecosystems share because they are all over the world.

Animals some time, just visit like Geese to rest and buffalo for a drink.



Lots of animals live in Bogs, Swamps, Marshes, and Everglades, like the green tree frog, beaver, Fisher spider, musk rat, Tiger salamander, and the mink.

Figure 8. Andrew's poem about the coastal ecosystem.

Fish, Salmon, large mouth bass
Rivers, streams, creek, pond, fresh
 water
Eel, pumphinseed
Salamander, newt, minos
Have been important to us for drinking
Water hyacinth, lily pads, dock, weed
Any where in the world
Trees, oak, maple
Every green trees
Rivers

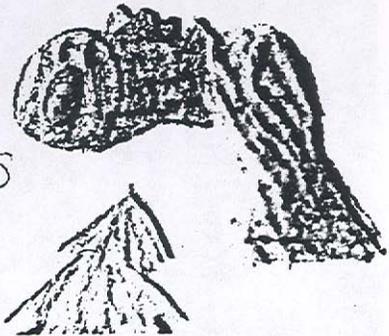


Figure 9. Bailey's poem about the freshwater ecosystem.

performed when asked to list four ecosystems. Fourteen students wrote four correct ecosystems. Susan listed all seven. Erin and Victoria wrote six. Kyla and Debbie were the only students to get one wrong.

After learning the ecosystems, we began to discuss the animals that inhabit them. We began with a 15 minute discussion about symbiosis. After reading about this concept, I asked the students to close their eyes. I then told them to picture two imaginary creatures. I told them it did not matter what they looked like, but they could not picture real animals. I encouraged them to be creative. Then, I told them to quickly sketch their imaginary creatures in their notebook and to give them names. I explained to them that their creatures had to have a symbiotic relationship – 1-way or mutualism. The next step was that they had to write a paragraph explaining to me what their creatures looked like, what their names were, and what type of relationship they had. They could not just write 1-way symbiosis or mutualism. They also had to explain how they depended upon one another.

The students went to work immediately. Everyone was writing. There was a feeling of overall excitement in the room. The students were also assisting each other with ideas.

I walked around, and their ideas were accurate and amazing. The students had to stop because they had library, and they did not want to take a break in their writing.

We did continue another day, and the students used their symbiosis paragraphs to write a letter from one of their imaginary creatures to the other. Their letter needed to show the relationship that they had with one another. All but one student correctly showed a symbiotic relationship. The students included what each creature did for each other and why they were missed. These letters showed a tremendous amount of creativity, while also showing any misunderstandings of symbiosis (see Figures 10-15). The only student I needed to work with was Jordan because she wrote a proper letter, but the information she included was not information about a symbiotic relationship.

To be able to fit science writing into a normal day when I only see the students for 45 minutes for science, I decided to have the students complete a science writing activity in the morning instead of writing in their regular language arts journal. When they arrived in the morning, there was a blank piece of paper and a picture of an animal on their desks. The instructions on the board told the students to write a story about their animal using as many science vocabulary words as they could. Not many students began writing right away because they were “oohing and aahing” their peers’ animals, showing a high level of interest because the animals were so cute. Tyler and Erin begin writing soon after they have seen the other’s animals. Kyla had difficulty starting. She wrote a sentence, erased

November 10, 2005

(Dear Blot,

I really need you. My beautiful green fur is so dirty. People used to always look at me now they barely look at me. I bet your r hungry without the dirt in my fur. I miss when you aren't around my body. My fur is just so ugly without you cleaning it. I'm sorry you can't be here right now. I hope you come home home soon. If you don't I'll have to go live in a cave so no one can see my ugly fur. See you soon.

Your friend,
Troll

Figure 10. Victoria's symbiosis letter from Troll to Blot.

November 10th 2005

Dear Pinlue,

Hello, how are you doing? Oh please come back. All of my predators like the eagle, and deer are trying to get me. When you were there, you scared them away by blowing air in your head. I could make my predators into prey, but not without your help. They are only my prey if they're frightened. Sometimes I think I'm not doing anything for you, then I've noticed after I eat the meat of that animal, you get the bones for snack. Now, I don't feel very guilty. Bye-bye!

Yours Truly,
Cueling

Figure 11. Susan's symbiosis letter from Cueling to Pinlue.

Nov. 10, 2005

Dear Cleaney,

I haven't seen you in a while. My fuzzy spots are so dirty. I need you to come polish my silk. Are you on vacation because... Well! my spots are your home. And you are not here. As soon as you get this letter mail me back. I really need you to come home.

Your friend/Home,
Dotty

Figure 12. Teresa's symbiosis letter from Dotty to Cleaney.

November 10, 2005

Dear, Longnecks

I really miss all the bugs that use to be on your neck. Are you still running? Dose everyone still tease you about your legs? I'm fine. But my wing did break. I never changed. Did you find some one to rap around your neck for you? I hope you don't have a better bug chacher than me!

Your friend,
Air Head

Figure 13. Debbie's symbiosis letter from Air Head to Longnecks.

November 10, 2013

Dear Powerless,

I am very lonely, when are you going to come and see me. Thank you for providing shelter for me. I just found some where else to live. I really had fun zapping creatures. Hope to see you soon!

Your Friend,
Pixie

Figure 14. Tyler's symbiosis letter from Pixie to Powerless.

Dear Blob,

Hi I miss you. When are you coming back. I am very thankful you are my friend. I would be lost if I didn't have you to protect my soft gums when I eat. I think we have to get together so we can eat again. Remember if you need me to protect you just call for me. Bye.

Your Friend,
lat

Figure 14. Tricia's symbiosis letter from Lat to Blob.

it, and then rewrote another sentence after five minutes. Her final copy included three science vocabulary words used correctly, and her story filled an entire page. She is a student who shows little imagination and is concerned with always being right.

