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The Impact of Problem-Based Learning on Students Critical Thinking Skills and Peer Relationships

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The Impact of Problem-Based Learning on Students Critical Thinking Skills and Peer Relationships

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ABSTRACT

Education is a field that is constantly in motion. It is changing and adapting as educators and researchers try new concepts or ideas. One shift is implementing mathematics curriculums that focus on problem-based learning. Throughout researching problem-based learning, there was a theme of its impacts on 21st-century skills that students possessed. Therefore, these research questions were created: How does problem-based learning in mathematics impact the critical thinking skills of middle school students? What is the impact of increased opportunities for critical thinking on students' collaboration with each other? Learners in an 8th-grade Algebra 1 class took a Likert survey at the beginning of the study, and then they proceeded to work through a three-week mathematics unit created around problem-based learning. Students took the same survey at the end of the unit. The results of the survey were compared. The researcher also completed a journal to document informal observations of critical thinking and collaboration in the classroom. The survey showed an increase in learners' viewpoints on their critical thinking skills. Learners went from not actively processing a concept to pausing and analyzing a situation and topic, then collaborating with those around them to preserve through the challenge.

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CHAPTER 1

INTRODUCTION

Introduction

Problem-solving is a crucial skill as we advance in the 21st century, and it is something that is lacking in mathematics curriculums. While working with middle school students in mathematics, there has been a typical pattern where students miss a deep understanding of the content and a method of working through unfamiliar problems. Students often will come across unknown problems and be unable to reason through them due to a lack of problem-solving skills.

Brief Literature Review

In the last decade, there has been a shift from lecture-style classrooms to classrooms focused on incorporating opportunities to build students' skills in areas that will help them succeed in locations outside of the school, these classrooms are following a problem based learning style curriculum. There are a variety of thoughts on the best way to teach students mathematical content. Still, an extensive range of information supports the benefits of problem-based learning for students both academically and outside of the school setting. Problem-based learning is challenging to implement. Educators need support to implement the curriculum effectively. Those supports include high-quality instructional resources, practice-based learning opportunities, and collegial learning that allows sharing of knowledge and commitment (Lewis et al, 2012). These supports enable teachers to help students productively struggle and ask them to get themselves 'unstuck' from problems. In addition, the supports allow teachers to not complete the problem for the students but allow students to process the information at a deeper level (McCallum, 2019).

Problem-based learning curriculums also help students build many critical 21st century skills that they will need as they continue past high school. For example, working through complex problems allows students to use creative and abstract thinking (Gerlings, 2018). In addition to creative and abstract thinking, VanTassel-Baska mentions these skills are also increased due to problem-based learning, higher levels of thinking, question asking, metaphor development, enhanced motivation, curiosity, reflection, and leadership skills (VanTassel-Baska, 2013). When students collaborate within a problem-based learning classroom, they practice and refine these skills.

Statement of the Problem

The research focuses on the outcomes of a problem-based learning curriculum and its effect on students. This study will include how problem-based learning will impact the critical 21st-century skills that students are developing. In addition to adjusting how the mathematics curriculum has been delivered in the last decade, the jobs available for students after completing college have also changed. Jobs in the United States are becoming more STEM (Science, Technology, Engineering, and Mathematics). These jobs focus on collaboration, teamwork, and critical thinking (Fajrina et al, 2020). Because of this shift in the focus of employment, preparing students for life after school is increasingly essential, and problem-based learning has been shown to increase these skills in students.

Purpose of the Study

This study aims to gather information from both teacher and student perspectives on the power of problem-based learning and also how problem-based learning is implemented in a

classroom. Additionally, I will look at the benefits of problem-based learning on students' academics and collaboration.

Research Questions

How does problem-based learning in mathematics impact the critical thinking skills of middle school students?

What is the impact of increased opportunities for critical thinking on students' collaboration with each other?

Definition of Variables

The following are the variables of study:

- Independent Variable: The researcher will conduct a classroom unit to implement problem-based learning. This unit will focus on teaching students through collaboration and problem-based learning. This unit will also include small lessons on 21st-century skills such as collaboration, teamwork, and problem-solving.
- Dependent Variable: The researcher will survey her students before and after the unit focused on problem-based learning.

Significance of the Study

This study has implications for all involved in education: teachers, students, educational support staff, and parents. The information could provide educators a clearer picture of how to best support students through developing soft skills like working collaboratively and managing time. As educators, we want to provide our students with the best education possible. Providing teachers with the knowledge of how to help the development of additional skills allows them to

structure their lessons more effectively. This knowledge could also help education support staff as they are usually the ones providing the curriculum. Understanding the benefits of a problem-based curriculum would give them more information on making that decision.

Research Ethics

Permission and IRB Approval. In order to conduct this study, the researcher will seek MSUM's Institutional Review Board (IRB) approval to ensure the ethical conduct of Research involving human subjects (Mills & Gay, 2019). Likewise, authorization to conduct this study will be seek from the school district where the research project will be take place (See Appendix B).

Informed Consent. Protection of human subjects participating in Research will be assured. Participant minors will be informed of the purpose of the study via the Informed Consent Letter (See Appendix C). Participants will be aware that this study is conducted as part of the researcher's Master Degree Program and that it will benefit her teaching practice. Informed consent means that the parents of participants have been fully informed of the purpose and procedures of the study for which consent is sought and that parents understand and agree, in writing, to their child participating in the study (Rothstein & Johnson, 2014). Confidentiality will be protected through the use of pseudonyms (e.g., Student 1) without the utilization of any identifying information. The choice to participate or withdraw at any time will be outlined both, verbally and in writing.

Limitations.

This study does have some limitations. The 4esearch will be done partly by student survey, and middle school students are unpredictable with their participation. In addition, the

students will be biased about active class participation. For example, some students might love it, and some might hate it. The students will also have multiple levels of abilities that directly connect with their confidence in speaking and collaborating, which might impact their answers on the student survey.

Conclusions

As we advance into the 21st century, problem-solving is just one of the critical skills that students will need, and it is something that is lacking in many mathematics curriculums. Mathematics courses can be the quickest way to build problem-solving and critical thinking skills. This is often done through discovery and collaboration, but many mathematics curriculums currently are taught in traditional, lecture-based methods. The next chapter provides a deeper view of the current state of problem-based learning supports offered to teachers and the impact that problem-based learning has on students' 21st-century skills.

