SOLVING AND REFLECTING ON REAL-WORLD PROBLEMS: THEIR INFLUENCES
ON MATHEMATICAL LITERACY AND ENGAGEMENT IN THE EIGHT
MATHEMATICAL PRACTICES

A Master’s Research Project Presented to

The Faculty of the Patton College of Education and Human Resources

Ohio University

In Partial Fulfillment
of the Requirements for the Degree

Master of Education

by

Anthony Joseph Bokar

August, 2013
This Master’s Research Project has been approved
for the Department of Teacher Education

Ralph Martin, Ph.D.
Professor Emeritus
Department of Teacher Education

Frans Doppen, Ph.D.
Associate Professor and Interim Chair
Department of Teacher Education

✓ Checking this box indicates this document has been submitted and successfully cleared a plagiarism check. Supporting documentation has been provided to the Department Chair.
Abstract

Using real-world problems is important to improving students’ mathematical literacy and thinking. Today’s students should enter the data-oriented world prepared to make well-grounded decisions that involve logical and mathematical reasoning. Students often struggle with seeing the relationship between math class and their lives; however, they can benefit from learning about relevant content. After we have shown students that math is in fact relevant to their lives, then we need to improve their abilities to apply math to real problems. The CCSSM’s Eight Mathematical Practices provide a useful framework of a student’s ability to engage deeply in a mathematical problem. Successfully implementing the Eight Practices into real-world problem solving might be aided by reflective journal-writing. As math educators, we should consider using real-world problems that are relevant to students’ lives and then have them reflect on their problem-solving techniques. For example, students might consider mathematical applications to a problem in a future career by modeling a real-world problem, and then they would be asked to think about the important aspects of their solution by reflecting in a journal. This paper suggests that math teachers should implement a structured, journal-writing curriculum, and journal-writing as an assessment tool, along with real-world projects, might also be worthwhile to investigate. Lastly, it is important to state the research question: how do students’ perceived mathematical literacy and perceived and actual capabilities to engage in the Eight Mathematical Practices change after solving real-world problems and writing in a reflective journal.
# Table of Contents

Chapter One—Introduction..................................................................................5-11

Chapter Two—Review of Literature...................................................................12-24

Chapter Three—Methods....................................................................................25-33

Chapter Four—Findings.....................................................................................34-54

Chapter Five—Discussion..................................................................................55-66

References..........................................................................................................67-69

Appendices.........................................................................................................70-83

Appendix A: Pre-Survey......................................................................................70-71

Appendix B: Post-Survey....................................................................................72-73

Prompts..............................................................................................................74-79

Appendix C: Prompt 1—Pool Problem (Pre-assessment)....................................74

Appendix D: Prompt 2—Reactor Problem............................................................75

Appendix E: Prompt 3—Remodeling Problem....................................................76

Appendix F: Prompt 4—Dart Problem.................................................................77

Appendix G: Prompt 5—Gumball Machine Problem..........................................78

Appendix H: Prompt 6—Putt-Putt Problem (Post-assessment)..........................79

Appendix I: Rubric entitled Standards for Mathematical Practice......................80

Appendix J: Journal Guidelines............................................................................81-83
Chapter 1—Introduction

Introduction

Using real-world problems is important to improving students’ mathematical thinking and literacy. Today’s students should enter the data-oriented world prepared to make well-grounded decisions that involve logical and mathematical reasoning. Yore, Pimm, and Tuan (2007) argued that “understanding, application, communication, and problem solving are all essential” if students are to successfully apply math to real-world problems. As math educators, we need to have students practice applying mathematics to real-world problems, so that they improve their mathematical thinking and mathematical literacy.

The importance of real-world problem solving has been increasingly recognized at the international level as the amount and transfer of quantitative data increases worldwide (Organisation for Economic Development [OECD], 2006). A study by the Organisation for Economic Co-Operation and Development’s Programme for International Student Assessment (PISA) explained the upon high school graduation students must decipher, interpret, and communicate data mathematically; that is, students need to be able to use mathematical discourse effectively (OECD, 2006). Therefore, students must gain experiences in real-world problem solving during high school, in order to be prepared for the increasing frequency and complexity of quantitative data.

Nationally, the National Council for Teachers of Mathematics (NCTM) has also discussed the importance of real-world problem solving. In NCTM’s Principles and Standards for School Mathematics, real-world applications were a point of emphasis. One section of Principles and Standards is entitled “Need for Math in a Changing World.” Here NCTM explains that students will frequently encounter quantitative information that is released through
the media. Moreover, the students must know how to process that information and make decisions based on what they have read or heard (National Council for Teachers of Mathematics [NCTM], 2000). The document explained four uses of mathematics in the real-world: mathematics for life, mathematics as a part of culture, mathematics for the scientific and technical community, and mathematics for the workplace (NCTM, 2000).

Based on NCTM’s emphasis on problem-solving, the Common Core State Standards for Mathematics (CCSSM) have also made provisions for problem-solving, career preparation, and modeling. (National Governors’ Association [NGA] & Council of Chief of State School Officers [CCSSO], 2010). The CCSSM focused on preparing student for their lives after school (NGA & CCSSO, 2010). Therefore, it is important that math educators prepare students to solve problems that they will encounter after they graduate from high school. Furthermore, the CCSSM devoted one section of the high school standards to modeling (NGA & CCSSO, 2010). This means that teachers need to focus on applying mathematics to real-world problems, in order to prepare students for their immediate and future lives.

It is important that students solve real-world problems so that they are prepared for their lives after high school. We need to promote student thinking, which can help improve their mathematical literacy. Since students should be prepared to apply mathematics to real-world problems, real-world application has been emphasized at the international, national, and state levels.

The Problem

Students seemingly face a dilemma each time they encounter a new mathematical concept. They understand that they need to know the material to pass the class, but, at the same time, believe that the concept will have no applicability to their real life. Consequently, they are
pulled in opposite directions, and, unfortunately, some students disregard the concept because they do not understand how it is relevant to their lives. Furthermore, students do not understand how to use mathematics to help them solve problems. As educators, it is our job to show the students how they will use math in the real world, and to get them to reflect on their thinking, in order to improve their abilities to apply mathematics.

Students often struggle with seeing the relationship between math class and their lives; however, they can benefit from learning about relevant content. Crumpton and Gregory (2011) showed in a study of low-achieving 10th grade students that academic relevancy improves student engagement. This is consistent with educational theories that support making content useful and relevant to students’ everyday lives. Therefore, it is important that we work to make the content as useful as possible for our students. Students will be more engaged and learn more in the class. Having students solve real-world problems could be one step taken to show students that mathematics is useful in their immediate lives.

After we have shown students that math is in fact relevant to their lives, then we need to improve their abilities to apply math to real problems. One way to improve students’ abilities to solve real world problems is to have them reflect on their problem solving strategies. Desautel (2009) discovered that instruction on written and oral reflection processes helped increase the students’ consciousness of their thinking processes. In mathematics, engaging students in metacognitive processes means that they comprehend, analyze, solve, and reflect on the problem and its solution. Students must analyze how and why they approached the problem in a certain manner, and what, if anything, could they change to make the solution more efficient. Therefore, teachers should help students learn how to reflect on their thinking processes, so that students can refine their problem-solving strategies through reflection.
Students have difficulties seeing the mathematics as relevant to their lives, and have trouble applying mathematics to real-life situations. As math educators, we need to make content relevant to students’ lives, so that they are engaged and see the usefulness of mathematics. Once they understand that math can be applied to their lives, we need to help them improve their problem-solving abilities. One method of improving student problem-solving abilities is through reflection. We should promote metacognition by teaching the students how to and having the students reflect on their solutions to real-world problems.

**Purpose and Research Question**

The new Common Core State Standards for Mathematics places an emphasis on students being able to justify their answers and solve real problems. Since students have traditionally had little experience with writing in math class, they are hesitant and do not often know how to write mathematically (Hamdan, 2005). It is, therefore, important that we prepare the students to write and reflect on their mathematical solutions. Once the students learn how to write mathematically, students could extend their mathematical thinking and explanation that is emphasized by the CCSSM (Carter, 2009).

The CCSSM’s Eight Mathematical Practices provide a useful framework of a student’s ability to engage deeply in a mathematical problem. The framework provides teachers and students with a way to measure and reflect on their mathematical thinking. In students’ problem-solving, the Eight Practices can be used for the students and teacher to evaluate the number and level of the practices that were used by the students. The individual characteristics of the Eight Practices provide markers for teachers to use to determine the degree to which the students approached the problem using practices of a proficient mathematics student. Moreover, the
students can reflect on how they incorporated the Eight Practices into the solution and how they could improve next time.

Successfully implementing the eight practices into real-world problem solving might be aided by reflective journal-writing. Journal writing is a way that students can reflect on their thinking and problem-solving abilities (Countryman, 1992). Because students think about their problem-solving methods, the students begin to take a more active role in the learning process. As they take more responsibility for their learning, students’ mathematical thinking abilities improve (Kostos & Eui-kyung, 2010). Williams and Wynne (2000) found that students also saw the benefits of reflective journal writing on their learning of mathematics because they were able to see the progression of their mathematical abilities. Justification is an aspect of mathematics that is difficult for students; however, students found that they were better able to justify their answers after participating in journal writing (Williams & Wynne, 2000). This finding is important because one of the eight mathematical practices involves constructing viable arguments (NGA & CCSSO, 2010). With the improvements in students’ mathematical thinking abilities, reflective journal writing is important to consider using in the classroom.

NCTM’s Principles and Standards (2000) points out the importance of fostering independent learning through reflection. By incorporating reflective journal-writing in the math classroom, students might be able to think deeply about real-world problems. NCTM’s Principles and Standards for School Mathematics explains that students can develop their thoughts through journal writing (NCTM, 2000). Through their reflective thinking and real problem solving, students might be able to see the applicability of mathematics to their everyday lives, learn how to investigate problems more deeply, and better understand how to improve their approaches to problems. As we can get students to reflect more on the application of math to
their everyday lives, they might further their mathematical literacy, which is an important characteristic of the 21st Century citizen (OECD, 2006; NCTM, 2000). Through reflection and application, we need to dispel of the myth that math is not useful to them in their lives.

Therefore, the purpose of this study was to examine the effects of reflective journal writing on students’ engagement in the CCSSM’s Eight Mathematical Practices and their mathematical literacy. Of interest was how students use the Eight Practices to solve real-world problems and their ability to reflect on how they approached a given problem. Furthermore, the researcher was also interested in discovering whether or not reflective journal writing has any effect on students’ understanding of how math applies to their everyday lives. Keeping the purpose in mind, the research question was how do students’ perceived mathematical literacy and perceived and actual capabilities to engage in the Eight Mathematical Practices change after solving real-world problems and writing in a reflective journal.

**Conclusion**

Students typically do not see the relationship between mathematics and their lives. It is our job as math educators to show them that math is useful, and then teach them how to apply math to real-life problems. Real-world problems are emphasized internationally, nationally, and at the state level. To help students improve in their abilities to apply mathematics to real-world problems, we might be able to use the Eight Mathematical Practices as a guiding framework. In addition, we could have the students reflect on their solutions to the problems, so that they could determine their strengths and weaknesses in solving real-world problems.

**Definitions**

*Mathematical Literacy* is defined to be “the capacity to identify, understand and engage in mathematics, and to make well-founded judgments about the role that mathematics plays
in an individuals’ current and future private life, occupational life, social life with peers and relatives, and life as a constructive, concerned and reflective citizen” (Organisation for Economic Co-operation and Development, 2001, p. 22)

Metacognition is simply defined to be thinking about one’s thinking. Metacognitive processes involve reflecting on how and why a person used certain thinking processes.

Real-world problems must be clarified. For this study, real-world problems are problems that students encounter in their everyday lives outside of the mathematics classroom. These problems require students to apply mathematics to problems in their personal lives, in their social life, and at their workplace.
Chapter 2—Review of Literature

Introduction

Mathematics educators must prepare students to live in a mathematical and technological world. Research suggests that we should have students solve real-world problems, so that they can develop an understanding of how mathematics can be used to their advantage in their lives. Furthermore, the literature on assessments and standards at the international, national, state, and local level have all expressed the significance of solving real problems mathematically. If students are exposed to real problems in their mathematics classes, then teachers can help improve their mathematical literacy. Literature also explains that students can reflect on how they solved real problems, so that they are better prepared to solve problems after school. The last portion of the literature explains that a way to incorporate reflection into the classroom is through journal writing, which has been shown to be beneficial to student learning.