Dennis was writing, which was unusual and exciting, because he does not like to write in his language arts journal. “What are our science words?” he asked, and I pointed to the bulletin board. He went back to look at the board, and then continued working on his story. He showed an interest, and after he handed it in, he wanted it back so he could add something. He only used one science word correctly in his story. His story, though, was very creative and finally was a writing activity that interested him.

Andrew struggled to begin, and I know he is hard on himself to be perfect. He did not start right away because he seemed to need think-time. When he was finished, his story filled an entire page, and he used six vocabulary words, which tied Tyler for the highest amount of words used correctly in this activity. Susan, and surprisingly Jordan, who has had incorrect information on all of the previous science writing assignments, used five science words correctly in their paragraphs.

Struggle Leads to Change

When we began our new discussion about biomes, I decided to see what the students had learned from our brief discussion the previous day and from their homework. So, I wrote this prompt on the board, “A new

thing I learned about biomes is. . . .” The students struggled with this prompt, especially because I did not let them look back at any information. Bridgette avoided the activity by doing other tasks around the classroom. Several students were looking around the classroom. After I collected them, I immediately read them. I was impressed with Tyler, Victoria, and Andrew. These three students did not just say they learned about biomes, and they did not have any incorrect information, as many of the other students did. Tyler remembered three facts about biomes. Victoria stated four facts, including examples of biomes and what is generally found there. Andrew wrote about one main idea and posed his own hypothesis about why it was true. In the other students’ journals, I read many incorrect statements, as well as some blank pages, so this writing activity showed me that we needed to continue talking about biomes.

I introduced a biome activity. This biome mission combined researching, writing, and reporting. The students were put into groups, and each group chose a biome they would like to study because in previous activities, choice was very important for students, and they showed more interest and ownership of the activity. Once they had a biome, the students did research and found several different facts about the biome, and then recorded their findings on a piece of paper to be copied and shared with the rest of the class. All of the groups worked through the entire science class period, and many of them needed more time. Each group presented their information to the rest of the class. While

the students were listening to each group, they had to write down one most interesting fact about each biome, and then we talked about these. Each group had all of the information that was asked for, and it was correct. Three of the groups chose to make an outline, and the other three groups chose to write a paragraph. The way they wrote their information was clear and concise and easily readable. It seemed that the students were able to gather and present the information in an effective way. The students had a pop quiz on this information after all the presentations were done. They had an opportunity to reread the notes from their classmates. The students did well on the assessment. The quiz average was 92.2%.

Writing + Science = Connection

We continued our discussion on biomes to help the students learn and understand more of this new information. During one of these discussions, Erin raised her hand to answer the question, “What kind of weather and animals are found in the tundra”? She said that when she researched the tundra for the ecosystem poem, she found out that “In the winter it’s really harsh and cold and in the summer, it’s really swampy. All the animals that live there are really adapted to living there.” She made a connection and remembered pertinent information from a previous writing activity. The researching and writing seemed to help her to learn a fact about her chosen ecosystem.

Interdisciplinary Connection

My study was coming to an end, but the effects outside of math and science class were still occurring. I collected and read Mike's language arts journal, and I noticed that he, a student whose handwriting is barely readable and whose parents think that he has a problem getting his ideas on paper, was responding to questions I had asked him with relation to his original journal prompt. He was writing a paragraph back in response to my question. This really stood out to me because he did not like to write in the beginning of the year, but has recently blossomed as a writer.

Final Survey

To end the study, the students were given the same survey as in the beginning of the year. The only difference was that all the students said that they wrote in science, whereas before the study, not everyone agreed that they had written in science.

Kyla was absent on the day I gave the survey, so she completed it the following day. I told her to do the survey instead of her language arts journal. When she was done with the survey, she asked if she could still do the journal. This comment was coming from a student who had remedial reading assistance last year and who I thought did not like language arts very much. I wondered if the journal topic had anything to do with it and if it was particularly interesting to her.

On the survey, the answers to the open-ended questions were exciting. In the following drama, students' thoughts as well as my thoughts are portrayed (see Figure 16).

After participating in writing activities for several months, the students responded in a more meaningful way to the questions on this survey than they had in the beginning of the year.

Drama

Teacher ~ What do you like about writing?

Tyler ~ I like being creative.

Teacher ~ Great! I changed my activities throughout this study to increase the amount of creativity that was involved.

Debbie ~ One thing I like about writing is that you get to tell people a story in words.

Teacher ~ Very true. Being a good writer means that your reader knows exactly what you are talking about. If you can do this, then you truly understand the material.

Erin ~ I like writing because it helps me review what I have learned.

Teacher ~ This is a very exciting statement because many of the studies I researched showed that this happened.

Susan ~ Writing makes me think more: form my thoughts into right words.

Teacher ~ Writing about math and science is difficult and is not an easy task, but it makes the students think and shows if they understand the material or not. Ok, now do you think writing helps you understand concepts/skills/new ideas?

Debbie ~ Yes, because if you write it down, you can look at that paper that you wrote it on and say hey I remember when Mrs. Kao taught me that.

Teacher ~ Writing down information helps you learn it.

Susan ~ Yes, because as I write, I wonder what to put and after I find out, I'll understand it better.

Teacher ~ Again, it takes time and patience.

Figure 16. Drama showing students' thoughts as well as my own about writing across the curriculum.

DATA ANALYSIS

Beginning from the first day of my study, I collected data in a variety of ways. I was always observing the students and writing down what I saw. I reflected on my observations by writing observer comments in brackets in my field log. Later, when I reread my field log, I added other reflections or ideas that were appropriate. Students completed surveys throughout the study. Students participated in many writing activities, including journals, prompts, creative writing, poems, and letters. I collected and read all of their written work. All of this data was kept in my field log. “When you use multiple sources to support your findings, you can build a compelling case for what you have discovered” (Hubbard & Power, 2003, p. 124). I also constantly referred back to my question to keep myself focused throughout the study.