CHAPTER 2

LITERATURE REVIEW

Introduction

In the last decade of education, there has been a shift in how direct instruction mathematics content has been delivered to our students. There has been a shift to problem-based learning and problem-solving. The change to problem-based learning happens in subject areas throughout the country and at multiple grade levels. This study aims to see how beneficial problem-based learning can be for students' knowledge in the classroom and their 21st-century skill development. There will also be information on why the shift to problem-based learning happens within more and more schools.

Problem-based learning comes in many different forms and can be different for everyone. For this research, the definition of problem-based learning (PBL) will be "collaborative work among students in the decision and solving problems involving conceptually complex material" (O'Brien et al, 2011, p. 149). In addition, I will be using the following definition from the National Council of Teachers of Mathematics for problem-solving: "Problem-solving means engaging in a task for which the solution method is not known in advance. To find a solution, students must draw on their knowledge, and throughout this process, they will often develop new mathematical understandings" (NCTM, 2000).

I have found many opinions on the best learning method to follow within the classroom throughout this research. I have found information on data surrounding the support given to teachers in their classrooms to help make the curriculum more successful and data supporting a schoolwide shift to problem-based learning. In addition, there has been information supporting

the benefits of PBL surrounding mathematics and different subject areas and students' 21st-century skill set.

Body of the Review

Context

Problem-based learning has been implemented in traditional classrooms for the last few years, and there are overarching benefits for students both academically and socially. However, the move from conventional teaching methods to problem-based learning is not always something that comes easily for both students and educators. There can be some pushback or ineffectiveness within the classroom. For problem-based learning to be successful for both students and educators, there are some supports administrations can offer their teachers. One of those is observation and practice (Lewis et al, 2012). Anything new can be challenging. Providing educators the opportunity to observe their fellow educators as they successfully host a lesson is an excellent strategy for helping teachers with implementation. Another strategy that helps is having teachers host problem-based lessons with other teachers to get a feel for allowing productive struggle and asking leading questions. For many educators, it goes against their training to let students struggle through problems, and being able to practice this with other educators can be helpful. Once students and educators adjust to problem-based learning within their classrooms, the different learning styles will often benefit. Those benefits will be revealed through this research and data analysis.

Facilitating Problem-Based Learning

The movement to Problem-Based Learning and working through mathematical content by problem-solving is a difficult task. Facilitation of this shift in the process does not come

easily to teachers, and it is also an adjustment for students. According to findings from Lewis, Perry, Friedkin, and Roth (2012), educators in the U.S. need the following scaffolds to implement PBL within their program successfully; 1) high-quality instructional resources, 2) practice-based opportunities to learn, and 3) collegial learning that allows for sharing knowledge and commitment. The high-quality instructional materials needed include the teacher's manual and common assessments educators give students. The manuals provided to teachers in the U.S. are not laid out to support rich discussion based on mathematics (Lewis et al, 2012). Within teacher's manuals for math curriculum in Japan, around 28% of the statements are dedicated to student thinking and anticipating student moves. In contrast, Lewis, Perry, Friedkin, and Roth (2012) found that only 1% of the statements in the United States teacher manuals were dedicated to the same thing. Another trend that Lewis, Perry, Friedkin, and Roth found was the opportunities for teachers to learn from each other in the United States were low. In contrast, in Japan, teachers "are given frequent opportunities to observe and discuss each other's lessons," this allows them opportunities to be using the same strategies as well as have a common language throughout their classrooms (Lewis et al, p. 371). Ray Bendici (2020) also mentions peer observations within his article *Real Math,* modeling PBL with each other can help educators understand the approach of asking guiding questions and learn from others who have had success with PBL (Bendici, 2020).

Although PBL is a difficult concept for teachers to implement within their classrooms, in addition to the scaffolds listed above, there are keys to facilitating PBL within a school. One important aspect is 'teacher moves' or the role of the teacher (Fi, Degner, 2012). Fi and Degner (2012) produced a list of five teacher moves that will help PBL be more successful within a classroom. They include giving the students the whole task/problem, allowing time for

exploration, focusing on big ideas and then narrowing them, making ideas visible, and providing time for reflection and closure (Fi, Degner, 2012). In addition to teacher moves provided, Polly (2021) found that raising rigorous questions within your classroom is essential, and it's crucial to know when to pose them. Polly's information says that students should start a lesson and engage in mathematics right away without teacher interference. This way, the students can engage in productive struggle and "explore cognitively demanding mathematical tasks" (Polly, 2021, p. 455).

Along with those resources provided by Fi, Degner, and Polly above, McCallum (2019) shares more interventions to implement problem-based learning. McCallum offers three points for implementation, which are as follows; 1) Cultivate positive attitudes about effort, 2) Implement instructional routines, and 3) Resist the urge to intervene too quickly (McCallum, 2019). While working on implementing PBL within classrooms, one of the best practice ideas to continue to engrain within the school is to "believe all students can solve problems on their own and giving them a chance to try." Supporting students in this belief can be challenging but creating an atmosphere where the students are overall positive helps the students have perseverance while working on problems (McCallum, 2019, p.42). Another key to facilitating problem-based learning within a classroom is to continually provide problems for students to work through and do this routinely. According to McCallum, this routine is crucial as it can help push students to have conversations about mathematics at the beginning of the hour. The students know what is expected of them. McCallum's third point for implementing problem-based learning within a classroom is to allow the students to productively struggle and ask them to get themselves 'unstuck' from problems, to not complete the problem for the students

(McCallum, 2019). Students need the opportunity to attack problems and use their critical thinking skills to work through the problem.

The concepts mentioned in implementing problem-based learning within classrooms revolve around ideas to help students be successful. Kress (2017) focused their article on ways to engage students through question-asking. According to Kress (2017), there are six essential questions to help students through problem-solving. These questions are designed to be a framework for supporting students while still reflecting "the belief that all students can learn and do mathematics" (Kress, 2017, p.192). Kress points out that students experience satisfaction and enjoyment when they can connect the mathematics they are learning now and mathematics from their past. The six essential questions help guide them through those connections and lead them to wonder about future relationships.