Real-World Problems

Students must be able to apply mathematics in real-life situations after they graduate from high school. Having students solve real-world problems helps students in a few ways. First, students develop a better understanding of how math applies to the real-world. They are able to see math as useful, not just a school subject. Second, students might be more engaged if the problems relate to their lives. Lastly, real-world problems that students can relate to make students more interested in learning because they see how they can use mathematics in their immediate and future lives. Because the world is becoming more data-based, it is important that students understand how to apply math to real-life problems.

Real-world problems have been thought to help students better understand the applicability of math to the world around them. Jurdak (2006) conducted a study of grade-12,
Lebanese students by examining their solving of problems in a real context. In the study’s discussion, the author claimed that solving real problems helps students “develop appreciation of the role, power, and limitations of mathematics in real-world decision-making” (Jurdak, 2006, p. 15). This suggests that student might be able to see the applicability of math in their lives, as well as understand that math cannot be applied aimlessly to real-world problems. Therefore, relating mathematics to the students’ lives might help them see mathematics as important.

Using real-world problems and relating content to students’ lives also keeps students engaged. Crumpton and Gregory (2011) conducted a study on low-achieving, at-risk, second-year high school students to determine if student-perceived academic relevance would positively affect academic achievement and engagement in the second year of high school regardless of the students’ achievement and engagement the previous year. They found that the more related the students felt school was to their lives the more engaged they were in class (Crumpton & Gregory, 2011). Consequently, they suggested that teachers “make school feel purposeful and applicable to the students’ daily lives” (Crumpton & Gregory, 2011, p. 48). The finding and the suggestion imply that to engage students teachers should implement real-world problem-solving in their classrooms as students are more interested in the material.

If students can see the connection between their life and the material, then they are thought to be more interested in learning. According to Bossé and Faulconer (2008), student interest increases if “they clearly recognize applicability to their own lives” (p. 13). They also emphasize the importance of keeping the problems within the students’ ability level, so that students can apply their knowledge to the problems (Bossé & Faulconer, 2008). Together, these suggestions imply that math teachers might capture their students’ interest by giving students
problems that are within their abilities, so that they can see the relationship between math and their lives.

Preparing students to use mathematics in their future and immediate lives is an important task for math educators. To prepare students to solve real problems using mathematics, teachers should incorporate real-world problems, so that students develop a better understanding of how mathematics is applied in the real world. Moreover, students are more engaged and interested in learning if the problems relate to their immediate and future lives. As math educators, we need students to practice solving real problems, so that they are prepared to contribute to a data-based society.

Standards

Since students benefit by applying mathematics to solve real-world problems, real-world problem-solving is emphasized in international, national, and state standards. The Organisation for Economic Development (OECD) gives the Programme for International Student Assessment (PISA), which is an international assessment. In the mathematics portion of the assessment, the PISA emphasizes real-world problem-solving. Since real-world problem-solving is emphasized internationally, NCTM established standards that also have a focus on real-life problem-solving. NCTM’s standards have also influenced the Common Core State Standards for Mathematics (CCSSM). As a result, the CCSSM include a section devoted to modeling with mathematics, which focuses on real-world problem-solving. Across the world, curriculums focus on real-life problem-solving, so that their students are competitive internationally.

Real-world problem solving is emphasized in international assessments such as the PISA, which is administered by the OECD. *Assessing Scientific, Reading, and Mathematical Literacy: A Framework for PISA 2006* explained that students be presented with real-world problems
instead of problems to simply practice skills (OECD, 2006). This suggests that teachers try to place mathematical problems in real-world contexts, in which the students can also enhance their mathematical skills. Moreover, students should be able to communicate and justify their solutions to the real-world problems (OECD, 2006). Real-world problems are, therefore, presented in the PISA and American students need to be prepared for them.

In order for the United States to compete internationally, real-world problems are a part of the NCTM’s *Principles and Standards for School Mathematics*. NCTM (2000) discussed four components to real-world mathematics: mathematics for life, mathematics as a part of culture, mathematics for the workplace, and mathematics for the scientific and technical community. These four components encompass most aspects of life and help express the necessity that students solve real-world problems, as they will encounter situations which involve mathematical problem-solving. Therefore, this suggests that we consider incorporating real-world problem-solving on a national basis. If real-world problem solving is emphasized nationally, then states will include it in their curriculums.

Because real-world problem-solving is a part of NCTM’s standards, the Common Core State Standards (CCSS) have also included it. Modeling, which is given its own section in the CCSS for mathematics, focuses on applying mathematics to real-world problems. The CCSS explained that a lack of mathematical understanding would inhibit students’ abilities to apply math to the real-world (NGA & CCSSO, 2010). Since modeling is emphasized in the standards, it is then important that math educators develop students’ mathematical understanding to prepare them to solve real mathematical problems. In summary, the CCSS for mathematics claims that meeting the standards will help the students become better prepared to solve real problems in
their lives after school (NGA & CCSSO, 2010). Although states set the standards, it is up to the districts to organize curriculums that focus on real-world problem-solving.

Since real-world problem-solving is a part of international, national, and state assessments and standards, mathematics curriculums should incorporate real-world problem-solving. Kaiser and Willander (2005) claimed that application of mathematics to real-world problems should be used in curriculums because students develop better conceptual understanding. This suggests that providing students with real-world problems will help improve their understanding of mathematics. If teachers can improve the students’ understanding, then the students will be in a better position to build their knowledge.

Real-life problem-solving is emphasized on all levels of mathematics curriculums. The OECD assesses students on their abilities to apply mathematics to real-world problems. NCTM has also highlighted the importance of real-world problems in mathematics curriculums in its *Principles and Standards for School Mathematics*. Since the CCSSM is related to NCTM’s standards, it has developed one section of the high school standards devoted to modeling with mathematics. In sum, curriculums need to include real-world problem-solving, so that students develop a better conceptual understanding.

**Mathematical Literacy**

Entering the real-world, students must be able to apply mathematics to solve problems, as the standards emphasized. Logical reasoning is developed in math class, and students must be able to apply logical reasoning to solve problems that arise in their everyday lives. In addition, the world is becoming more data-oriented, which requires students to be able to interpret information. After students interpret information in problems, they must be able to represent the problem and communicate their solutions. Interpreting the problem requires logical reasoning.
Students should be prepared to use logical reasoning to solve problems that they encounter in their everyday lives. The OECD (2006) also explained that people must be able to analyze and judge arguments as they encounter them more frequently. Moreover, these arguments, as well as other problems, are becoming more quantitative, spatial, probabilistic, and mathematical (OECD, 2006). Consequently, students must be able to apply logical reasoning to interpret and take positions on arguments and problems, which are becoming more prevalent in today’s data-driven society.

As the world is becoming more mathematical and data-oriented, students must be prepared to extract as much information as possible from different sources. Yore et al. (2007) explained that people must be able to understand and interpret newspapers and media messages, and then formulate critical responses. Students should be able to read the newspaper and decipher the data from a crime rate report, for example, and determine whether or not the article makes valid claims based on the data. Yore et al. (2007) summarize their ideas by stating, “Mathematics as human and social activity requires mathematical literacy to be functional and to prepare to live, understand, and act critically in a modern, mathematised society” (p. 574). The final quote highlights that the world is becoming more data-driven and that students need to be prepared to evaluate arguments using mathematical reasoning.

Students need to be able to interpret, represent, and communicate their reasoning in different ways to solve problems (Thompson & Chappell, 2007). By interpreting, representing, and communicating in multiple and unique ways, students will improve their mathematical understanding (Thompson & Chappell, 2007). If students can be prepared to use mathematics in different ways to interpret real problems, they will have a better mathematical understanding and
be prepared to solve real-world problems. Representing and solving these problems is not easy; it requires high-level thinking.

Representing real problems using mathematics stems from the ability to use higher-order thinking. Meaney (2007) found that high-level thinking was required for students to reach the highest levels of mathematical literacy, with were described in the study done by Kaiser and Willander (2005). This suggests that teachers should challenge students with difficult, real-world problems in order to improve students’ mathematical literacy. If students can reach high levels of mathematical literacy, then they will be better prepared to apply mathematics and mathematical thinking to real-life problems.

Student must be prepared to apply mathematical reasoning in real-life problems. They should be able to interpret data in a mathematical world. When solving the problems, students need to represent the problem, which requires high-level thinking. After solving problems, students should be able to communicate their solutions and arguments clearly. To function in society students must be able to reason logically and apply mathematics to solve problems.

**Reflection**

Students might be able to improve their mathematical literacy and their understanding of the use of mathematics in the real world through reflection, which has shown to be beneficial. Student reflections help the teacher see what the students are struggling with and what they understand. Teachers can have students reflect through writing, which promotes and extends student thinking. Reflection extends student thinking by posing questions and experimenting with ideas. These ideas can be refined if the teacher has insight in to the students’ understanding.
Student reflections give the teacher insight into students’ conceptual understanding. Countryman devoted part of her book, *Writing to Learn Mathematics*, to student reflection. She explained that, through her experiences, student reflections help the teacher better understand the students’ conceptual understanding (Countryman, 1992). This suggests two things. First, teachers might be able to understand how students apply math to real-world problems; that is, teachers can better understand students’ mathematical literacy. Second, reflection could give the teacher a better understanding of the students’ mathematical understanding, since they must use mathematics to solve real-world problems. Once the teacher has insight into student understanding, then the teacher can help improve student thinking.

Extending students’ thinking has been thought to be a consequence of reflection. Carter (2009) conducted a study on reflective journal writing in an elementary school classroom. She found that reflection extended student thinking. This suggests that students could reflect on their solutions to real-world problems. In doing so, students could investigate their problem-solving process, thinking processes, and overall solutions; therefore, they would be required to criticize and analyze their arguments and strategies. Once students begin to analyze their own arguments, they are working toward independent learning.

It has also been thought that students work toward becoming independent learners through reflection. In a study conducted in Queens, New York, with a group of 2nd grade students, Desautel (2009) concluded that student self-reflections led to more self-awareness and facilitated independent learning. This suggests that students could become more conscious of their problem-solving skills in real situations. Students could examine their procedures and begin to question how they could have approached the problem in other ways. Questioning their
approaches to real-world problems moves them toward becoming independent learners, while also preparing students to become independent problem-solvers.

Reflection has helped teachers gain insight into students’ understanding. Reflection is thought to improve and extend student thinking, as well as develop independent learners by having them reflect on real-world problem-solving. Reflecting on solutions to real-life problems could help students prepare to be independent problem solvers in their lives after school.

Journal Writing

A tool that is commonly used as a reflection tool and rarely used in a mathematics class is the journal. Journal writing has been used for reflective writing and to engage the students that are usually less engaged. If students write in journals, it has been shown that students see journal writing as beneficial in the learning process. Journals allow the students to build their own representations of the material, as well as construct new knowledge. We have also seen that journal writing develops conversations between students and teachers. Consequently, teachers can also use journals as appropriate assessment tools, so that they can gauge student progress. Therefore, teachers should utilize journal-writing in math classrooms, and one use of journal writing is reflection.

Journals can be used for reflective writing, and it has been thought to help promote student thinking. Countryman (1992) suggested that reflective writing forces students to think, question, and experiment with new ideas. While writing students can think of questions they might have, or explain any new ideas that might have occurred to them during the lesson. Posing questions and explaining new ideas are two ways to promote student thinking, since students must think about what they know and what they would like to know. They must also make connections between what they already know in order to pose questions and create new ideas.
Creating new ideas is important to improving one’s understanding of how to apply math to the real-world. As well as using journals for reflective writing, educators can use journals to engage students.

We have seen that journal writing might be used to engage students. Baxter, Woodard, and Olson (2005) conducted a study on 28 7th and 8th grade math students, from which they selected four of the lowest-achieving students to examine. Despite that these students were typically disengaged, they found that the lowest-achieving students were more engaged in journal writing (Baxter et al., 2005). This finding, along with the findings of Crumpton and Gregory (2011), might be combined to suggest that journal-writing about real-world problems would get some students engaged in class. Since the students see the relevancy of the problem to their lives, they might be more inclined to learn and write about the material. When students have written in journals, they have seen some benefits.