Data analysis is the process of systematically searching and arranging the interview transcripts, fieldnotes, and other materials that you accumulate to increase your own understanding of them and to enable you to present what you have discovered to others” (Bogdan & Biklen, 1998, p. 157). Analysis is therefore an ongoing process. I used many different forms to analyze all of my field log data. This included coding and re-coding my field log, putting the codes into bins, using the bins to create theme statements to help with my findings, creating reflective memos based on the data I collected, writing analytic memos to relate my study to

educational theorists, and generating narrative forms as a way to share my data with others.

Coding was the first step in analyzing my data. Hubbard and Power (2003) stated that coding data is important to begin to narrow your focus. As my study went on, I coded my observations, student work, surveys, and questionnaires. These codes were words or phrases that created connections to my question and the data in my log. As my study was ending, I compiled the codes into a table and then began the process of combining codes that went together.

The next step was to put my codes into related groups which is known as binning. I created a graphic organizer to list my bins and codes (see Figure 17). Creating the bins helped me to look for and identify reoccurring themes within my data, and I was able to identify the data that directly corresponded to my question and study. I used these reoccurring themes to create theme statements, the major findings of my study, and my bins and codes fell under specific themes.

Arhar, Holly, and Kasten (2001) describe analytic memos as apparatus you can use to “write a memo to yourself about what you see emerging as patterns of behavior, words, key ideas, events” (p. 187). I wrote analytic memos connecting my data with the ideas of educational theorists. These were helpful when trying to analyze the data from a perspective other than my own.

I used a number of narrative forms to analyze my data. I created a vignette, poem, layered story, drama, and two pastiches to aid in analyzing and interpreting my data for others as well as myself. These narratives assisted me in learning about and telling my story.

When I analyzed student work, I looked for understanding of the math and science concepts and the Bloom's Taxonomy (1956) level of their response. When I analyzed surveys, I looked for student appreciation of writing, as well as interest, motivation, and creativity.

Since my study was action research, it was continually evolving based on my perceptions of how the class was flowing and my analysis of data collected. If I saw the need, I made changes along the way.

I also asked for opinions from students and from my researcher group for interpretation of data. By seeking broad consent within a group, teacher researchers develop and test for "truth" (Arhar, Holly, & Kasten, 2001).

Through using all of these analytical methods, I have developed five theme statements which describe the results of my study.

1. Frustration, both student and teacher, becomes unavoidable when adding an extra activity into the day and when pushing the students to use higher-level thinking skills.
2. Writing in math and science classes promotes student interest,

creativity, and motivation, especially when students are able to choose the writing activity or use their imagination, and the writing positively affects quiz and test scores.

3. Interaction between the teacher and her students, and between the students, increases as students continue to write their ideas and explanations, and this interaction shows concrete understanding.

4. Instruction, given by the teacher, enables students to correct mistakes and misunderstandings, as noted in the students' writing.