Benefits of Problem-Based Learning

A few of the problem-based learning movement's benefits are higher test scores, 21st-century skills, and other subject areas implementing the same philosophy. Hummell (2016) focuses on students' critical thinking skills while learning through a problem-based curriculum. Although the fundamental skills of critical thinking are developed during elementary age years, it is crucial that students can explore, question, experiment, and discover their learning. According to Hummell (2016), each of these helps students "become productive community members," which are the keys to being successful, as well as allows the students to develop rational, productive lives and overall become better citizens (Hummell, 2016, p. 5). Gerlings (2018) adds that working through complex problems in addition to critical thinking skills allows students to use creative thinking and abstract thinking. The students must think outside the box and approach problems differently to find unique solutions. Problem-based learning also allows

students to "understand logical progressions of procedures" and then will enable them to apply that procedure (Gerlings, 2018, p. 417).

Within VanTassel-Baska's 2013 article about *Curriculum Issues* within the gifted and talented curriculum, they also talk about how a problem-based learning curriculum provided additional skill benefits for students, emphasizing students in the gifted and talented population. Some of the skills VanTassel-Baska mentions that are increased due to problem-based learning are higher levels of thinking, question asking, metaphor development, creative thinking, enhanced motivation, curiosity, reflection, leadership skills, and critical thinking (VanTassel-Baska, 2013). These skills are essential to help develop students into their best selves, and problem-based learning naturally helps develop them.

The use of problem-based learning has become higher in subject areas outside of mathematics as well. For example, Fajrina, Lufri, and Ahda (2020) reviewed problem-based learning within Science, Technology, Engineering, and Mathematics (STEM) classes. They found that the 21st-century skills that students were developing within problem-based learning would be fundamental in the future as jobs in "STEM will increase by 17% while non-STEM jobs only increased by 10%" (Fajrina et al. 2020, p. 95). Another piece that they pointed out was that STEM classes aim to increase the use of "critical thinking, creativity, communication, and collaboration known as the 'Four Cs.' These four pieces help students develop independent thinking, direct inquiry, open exploration, self-confidence, flexibility, persistence, teamwork, and leadership (Fajrina et al. 2020, p. 96).

In addition to problem-based learning in STEM classrooms, problem-based learning has found its way into college Chemistry classrooms. In an article from Siburt, Bissell, and Macphail in 2011, they implemented a new problem-based learning curriculum in a one-second semester

chemistry classroom and compared the students learning to a different second-semester chemistry classroom that uses traditional teaching styles. They measured the impact of problem-based learning through a direct comparison between a problem-based learning course and the traditional course. At the end of the semester this study was conducted, they collected student surveys three years in a row, six total semesters. One hundred forty-four students took part in the problem-based learning classroom, and they collected 139 surveys. Siburt, Bissell, and Macphail collected qualitative and quantitative data from their students through the surveys. They collected the following information: 87% of the students preferred the problem-based learning format, 88% thought the format should be continued, 80% found it to be helpful, 87% said that they felt prepared for midterm exams, and 92% of the students said they enjoyed the group work that was required (Siburt et al. 2011). In addition, the comparison that they were able to find was that the problem-based learning class had increased awareness of their thinking, improved teamwork, student participation, deliberate exploration, connection making, and students being able to assess their understanding (Siburt et al., 2011). They also found some interesting quantitative data. Compared to the traditional classroom, the test scores at the end of the semester showed no drastic difference. The problem-based learning course "did not have a negative impact on examination performance, and likely had a positive impact on other areas of learning (e.g., collaborative problem solving, metacognitive skills, etc.)" (Siburt et al. 2011, p. 1493).

The problem-based learning style has also made its way into other college classrooms as well. For example, in an article from Rosenbaum (2015), problem-based learning was also used within a marketing course. This course chooses to implement problem-based learning because "management requires leadership and integrating skills so that managers may solve complex

problems by weaving together different kinds of knowledge" (Rosenbaum, 2015, p. 182). Problem-based learning allowed the students and instructors to have authentic and meaningful discussions while applying knowledge and skills to problems that they might be unfamiliar with.

Another resource that showed quantitative data support for problem-based learning is Sutton and Knuth (2017), they followed a high school that implemented problem-based learning schoolwide. Sutton and Knuth looked at Advanced Placement class participation and scores from before the school implemented problem-based learning and then again after problem-based learning had been taking place for four years. Their observations showed benefits academically as well as socially. The academic findings showed that "the treatment group outperformed the comparison group on multiple AP tests, showing statistically significant gains on AP scores across [multiple classes]" (Sutton, Knuth, 2017, p.68). They also observed the positive effects of problem-based learning on students in non-academic areas, such as their social and emotional development. Sutton and Knuth end their article with this statement, "it is equally important to focus our attention on all the ways PBL can help schools and teachers produce better people" (Sutton, Knuth, 2017, p. 70).

Theoretical Framework

A problem-based learning curriculum has been studied in multiple different settings. The most common way to measure how successful problem-based learning is on students' social and personal development is through interviews and surveys with students and educators and observations. Although to calculate how successful problem-based learning is on the students academically, someone would want to do qualitative results from test scores. This cannot be easy because each class is formulated differently and has different skill levels.

The steps that I will be taking in my research include observing my 8th-grade students and then giving a survey two times. The observations will be looking for the 21st-century skills listed above in theme two and student engagement with the content and their peers. The survey will include student opinions of how the content is delivered within the classroom and their perspective on how their 21st-century skills are impacted.

Research Questions

How does problem-based learning in mathematics impact the critical thinking skills of middle school students?

What are the impacts of increased opportunities for critical thinking on students' collaboration with each other?

Conclusions

After reviewing articles and documents related to the support for teachers to facilitate problem-based learning in their classroom and the benefits of problem-based learning academically and developmentally for students, it is evident that there is strong potential in curriculum based on problem-solving. With the proper support for educators and students, outcomes might not be seen in a traditional classroom.