Students have been shown to see the benefits of journal writing. After a study on students in an advanced Algebra II and a Geometry class, students reported that they felt journal writing improved their grades, explanation skills, and understanding of the material (Williams & Wynne, 2000). This suggests that students might have positive outlooks on journal writing in a math class. The finding also suggests that if students wrote about their solutions to real-world problems, then they might improve their understanding of real-world problem solving procedures and thinking. When solving real-world problems, it is important that students think and represent problems in their own way.

Students benefit from journal writing because they can interpret the mathematics in their own way. Hamdan (2005) did a study of 44 computer-science college students in a Linear Algebra class. Hamdan (2005) found that after writing in journals about invertible matrices,
students built their own representations of the material. Wilcox and Monroe (2011) also found that students build their own relationships when they write in learning logs. This suggests that journal-writing can be used to help students better understand the material in a way with which they are comfortable. Students might construct their knowledge based on these representations and build bridges across concepts.

Journal writing helps students learn by building new knowledge. Lew and Schmidt conducted a study on self-reflection and journal writing. They found that journal writing helped students create new knowledge, record used strategies, and increase their awareness of their thinking (Lew & Schmidt, 2011). This suggests that having students write and reflect about solving real-world problems might help them construct new knowledge. By writing in journals, the students might be able to relate mathematical concepts to the problem that they solved; consequently, they would build new knowledge of how to apply mathematics to real problems. To refine their real-world problem-solving skills, teachers must provide feedback.

Teachers can use journal writing to develop a conversation between the student and the teacher. Along with showing that students develop their own representations if they write in journals, Hamdan (2005) explained that journal writing develops a conversation between the teacher and the students. This suggests that by using journal-writing about real-world problem-solving, the teacher and the students can begin a conversation that might include exchange of ideas or new insights into how to improve solutions, for example. Because conversation emerges between the students and the teacher, the teacher can gain valuable information about student’s problem-solving ability.

Journals provide the teacher with a different assessment tool, from which teachers can make adjustments in their lessons. Teachers have used journals to identify students’
mathematical strengths and weaknesses (Kostos & Eui-kyung, 2010). Because journals provide insight into student strengths and weaknesses, teachers might be able to use journal-writing about real problems to determine students’ abilities to solve real-world problems. If teachers are aware of student abilities, they can adjust their lessons according to the students’ abilities. For example, the teacher might be able to use an x-y table to help students better understand modeling with functions, if the teachers sees that students are writing that they are having difficulty plotting appropriate points.

Mathematics teachers can make use of journal-writing in a few ways. Journals have been used for reflective writing and also shown to engage student that are typically less engaged. Moreover, students have seen journal writing to be beneficial to the learning process. Journals allow students to make their own representations of the material, which in turn can help construct new knowledge. Teachers can also utilize journal writing as an assessment tool, since journals are thought to develop conversation between the teacher and students.

Conclusion

Students should be prepared to apply mathematics to real problems. It is our job as mathematics educators that we have students solve real-world problems, so that they develop mathematical and logical reasoning, which can be applied to solving problems. Because real-world problem-solving is important, organizations such as OECD, NCTM, and the CCSS emphasize modeling and real-world applications of mathematics. The idea is that students must develop their mathematical literacy, which is their ability to apply math to their immediate and current lives. If students reflect on their abilities to apply math to real problems, they might develop a better understanding of mathematical concepts and its use in the real world. Lastly, journal writing can be used for students to reflect on their solutions to real-world problems.
Journals have been shown to promote conversation between the students and the teacher, as well as be used as an assessment tool for the teacher. In summary, it is important that math educators have students solve real problems and reflect on their solutions, so that students are prepared to use math in their lives after school.
Chapter 3—Methods

Introduction

The study was conducted to determine if reflective journal writing affects students’ perceived mathematical literacy as well as their perceived and actual abilities to engage in the Eight Mathematical Practices when solving real-world problems. The study was conducted over a period of six weeks with the researcher functioning as a teacher-researcher throughout the study. The data was gathered using pre- and post-surveys, pre- and post-assessments, and journal entries. The researcher analyzed the data for the pre- and post-surveys using descriptive statistics, and the same is true for the pre- and post-assessments. The six problems, of which the first and last functioned as the pre- and post-assessments, respectively, were analyzed using a rubric designed to measure the Eight Mathematical Practices. The journal entries were analyzed qualitatively by looking for trends in the entries. Guidelines were administered to the students to serve as their journal writing prompts.

Description of the Participants and Setting

This study was conducted in a rural school district in southeastern Ohio. The district’s schools were located in the same building, and the research was conducted in the high school. For the school year 2010-2011, the high school was rated “effective” by the Ohio Department of Education (Ohio Department of Education [ODE], 2011). Using the same ODE report card for 2010-2011, a total of 388 students were enrolled in the high school during the 2010-2011 school year. Moreover, 97.3% of the student body was considered white, non-Hispanic and no students were English Language Learners (ELLs) (ODE, 2011). Lastly, 21% of the student body was considered to have learning disabilities, while 54.5% was economically disadvantaged. A
poverty rate of 54.5% categorizes the high school at the medium-high poverty level (ODE, 2011).

The study was done in two advanced geometry classes by a pre-service teacher during his professional internship. The teacher-researcher was with the classes for the entire year, and by the beginning of the study, had established a good rapport with the classes. Furthermore, the teacher-researcher assumed full control over the classes during the study. His mentor teacher was not involved in the study. The classes totaled 33 students, nine of which were boys and 24 of which were girls. There were also four 10th-grade and 29 9th-grade students included in the study. The students were all advanced students and most of them were doing fairly well in the class. There were no students with special needs.

**Instruments**

*Surveys*

The researcher used a pre- and post-survey. The pre-survey consisted of 15 Likert-Scale questions, and the post-survey of 25 questions, with responses as follows: 1—strongly disagree, 2—disagree, 3—neutral, 4—agree, and 5—strongly agree. The pre-survey had two parts, A and B. The post-survey had the same parts A and B, as well as Part C described below. The purpose of the pre-survey and Parts A and B of the post-survey was to determine students’ perceived mathematical literacy and perceived abilities to engage in the Eight Mathematical Practices at the beginning and the end of the study, respectively. Part A of the survey addressed the mathematical literacy of the students, while Part B addressed the students’ perceived abilities to engage in the Practices.

There was one difference between the pre-survey and the post-survey. While all of the questions were the same for Parts A and B, Part C was added in the post-survey. Part C
contained ten Likert-Scale questions related to the students’ perceptions as to whether or not they felt reflective journal writing helped them engage in the Eight Mathematical Practices and improved their mathematical literacy.

*Pre-assessment*

The purpose of the pre-assessment was to obtain baseline scores for the students’ abilities to use the Eight Mathematical Practices. The pre-assessment was the “Pool Problem” in which students were only given certain dimensions. The students were to determine where one player should hit the cue ball in order to hit the 8-ball. The main concepts that could be used to solve the problem were congruent triangles and angles. At the end of the task, the students were asked to reflect on their solution in their journals by answering specific questions that pertained to the solution process.

*Problems*

There were a total of ten real-world problems that were used in the study. The first problem was used as the pre-assessment and the last problem was used as the post-assessment. The purpose of the problems was to determine the students’ engagement with the Eight Mathematical Practices. The problems focused mainly on concepts in geometry and their application to the real-world, as the students were in an advanced geometry class. The problems were also within contexts that the students’ were familiar with or ones that they might encounter in the future. The problems were as open-ended as possible, and the students were only given the minimum amount information to find a solution to the problem. The problems also contained information that was unnecessary to solve the problems.
Journal Entries

For each of the six problems that the students solved they answered three questions that came from the list of ten questions in the guidelines. The purpose of the journals was for the students to reflect on their problem solutions and their use of the Eight Mathematical Practices. The students were required to answer the three questions posed by the teacher. The students were allowed reflect further on their solution, and the hope was that they would, but they had to answer at least the three questions.

Post-assessment

The purpose of the post-assessment was to obtain a final score for each student regarding their abilities to use the Eight Mathematical Practices. The “Putt-Putt Problem” was similar to the “Pool Problem” used for the pre-assessment. In the “Pool Problem,” the main concepts were congruent triangles and angles. In the “Putt-Putt Problem,” the main concepts were similar triangles and angles. The students were asked to reflect on three specific questions regarding how they solved the problem.

Rubric for Problem Solutions

The rubric, entitled Standards for Mathematical Practice, was taken from Freel (2012) to measure the Common Core State Standards for Mathematical Practice. The purpose of the rubric was to measure the level of engagement in the Eight Mathematical Practices in the pre- and post-assessments as well as the other solutions to the problems in the study. The rubric provided a score out of eight points for each problem. Each of the Eight Mathematical Practices received a total of one point. The rubric was broken into eight categories related to the Eight Practices. Within the category of each standard there were at least three markers and at most six markers. The one point for each of the eight categories was broken down per marker. For example, there
are five markers under the first category, “Makes sense of problems and perseveres in solving them,” so each marker was awarded 0.2, or 1/5, of a point.

Guidelines

The guidelines for the journal entries were to set out the expectations for the students and to provide them with the questions that were asked. The questions for the reflective journal entries were listed on the first page of the guidelines. The questions directly related to the Eight Mathematical Practices. The rubric attached to the guidelines was for grading the journal entries as a part of the class and was not used in the study.

Data Collection

Surveys

The data from the surveys were collected at two different times. The pre-survey was collected two days before journal writing began. The post-survey was collected two days after journal writing ended. Data from both of the surveys were gathered using Microsoft Excel and the mean and median response number was calculated for each of the questions. That data was collected in tables included in the results section of this study. The tables contained the mean and median response values from both the pre- and post-survey.

Pre-assessment

The “Pool Problem” was administered as the first problem of the set of six problems used to determine the students’ abilities to engage in the Eight Mathematical Practices. It was administered during the first week of the project. Each student solved his/her own problem and turned it in on the due date. The students were allowed to use any resource available to them to solve the problem. The researcher collected whatever paperwork the students used to solve the
The data from the solutions was gathered and organized in a spreadsheet. A sample of the students’ work was copied as examples.

Problems

The real-world problems were given once per week for six weeks. The students solved each problem individually, or consulting their neighbor for help. The researcher collected the students’ solutions and materials used to solve the problems. The students were allowed to use any resources available to them. They were allowed to ask the teacher questions about the problems. The teacher clarified any confusing questions and provided examples, if necessary. The data from the solutions were gathered and organized into a spreadsheet, in which each problem’s scores were organized. A sample of students’ work was copied as examples.

Journal Entries

Journal entries were collected the same days as the solutions; therefore, they were collected once per week for a total of six times. The researcher collected some samples of student writings. Trends, or any other observations by the researcher, were recorded in a word-processing file for each of the journal entries. Copies of students’ work were made for a representative sample.

Post-assessment

The “Putt-Putt Problem” was given as the last of the six problems in the study. It was used to determine the students’ final abilities to use the Eight Mathematical Practices. The post-assessment was given during the sixth week of the study. Students turned in their own solutions along with any paperwork they used to solve the problem. The students were allowed to use any resources that were available to them. The data from the post-assessment was gathered and
organized into a Microsoft Excel file. Copies of students’ work were made for a representative sample.

**Data Analysis**

*Surveys*

The data gathered from Parts A and B of the pre- and post-surveys were compared and contrasted. The table allowed for easy comparison between the mean and median response numbers. The researcher investigated the data to look for any differences between the mean and median response number for each question from the pre-survey to the post-survey. Part A pertained to the students’ perceived mathematical literacy and the researcher looked for any change regarding the students’ beliefs that math is useful in their current and future lives. Part B dealt with the students’ perceived abilities to engage in the Practices. The researcher looked to see if the students’ perceptions had changed from the beginning of the study to the end. Overall, the researcher looked at the tables to determine if any trends in the data emerged.

Part C of the post-survey was analyzed by calculating the mean and median response for each question. The data were then analyzed to describe any trends that evolved. The researcher’s main interest was the students’ perceptions of whether or not reflective journal writing helped them use the Eight Mathematical Practices and see math as useful in their lives. The researcher used the mean and median responses to make some suggestions about the students’ perceptions.

*Pre-assessment*

The “Pool Problem” was analyzed using the *Standards for Mathematical Practice* rubric used for the problem solutions. The problem was scored and the mean and median scores were calculated for the entire sample. The mean and median scores were calculated so that the scores
could be compared and contrasted with the mean and median scores of the post-assessment “Putt-Putt Problem.” The researcher also analyzed the scores to determine any trends in the scores for the problem.