5. Students' understanding can increase due to writing about math and science concepts.

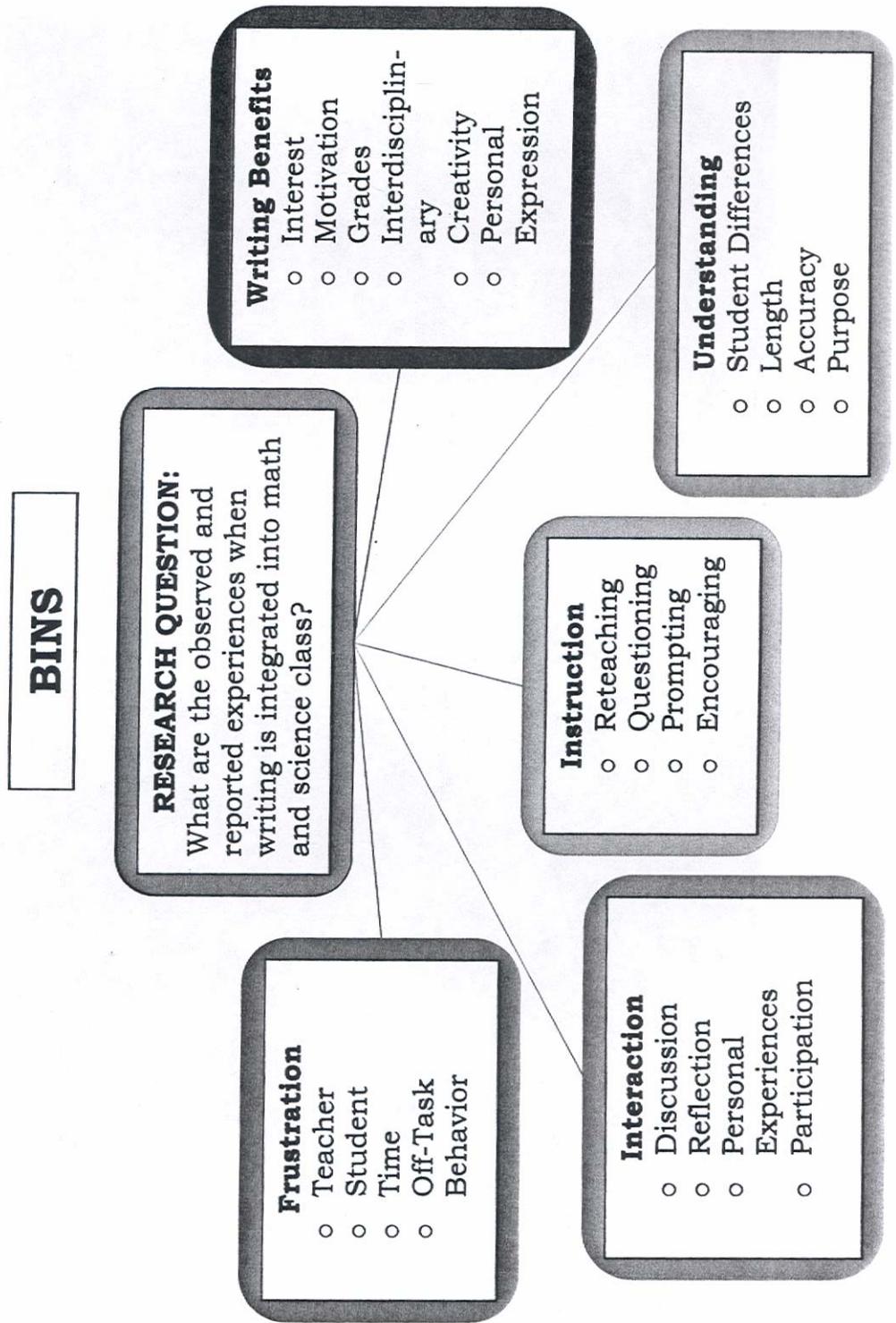


Figure 17. Bins formed by codes from field log.

FINDINGS

My goal of this study was to observe and report experiences when writing was integrated into math and science classes. My findings from this study centered on conceptual understanding, writing benefits, interaction, instruction, and frustration.

Understanding: Students' understanding increased due to writing about math and science concepts.

It did not seem that writing was easy for any student in the beginning. There definitely were student differences when asked to explain their math and science work using their own words, and the gifted students, in particular, had to work hard to improve their written explanations. As the students had more varied writing experiences, writing confidence did start to build.

Maria was a student in my math class who did not seem like she felt confident in math. She struggled in the beginning to write her ideas in her journal, but as time went on and she read my comments, she became much more secure in her written work. Her journal answers were correct and well explained, and she began to participate more during class. She became the one to explain the answer to her peers, rather than having someone explain it to her.

On the other hand, Robert, Doug, and Frank were students in the gifted program, and I did not expect these math writing activities to be difficult for them. It turns out that they had an extremely hard time putting

math work into words. All three boys, in the beginning, wrote a maximum of two sentences in response to a math prompt in their journals. While their answers were correct, they could not explain what they did using words. Frank admitted on a survey that he had a difficult time writing about math, and his writing did not improve much throughout this study. Doug and Robert's writing did improve as the study continued, and by the end, both boys were writing a minimum of two sentences and correctly explaining what they did in their heads. They began to participate more in class discussions, and like Maria, became the students who explained the answers to their peers. Manning and Manning (1996) agree that the more you write in content areas, the more improvement you will see in students' thinking. This was true for my students, especially Robert and Doug.

When teaching concepts such as symbiosis and ecosystems to fifth grade students, writing was a way to make this difficult information more concrete. After reading our science text about symbiosis, many students could not put the information into their own words. After having to create their own symbiotic relationship and write about it, 16 of my 17 science students were able to accurately show a symbiotic relationship. Similarly, after reading about ecosystems, students could recall very little information about them several days later. Once they had researched and written a poem about a particular ecosystem, the information was learned, and one student was able to reference information from her poem a month later during a science discussion. "Personal writing, in which students

choose their own words to discuss what they are learning, will allow students to sort through and clarify their ideas” (Dickinson, 1996, p. 5).

This was true for my students.

An increase in student understanding was also seen in students’ quiz and test scores. The writing in math and science classes positively affected assessment scores. In math class, students earned As and Bs on all of the quizzes. For all of the math assessments, the class average was 92% and above. In science, the class average for the first quiz was 83.6%. Although students participated in a writing activity relating to the quiz concepts, misunderstandings were not corrected before the assessment. The class assessment averages went up after this initial quiz, and I did address misconceptions before all of the further assessments. For the rest of the science assessments, the averages ranged from 88.2% to 93.9%.

Students’ conceptual understanding increased as shown in their writing and assessments.

Writing Benefits: Writing in math and science classes promoted student interest, creativity, and motivation, especially when students were able to choose the writing activity or use their imagination.

During this study, in math class, students mainly wrote in their journals. So, when the students were instructed to create a math prompt for another student to answer, they were excited. When they answered the peer-created prompt, they began right away and were done within one to two minutes. All but one student commented in their journals that they

liked this activity. When it was over, many students remarked that it was fun. During another math class, students were given an exit slip to fill out, and the instructions were that they could not leave the room, or exit, until they completed the prompt. They thought this idea of not leaving until the exit slip was completed was very intriguing and began writing immediately. When math writing activities varied from the journals, students showed increased interest.

In science, the students did a research-writing activity. The students researched an ecosystem and created a poem with this information. The students were enthusiastic and on-task the entire time. They liked being able to choose their own topic and present their research in their own poetic form. Similarly, during our study of symbiosis, the students were able to create their own imaginary creatures. They drew their two creatures and wrote a letter from one to the other, showing a symbiotic relationship. This higher-level thinking activity proved very successful. There was only one student who did not correctly show this relationship. All of the other students' letters were accurate and creative. They took a very difficult concept, and through this activity, showed their understanding. Finally, the science writing activity that showed the most interest and enthusiasm were the animal stories. Students were given a cute picture of an animal and told to write a story about this animal using as many science words as possible. Dennis, a student who does not like to write, was on-task the entire time. He was asking questions and looking

at the science vocabulary words. There was a high level of interest in this activity.

During all of these writing activities, students did not want to stop. When students have a choice and participate in different writing activities, they are more engaged and produce quality work.

Problems or Challenges

Creative writing activities generally take more time, and during a regular day, there is not a lot of time to devote to these high-interest writing assignments.

Interaction: Interaction between the teacher and her students, and among the students, increased as students continued to write their ideas and explanations, and this interaction showed concrete understanding.