CHAPTER 3

METHODS

Introduction

Within the last few decades, the teaching style and the layout of mathematic curricula have transitioned. In the history of education, classrooms and the delivery of mathematical content were mainly lecture-based, which is traditional teaching. However, there has been a recent shift to problem-based learning and a teaching style based on collaboration and teamwork. Although problem-based learning is challenging, giving teachers support to facilitate the curriculum means this type of curriculum style can be implemented effectively. Significant support needed for teachers includes high-quality resources, educators' opportunities to practice and learn, and a commitment to sharing knowledge, learning, and expertise between all educators (Lewis et al., 2012). With the proper support for educators, implementing problem-based learning can improve many 21st century skills for students. Working through complex problems with peers allows students to develop critical thinking skills and outside-the-box reasoning and approaches. As a result, students can use problem-based learning to become well-rounded individuals and learn skills essential to taking on future endeavors (Hummell, 2016).

Research Questions

How does problem-based learning in mathematics impact the critical thinking skills of middle school students?

What are the impacts of increased opportunities for critical thinking on students' collaboration with each other?

Research Design

This study used a qualitative research design to collect information about the impact of problem-based learning on students' 21st-century skills, academics, and relationships with peers. A survey combined with journaling was used for this study. The survey was chosen to see how students viewed their critical thinking skills, academics, and relationships at the study's beginning and end. In addition to the survey, journaling from the researcher was used to make observations to draw connections between student viewpoints and educator viewpoints throughout the study.

Setting

This study took place in a large community in the Minnesota Metro area. The school district consisted of multiple communities and contained roughly 12,000 students from kindergarten through twelfth grade. Around the community, there were many different activities such as shopping areas, outdoor activities, and a variety of other interests. Within the school district, the families were vastly different. The study occurred within the middle school during the 2021 – 2022 school year. There are around 1,200 students, and roughly 10% of the students receive free or reduced lunch, and 43% of the students identify as a minority race; the student body is 54% male and 46% female (National Center for Educational Statistics, 2021). The school also offers special education services and a gifted and talented program. The community itself has many different aspects, and the school provides an abundance of sports and academic activities. Some extracurriculars that are a highlight of the school include football, volleyball, theater production, and the science bowl.

Participants

Within this study, there will be twenty-eight 8th-grade students participating. All the students range between thirteen and fourteen years of age. The classroom demographics closely follow the school's demographics: ten BIPOC (black, indigenous, people of color) students, thirteen females, and fifteen males. One student received special education services within the classroom, two students were on 504 plans, and four received gifted and talented services. There were no students within the classroom receiving English language support.

Sampling.

Due to the researcher's role as a teacher, the study is based on a random purposive sampling of the twenty-eight students enrolled in their 8th-grade mathematics class. The research is on the effects of problem-based learning on students' critical thinking skills, academics, and peer collaboration. These questions were based on knowing the students in the classroom, how they were engaged, and how they have previously performed in mathematics.

Instrumentation

The instrument used to collect information was a survey delivered through Google Forms (see Appendix A). The survey questions were given in the same order each time. The researcher developed the questions for the survey through the articles and research studied within chapter two and used knowledge of curriculum and instruction to create feedback questions. The researcher also made informal observations that were considered as students worked through the unit. The researcher interviewed participants throughout the informal observations to clarify classroom behaviors or survey responses.

Data Collection.

Due to the availability of technology for each student, the data from the survey (Appendix A) was collected on a Google Form document, then later transferred to a Google Sheets spreadsheet for analysis. The survey was given in class at the beginning and end of the unit. The research also observed students' behavior, looking specifically at students' 21st-century skills, or lack of, as well as student-to-student peer collaboration.

Data Analysis.

After collecting data from the survey (Appendix A), the raw data is transferred to a Google Sheet spreadsheet. The researcher summarized the information based on how each student answered the questions on a scale of 1-5 which translated to strongly disagree to strongly agree. This process was repeated both times the survey was administered. These summaries were then used to look for any data trends and outcomes from the study. In addition to data collected through the survey, the researcher reviewed and summarized their informal observation information.

Research Questions and System Alignment.

The table below (i.e., Table 3.1) provides a description of the alignment between the study's Research Questions, and the methods used in this study have been accounted for adequately.

Table 3.1.

Research Question Alignment

Research Question	**Variables**	**Design**	**Instrument**	**Validity & Reliability**	**Technique (e.g., interview)**	**Source**
How does problem-based learning in mathematics impact the critical thinking skills of middle school students?	IV: Mathematics unit centered around Problem-based learning DV: Student's participation in a survey before, during, and at the end of the unit.	Cross-sectional survey and Semi-structured interviews	Survey through Google Forms, Data analysis through Google Sheets	The same format for every summative assessment will stay consistent. In addition, homework assignments will be consistent in comparison to previous units. Survey responses by all participants will be compared; from multiple perspectives and lead to a better understanding of the research question.	Survey, observation, and occasional interview as needed.	28 8th grade mathematics students.
What are the impacts of increased opportunities for critical thinking on students' collaboration with each other?						

Procedures

This study took place over three weeks during the second semester of the school year. During this time, the students used a curriculum centered around problem-based learning. The lessons were happening three to four times a week, with a formal assessment at the end of each week. This class period was from 10:11 A.M. – to 11:07 A.M. each day. The students were randomly assigned to this class period. The problem-based learning lessons incorporated collaboration and teamwork each day with a short five-to-seven-minute recap at the end that would be similar to a closure of a lecture-style classroom. At the beginning of the study, a survey was administered to the students. Then, the students were provided a breakdown of the essential vocabulary from the survey. This survey was repeated at the end of the unit.

Throughout the study, the researcher took the role of facilitator for the group work, each day starting with a reminder of the expectations for group work from the researcher. Then the students were instructed in a format conducive to working together and building from their previous knowledge of the topic. The researcher circulated the room while students worked together to complete the activities, giving small directions or redirecting students back to their groups. During this time, the researcher also wrote down any informal observations they had about students' development or lack of 21st-century skills and their interactions with peers. These observations were used as directly observed. Finally, the researcher summarized and looked for trends.