Problems

The problems were analyzed using the *Standards for Mathematical Practice* rubric. Using the rubric, mean and median scores for the entire sample were calculated for each problem. The data were analyzed to determine if any trends emerged over the course of the study. For example, the researcher might have considered how one specific element of the Eight Practices changed over the solutions. The researcher also looked at mean and median problem scores of the problems to determine if the students progressed in their use of the Practices.

Journal Entries

The researcher analyzed the journal entries by looking for trends in the reflections. Specifically, the researcher looked at how the students answered the three questions for each entry. The researcher also looked for any changes in the level reflection of the students throughout the course of the study. Changes in the level of reflection were determined by observation based on detail, thought, and effort. Moreover, the researcher looked for similarities and differences among the responses. The researcher also looked at if the students’ journal entries reflected their level of engagement in the Eight Practices more frequently and how they saw math as applicable to their lives.

Post-assessment

The “Putt-Putt Problem” was analyzed using the *Standards for Mathematical Practice* rubric used to score the problems. The mean and median scores for the entire sample were recorded. Then, the mean and median scores were compared and contrasted with those of the
“Pool Problem” to determine if there were any changes over the course of the study. In addition, the researcher looked for any trends that emerged in the scores of the problem.

**Summary**

The purpose of the project was to examine the effects of reflective journal writing on students’ perceived mathematical literacy and their perceived and actual abilities to engage in the Eight Mathematical Practices when solving real-world problems. It was conducted over six weeks and data was collected by means of pre- and post-surveys, pre- and post-assessments, and journal entries. Data from the pre- and post-surveys were analyzed using descriptive statistics, which were compared to determine if there were any trends. The data from the pre- and post-assessments were analyzed using the *Standards for Mathematical Practice* rubric, and descriptive statistics were obtained. The statistics were compared between the pre- and post-assessments. Lastly, the journal entries were analyzed qualitatively to determine if any trends emerged in the students’ entries.
Chapter 4—Findings

Introduction

The findings and data are presented in the chapter that follows. The chapter is structured in the following way. First, the data and findings of the pre- and post-surveys will be presented. These data are broken into Part A (pre- and post-surveys), Part B (pre- and post-surveys), and Part C of the post-survey. Following the surveys’ data, the pre- and post-assessments’ data are compared. The pre- and post-assessments were administered as the first and sixth problems of a set of six real-world problems. The data of problems two through five are presented following the pre- and post-assessment data. As a reminder for the reader, the research question was how do students’ perceived mathematical literacy, perceived engagement in the Eight Practices, and actual engagement in the Eight Practices change after solving real-world problems and writing in a reflective journal. Finally, the students reflected on their solutions and problem solving strategies using journal entries, whose data is presented at the end of this chapter.

Surveys

In this section, the researcher presents the findings of the two surveys. The pre-survey was administered two days before journal-writing began. The pre-survey contained two parts, Part A and Part B. Part A focused on the students’ perceived mathematical literacy, while Part B measured their perceived abilities to engage in the Eight Mathematical Practices. The post-survey contained identical Parts A and B as the pre-survey; however, a third section, Part C, was added to the post-survey to measure whether or not the students believed journal writing helped them to use the Eight Practices and impacted their perceived mathematical literacy. This subsection contains a description of the pre-survey’s findings, followed by the post-survey’s
findings, and then a comparison between the surveys. Lastly, there were 30 students surveyed in each survey.

For a full break-down of the data, please see Tables 1, 2, and 3. Table 1 contains the data based on survey question number for Part A of the pre- and post-survey. Table 2 contains the data for each question number for Part B of the pre- and post-survey. Table 3 contains the data for Part C of the post-survey, again listed by question number. In the following paragraphs, the question number’s content will be addressed and not the question number. For a list of the prompts and their corresponding question number of the pre-survey, please see Appendix A. For a list of the prompts and their corresponding question number of the post-survey, please see Appendix B.

Part A of the pre- and post-surveys addressed the following portion of the research question: whether or not the students’ perceived mathematical literacy changed over the course of the study. The data of Part A of the pre- and post-surveys are presented here.

This paragraph contains the description of the data of Part A of the pre-survey. To start, most students were neutral or agreed slightly that math is useful in their current lives, but most students agreed that they will use math in their future careers. Students were also neutral or slightly agreed that math is, or will be, important to their social and private lives. With regard to using math in the real-world, students agreed that math was important. Moreover, 22 students agreed or strongly agreed that math is important to being a productive U.S. citizen. Students also felt that they are logical thinkers and agreed that they can use supporting arguments to make decisions. The students were asked to respond to the same prompts in the post-survey.

Part A of the post-survey was written exactly as Part A of the pre-survey. In the post-survey, 29 students agreed or strongly agreed that they can reason logically. Twenty-five
students agreed or strongly agreed that they can use supporting arguments to make decisions, and, on average, students agreed that math is important to their current lives. With regard to their future careers, students agreed that they will use math in their future jobs. It is interesting to note that no student disagreed to any extent with the previous statement. Sixteen students and seven students agreed or strongly agreed, respectively, that math is, or will be, important to their private and social lives. Students agreed that math is important to function in the real-world. In total, 25 students agreed to some extent with the previous statement. Lastly, students agreed that math is important to being a productive U.S. citizen. These results seemed to compare similarly to the results from the pre-survey.

Part A of the pre- and post-surveys seemed to produce similar results, but with slight increases on the post-survey. For four of the seven prompts, the median response number did not change; however, for the third and sixth prompt the medians increased by 0.500, and the median of the seventh prompt decreased by 0.500. Overall, the mean response for six of the seven prompts increased and the seventh prompt’s mean did not change. Together, the changes in the mean and median responses show that the students seemed to agree with those prompts more often in Part A of the post-survey, a trend that occurred in Part B as well.

**Table 1**

*Data comparison of Part A of the pre- and post-surveys.*

<table>
<thead>
<tr>
<th>Part A Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-survey results</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>4.0000</td>
<td>4.0000</td>
<td>3.5000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>3.5000</td>
<td>4.5000</td>
</tr>
<tr>
<td><strong>Post-survey results</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
</tr>
<tr>
<td><strong>Difference in Results</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.3334</td>
<td>0.1000</td>
<td>0.2000</td>
<td>0.2000</td>
<td>0.0667</td>
<td>0.3333</td>
<td>0.0000</td>
</tr>
<tr>
<td>Median</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.5000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.5000</td>
<td>-0.5000</td>
</tr>
</tbody>
</table>
Part B of the pre-survey measured the students’ perceived abilities to engage in the Eight Mathematical Practices. In general, the students were neutral or agreed that they can understand a problem and stick with the problem to find a solution. Twenty-six students agreed or strongly agreed that they can work with symbols and numbers. On average, the students agreed that they can make practical arguments and analyze others’ reasoning. Furthermore, students seemed to agree that they can model with math, and 25 students strongly agreed that they can use mathematical tools (e.g. calculators and computers) to solve problems. While solving problems, students agreed that they look for mathematical patterns. Furthermore, 19 students strongly agreed that they look for shortcuts or general methods to solve mathematical problems. With regard to arguments to defend their solutions, 26 students were neutral or agreed that they can make precise arguments. Students took Part B of the post-survey to determine if their perceptions changed over the six-week study.

Part B of the post-survey helped determine if the students’ perceived abilities to engage in the Eight Practices changed over the course of the study, and contained the same prompts as Part B in the pre-survey for easy comparison. In Part B of the post-survey, on average most students agreed that they are able to understand a problem and stick with it to find a solution. With regard to the extent to which students believe that they can use symbols and numbers to solve problems, 24 of 29 students agreed. No student disagreed to any extent that they can make practical arguments and analyze others’ arguments; instead, students agreed on average with the previous statement. It was evident that the students also believed that can model with mathematics and use mathematical tools, such as calculators or computers, to solve problems. Moreover, students believed that they can make precise mathematical arguments to defend problems’ solutions. Lastly, students agreed that they look for mathematical patterns during
problem solving, and most students strongly agreed that they look for shortcuts or general methods to solve problems. These results from Part B of the post-survey were compared with the pre-survey’s results.

Part B of the pre- and post-surveys also produced similar results, with most of the average scores changing. Of the eight prompts in Part B, only the eighth prompt’s median changed and it increased by one point. Six prompts had an increase in their mean response, but the ninth prompt saw a decrease of 0.095 and the twelfth prompt’s mean did not change. The most change occurred on the eighth prompt. It appeared that more students believed that they could understand and stick with problems to find a solution (eighth prompt). The ninth prompt was the only one that decreased on average, but its median did not change. Therefore, it does not appear that there was much difference in the students’ perceived abilities to use symbols and numbers to solve problems (ninth prompt). As for the rest of the prompts, the students showed a slight trend in agreeing with more statements on the Part B of the post-survey.

Table 2

Data comparison of Part B of the pre- and post-surveys.

<table>
<thead>
<tr>
<th>Part B Question</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-survey results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>3.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>5.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>5.0000</td>
</tr>
<tr>
<td>Post-survey results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>5.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>5.0000</td>
</tr>
<tr>
<td>Difference in Results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.4334</td>
<td>-0.0960</td>
<td>0.2000</td>
<td>0.2667</td>
<td>0.0000</td>
<td>0.4000</td>
<td>0.2666</td>
<td>0.0667</td>
</tr>
<tr>
<td>Median</td>
<td>1.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>
Part C of the post-survey was an independent survey and had no corresponding part in the pre-survey. The first eight prompts measured the perceived impact of journal writing on students’ abilities to use the Eight Practices and the last two prompts determined the impact of journal writing on their perceived mathematical literacy.

The data of Part C of the post-survey contained the following results. On average, students were neutral or agreed that journal writing helped them understand problems. When solving problems, students were again neutral or agreed that journal writing influenced how they used symbols and numbers; however, students agreed that journal writing improved their abilities to make and analyze arguments. Twenty-one students agreed to some extent that journal writing helped them understand how to use math to model problems. In addition, journal writing seemed to help students learn how to use mathematical tools (e.g. calculators, computers) to solve problems. Regarding mathematical communication, students believed that journal writing helped them to communicate more clearly. Students also agreed that journal writing helped them to look for mathematical patterns and shortcuts when solving problems. Finally, twenty-two students agreed to some extent that journal writing helped them see that math can be used in their current lives, while 14 students strongly agreed that journal writing helped them see how math could help them in the future.

Table 3

Data from Part C of the post-survey.

<table>
<thead>
<tr>
<th>Post-Survey: Part C Question</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
<th>23</th>
<th>24</th>
<th>25</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Median Response</strong></td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
<td>4.0000</td>
</tr>
</tbody>
</table>
Part C of the post-survey showed that the students felt that journal writing helped improve the students’ mathematical literacy and engagement in the Eight Practices. Based on Table 3, the data showed that the students agreed or were neutral, in general, with each of the ten statements in Part C of the post-survey.

Parts A and B of the pre- and post-surveys changed slightly with regard to data, while the students either were neutral or agreed, on average, with the statements in Part C of the post-survey. According to Table 1, the students had slight increases in their average scores indicating that they agreed more often on the post-survey. Table 2 explains that the average scores from Part B of the surveys seemed to increase indicating that the students agreed more often in the post-survey. Finally, Part C of the post-survey, whose data is contained in Table 3, showed that the students agreed or were neutral with median scores of four and means ranging from 3.4000 to 4.1000.

**Pre- and Post-Assessments**

The pre- and post-assessments were used to determine the change in the students’ actual abilities to use the Eight Practices based on the evidence in their solutions to the problems, which was component of the research question. The pre-assessment, the “Pool Problem,” and the post-assessment, the “Putt-Putt Problem,” could be solved using similar ideas, so they made for appropriate assessments. A description of the findings for both assessments, as well as a comparison of the two, follows. Data containing the scores for the pre- and post-assessments can be found at the end of this subsection in Table 4.

The pre-assessment consisted of 32 students. The mean score given by the *Standards for Mathematical Practices* rubric was 1.9745 and the median was 1.9833. These scores were both out of eight possible points. Trends found in the students’ problem solutions include that almost
all of the students seemed to understand the problem, as evident by their diagrams, which almost all students drew. As an example, a student drew pictures of three scenarios to show how the cue ball would bounce, if it did not hit in the correct spot. No student used symbols, solved the problem algebraically, checked their answers, or used mathematical tools, besides pencil and paper. When scoring the pre-assessment, all students received a mark for solving real-world problems, and angles were considered a pattern in the problem. These results were gathered and then compared with results from the post-assessment, which was administered during the sixth week.