In the beginning of the school year, students did not talk about math much, and when answering questions, they gave short answers. I had to prompt and probe the students to explain their answers and to provide more complete responses. The students struggled to put the numbers into words. However, after having to explain their ideas in their journals several times a week, student conversations became more meaningful and content-driven. Halfway through my study, this became obvious. During a discussion about a math unit review, I was expecting the same short discussions with a lot of off-task conversations going on; however, the opposite occurred. Students were fully engaged in math talk

and were explaining and defending their answers to their classmates. All of the students were on-task, and the activity was extended to allow this meaningful discussion to continue. The students excitedly shared with me what they talked about and how they may have helped their fellow classmates.

The students knew I now had higher expectations of their math discussions, and every time they answered a question, they made sure their thought was complete. If I did not respond to them right away, they knew they had to rethink their answer or add more information to be complete. The students were conscious of their math understandings and how they formed them into words. They felt proud when they were correct and could explain their thoughts because it was not easy for them in the beginning of the study. As Burns (2004) found with her students, writing helped them think more clearly and deeply about math. Writing had this effect on my students as well.

In science class, students presented research information about biomes. My science class arranged their information in an easy-to-read written form. They included all of the appropriate and correct information about their biome. When they presented the information, they were clear and concise.

Increased discussion and participation in the classroom enabled me to see the students' understanding, and the students' oral explanations were improving after math and science writing activities.

Interaction between the students and me occurred in the journals. Burns and Silbey (2001) discussed the importance of giving responses to address what the student wrote. "Focus on the mathematics in the task and indicate your interest in how they think and reason, offering suggestions for further thinking" (Burns & Silbey, 2001, p. 20). I wrote questions or notes about what the students had written in their journals, and I expected them to respond. On a math survey, Colleen wrote, "Most of the time writing down how to do it and then doing it helps me, especially if Mrs. Kao corrects it, then I'll know what I did wrong." Not all of the students felt the same way Colleen did. At first, only two or three students were responding to my questions and correcting their mistakes. So, I asked the students why I wrote in their journals. Of course, they knew that I was trying to help them understand and to correct their mistakes. I told them that if I asked questions it was to help them, and they needed to respond and answer my questions. At this point, most of the students looked back through the pages of their journal and answered some questions.

There were three students who answered all of my questions. All three of these students are dedicated and want to do their best. Andrew not only found answering my questions valuable, but he thanked me for every positive comment I wrote in his journal. Jeven is a student who needs to be right, so he was sure to respond to my questions. Math is not

easy for Maria, so knowing this, she felt it was very valuable to continue our conversation in her journal.

Many students answered about half of my questions and left the other half unanswered. Some students never responded to my writing at all. This was unfortunate because that could have been one way for them to correct their misunderstandings.

When the students responded to my comments and questions in their journals, they had a better understanding of the concepts and material.

Problems or Challenges

One problem was that some math students chose not to look back in their journals to see what they did wrong and to rethink the problem.

Instruction: Instruction, given by the teacher, enables students to correct mistakes and misunderstandings, as noted in the students' writing.

After reading the students' writing, I retaught any misunderstood concepts before it was too late. "A short writing assignment is a good way to evaluate the relevance of what you are teaching and to check for misconceptions the students may have" (Fortner, 1990, p. 35).

One math journal asked the students if two decimals were equivalent. One-third of the class had the incorrect answer. I knew that I had to review and possibly reteach this concept the next day before we could move on to new material. Burns (1995) found that writing in math

was a benefit for the teacher because she could see what her students knew and what misconceptions her students held. Having this type of immediate informal assessment was very valuable for me and my students.

In science, the key-word paragraphs, as suggested by Yockey (2001), clearly showed me what the students understood and what they did not understand. Yockey (2001) said that by writing about these key concepts, the information sticks with the student, which is what every teacher wants to happen. After reading the students' key-word paragraphs, I met with students who had factual errors in their writing and retaught the information. Unfortunately, this did not happen before the first science quiz. I could not meet with them to correct misunderstandings from their first writing assignment. Therefore, the students who made errors in their writing performed poorly on the assessment. Jordan earned a 61%, Dennis earned a 33%, and Troy earned a 44%. Students who had all accurate information in their key-word paragraphs, however, were successful and earned scores between 89% and 100%.

After the second writing activity, I did individually reteach students who had misunderstood the material before they took the quiz. After being retaught material, students' quiz scores went up. Jordan earned an 80%, Dennis earned a 63%, and Troy earned a 93%. Debbie and Mike also had incorrect information in their writing, and after correcting their misconceptions, earned 80% and 87%, respectively. Again, students who

had completely accurate information in their paragraphs, earned grades between 87% and 100%. Being able to see these inaccuracies prior to assessments was beneficial to me and my students.

An exit slip in science provided me with some valuable information. When asked to write about their favorite ecosystem, many students could not remember what the ecosystems were, so we did a mini-research, creative-writing activity. On the quiz, all but two students could list the ecosystems, and these two students only got one wrong.

Doing these activities, in which I can catch misconceptions early, helped the students before they were formally assessed on a test.

Frustration: Frustration, both student and teacher, became unavoidable when adding an extra activity into the day and when pushing the students to use higher-level thinking skills.

Implementing writing activities in math and science classes was frustrating for me because more time was needed, and the curricular demands were already time-consuming. In math, there were always students who needed to finish their journal the next day or who held up the rest of the class from moving on to a new activity. I never felt like the students had the time they deserved to fully write and explain their thoughts. Having to basically cover the entire curriculum before standardized state tests in March, I felt like I could not devote much more time to math writing, even though I was seeing how valuable it was for my students. In science, I had the children complete science writing as a

morning activity, instead of doing the regular language arts activity, because our precious 45-minute science class three times a week was not enough time. In fact, we did the first key-word paragraph during science class, and I decided to give them a five minute time limit so that they would complete it during that class, and it would not carry over into another science class. Most of the students did not like the time limit. They felt stressed and rushed, and they wanted more time to write their ideas. I was not the only one feeling the time crunch.