Ethical Considerations

To ensure that the study was ethical, the researcher ensured that all participants and guardians of participants were informed of the study and that consent was received from both

parties. Students and guardians had the opportunity to decline participation or ask further clarifying questions. The students or guardians were also informed they could leave the study at any time. Using a problem-based learning curriculum does not create any concerns for student safety within the classroom or concerns for negative effects on student learning. All responses and observations during the study were kept confidential.

Conclusions

Problem-based learning can be beneficial to students in their 21st-century skill development, academic development, and the development of positive peer interactions. This chapter described the research that will be performed surrounding the student participants and the inclusion of problem-based learning. The researcher explains how the study was conducted and how the data was collected and analyzed. The next chapter will include the results of the study.

Chapter 4

DATA ANALYSIS AND INTERPRETATION

A qualitative study was conducted to see if a problem-based learning curriculum within a mathematics classroom impacted middle school students' critical thinking skills and peer relationships. This was analyzed from a student perspective via a survey given through Google Forms. It was also analyzed from a teacher's perspective through informal observations over a three-week instruction period. Another significant part of the Research leading to the study and before conducting the study was to see how problem-based learning is implemented. There has been an increased emphasis on STEM career fields and the focus on being able to problem solve within a job. Problem-based learning has been found to help students develop and build many 21st century skills, such as problem-solving, that they will utilize in their post-secondary endeavors (Gerlings, 2018).

Data Collection

The researcher collected qualitative data through two Google Form surveys given to students. The researcher also collected data through information observations during lesson worktime. The Google Form survey asked participants to reflect on their experiences within the classroom in the previous three-week period. The survey was given at the beginning of a three-week instruction period and the end of the three-week instruction period. The survey also asked students to reflect on how the mathematics content and delivery within class allowed them to work through multiple 21st-century skills such as problem-solving, leadership, communication, and teamwork. They were also asked to reflect on the opportunities to create connections between previous learning. Through participants' responses to these questions, the researcher

identified common themes at the beginning of the instructional period and then compared that to data collected at the end of the instructional period.

In addition to the insights from the student perspective, the researcher also took informal observations of students' behavior and interactions. The researcher was looking to answer similar questions that the students did but from an adult perspective. The researcher watched and noted peer interactions during group work.

Before the three-week instruction period for the survey, the mathematics classroom in which the study took place was a traditional lecture-style classroom. The average class was 55 minutes long. The lessons within the class, on average, were 35 minutes in length. They included multiple small opportunities for students to speak with each other to complete a similar problem to one they have already seen completed on the board via the lecture.

Results

Research Question #1: How does problem-based learning in mathematics impact the critical thinking skills of middle school students?

While analyzing the data collected at the beginning and end of the survey and the informal observations the Research made throughout the survey, the following themes appeared. First, the students answered with an overwhelming response that they were not practicing many 21st century skills within class daily. At the end of the three-week instructional period, the data shows they felt different. The questions given (Appendix A) were able to show from the student's perspective that they were not provided with the opportunity to work on real-world problems with their peers to develop those 21st-century skills, particularly critical thinking skills, before the study. With the frequency graph in Figure 4.1 from the following questions: 3, 6, 7,

and 9, most students strongly disagreed, disagreed, or felt neutral to statements that focused on critical thinking opportunities provided in the classroom. The data shown in the frequency graph in Figure 4.2 shows the students' perspective at the end of the three-week instructional period using problem-based learning on the same survey questions.

Figure 4.1

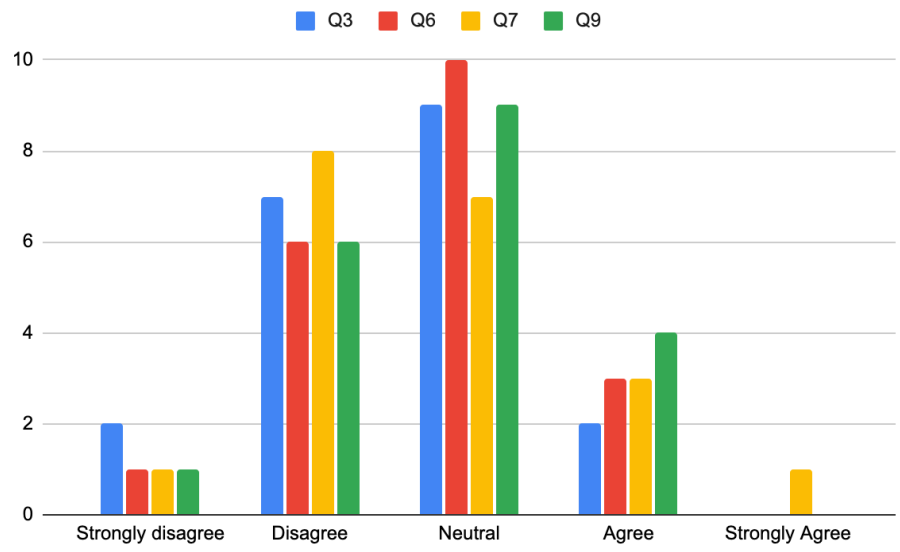
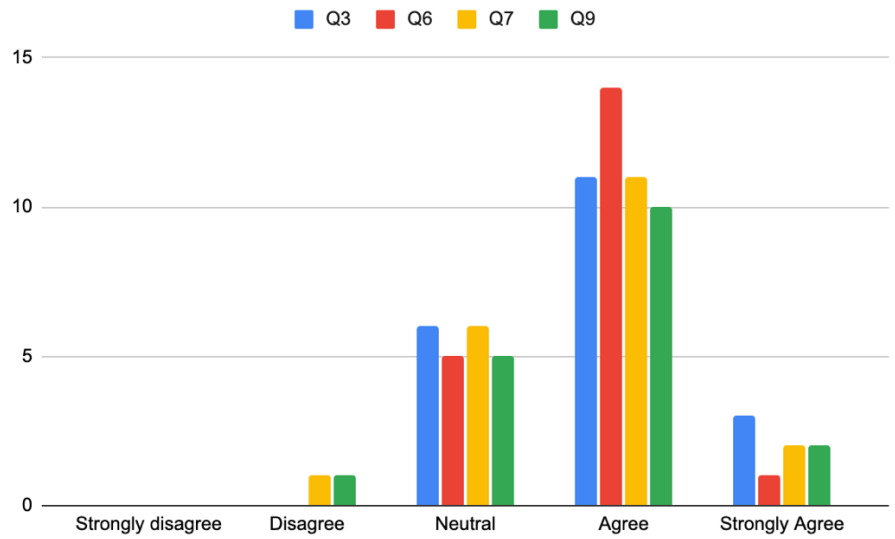


Figure 4.2



Data Analysis.