The post-assessment consisted of 29 students. The mean score given by the Standards for Mathematical Practice rubric was 2.0581 and the median was 2.0667. Students searched for patterns in their solutions. For example, students searched for relationships between angles (angle of incidence versus the angle of reflection) and they also showed how to use a “zigzag” pattern to find a solution. Almost all students drew a diagram or a picture to represent their solution to the problem. No student solved the problem algebraically or incorporated ideas involving similar triangles. Some students used a protractor to make more precise measurements and approximations of the angle measures in their diagrams; however, not all students used protractors. When scoring the post-assessment, a drawing was not considered a plan, as it was not considered a plan in the pre-assessment. This method helped keep the scores consistent. Furthermore, if the students explained that the angle of incidence is equal to the angle of reflection, the students understood relationships. Angles and any attempt to explain relationships between angles were considered patterns. These data were compared with the data from the pre-assessment, and differences were found.
The problems used for the pre- and post-assessments were chosen because they had similar pathways to a solution, but the post-assessment had higher mean and median scores than the pre-assessment. Because of the differences in the mean and median scores, it appeared that students used more components of the Eight Practices in the post-assessment. Most students drew diagrams to solve each problem, but perhaps the difference in the scores was that students used protractors in the post-assessment, while they did not use them in the pre-assessment. Because the students used protractors, it was evident that the students tried to communicate their solution more precisely in the post-assessment by using angle measures to determine the exact angle at which to putt the golf ball into the hole. According to Table 4, the differences in the mean and median scores for the pre- and post-assessment were only small. Using the protractors on the post-assessment possibly accounted for this difference. Lastly, many students also claimed to have played putt-putt in the past compared to having played pool, so that could have helped them understand the post-assessment more deeply.

Overall, the students showed a small change in their abilities to engage in the Eight Practices from the pre-assessment to the post-assessment. In the post-assessment, the students used mathematical tools (i.e. protractors), which could have been the main difference in scores of students’ solutions.

**Table 4**

*Data comparison of the pre- and post-assessments.*

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Mean Score</th>
<th>Median Score</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-assessment</td>
<td>1.9745</td>
<td>1.9833</td>
<td>32</td>
</tr>
<tr>
<td>Post-assessment</td>
<td>2.0581</td>
<td>2.0667</td>
<td>29</td>
</tr>
<tr>
<td>Change</td>
<td>0.0836</td>
<td>0.08337</td>
<td>--</td>
</tr>
</tbody>
</table>
Problem Solutions and the Eight Practices

Each week students solved one real-world problem followed by a reflection. The six problem solutions were scored using the rubric Standards for Mathematical Practice to obtain a score out of eight for each student. The students’ scores were then used to calculate the mean and median score for each problem. The researcher will use the mean and median scores to describe the data of the problems. The first and sixth problems were the pre- and post-assessments, so their data has already been described in the previous section. Table 5, which is located at the end of this subsection, contains the data for problems two through five. What follows are the findings from the four other problems and any trends in the problem solutions throughout the study.

The second problem of the six was entitled the “Reactor Problem.” Thirty-one students worked on this problem, and together, their scores had a mean score of 2.3785 and a median of 2.3167. In general, the students were able to understand the problem and each student received a mark on the rubric for solving a real-world problem. All students attempted to solve this problem by drawing diagrams. They checked their work by arguing using area or distance. For example, two students drew two diagrams to compare the areas of the circles in different positions. One student also argued that the square is longer corner-to-corner than it is on its sides; therefore, the circles should be located in the corners. Finally, most solutions were imprecise. Circles were drawn inaccurately; the students did not use compasses or rulers in their diagrams, although the tools were available. All of the above findings contributed to the reported scores. The students’ scores were higher during week three.

The third problem was entitled “Remodeling a Room.” In total, 32 students submitted a response to this problem. The students’ mean score was 3.0068 and their median score was
Most of the students were able to use area formulas for triangles and rectangles to solve the problem. They recognized that the area was necessary to calculate the cost of the paint and the carpet for the room. To solve the problem, all students used a calculator; however, students only received a mark on the rubric for accurate calculations if each value was calculated correctly. A calculation was considered correct if the calculation yielded a correct value and it was an appropriate calculation. This was needed to avoid counting calculations that were correct, but irrelevant to the problem. Students’ explanations were considered carefully explained, if their reasoning or explanation supported their solution. As examples, a few students explained that the family would choose the cheaper contractor to remodel their room, while another student explained that they would choose the more expensive contractor because the quality of their material might be better. On the third problem the students had average and median scores that were higher than both weeks two and four.

The fourth problem was called the “Dart Problem.” The students received a mean score of 2.5250 and a median score of 2.725. Only 24 students submitted a response to this problem due to state testing. The students followed the assumptions made, which are located on the problem. The main approach to the problem was to make a list of all of the possible combinations. Some students found a pattern to the list and organized it well; however, other students made a random list and often repeated combinations. All students attempted to make a list of the possible combinations of dart throws that sum to 33 points, but only a few students attempted to calculate the probability of throwing one 20 and one 13. These students used the area and circumference of the circle, but did not understand how these calculations related to the problem. Finally, the students received a mark for accurate calculations if all of their calculations were correct, since they only needed to find triples that summed to 33. Most
students were able to perform the basic calculation, but the tediousness of the task accounted for some mistakes. Overall, the students were able to understand the problem and could create lists to find possible combinations, but struggled to compute any probability of throwing a 20 and 13. The scores from week four were lower than the scores achieved during week five.

The fifth problem had the title “Gumball Machine,” and was completed by 29 students. The students’ mean score was 2.8902 and the median score was 2.9333. Most students were given a hint as to how to start the problem, since they were confused. The students consulted each other during class for ideas on how to approach the problem. The students made an approximation to the solution because they could not calculate the volume between the gumballs. Most students’ plans involved calculating the volume of the glass globe and each gumball to determine the number of gumballs in the machine. One student added a variable to the problem to represent the probability of winning $100, and only some students attempted to use units in the problem; the units were often used incorrectly. Some students explained their solutions, which was in addition to using the formulas for volume or surface area of a sphere.

Throughout the problems’ solutions the students’ engagement in the Eight Practices varied problem to problem. The students were not consistent in their use of the Eight Practices. There was no evidence that the students engaged in the Eight Practices more or less frequently from the beginning of the study to its end. Oftentimes the students understood the problems, but they did not always use mathematical tools that were available. Moreover, some students explained their solutions, while others did not. Diagrams were used to solve some of the problems that already contained diagrams, on which the students could draw. Students also used formulas, specifically area and volume formulas, and lists to solve problems. Lastly, the students varied in precision. Some students communicated their solutions using units and correct
mathematical terminology, but other students either did not explain their solutions or communicated their thoughts vaguely.

**Table 5**

*Data comparison for the solutions to the six weekly problems, which were scored using the rubric entitled Standards for Mathematical Practice.*

<table>
<thead>
<tr>
<th>Problem Number</th>
<th>Mean Score</th>
<th>Median Score</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Pre-assessment)</td>
<td>1.9745</td>
<td>1.9833</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>2.3785</td>
<td>2.3167</td>
<td>31</td>
</tr>
<tr>
<td>3</td>
<td>3.0068</td>
<td>3.0667</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>2.525</td>
<td>2.725</td>
<td>24</td>
</tr>
<tr>
<td>5</td>
<td>2.8902</td>
<td>2.9333</td>
<td>29</td>
</tr>
<tr>
<td>6 (Post-assessment)</td>
<td>2.0581</td>
<td>2.0667</td>
<td>29</td>
</tr>
</tbody>
</table>

**Journal Entries**

Following each problem set, the students answered prompts that asked them to reflect on parts of their problem solutions. Each week the students answered three questions that were selected from a list of ten questions listed in the Journal Guidelines. The questions pertained to the Common Core’s Eight Mathematical Practices and to the students’ mathematical literacy. The following section is a description of the trends in the journal entries for each week and a description of general trends that were found.

The first journal entries pertained to the “Pool Problem” and used questions 1, 6, and 8 in listed in the Journal Guidelines. Most of the students understood the problem easily. Students’ entries varied in levels of reflection. Some students considered other solutions, such as hitting the ball off a different wall, while others did not explain their thinking very well by stating that the problem was “common sense.” Students thought about aspects of the problem that made it easier or more difficult to solve. For example, students explained that the visual made the problem easier to understand and solve using a diagram; however, students, who had never
played billiards, had difficulties understanding the problem. In addition, students determined that using angles in the problem solutions was a pattern. Moreover, students explained that they used diagrams and drawings to solve the problem. All together the students’ levels of reflection varied considerably, and there was no indication that the students engaged in the Eight Practices more often than necessary to solve the problem. This last trend continued on the second week’s journal entries.

Questions regarding the students’ solutions to the “Reactor Problem” were answered in the second week’s journal entries. The journal entries involved students discussing questions 3, 7, and 8 on the Journal Guidelines. The students varied in whether or not they believed their explanations to the problem were complete. For example, some students believed their explanations were complete since they used all of the available resources in the room, or that they included a reason to support it. Other students believed that their explanations could be improved, but did not provide an alternative, while others thought their explanations were not complete and did not explain why. Most students wrote that they solved the problem in ten minutes or less. They also provided alternative solutions such as changing the positions of the reactors in their diagram.

Overall, the student reflections were relatively weak. They focused more on answering the questions as briefly as possible and not explaining their responses. Responses were also vague. For example, a student’s response was, “I could solve the problem differently by thinking it through more.” It is unclear as to what the student means and how to interpret the statement. As compared to the first week’s journal entries, the students’ journal entries did not suggest that they used the Eight Practices any better than the first week, but not as well as in the third week.
The third week’s journal entries were about the “Remodeling Problem” and used questions 2, 4, and 7 from the Journal Guidelines. Before the start of the problem, the teacher-researcher gave the students an example of the difference between a variable and a symbol. Most students did not use variables to solve the problem, so no student mentioned variables. One student explained that they symbolized words, but did not elaborate on that statement. Another student explained that they used “$” to represent monetary units in the problem. The students also explained that they used numbers in computing the contractors’ costs; therefore, they explained that they used the problem’s words to determine their solution. Students also explained that they used area to solve the problem. One student changed the problem’s words to math but “diagramming the problem.” In his journal entry, he wrote that he used variables and expressions by providing the example of $12.50x$ and $18.50x$ to represent a cost. The students took, in general, between ten and 40 minutes to solve the problem. Some students explained that it took them various durations to solve the problem because they wanted to check their work; they were confused; or some students were distracted. In any case, the students provided some rationale for the duration of time it took to solve the problem, which was better than the previous weeks.

As compared to the first two weeks of journal entries, the reflection improved in week three. Students justified their reasoning more often by citing supporting statements such as that they were confused or that they needed some help to start the problem. There were still students that provided limited justification, however. For example, a student explained that they symbolized words, but did not explain how or to which words they referred. The third week’s entries improved from the first two weeks’ entries, but were improved upon during week four.
The fourth journal entry’s prompts regarded the “Dart Problem,” and the prompts were questions 1, 4, and 9. The students’ levels of reflection still varied, but some students supported their arguments using precise reasons. For example, some students had difficulties understanding the problem, since they had never played darts. Other students explained that the problem was challenging because they could not figure out the combinations; however, a student noted that a pattern made the solution easier to find. Students also explained that finding numbers that add to 33 was a pattern. In this case the student felt that her thinking process did not change, since the student only had to find numbers that sum to 33; however, others’ thoughts changed and were noted.

Some students’ thinking processes changed and they noted the changes. One student explained that her rate of thinking changed from “slow” to “fast” to “a lot faster.” Once she figured out the “process,” her thinking rate changed. Another student explained that her thinking changed from “easy thinking to complex thinking” because she needed to “think really hard about the problem in order to get answers.” These statements show that there was some evidence for students using metacognitive processes.

With regard to how students changed the problem’s words into math, most students showed low levels of reflection. They did not explain how they changed the problem’s words into math. For example, one student explained that they “used numbers to figure it out.” This student did not explain how or why they used certain numbers; therefore the response was vague. At least one student, on the contrary, explained how they changed the problem’s words into math. She explained that she considered the given information and the two equations, but was confused by “the diameter, circumference, radius, and area.” She also noted that “there were a bunch of numbers” and “addition,” which was evidence that she considered how the problem’s
words and numbers determined her mathematics. As evident, students’ responses still differed in levels of reflection.