For students, there was also frustration because they were being asked to apply what they had learned and put their understanding into words. Many times, the students had to use higher-level thinking skills and their imagination, which was very challenging for some students. One science activity asked the students to name their favorite ecosystem and explain why. Only two students showed mastery of factual information and application of what they had learned. However, after more writing opportunities, the students became more confident. During the symbiosis activity, all but one student showed an application level of understanding.

As expected with any new activity and with adding something else into a full schedule, there was frustration for me and for my students.

Four Students

Tyler, Andrew, Erin, and Susan were in my science and math class and experienced writing in both subject areas. These four students are

mentioned frequently and greatly benefited from writing across the curriculum.

Tyler was able to use higher-level thinking skills in science and wrote many creative, thorough, accurate stories and paragraphs using the information from science class. He struggled, however, when writing in math class. He joined my math class about three-quarters of the way through the study. At that time, he had a hard time putting his math work into words, but I could see improvement in the little bit of time I observed him.

Erin and Susan's writing always showed understanding of the material as well as analysis of the subject matter. They could take the information and reach higher levels of Bloom's Taxonomy (1956) through their writing. They did not seem to find writing in one subject easier or harder for either of them.

Andrew is a struggling writer because he has a hard time putting his thoughts into one or two paragraphs. His writing can get lengthy and jump from one idea to another. For him, this occurred in math. He had a harder time explaining math concepts clearly. In science, his writing was well thought out and concise.

All four of these students benefited from writing in math and science class, and their content writing strengths and weaknesses were visible.

WHERE DO WE GO FROM HERE?

Writing in math and science classes has many benefits for my fifth grade students. Writing promotes student interest, creativity, and motivation. Writing in math and science classes increase students' understanding of the concepts and positively affects quiz and test scores. Student interaction increases as students continue to explain their ideas through writing, and these interactions show concrete understanding. Math and science writing shows students' misunderstandings and enables the teacher to reteach these necessary concepts.

As the next step, I plan to continue refining and adapting my activities to incorporate writing in math and science classes. The writing activities will allow for the students to put their understandings into words, for student choice, and for the students to be creative. I will continue to analyze their written work and make instructional modifications based on their work, and I will continue to push the students to use higher-level thinking skills.

I would like to continue writing in math at least two times per week and in science at least one time per week. However, I need to become more creative with time, so that I am able to teach the curriculum, while giving the students adequate time to write.

I also want all three of my science classes to participate in the writing activities, rather than just continuing to include my homeroom science students. All of my science students deserve the opportunity to

benefit from writing, and I wonder if writing will have the same effects in the other two classes.

As we continue writing in science, I want the students to compile science portfolios with all of their science writing. Portfolios are a very valuable assessment and reflection tool for the students and the teacher (Liftig, 2002). Students will include certain required writing, as well as choosing their own pieces. They will reflect on each piece in their portfolio by answering questions or completing prompts. For example, they will think about what they did well, what they could have done better, and what they now understand. The students will then meet with me to discuss their portfolios. I am interested to see the effects science portfolios will have on students' writing and understanding.

For next year, I will encourage the other fifth grade teachers to include writing in their math classes. Since they have lower math classes, I wonder if these students would benefit just as much, or maybe even more, than my higher math students. I will encourage writing in social studies. It would also be interesting to see if writing every single day in content areas would have the same effects as writing several times a week.

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Appendix A: Principal Consent Form

September 15, 2005

Dear [REDACTED]

I am completing a Master of Education degree at Moravian College. My courses have enabled me to learn about the most effective teaching methods. One of the requirements of the program is that I conduct a systematic study of my own teaching practices. This semester, I am focusing my research on writing. The title of my research is "Writing in Math and Science Class". My students will participate in writing activities that will enhance their writing skills and their understanding of math and science concepts.

As part of the regular curriculum, students will be asked to complete a pre- and post-survey, a math and science journal, a math and science learning log, three math prompts, science worksheets, and a science portfolio. This study will take place from September 6, 2005 through December 15, 2005.

The data will be collected and coded, and held in the strictest confidence. No one except me will have access to the data. My research results will be presented using pseudonyms – no one's identity will be used. I will store the data in a locked cabinet in my classroom. At the conclusion of the research, the data will be destroyed.

A student may choose at any time not to participate in this study. However, students must participate in all regular class activities. All the activities above are regular classroom activities for students. Data from non-participants will not be included or analyzed in this research.

I welcome questions about this research at any time. Your child's participation in this study is voluntary; refusal to participate will involve no penalty or consequence. Any questions you have about the research can be directed to me, Karin Kao, 610-965-1645, [REDACTED], or my instructor, Dr. Charlotte Rappe Zales, Education Department, Moravian College, 610-861-1482, crzales@moravian.edu.

Sincerely,

Mrs. Kao

I agree to allow Karin Kao to conduct this research study in her fifth grade classroom.

[REDACTED]
Principal

9/15/05
Date

This is an awesome research project. Good Luck!

Appendix B: Human Subjects Internal Review Board Letter



July 12, 2005

Karin M. Kao
2321 West Allen Street
Allentown, PA 18104

Dear Karin M. Kao:

The Moravian College Human Subjects Internal Review Board has approved your proposal: Writing in Math and Science Classes. Given the materials submitted, your proposal received an expedited review. A copy of your proposal will remain with the HSIRB Chair.

It is requested, however, that you consider the following points before continuing your research.

Please note that you should consider the impact of the study on students who may be allergic to plants with which they come into contact during the study.