The purpose of questions 3, 6, 7, and 9 was to analyze from a student's perspective if they were using critical thinking skills within the classroom before the study and then during the study. This type of questioning was to broaden students' understanding of critical thinking and see the actions included in critical thinking. This data follows how instruction was being given in class before the study. The classroom was a traditional lecture style with limited opportunities for students to work together each class period. I did expect the initial survey results. Initially, very few students agreed with the statements that they were provided an opportunity to use their critical thinking skills in class. At the end of the study, I was surprised at how aware the students were of their critical thinking skills. By the end of the three weeks, the data shows that almost all the students chose neutral, or they agreed to some degree that they were able to practice those parts of critical thinking. During the study, I took informal observations based on the survey questions the students completed. I noticed an improvement for most students towards the end of the second week in their critical thinking skills and, more so, their willingness to put themselves out there to attempt a problem. Students were more open to asking questions, and their curiosity increased.

These findings reinforce the work that VanTassel-Baska wrote about in their article *Curriculum Issues*. Within *Curriculum Issues*, VanTassel-Baska mentions that students show higher levels of thinking and increased critical thinking, leadership, and creative thinking due to problem-based learning (VanTassel-Baska, 2013). In addition, VanTassel-Baska (2013) talked about engaging the learner and promoting higher-level thinking. Problem-based learning is frequently mentioned due to its scaffolding for higher-level thinking, creative thinking, and critical thinking skills.

RQ 2: What is the impact of increased opportunities for critical thinking on students' collaboration with each other?

Within the survey, two distant parts provided insight into the impact on students' relationships with each other concerning critical thinking skills. The first part was direct questions on if students had an opportunity to collaborate within their critical thinking to complete the mathematics. These are questions 1 and 2. In Figure 4.3, you will see the students' initial results in blue from the first statement, 'In the last three weeks of class, I had the opportunity to communicate with others to coordinate and complete tasks.' After the three-week instructional period is shown in red, Figure 4.3 is a direct comparison of the two surveys. In Figure 4.4, you will see the results from the second statement, 'In the last three weeks of class, I had the opportunity to seek help from team members to help complete tasks.' Figure 4.4 is another direct comparison of the initial survey results and the end survey results.

Figure 4.3

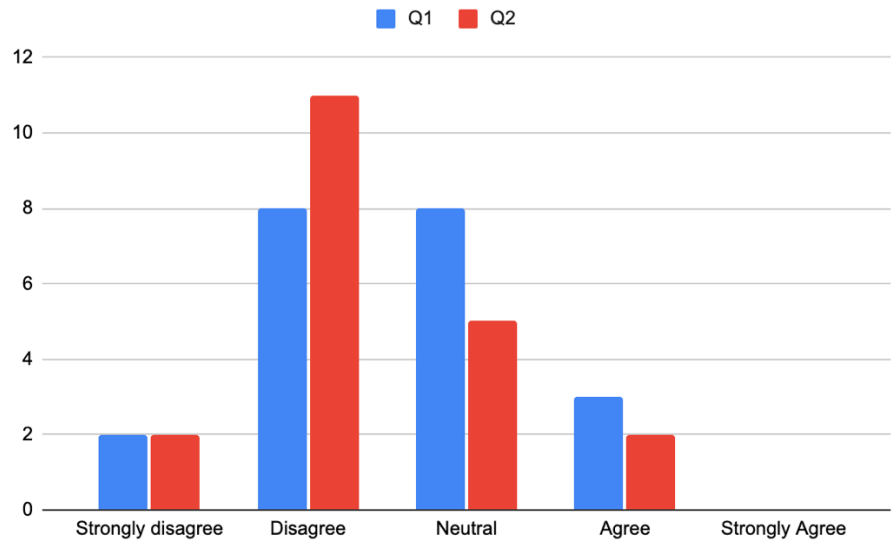
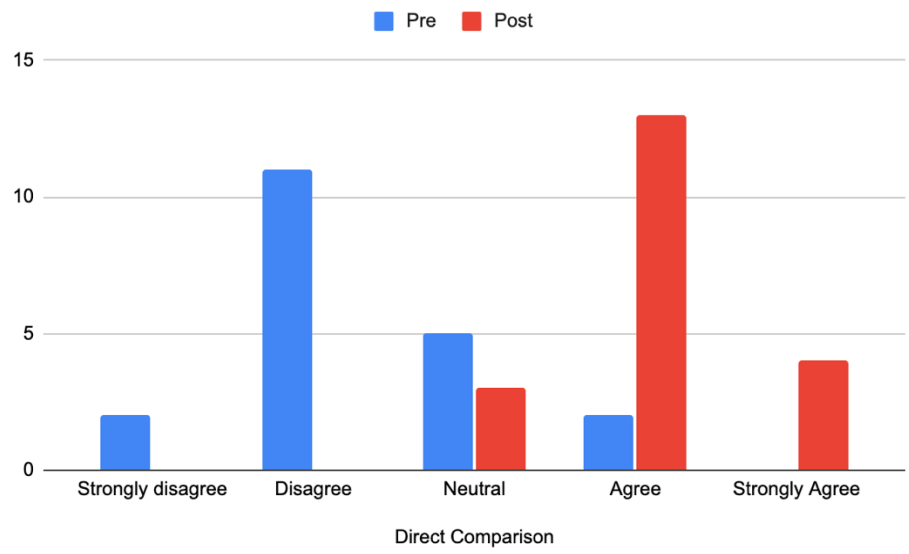


Figure 4.4



In addition to questions 1 and 2 asking students if they had the opportunity to collaborate, questions 4, 5, and 8 focused more on how critical thinking skills were included in those opportunities for collaboration. Figure 4.5 shows the results from the initial survey, and figure 4.6 shows the results at the end of the three-week instructional period. These two figures show that as students completed the mathematics content based on problem-solving, they had opportunities to work on their teamwork, leadership, and communication skills.