The students’ reflections still varied during week four, but some students began to better support their reasoning. Students also evaluated their rate of thinking and if their thinking changed in complexity throughout their problem solutions. Most variability was in the students’ responses to how they changed the problem’s words into math. Responses ranged from “used numbers to figure it out” to considering given information and noting operations that were used to solve the problem. Overall the fourth week’s journal entries improved slightly from the previous week by providing more support for their reasoning. The fifth week’s journal entries seemed to continue the trend of improving reflection.

The fifth journal entry’s used the problem entitled the “Gumball Machine.” The prompts were based on questions 2, 3, and 10 in the Journal Guidelines. As compared to the first four journal entries, the students’ reflection improved on this assignment. Most students explained their reasoning. For example, a student explained that another person must understand rounding in order for that person to understand her solution. This is evidence showing that a student thought about what others must understand in order to comprehend her solution. Another student explained that their answer would convince another person that their solution is correct because the student “solved each part of the problem completely.” A student representing the minority of students, who did not reflect well, explained that their solution is complete and would convince another person that their solution is correct, but provided no rationale. All together, students explained variably, why they believed their solutions would convince others that they were correct. A similar finding occurred in responses to another question.
Students reflected moderately well with regard to how they used numbers, variables, and symbols in their responses. One student explained that she approximated pi with 3.14, which was evidence for how she simplified numbers. Two other students explained how they used variables. One student simply stated that the variables helped her “understand the equations,” while another student explained that they added their own variable “x,” which represented the probability that a person wins $100. Another student explained how they used numbers very well. This student explained that she “had to divide the sphere volume by the gumball volume” in order to solve the problem. This statement was evidence that she considered how to use quantities to make an appropriate calculation. Finally, a student that did not provide sound reasoning explained that he found a solution using his “amazing math skills.” Consequently, there was evidence that some students either could, or could not, explain how they used variables, numbers, and symbols in their solutions.

Although some students could explain how they used numbers, variables, and symbols in their solutions, the students struggled to think of similar, real-world problems. The students understood how to use the numbers presented in the problem, but a commonly suggested, similar problem was a raffle. The raffle suggestion was evidence that the students considered a problem that involved selecting objects from a container, which was the setup of the fifth problem. Students did not suggest general probability problems such as selecting cards from a deck or selecting a committee from a predetermined group of people. Thinking of similar, real-world problems was easily the most difficult prompt for the fifth journal due to the students’ struggles to find other examples other than a raffle. However, the level of reflection was not hindered because of this challenge.
Although the students struggled to think of problems similar to the “Gumball Problem,” the journal entries for week five still improved overall with regard to reflection. The students provided more defending statements to the three questions. Students explained that their solutions would convince other people that their solutions were correct because they completely solved the problem. Moreover, students explained how they used numbers, variables, and symbols moderately well with the reflection varying from very detailed steps to statements that lack reason. Lastly, the students struggled to determine similar problems to the “Gumball Machine” problem. Most students suggested that a raffle would be similar to this problem, but more general probability problems were not suggested. Overall, the journal entries improved with regard to reflection, as compared to the previous four weeks’ entries.

The sixth week’s journal entries were based on the “Putt-Putt Problem;” declined in the overall level of reflection; and used prompts 3, 5, and 6 from the Journal Guidelines. With regard to the completeness of the students’ responses, the students were vague in their explanations. For example, a student explained that her solution “could convince others” that she was correct, if she “just explained exactly” how she used “important things.” This was a very vague statement because she did not elaborate on “important things.” Other students also wrote that their explanations were acceptable, but did not include any reasoning for that statement. An example of a lower-level response to this prompt was “Yes Yes I included how I got my solution.” This statement did not include any reference to important components to the student’s solution, which would have provided support to their statement.

The fifth prompt asked the students to reflect on how they used mathematical tools to solve the problem. Students’ responses varied with regard to this prompt. For example, one student stated that the brain was a mathematical tool, but did not justify it. Other students
explained that they either needed a protractor or just used a drawing. As an example, one student explained that she did not need mathematical tools because she had played putt-putt in the past. A student that reflected better than the previous two examples stated that she could visualize the path of the ball, so she chose not to use other tools, such as protractors. These three examples show that the students reflected at all levels when they responded to this question. This trend continued in responses to the sixth question.

The sixth question asked students to explain patterns and how the patterns helped them solve the problem. Most students noticed that the angles of incidence and reflection were equal, but varied in their reflection. One student explained that the angles helped them “line it up so it goes in.” Another student explained that the angles helped him determine a direction in which the ball should be hit. Other students simply stated that the angle of incidence is equal to the angle of reflection without explaining how it helped them. For example, a student wrote that “the ball bounced of [off] the wall at the same angle that it came in at.” Since students explained how angles helped them solve the problem, while others did not, the students’ levels of reflection varied when answering the last question.

Combining the trends from the sixth journal entry the students had low or moderate levels of reflection. The students did not expand on their responses. They answered only the questions, and most students did not explain how or why they answered the way that they did. For example, some students simply responded “yes” to whether or not they believed their solution would convince other people that they are correct. Some people did not explain why they felt that way. Because most students only reflected at low or moderate levels, there was no evidence to suggest that the students engaged more deeply in the Eight Practices. The lack of support provided by the students to defend their solutions supports the previous statement.
Conclusion

In the study, students solved real-world problems and reflected on their solutions each week for six weeks. The students were surveyed two days before and after journal writing began and ended, respectively. The surveys showed that students agreed with most of the statements presented. Students made a small change in their engagement in the Eight Practices based on the scores on the pre- and post-assessments from the Standards for Mathematical Practices rubric. The scores for the individual problems were inconsistent week-to-week, and went up or down depending on the problem asked. Finally, the journal entries showed low to moderate reflection for the majority of the entries, and the trends showed that the students did not necessarily engage more deeply in the Eight Practices based on their journal entries.
Chapter 5—Discussion

Introduction

This chapter contains a discussion of the findings presented in Chapter 4. The major findings, on which the discussion is based, are as follows. First, the pre- and post-survey data showed that the students agreed, in general, with most of the surveys’ prompts. Second, the journal entries indicated that the students had low or moderate levels of reflection, in general, and did not expand very well in their writings. Lastly, there was a slight increase in the scores from the pre-assessment to the post-assessment; however, the scores from the six problem sets were inconsistent, and there was no general trend that was found. The lack of a trend could be attributed to the individual problems or perhaps the length of the study.

This chapter is organized as follows. The data from the pre- and post-surveys are the most interesting, so they are discussed first. Following the discussion of the surveys’ data, the data from the journal entries are discussed. Before the implications for practice and recommendations for further research, the data from the problems and assessments are discussed. Any implications for practice and recommendations for further research conclude the paper.

Discussion of Findings

The data explained in the previous chapter answered the research question, in general. As a reminder, the research question was as follows: how do students’ perceived mathematical literacy, perceived abilities to engage in the Eight Practice, and actual abilities to use the Eight Practices change after solving real-world problems and writing in a reflective journal. The data from the surveys and journal entries showed that real-world problem-solving and journal-writing could be useful in the math classroom. In addition, the students showed little increase in their
actual abilities to use the Eight Practices, as determined by the data from the assessments and problems’ solutions. Despite these findings, the researcher still believes that real-world problem-solving and journal-writing could be useful in a better structured classroom over a longer period of time. Math teachers must incorporate real-world problem-solving and journal writing in the classroom, so that the students’ problems-solving and argumentation skills improve.

To begin, mathematics educators often encounter the question, “Why do I need to know this?” The students usually wonder when they will ever use mathematics in their lives. According to the Part A of the surveys, the students believed that math is important to their current lives and in their current social and private lives. What this means is that the students understand the importance of mathematics to multiple facets of their current lives. In some way or another, they see the subject as useful day-to-day. Therefore, the students’ perceived mathematical literacy improved slightly, which suggests that the students gained a better understanding of how math can be applied in their everyday lives, a purpose of the study. Moreover, the data from Part A of the surveys suggested that the students understand that math skills are useful in their future lives, which include their careers, citizenship, and general functionality. In relation to the research question, these findings further reinforce that their mathematical literacy has slightly improved. It was reassuring, from a math teacher’s standpoint, that the students considered math important to their current and future lives, since these skills must be refined in the classroom. Lastly, the students also believed that they were able to reason logically and construct viable arguments. Since the definition of mathematical literacy includes a portion designated to proper arguments, these data also support that the students’ perceived mathematical literacy increased from the beginning to the end of the study.
The data from Part A of the surveys supported the purpose of this project. The data supported that the students’ mathematical literacy increased by the end of the study. The increase in the students’ mathematical literacy suggests that real-world problem-solving could be helpful in developing the students’ mathematical literacy by exposing them to useful and relevant problems. Moreover, it could also be beneficial to students, if they write in a reflective journal, in which they answer questions that pertain to the real-world problems. Since a purpose of the study was to determine if students’ perceived mathematical literacy changed from start to end, the data help support that their perceived mathematical literacy has changed. In addition, the study also examined changes in the students’ perceived abilities to engage in the Eight Practices; the data from Part B of the surveys dealt with this purpose.

The data from Part B suggests that the students’ perceived abilities to use the Eight Practices slightly increased throughout the study; therefore, the data support the research question. What the data from Part B explain is that students generally understand problems and believe they are able to work with numbers and symbols. This suggests that less time could be spent on understanding the meaning of problems and symbols, while spending more time on problem-solving methods or strategies. Furthermore, students might need less help with using computers or calculators to solve problems, whereas they may need more assistance with modeling problems. Although the students were all comfortable with using a four-function calculator, more instruction would be needed on how to use a graphing calculator or computer to solve problems mathematically. Solving problems using technology is a skill that needs practice, just as students need more practice in modeling problems.

Of the prompts in Part B, prompt eleven, which asked students about modeling using mathematics, scored the lowest, but the students still agreed that they could do it. Since the
students were confident in their abilities to model mathematically, it might be easier to improve these skills because of their self-confidence. Parts of these skills are finding patterns, shortcuts, or general methods, for which the students always searched, according to their responses. Since the students look for these patterns, they could need some coaching in how to be more efficient pattern-, shortcut-, or general-method-finders. Again the data regarding modeling and pattern-finding support the research question that the students perceived abilities to engage in the Eight Practices increased slightly over the course of the study. Problem-solving skills like modeling or pattern-finding are important to students’ mathematical success. In addition to solving the problem, the students should also explain their reasoning.

Over the course of the study, the students’ perceptions of whether they could argue precisely and evaluate others’ arguments increased, which might imply that they gained confidence through journal writing. Since arguing precisely and evaluating others’ arguments are logical skills that are expected in the Eight Practices, the data support the research question. These data explain that differences in the students’ perceived abilities to use the Eight Practices, which was a purpose of the study. Moreover, the students’ gains in their perceptions of their arguing abilities might be attributed to journal writing, which asked the students to explain various aspects of their solution. The journal prompts required the students to explain their reasoning, which could have influenced the precision of their writing; consequently, the students’ response scores were slightly higher with regard to argumentation on Part B of the post-survey.

The increase in scores on Part B of the surveys supported the research question, which regarded the students’ perceived engagement in the Eight Practices. Because the students believe that they are able to find patterns, use technology, model with math, and construct mathematical arguments, it might be easier to improve their problem-solving abilities through
real-world problems and journal writing. Whether or not the students believed that journal writing helped improve their abilities to engage in the Eight Practices and their mathematical literacy was answered in Part C of the post-survey.

According to the data collected from Part C of the post-survey, the students found that journal writing was helpful. The median scores revealed that the students agreed with every prompt in Part C. Therefore, journal writing could help the students’ self-perceptions as problem solvers and could help improve their mathematical literacy. These findings answered the research question, in that the students determined that journal writing aided them in seeing how math could apply to their current and future lives. Based on these data, it is clear that the students’ believed that journal writing had an effect on their problem-solving skills and mathematical literacy; however, we cannot be certain that journal writing had any direct effect on their actual abilities to engage deeper in the Eight Practices. Having said this, journal writing could serve as an avenue to more rapidly improve the students’ use of the Eight Practices, which would help develop their problem-solving skills.

In addition to developing their problem-solving skills, the students must also develop their abilities to explain their solutions. The journal entries were designed to determine if journal writing helps improve the students’ abilities to engage in the Eight Practices and their mathematical literacy. Overall, the students had low to moderate levels of reflection throughout most of the entries. The levels of reflection varied from student to student and problem to problem, but some insights could be drawn from the entries.