Please note that some of the wording in the Parent/Guardian and Principal Consent forms should be modified. First, the forms should state that students will participate in the activities "as part of the regular curriculum," rather than "as part of this study." Second, the phrase, "will have no influence on any aspects of the class," must be removed or explained further. Also, the faculty sponsor indicated on all consent forms should be your MEDU 702 instructor. Please be certain to provide the correct name and telephone number.

Please note the committee's preference that, whenever possible, data is not stored on school grounds.

Please note that if you intend on venturing into other topics than the ones indicated in your proposal, you must inform the HSIRB about what those topics will be.

Should any other aspect of your research change or extend past one year of the date of this letter, you must file those changes or extensions with the HSIRB before implementation.

Copies of this letter have been sent to you through e-mail and campus mail. Please retain at least one copy for your files. Good luck with the rest of your research.

Debra Wetcher-Hendricks
Chair, Human Subjects Internal Review Board
Moravian College
610-861-1415 (voice)
medwh02@moravian.edu

Appendix C: Student Consent Form

September 2005

Dear Parent/Guardian:

I am completing a Master of Education degree at Moravian College. My courses have enabled me to learn about the most effective teaching methods. One of the requirements of the program is that I conduct a systematic study of my own teaching practices. This semester, I am focusing my research on writing. The title of my research is "Writing in Math and Science Class". My students will participate in writing activities that will enhance their writing skills and their understanding of math and science concepts.

As part of the regular curriculum, students will be asked to complete a pre- and post- survey, a math and science journal, a math and science learning log, three math prompts, science worksheets, and a science portfolio. This study will take place from September 6, 2005 through December 15, 2005.

The data will be collected and coded, and held in the strictest confidence. No one except me will have access to the data. My research results will be presented using pseudonyms – no one's identity will be used. I will store the data in a locked cabinet in my classroom. At the conclusion of the research, the data will be destroyed.

A student may choose at any time not to participate in this study. However, students must participate in all regular class activities. All the activities above are regular classroom activities for students. Data from non-participants will not be included or analyzed in this research.

We welcome questions about this research at any time. Your child's participation in this study is voluntary; refusal to participate will involve no penalty or consequence. Any questions you have about the research can be directed to me, Karin Kao, 610-965-1645, [REDACTED] or our principal, [REDACTED] or my instructor, Dr. Charlotte Rappe Zales, Education Department, Moravian College, 610-861-1482, crzales@moravian.edu.

Sincerely,

I agree to allow my son/daughter to take part in this project. I understand that my son/daughter can choose not to participate at any time.

Parent/Guardian Signature

Date

Student's Name

Appendix D: Survey

1. What do you like about writing? _____

2. What don't you like about writing? _____

3. Have you written, or participated in writing activities, during:

math? _____

language arts? _____

science? _____

social studies? _____

art? _____

music? _____

physical education? _____

library? _____

4. For one of the above classes, what kind of writing, or writing activities, did you do in those classes? _____

5. Do you think, by writing about new concepts and skills, you understand the material better?

Appendix E: Math Journal Topics

Chapter 7 ~ Lesson 1

Why do we use graphs to organize data?

Chapter 7 ~ Lesson 3

How do you find the median, mode, and mean for this set of data:

3, 2, 6, 7, 1, 5, and 4? Are they the same or different? Why?

Chapter 8 ~ Lesson 1

Explain how you would choose the scale and interval for a graph, given the following data – 5, 25, 17, 20, 9, 23, and 28.

Chapter 1 ~ Lesson 3

List and explain the steps to compare 187,975 and 136,412.

Chapter 1 ~ Wrap-up

Dana is thinking of a six-digit number. The digit in the thousands place and the digit in the tens place have a sum of 7. Find the least number that Dana could be thinking of. How did you select the digits?

Chapter 2 ~ Lesson 1

Do 0.4 and 0.04 name the same decimal? Explain.

Chapter 3 ~ Lesson 1

Greg rounded 279,412 to 280,000. Josh rounded the number to 279,000. Who is right? Explain.

Chapter 3 ~ Self-created prompt

Create a prompt or question that a peer will answer. The prompt or

question must pertain to concepts we have learned in math this year.

Chapter 4 ~ Lesson 5

A science book has information about the planets in the solar system. It includes the planets' diameters, temperatures, and distances from the sun. Would these data about planets be expressed as exact numbers or estimates? Why?

Chapter 5 ~ Lesson 2

Compose a problem that is represented by the equation $6 + n = 11$.

Chapter 5 ~ Lesson 4

What addition property is used in the following equations:

$$5 + 7 = 7 + 5 \quad \underline{\hspace{2cm}} \quad \text{Why? } \underline{\hspace{2cm}}$$

$$2 + (3 + 6) = (2 + 3) + 6 \quad \underline{\hspace{2cm}} \quad \text{Why? } \underline{\hspace{2cm}}$$

Chapter 6 ~ Lesson 1

Explain how to evaluate the expression $12 - (8 + n)$ if $n = 1$.

Chapter 6 ~ Lesson 2

Mark said the value of $6 + 2 \times 4 - 2$ was 30. What was his error?

Appendix F: Math/Science Learning Log

Sample Questions which may vary week to week:

- What I learned today...
- Why it is important...
- Questions I still have...
- A new understanding of math/science that I have developed in the past [several] week[s] is...
- I can improve my understanding of math/science ideas by...
- I would like to learn more about...

Appendix H: Science Key Words

Unit B, Chapter 1

Lesson 2: water cycle, evaporation, condensation, precipitation, transpiration

Unit B, Chapter 2

Lesson 1: individual, population, community, ecosystem, habitat, niche

Appendix I: Science Exit Slip

EXIT CARD



My favorite ecosystem is _____ because

EXIT CARD



My favorite ecosystem is _____ because

Appendix J: Symbiosis Letter

Name

Date

Think about the two creatures you created as an example of a symbiosis relationship. Choose one and pretend to be that creature. Write a letter to the other creature explaining how you feel about your relationship. Mention whether or not you like the long term relationship. Give detailed sentences explaining why or why not.