Figure 4.5

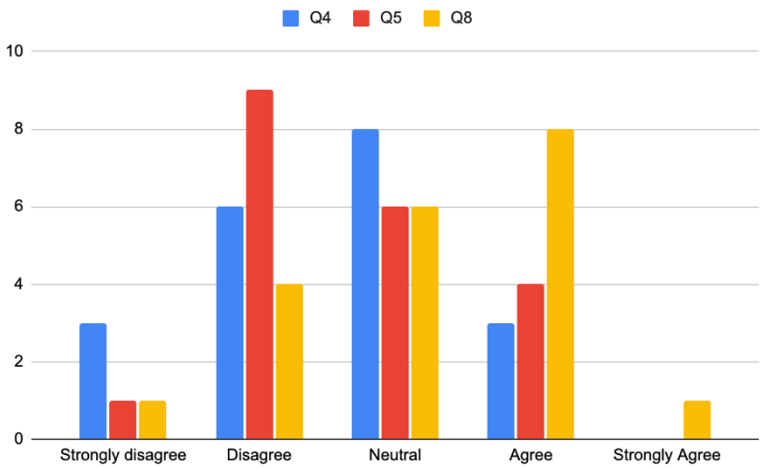
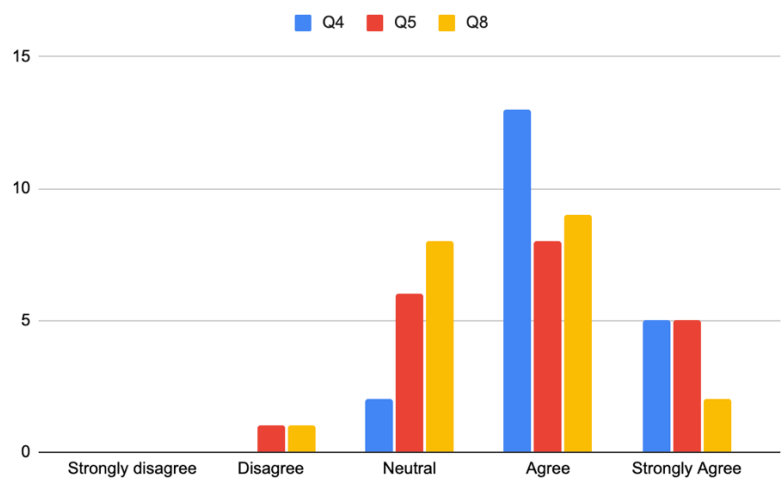


Figure 4.6



Data Analysis.

Questions 1 and 2 give a bird's eye view of peer interactions in the classroom lessons. The weeks leading to the survey were based on the traditional lecture style, and then during the study, each class was problem-based learning curriculum focused. The students were given significantly more time to explore, collaborate, and discover mathematics with their peers. That time provided is reflected in the survey results in Figures 4.3 and 4.4. These results were more dramatic than expected for both surveys. More students disagreed or strongly disagreed with the statements that I expected. Students were given time before the study during the traditional style lectures to collaborate, but they were not given time to discover and explore as they were during the problem-based learning curriculum. This challenges the concept of what a task is and how we assign work in a classroom. These results challenge educators to investigate how challenging tasks are given to students during work time and how beneficial students feel those tasks are to their learning and futures.

Fi and Degner talk about how to best practices for implementing problem-based learning in their article *Teaching through Problem Solving*. One large concept is 'teacher moves,' the teacher needs to provide opportunities that "empower students to be able to make decisions" by giving a whole task/problem to students (Fi, Degner, 2012, p.455). This prevents teachers from breaking down the complexities of the problem and allows students to focus on the big idea to discover the concept and joy of mathematics. This research coincides with the results of the survey. Students were allowed to collaborate before the study began though during the study when they were presented with different types of tasks that challenged them, they viewed the collaboration differently.

The other piece of data that formed a theme was from questions 4, 5, and 8. Similar to the statements connected to Research Question #1, these were broken down to see if critical thinking skills were used while collaborating with other students. One interesting observation of this data is the difference of opinions between the students in the first survey. Some students, the ones who agreed or strongly agreed, were receiving what they needed for collaboration around critical thinking, but others who disagreed or disagreed were not. After the study, there was a significant change to the survey results. More students felt that they were provided the opportunity to collaborate and work on critical skills such as teamwork, leadership, and effective communication.

It is a good practice for all teachers to believe that every student can and should be able to show these critical skills. However, the data reinforces that that opportunity is sometimes not always provided in a traditional-style classroom. William McCallum says that a problem-based learning curriculum reinforces the mentality that all students can learn and solve high-level problems while also giving them a chance to try (McCallum, 2019).

Conclusion

In conclusion, the data collected shows that problem-based learning impacts students' critical thinking skills and their collaboration with each other from a student's perspective. The student survey showed an change in student opinion on key aspects of critical thinking and also how critical thinking was allowing them to collaborated.

Chapter 5

IMPLICATIONS FOR PRACTICE

This study was completed within a mathematics classroom to see the impact of problem-based learning on students' critical thinking skills and peer collaboration. Problem-based learning has been found to have many beneficial outcomes for students of all ages within many different subject areas. One of these benefits is raising each student to a high potential and a higher level of learning by assigning challenging tasks. Another possible outcome of a curriculum focused on problem-based learning would be to increase applicable collaboration, communication, and leadership skills for future careers. The researcher provided three weeks of instruction focused on problem-based learning. The participants completed a survey at the beginning and the end of the three weeks. The data from the survey showed an increase in critical thinking skills from a student's perspective. The Research also took informal observations throughout the three weeks based on the survey questions presented to the students. The observations reinforced the data the students provided through the survey.