The fact that the majority of students’ levels of reflection were low or moderate may be explained by different factors. First, this was the first time that the students ever wrote in a
reflective journal that asked them to answer questions about their problem-solving skills. Therefore, the unfamiliarity or discomfort with this type of writing could have influenced their levels of reflection. Second, the students rarely expanded in their responses. As explained before, many students simply answered with “yes,” “no,” or a short sentence. If the students explained “how” or “why” they responded the way they did, then their levels of reflection would have improved. Had the students taken more time and been given multiple examples of journal entries, their levels of reflection could have improved.

The last statement in the above paragraph leads to one more point. Although the students’ level of reflection was low to moderate, journal writing still served as a valuable experience, especially based on the data from the survey. Together, the journal entries and Part C of the post-survey imply that the students would learn very much about their mathematical problem-solving skills and could improve on those skills by writing in a reflective journal, since they believed that journal writing helped their engagement in the Eight Practices and their mathematical literacy. Being able to explain one’s reasoning, when solving a mathematical problem, should be made a priority in a math classroom. The benefits that the students saw to journal writing and the evidence that some students reflected well, on occasion, showed that journal writing can make an impact in the math classroom.

Journal writing in the math classroom can be used to write about solutions to real-world, mathematical problems, as it was setup in this study. The real-world problems are relevant to the students, and that makes learning mathematical concepts more valuable. Once the students solve the problems, they can reflect on their solution methods, which might help them improve their methods the next time. The data gathered from the six real-world problems, which include the
pre- and post-assessments, showed that the students were inconsistent in their use of the Eight Practices, and it could be attributed to the types of problems.

The pre- and post-assessments indicated that there was a slight increase in the students’ abilities to use the Eight Practices when solving real-world problems; however, based on the four other problems used in the study, the inconsistencies found in the students’ solutions refute that the students’ actually improved in their abilities to use the Eight Practices. Therefore, the findings based on the assessments and the other problems do not support the research question. The students’ actual abilities to engage in the Eight Practices did not improve. The researcher believes that there are two main reasons as to why the students’ abilities to use the Eight Practices did not improve—problem dependency and the length of the study.

Over the course of the study, the students only used certain mathematical practices when they were needed. An example is the use of calculators. In certain problems, such as the “Dart Board” and “Gumball Machine” problems, the students needed calculators. However, in other problems, such as the “Pool” problem and the “Putt-Putt” problem, the students did not need a calculator. So, the students used mathematical tools differently depending on the problem. Another example would be the students’ use of diagrams. In the “Reactor” problem and the “Putt-Putt” problem, the majority of the students drew pictures to solve the problems. On the other hand, few students drew pictures to solve the “Dart Board” problem. These examples show that the engagement in the Practices was conditional. Another thought is that the study may not have been long enough to see improvements. Engagement in the Eight Practices requires much practice on a variety of problems, which must be accompanied by solid feedback. In a six week time period, it was difficult to foster use of the Eight Practices, since the students
were not necessarily in a routine and six weeks may not have been sufficient time for the
students to read and apply feedback to many problems.

All together, the assessments and the problem sets implied two things. First, as
mentioned above, the number of Practices that the students engage in is problem-dependent.
Second, solving real-world problems can help the students practice using the Eight Practices.
Despite their lack of improvement, at some point in the study, the students used each practice.
Had the study been longer and the problem set improved, the researcher believes that the
students’ problem-solving skills would have improved and changes in their abilities to use the
Eight Practices would have been seen. The reason for this thought was that the students believed
that some of the problems were interesting and were willing to solve them. As a full-time
teacher in a structured classroom, the researcher believes that expectations could be set forth that
the students would follow, and, in turn, make an impact on their problem-solving skills.

In summary, the data from the study supported the research question, in general. The
data suggested that students’ perceived mathematical literacy and perceived engagement in the
Eight Practices increased. They also believed that journal writing helped improve their
mathematical literacy and their use of the Practices. Together these implied that real-world
problem-solving and journal writing could help the students become better problem solvers. It
might be easier to improve on problem solving skills, since the students’ self-confidence was
high. Furthermore, journal writing could be used to help the students explain their reasoning and
to consider new solution methods. The assessments and the solutions to the problems implied
that their actual abilities to engage in the Eight Practices did not necessarily improve. The
problem solutions implied that engagement in the Eight Practices is problem-dependent, and that
real-world problem-solving could be useful in a better structured classroom.
Implications for Practice

The discussion of the data in the study has some implications for practice. In particular, there are two main implications, which have already been hinted at in the study. First, real-world problem-solving is valuable. These problems are relevant to the students, and, consequently, pique their interest, while still reinforcing the mathematical concepts. Second, journal-writing can help the students’ argumentation and writing skills. As a result, students’ problem solving methods could improve.

Real-world problems that are relevant to the students’ lives could give them opportunities to use mathematics in meaningful scenarios, which could deepen their understanding of mathematical concepts and pique their interest. Problems that are relevant to the students are more motivating and students’ interest might be piqued. As math teachers, if we could use students’ interests and relevant scenarios to create problems or projects for the students to complete, the students’ understanding of the concept would deepen. By incorporating scenarios, such as data from a meaningful study or a recent real-world event, we can show students how math applies to their everyday lives. Projects could be based on careers and problems relating to those careers to show the students how math could be applied to their future lives. The researcher believes that real-world problem-solving could show the students the value of their learning, which would create a more meaningful experience. What could enhance their problem-solving skills and writing skills is journal-writing.

Journal writing in the math classroom could be a beneficial experience for the students. Journal writing can help the students improve their problem-solving skills by reflecting on their solutions to previously solved problems. Students could write about different strategies or look
for components of their solution that would change. Journal writing could also be used to enhance argumentation skills, since students could be asked to defend their solution and explain why it is correct or incorrect. Finally, journal writing gives students an opportunity to collect artifacts and see their growth throughout the year. Journals can be kept as a type of project, in which the students see how their writing and problem-solving skills improved throughout the year.

The researcher has two final comments about using journal writing in a math classroom based on the teacher-researcher’s experiences in this study. First, several students may not have used mathematical journal writing before it is implemented. Therefore, it is imperative that the teacher gives multiple examples of appropriate and thoughtful journal entries; these will give the students goals to achieve throughout the year. Second, journal writing should always be deemed important and a routine put in place. The students might not believe that writing in the math classroom is important. Thus, teachers must sell that journal writing will benefit the students. A routine must be established because routines will help the students become acclimated to journal writing. After two weeks of journal writing on Fridays, the students in this study began to expect journal writing and came fully prepared. Overall, a routine helped the students to transition more smoothly into journal writing.

Recommendations for Further Research

As this paper concludes, the researcher has two suggestions for further research. The first suggestion is to investigate journal-writing as an assessment tool. Throughout this study, the researcher saw that journal writing could tell a teacher much about their students’ learning. Since journal writing is not often used in the math classroom, it might be beneficial to investigate
how journal writing influences comprehension of mathematical concepts, or how journal writing helps students communicate their strengths and weaknesses. For example, some students in this study explained that they did not understand some problems. If math teachers would use journal writing to ask questions about mathematical concepts, the students would be able to communicate their comprehension and the teacher could make instructional adjustments. The researcher also found that journal writing helped the teacher better understand the strengths and weaknesses of the more reserved students, since they did not ask or respond to questions very often.

Another recommendation for research is to examine real-world projects. Project-based learning is becoming more prevalent, and projects that incorporate careers and problems that arise in everyday life could be worthwhile for the students to investigate. Using real-world projects would extend the idea of real-world problem-solving presented in this paper. For example, it would be worthwhile for students to investigate problems in physics, chemistry, accounting, business, engineering, medicine, or other careers that involve math. By having the students create projects based on these problems, the students can learn how to model mathematically; learn how approximations can be beneficial; learn the mathematical concept; and investigate potential future careers. Any time educators can make the students’ learning meaningful, it should be done, and problem-based learning using real problems could be one method.
Conclusion

The findings of this project supported the research question and had some implications for the classroom. Based on the data from the surveys, it might be beneficial to implement real-world problem-solving in the classroom, since the students’ perceived mathematical literacy and engagement in the Eight Practices increased. Although the assessments and problem sets did not reveal a trend to suggest that the students’ actual use of the Eight Practices increased, some of the better solutions suggested that real-world problem solving can help students see the value of mathematics in their current and future lives. Moreover, the students felt that journal writing helped improve their mathematical literacy and their engagement in the Eight Practices based on Part C of the post-survey. This implied that journal writing could be helpful in the math classroom, since the students believed that it was beneficial. Journal writing must be well-organized and the students should have plenty of well-written examples, after which they could model their writing. If this is done, the researcher believes that the students’ argumentation and problem-solving skills would improve, because reflective journal writing not only helps the students defend their arguments, but it also forces them to consider alternative solutions. Altogether this data and these implications supported the research question to some extent. Only the students’ actual engagement in the Eight Practices cannot be considered to have improved throughout the study. Their perceived mathematical literacy and perceived use of the Eight Practices did improve, and the students concluded that journal writing was beneficial to this change.
References


Appendix A
Pre-survey
Survey

Please complete the survey and return it to me before the end of class. Do not put your name on this paper.

Please circle a number 1 - 5. The numbers stand for the following statements:

1—Strongly Disagree  2—Disagree  3—Neutral  4—Agree  5—Strongly Agree

Part A
1. I am able to reason logically. 1 2 3 4 5
2. I am able to successfully use supporting arguments to make decisions. 1 2 3 4 5
3. Being able to use math is important to my current life. 1 2 3 4 5
4. I use will use math in my future job. 1 2 3 4 5
5. I need math skills in order to be a productive U.S. citizen. 1 2 3 4 5
6. Math skills are used (will be used) in my (future) social and private lives. 1 2 3 4 5
7. I must be able to understand math to function in the real world. 1 2 3 4 5

Part B
8. I am able to understand a problem and stick with it to find a solution. 1 2 3 4 5
9. I am able to work with symbols and with numbers. 1 2 3 4 5
10. I can make practical arguments and analyze other peoples’ arguments. 1 2 3 4 5
11. I can use math to model a problem and find a solution. 1 2 3 4 5
12. I can use mathematical tools (ex. calculators/computers) to solve a problem. 1 2 3 4 5
13. I can make precise mathematical arguments to defend my solution. 1 2 3 4 5
14. I look for mathematical patterns that help me solve problems. 1 2 3 4 5
15. I look for shortcuts or general methods that might help me solve a problem. 1 2 3 4 5
Appendix B
Post-survey
Survey

Please complete the survey and return it to me before the end of class. Do not put your name on this paper.

Please circle a number 1 - 5. The numbers stand for the following statements:

1—Strongly Disagree  2—Disagree  3—Neutral  4—Agree  5—Strongly Agree

Part A

1. I am able to reason logically. 1 2 3 4 5
2. I am able to successfully use supporting arguments to make decisions. 1 2 3 4 5
3. Being able to use math is important to my current life. 1 2 3 4 5
4. I use will use math in my future job. 1 2 3 4 5
5. I need math skills in order to be a productive U.S. citizen. 1 2 3 4 5
6. Math skills are used (will be used) in my (future) social and private lives. 1 2 3 4 5
7. I must be able to understand math to function in the real world. 1 2 3 4 5

Part B

8. I am able to understand a problem and stick with it to find a solution. 1 2 3 4 5
9. I am able to work with symbols and with numbers. 1 2 3 4 5
10. I can make practical arguments and analyze other peoples’ arguments. 1 2 3 4 5
11. I can use math to model a problem and find a solution. 1 2 3 4 5
12. I can use mathematical tools (ex. calculators/computers) to solve a problem. 1 2 3 4 5
13. I can make precise mathematical arguments to defend my solution. 1 2 3 4 5
14. I look for mathematical patterns that help me solve problems. 1 2 3 4 5
15. I look for shortcuts or general methods that might help me solve a problem. 1 2 3 4 5

Part C
16. Journal writing helped me better understand problems. 1 2 3 4 5
17. Journal writing influenced how I used symbols and numbers in problems. 1 2 3 4 5
18. Journal writing helped improve my ability to make and analyze arguments. 1 2 3 4 5
19. Journal writing helped me understand how to use math to model problems. 1 2 3 4 5
20. Journal writing helped me see how to use mathematical tools. 1 2 3 4 5
21. Journal writing helped me learn how to communicate my ideas more clearly. 1 2 3 4 5
22. Journal writing helped me learn how to look for patterns in my reasoning. 1 2 3 4 5
23. Journal writing helped me learn how to look for shortcuts. 1 2 3 4 5
24. Journal writing showed me how math can be used in my current life. 1 2 3 4 5
25. Journal writing showed me that having math skills can help me in the future. 1 2 3 4 5
Kim is playing Bob in a game of pool. To win, Kim only has to make the 8-ball (the black ball). When Kim shoots at the 8-ball, she cannot hit the 5-ball before she hits the 8-ball, and she must hit the 8-ball. Otherwise, Bob can put the ball wherever on the table that he chooses and Kim could lose the game.

a) Where should Kim hit the cue ball (the white ball) in order to give herself the best chance at hitting the 8-ball and also avoiding the 5-ball? Explain your answer. You don’t need any other dimensions.

b) What are some real-world factors might influence this problem?