Appendix K: Science Journals

~ Using the animal picture, write a story about the animal. Include as many science words in your story as you can.

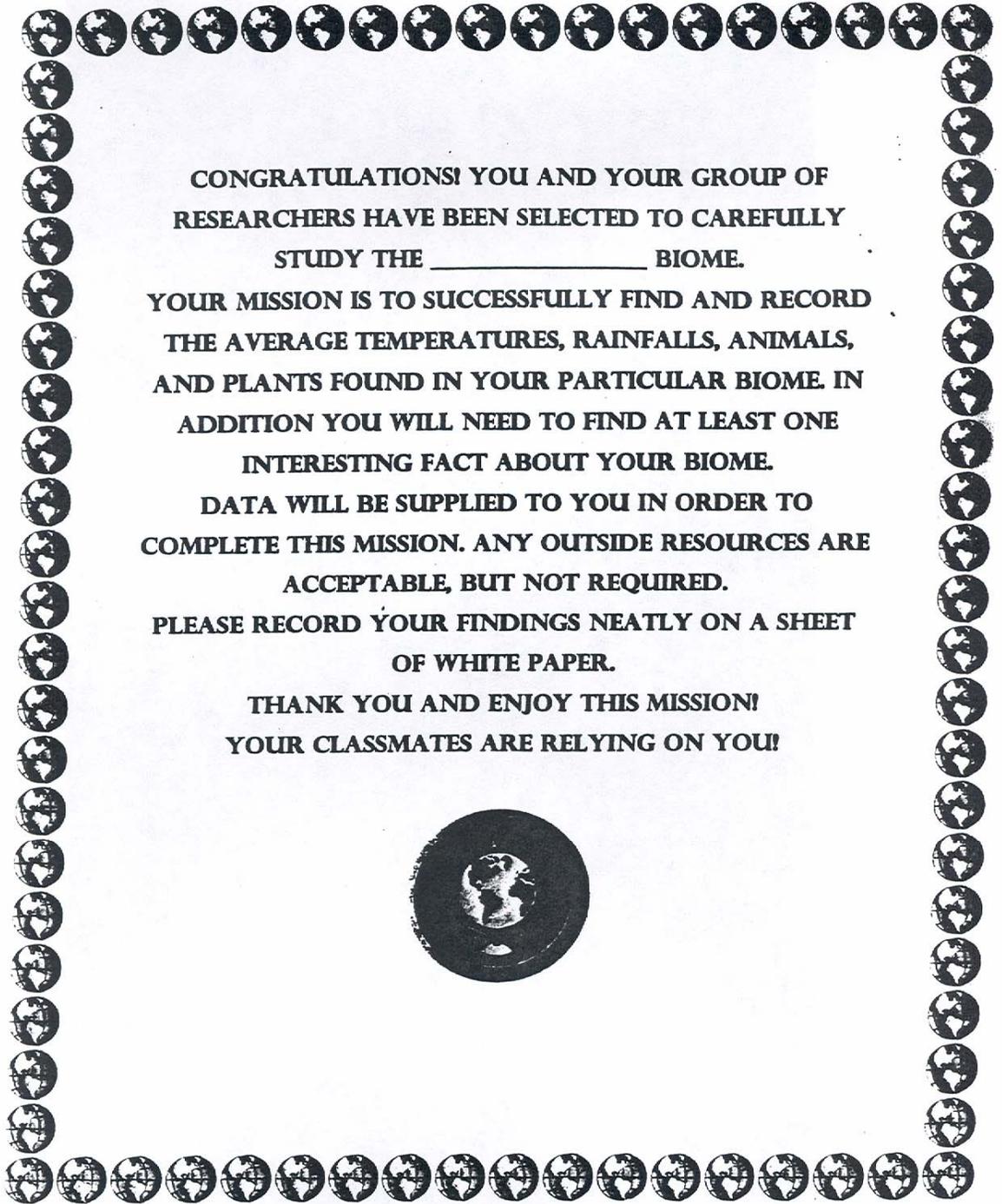
~ After yesterday's biome lesson and doing my science homework, a new thing I learned about biomes is...

Appendix L: Endangered Animal Poster

Poster Directions:

- ~ First, choose an endangered animal from the list: panda, rhinoceros, tiger, whale/dolphin, turtle, gorilla, or elephant.
- ~ Then, read the computer printout, which gives information about the animal, its habitat, and why it is extinct.
- ~ Use this information and the pictures to create a poster persuading others to help save this animal. Include a picture and at least two reasons why we should try to save the animal from extinction.

Appendix M: Biome Mission



CONGRATULATIONS! YOU AND YOUR GROUP OF RESEARCHERS HAVE BEEN SELECTED TO CAREFULLY STUDY THE _____ BIOME.

YOUR MISSION IS TO SUCCESSFULLY FIND AND RECORD THE AVERAGE TEMPERATURES, RAINFALLS, ANIMALS, AND PLANTS FOUND IN YOUR PARTICULAR BIOME. IN ADDITION YOU WILL NEED TO FIND AT LEAST ONE INTERESTING FACT ABOUT YOUR BIOME.

DATA WILL BE SUPPLIED TO YOU IN ORDER TO COMPLETE THIS MISSION. ANY OUTSIDE RESOURCES ARE ACCEPTABLE, BUT NOT REQUIRED.

PLEASE RECORD YOUR FINDINGS NEATLY ON A SHEET OF WHITE PAPER.

**THANK YOU AND ENJOY THIS MISSION!
YOUR CLASSMATES ARE RELYING ON YOU!**

Appendix N: Participant Log

What students said/wrote

My thoughts/reflections