Action Plan

This study showed an increase in students' critical thinking skills through a problem-based learning curriculum. After completing this study, I plan to continue to incorporate problem-solving and lessons around problem-based learning at least three times a week. The research leading to the study showed multiple supports needed for educators to implement problem-based learning within their classrooms successfully. I would need more preparation and support to implement this curriculum style successfully and consistently. These supports could include a curriculum that naturally facilitates problem-based learning, observing teachers who

successfully implement problem-based learning, and practicing with educators. The three-week period of this study gave me a small glimpse of what would be needed regularly of a teacher to implement this curriculum in a classroom that isn't using it currently. It takes extra hours to prepare lessons to implement correctly. Although, through my preparation of each lesson, I did find additional resources and curriculums online that are already centered around problem-based learning. A curriculum already focused on problem-based learning would help ease the teacher's transition, but it would not be necessary to implement it.

Another piece that I found interesting in the data was the opportunity that problem-based learning gave each student to collaborate in a meaningful way. Each student deserves to learn at a high level, and this study showed that when presented with a problem through problem-based learning, students' critical thinking skills and level of thinking grew. Challenging each student to think at a higher level is extremely important as an educator. I plan to incorporate something each day that allows students to continue this, even when the content is delivered in a more traditional lecture style.

This style of content delivery could have a significant impact on students, teachers, and administration. It could be a slight shift in practice for individual teachers or a considerable culture shift within schools and districts. This shift would allow for students to continue to grow their communication, leadership, teamwork, and critical thinking skills at a deeper level. In addition, starting problem-solving at a younger age could potentially help these skills develop sooner. A stronger development of these skills at a younger age could influence the overall school and district climate by setting high expectations for students and providing them with opportunities to practice and meet those expectations.

Plan for Sharing

I plan to share the results of my study with my colleagues within my content Professional Learning Community (PLC) and my administration. Each of these groups has been aware of my Research and curious about the outcome. My PLC has been helpful and encouraging with the desire to create lesson plans around problem-based learning, and I want to encourage continued conversations about how we can better meet the needs of our students. I also want to share my results with my students who participated in the study. I want them to see overall results to foster discussion around critical thinking and what it looks like to them. I also want to continue my students' work and skill learning, they did over the three weeks using problem-based learning.

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Appendix

Appendix A

Survey questions 1 – 9 use the following scale:

1 – Strongly disagree, 2 – Disagree, 3 – Neutral, 4 – Agree, 5 – Strongly Agree

1. In the last 3 weeks of class, I had the opportunity to communicate with others to coordinate and complete tasks.
2. In the last 3 weeks of class, I had the opportunity to seek help from team members to help complete tasks.
3. This class provided me with the opportunity to gather information from others to identify a problem, find and view similar problems, analyze my answers, and justify my solution.
4. In class I have the chance to work on my teamwork and communication skills.
5. Class lets me provide leadership to a team conducting a complex task.
6. I have the opportunity to work on problems encountered by professions (at an age and skill appropriate level).
7. I can analyze information to determine what is relevant to the problem
8. I can explain problems and solutions to others effectively.
9. The delivery of math content allows for me to create links between concepts we have previously learnt and use that knowledge to other problems.
10. If you had to choose a class taught using only traditional lectures or one based on problem-based learning, which would you choose?

    Answer Options:

- A traditional based class
- A problem-based learning class

Appendix B

Institutional Review Board

MINNESOTA STATE UNIVERSITY MOORHEAD

DATE:	March 1, 2022
TO:	Kristen Carlson, Principal Investigator Rebecca Ostby, Co-investigator
FROM:	Dr. Robert Nava, Chair Minnesota State University Moorhead IRB
ACTION:	**APPROVED**
PROJECT TITLE:	[1878334-1] The Impact of Problem Based Learning
SUBMISSION TYPE:	New Project
APPROVAL DATE:	March 1, 2022
EXPIRATION DATE:	
REVIEW TYPE:	Exempt Review

Thank you for your submission of New Project materials for this project. The Minnesota State University Moorhead IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Exempt Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others and SERIOUS and UNEXPECTED adverse events must be reported promptly to the Minnesota State University Moorhead IRB. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to the Minnesota State University Moorhead IRB.

This project has been determined to be a project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of .

Please note that all research records must be retained for a minimum of three years after the completion of the project.

If you have any questions, please contact the Minnesota State University Moorhead IRB. Please include your project title and reference number in all correspondence with this committee.

This letter has been issued in accordance with all applicable regulations, and a copy is retained within Minnesota State University Moorhead's records.

Appendix C – Informed Consent Letter

March 4th, 2022

305 Vicksburg Ln N

Plymouth, MN 55447

Dear Parent or Guardian,

Your child has been invited to participate in a study to observe the effects of problem-based learning inside their math classroom.

Your child was selected because they are in my regular education classroom. If you decide to participate, please understand that your child will be asked to do the following, and these are typical classroom activities that involve no risk to your child.

- Your child will be continuing to use the CPM curriculum, there will be increased emphasis on using problem-solving skills to work through the problems within groups. There will be direct instruction on problem-solving skills/tools and collaboration throughout the unit.
- Students will be given a pre and post survey to gather their opinion on their own problem-solving skills as well as their opinion on problem-based learning.

Although Wayzata Public Schools has granted me permission to conduct this study, since this information is being used to help me complete my master's degree at Minnesota state University Moorhead, I need to have parental consent to use this information in my final paper that I am required to do as part of my degree. If I didn't need this information to complete my master's

degree, I would be conducting this same type of research in my normal everyday lessons. If you sign this form, you are giving me consent to use the information that I gather. All information that is used will be confidential, no names or identifiers will be used. Please also note, that your child can choose to not participate at any time without any consequences.

Please feel free to ask any questions you have regarding this study. You may contact me here at school though email at Rebecca.ostby@wayzataschools.org or phone: 763-745-6120, or Principal Investigator Dr. Kristen Carlson at 218-477-2721, or by email at kristen.carlson@mnstate.edu. Any questions about your rights may be directed to Dr. Robert Nava, Chair of the MSUM Institutional Review Board, at 218-477-2134 or by email at irb@mnstate.edu.

You will be offered a copy of this form to keep. You are deciding whether or not to have your child participate in the survey and study. Your signature indicates that you have read the information provided above and have decided to participate. You may withdraw your child at any time without prejudice after signing this form should you choose to discontinue participation in this study. This study will take approximately 3 weeks or one classroom unit.

_____ _____

Signature of Parent or Guardian Date

_____ _____

Signature of Investigator Date