Questions to answer in your journal: 1, 6, 8
Appendix D
Prompt 2
Reactor Problem

Civil engineers design structures that are used in society. A team of civil engineers has the task of building two identical, nuclear reactors within a fenced area. Each reactor is shaped as in the picture below. They do have circular bases. The fenced area is a square measuring 200 feet by 200 feet. Determine where the engineers should build these two reactors inside the fenced area, if they are supposed to build the largest reactors possible. Largest possible refers to the size of the reactors’ bases. If you can, determine the dimensions of the reactors assuming they are 250 feet tall. Explain any real-world factors that might influence how and where these reactors are actually built.

Journal Questions: 3, 7, 8
Appendix E  
Prompt 3  
Remodeling a Room

A family wants to remodel their living room. They want to re-carpet and paint all of the walls. The ceiling in the living room is 10 feet high, and the shape of the room is diagrammed below.

They have contacted two contractors and have to decide on which to choose. The contractors charge the following.

<table>
<thead>
<tr>
<th>Contractor</th>
<th>Fixed Labor Cost</th>
<th>Cost Per Gallon of Paint (One gallon covers 350 square feet)</th>
<th>Cost per square foot of carpet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Really Fast Remodeling</td>
<td>$215</td>
<td>$18.50</td>
<td>$14.00</td>
</tr>
<tr>
<td>Tear-Down and Restore</td>
<td>$205</td>
<td>$21.00</td>
<td>$12.50</td>
</tr>
</tbody>
</table>

Which contractor should the family use? Explain your reasoning mathematically and in words.

Questions for the journal: 4, 7, 2
Appendix F
Prompt 4

Dart Problem

Jake and Sara are playing darts, and they are tied with 33 points left. In darts, the person who gets to zero first wins. Each dart thrown will reduce the score. For example, if Jake hits six, then her new score would be 27 points (33-6=27). In addition, you can’t score more points than you have left. For example, if Sara has 33 points left and she hits two 20s, then she will score 40 points; however, 40 is more than 33, so she went over her score. She is not awarded any points, and still remains at 33.

In darts, each player rotates throwing three darts. Jake and Sara play on a special dart board below. Jake goes first and scores 25 points. Sara knows that Jake will win with her next three shots, so she needs to get to zero with her next three shots. How many different ways can Sara win this game in three shots? What are the chances that Sara wins if her plan is to hit one 20 and a 13?

*Note: they are not playing by the rules that the winner must hit a double. You can also ignore the double and triple ring.

The area of a circle is $A = \pi r^2$ and the circumference of a circle is $C = 2\pi r$.

Questions for the journal: 1, 4, 9
Appendix G
Prompt 5

Gumball Machine

In a gumball machine with a 15-inch diameter globe there are only ten white gumballs. If you get a white gumball, you win $100. The average gumball is about one inch in diameter, and you can assume that it is completely filled with gumballs. So, it’s not like the picture, in which some gumballs are missing. What is the approximate probability that you win $100?

The surface area of a sphere is $S = 4\pi r^2$ and the volume of a sphere is $V = \frac{4}{3}\pi r^3$.

Journal Questions: 10, 2, 3
Appendix H
Prompt 6 (Post-assessment)—Putt-Putt Problem
Putt-Putt Problem

Jim and Morgan are in a putt-putt contest, and Jim needs to make his next putt or he loses. How does Jim need to putt the ball so that he has the best chance of making the ball in the hole? Explain your answer. You do not need other dimensions to come up with a solution.

What other factors might come into play in a real scenario that would influence your answer?

Questions to answer in your journal: 3, 5, 6
Appendix I
Rubric Entitled Standards for Mathematical Practice
Draft 1/2011 Adapted from Common Core State Standards for Mathematics: Standards for Mathematical Practice

Teacher(s): Mathematical Topic(s): Date:

1. Makes sense of problems and perseveres in solving them
   - ☐ Understands the meaning of the problem and looks for entry points to its solution
   - ☐ Monitors and evaluates the progress and changes course as necessary
   - ☐ Analyses information (givens, constraints, relationships, goals)
   - ☐ Checks their answers to problems and ask, “Does this make sense?”
   - ☐ Designs a plan

   Comments:

2. Reason abstractly and quantitatively
   - ☐ Makes sense of quantities and relationships
   - ☐ Represents a problem symbolically
   - ☐ Considers the units involved
   - ☐ Understands and uses properties of operations

   Comments:

3. Construct viable arguments and critique the reasoning of others
   - ☐ Uses definitions and previously established causes/effects (results) in constructing arguments
   - ☐ Makes conjectures and attempts to prove or disprove through examples and counterexamples
   - ☐ Communicates and defends their mathematical reasoning using objects, drawings, diagrams, actions
   - ☐ Listens or reads the arguments of others
   - ☐ Decide if the arguments of others make sense
   - ☐ Ask useful questions to clarify or improve the arguments

   Comments:

4. Model with mathematics.
   - ☐ Apply reasoning to create a plan or analyze a real world problem
   - ☐ Applies formulas/equations
   - ☐ Makes assumptions and approximations to make a problem simpler
   - ☐ Checks to see if an answer makes sense and changes a model when necessary

   Comments:

5. Use appropriate tools strategically.
   - ☐ Identifies relevant external math resources (digital content on a website) and uses them to pose or solve problems
   - ☐ Makes sound decisions about the use of specific tools. Examples may include:
     - ☐ Calculator
     - ☐ Concrete models
     - ☐ Digital Technology
     - ☐ Pencil/paper
     - ☐ Ruler, compass, protractor
   - ☐ Uses technological tools to explore and deepen understanding of concepts

   Comments:

6. Attend to precision.
   - ☐ Communicates precisely using clear definitions
   - ☐ Provides carefully formulated explanations
   - ☐ States the meaning of symbols, calculates accurately and efficiently
   - ☐ Labels accurately when measuring and graphing

   Comments:

7. Look for and make use of structure.
   - ☐ Looks for patterns or structure
   - ☐ Recognize the significance in concepts and models and can apply strategies for solving related problems
   - ☐ Looks for the big picture or overview

   Comments:

8. Look for and express regularity in repeated reasoning
   - ☐ Notices repeated calculations and looks for general methods and shortcuts
   - ☐ Continually evaluates the reasonableness of their results while attending to details and makes generalizations based on findings
   - ☐ Solves problems arising in everyday life

   Comments:
Appendix J
Journal Guidelines

Advanced Geometry Journal: Format and Rubric

Purposes

1. To practice solving real-world problems and reflect on how you solved them.
2. To build problem-solving abilities and mathematical vocabulary.
3. To reflect on and improve your mathematical reasoning and explanation.

So, what should you write about?

First, there will be weekly prompts for you to write about. You will be expected to answer those prompts completely. When answering those prompts, you should think about the following list of questions. You do not need to answer all of these questions. I will tell you to answer two questions from this list for each entry.

1. Was the problem easy or hard to understand? Why?
2. How did I use symbols, variables, and numbers to solve the problem? Explain.
3. Was my explanation complete? Would it convince someone else that my answer is acceptable? What are important things to include in an explanation of my solution?
4. How did I change the problem’s words into math?
5. How did I use tools to solve the problem? (e.g. calculator, ruler, compass, computer,...)? If I didn’t use anything besides a pencil/pen and paper, why didn’t I use other tools?
6. What patterns did I see while solving the problem (e.g. repeated thoughts, calculations, ...)? How did they help me? If I didn’t see patterns, why not?
7. How long did it take me to figure the problem out? Did I stick with the problem?
8. How could I solve the problem differently?
9. How did my thinking process change as I worked through the problem? Could there be any shortcuts?
10. What are some other real-life problems that are similar to the problem you just solved?

Second, the journal is yours. Feel free to write about whatever you would like me to read. You must answer the weekly prompts, but you can write about anything that you want after you are done with the prompts. Be sure that your entries are school-appropriate.
appropriate. In addition, you may decorate, color, or design your journal in any way that you choose.

You have to...

1. Write one entry per week. You must answer all of the questions in the prompt. Each entry should be dated and numbered. I will adjust homework and accommodate for time to study for tests and quizzes. So, don’t worry; this won’t bog you down.
2. You should write to answer the prompt completely. Your entry should be at least one full page. If you need to write more than one page to answer the prompt, make sure you do so.
3. **Be school appropriate. If you write it, I will read it. If the entries are not appropriate, I will turn in your journal to the administration.**

You get to...

1. Write in any color you want (except highlighter yellow—it will blind me).
2. Format your journal any way you want.
3. Design, decorate, or color your journal any way you would like.
4. Be creative in your responses.

Grading

Each journal entry will be graded out of 10 points. I will use the rubric that is at the end of this paper to grade your entries. You will submit one entry per week. The entries should be as neat and organized as possible.

Confidentiality

Your journals will not be shared with anyone else except the teachers. If you would like to share some of your entries, you are more than welcome. If you ever want me to share your entries, I will. You never have to share any entries. These journals are yours, so you make the decisions about who reads them besides me.

Rubric

You will never lose credit for an incorrect answer. Your grade is based off of effort and the rubric below. This is intended to be different, fun and to improve your grade. In order to improve your grade, you must do the assignments and do them well. ANY LATE SUBMISSION WILL BE SCORED AS USUAL, BUT WILL ONLY RECEIVE HALF
OF THE POINTS THAT IT EARNs. IN OTHER WORdS, THE MAX SCORE YoU CAN GET IS 5/10 IF YOU TURN IT IN LAtE.

<table>
<thead>
<tr>
<th>Length</th>
<th>2 points—The entry is about one page in length.</th>
<th>1 point—The entry is between $\frac{1}{2}$ and 1 page in length.</th>
<th>0 points—The entry is $\frac{1}{2}$ page or less in length.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prompts</td>
<td>3 points—The student answers all of the questions completely. The student's answers relate to the prompt.</td>
<td>2 points—The student answers most of the questions and these answers relate to the prompt.</td>
<td>1 point—The student does not answer the prompt or the answer is irrelevant.</td>
</tr>
<tr>
<td>Reflection and explanation</td>
<td>3 points—The student clearly reflected on how they solved the problem, and why they used their method. The answers are detailed and thoughts are organized.</td>
<td>2 points—The student showed some reflection by explaining either how they answered the problem or why they chose a certain method. The answers are somewhat vague and the thoughts are organized.</td>
<td>1 point—The student attempted to reflect on their solution to the problem, but their thoughts are disorganized and ideas are unclear.</td>
</tr>
<tr>
<td>Organization</td>
<td>2 points—The entry is dated, numbered, and organized into a solution and paragraph explanations.</td>
<td>1 point—The entry is dated and/or numbered, the solution is clearly marked, and the explanation is not organized into paragraphs</td>
<td>0 points—The entry is not dated or numbered, the solution is not apparent, and the explanations are not organized into paragraphs.</td>
</tr>
</tbody>
</table>
Grammarly found 33 critical writing issues and generated 1 word choice correction for your text.

Score: 62 of 100
(most issues resolved)

Plagiarism
✓ The text in this document is original

Contextual Spelling Check
6 issues
- Spelling (6)
- Ignored words
- Commonly confused words

Grammar
21 issues
- Use of articles (3)
- Sentence structure (4)
- Wordiness (11)

Punctuation
4 issues
- Punctuation within a sentence (1)
- Capitalization (3)

Style and Word
2 issues
- Verbiage (2)

Get a FREE 7-day trial

Full name

E-mail

Re-enter E-mail

Preferred password

I'll use Grammarly mostly for:

-- Please select --

How did you hear about Grammarly?